23 Acute Gastrointestinal Bleeding in Adults and Children: Evidence-Based Emergency Imaging

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Key Points

- Computed tomography (CT) angiography has high diagnostic performance in the setting of acute lower gastrointestinal (GI) hemorrhage (strong evidence). CT angiography should be performed prior to catheter angiography where possible as it increases the likelihood of successful angiographic localization of bleeding (moderate evidence). CT angiography may be superior to colonoscopy as the initial investigation/evaluation in acute lower GI bleeding, but further studies are required to support this (limited evidence).
- Superselective microcoil embolization is a safe and effective treatment for acute lower GI bleeding (moderate evidence). CT angiography should be performed prior to embolization where possible (moderate evidence). A randomized study comparing colonoscopy with CT angiography and embolization has not been performed.
- Endoscopy is currently accepted as the first-line investigation in upper GI bleeding. CT angiography is the imaging modality of choice in cases where endoscopy has failed to localize or control the bleeding (strong evidence). It has been proposed that CT angiography may be useful as a first-line investigation prior to endoscopy, but more research is required to support this claim (limited evidence).
- Superselective microcoil embolization is the initial treatment of choice in acute non-variceal upper GI bleeding refractory to endoscopic management and has been shown to have a lower 30-day mortality rate when compared with surgery (moderate evidence). In acute variceal upper GI bleeding, emergent transjugular intrahepatic portosystemic shunt (TIPSS) formation may control hemorrhage in cases refractory to endoscopic management (moderate evidence).

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Definitions and Pathophysiology

This chapter focuses on the radiological investigation and management of acute hemorrhage originating in the upper and lower GI tracts. As the radiologist plays a central role not only in the investigation but the treatment of GI bleeding (often during the same procedure by means of catheter angiography and embolization), both subjects are addressed. Upper gastrointestinal bleeding is defined as originating proximal to the ligament of Treitz, with lower gastrointestinal bleeding arising distally. Upper GI bleeding accounts for approximately 76% of cases [1]. Causes of upper GI bleeding include duodenal ulcers (24%), gastric erosions (23%), varices (10%), Mallory-Weiss tears (7%), esophagitis (6%), duodenitis (6%), neoplasia (3%), and esophageal ulcers (2%) [2, 3]. Common causes of lower GI bleeding are diverticular hemorrhage (42%), colorectal malignancy (9%), and ischemic colitis (9%) [4]. Other less frequent causes include vascular ectasia, Crohn's ileitis, Meckel's diverticula, and small bowel tumors [5]. Risk factors associated with an increased risk of gastrointestinal hemorrhage include age, aspirin, nonsteroidal anti-inflammatories, selective serotonin reuptake inhibitors, warfarin, and chronic liver disease [2, 3, 5–7].

Epidemiology

The estimated annual incidence of upper GI bleeding in the United States in 2009 was 66.0/100,000, a decrease from 78.4/100,000 in 2001 [8]. Bleeding ascribed to gastroduodenal ulcers or gastritis/duodenitis decreased by more than one third between 2001 and 2009, with a decrease in the prevalence of *Helicobacter pylori* and an increase in the use of acid-suppressing medications proposed as potential explanations [8]. The mortality rate in 2009 for cases of upper GI bleeding was 2.95%. The incidence of lower GI bleeding in 2009 was estimated at 25.7/100,000 in 2009 compared with 41.8/100,000 in 2001, with a case fatality rate of 1.93%. Both upper and lower GI bleeding have a significantly higher incidence in patients aged over 75 [8].

Overall Cost to Society

The estimated annual cost of upper GI bleeding in the United States has been estimated to be $2.5 billion, with 300,000 hospital admissions every year [9]. The annualized US healthcare costs for a patient with an upper GI bleeding event have been estimated to be $20,405 [9]. While no formal estimates for the annual cost of lower GI bleeding in the United States are available, the cost of diverticular hemorrhage, the most common cause of lower gastrointestinal hemorrhage, was estimated to be $1.3 billion in 2001 [10].

Goals of Imaging

The primary goal of imaging in patients presenting with acute gastrointestinal bleeding is to correctly identify the site and cause of bleeding and to triage the patient to the correct management pathway, whether that be endoscopy, catheter angiography and embolization, surgery, or conservative management.

Methodology

A comprehensive MEDLINE search (US National Library of Medicine database) for original articles published between 1995 and 2015 using the PubMed search engine was performed using a combination of the following MeSH headings: *Gastrointestinal Hemorrhage*; *Tomography, X-Ray Computed*; *Nuclear Medicine*; *Radiopharmaceuticals*; *Angiography*; *Angiography, Digital Subtraction*; *Embolization, Therapeutic*; *Adolescent*; *Infant*; *Child*; *Pediatrics*; *Costs and Cost Analysis*; and *Epidemiology*. The abstracts were reviewed and selected on the basis of relevance and methodology. Additional relevant articles were identified from the references of the reviewed articles and by use of the reverse citation trail [11].

Discussion of Issues

What Is the Most Appropriate Imaging Modality for the Diagnosis of Acute Lower GI Bleeding?

Summary of Evidence Computed tomography angiography (CTA) has high diagnostic performance for detecting and localizing lower gastrointestinal hemorrhage (strong evidence). It is superior to techetium-99m-labeled red blood cell scintigraphy for accurately localizing the source of bleeding (moderate evidence). Performing CTA prior to catheter angiography improves localization of the bleeding site compared with catheter angiography alone (moderate evidence) suggesting CTA should be performed if catheter angiography is being considered, where clinical circumstances permit. One small prospective study found CTA to be more sensitive and specific than colonoscopy (limited evidence) [12] suggesting it may be useful as the initial test in lower GI bleeding; further data is required to substantiate this.

Supporting Evidence

CT Angiography

The role of imaging in the patient presenting acutely with lower gastrointestinal bleeding is to identify the site and source of bleeding and to triage the patient to the appropriate management pathway. Endoscopy has long been the initial test of choice, and current guidelines from the American Society of Gastrointestinal Endoscopy and the Scottish Intercollegiate Guidelines Network continue to recommend upper and lower GI endoscopy as the first investigations in patients presenting with hematochezia, with radiological investigations reserved for those in whom endoscopy fails to identify or control the source of bleeding [13, 14]. However in the setting of active large-volume bleeding, colonoscopy can be challenging, and its ability to treat the cause of bleeding may be limited [15]. For this reason, the American College of Radiologists Appropriateness Criteria on lower GI bleeding suggest catheter angiography is more appropriate than colonoscopy in the unstable patient with lower GI bleeding, although CT is still deemed second line [16]. Similarly, guidelines from the American College of Gastroenterology suggest that angiography may be more appropriate than colonoscopy in severe active bleeding [17]. Recent developments in multi-detector CT technology and its widespread dissemination have led to increased interest in its role in the setting of acute lower GI bleeding, both in patients failing endoscopic management and also as a potential first-line investigation [12].

A meta-analysis and systematic review of 22 studies published in 2012 by Garcia-Blazquez et al. found CT angiography to have high diagnostic performance in detecting and localizing acute gastrointestinal bleeding (both upper and lower) with an overall sensitivity of 85.2% (95% confidence interval 75.5%–91.5 %), overall specificity of 92.1% (95% confidence interval 76.7%–97.7%), likelihood ratio for a positive test result of 10.8 (95% confidence interval 3.4–33.4), likelihood ratio for a negative test result of 0.16 (95% confidence interval 0.1–0.027), and an area under the curve (AUC) of 0.935 (95% confidence interval 0.693–0.989) (strong evidence) [18]. These high sensitivity and specificity values were replicated in two earlier systematic reviews of the diagnostic performance of CT angiography published in 2008 and 2010 [19, 20]. The studies included in these three systematic reviews demonstrate somewhat variable methodological quality with a minority being prospective in design, and they show significant differences in the reference standards used [21–37]. The majority of the primary studies in these meta-analyses utilized multi-detector CT technology with a minority utilizing single-detector technology.

CTA has previously been shown to be capable of detecting bleeding rates of as little as 0.3 ml/min [38], compared with 0.1 ml/min for radionuclide scans [39] and 1 ml/min for first-order aortic branch-selective digital subtraction angiography [40]. While CTA may be less sensitive for slow active bleeding than radionuclide scanning, it has significant advantages when it comes to availability and speed of imaging, and it also performs superiorly at correctly localizing the bleeding source. A 2015 study comparing CTA and technetium-99m red blood cell (RBC) scintigraphy prior to catheter angiography found that although CTA and RBC scintigraphy had similar sensitivity and specificity, localization of the bleeding site was more precise and consistent with CTA (moderate evidence) [41]. The same study showed that performing CTA prior to catheter angiography improved localization of the bleeding site when compared with catheter angiography alone. These findings suggest CTA should be performed prior to catheter angiography where possible.

In addition, a retrospective review published in 2015 by Chan et al. showed that of 115 patients undergoing urgent CTA for lower GI bleeding, 77% of patients with a negative CTA did not rebleed [42] and a negative CTA may therefore be useful for identifying those that will not need emergent intervention (moderate evidence). A small retrospective review of 20 patients published in 2010 showed that of ten patients with a negative CTA, only one required intervention to secure hemostasis, and a positive CTA allowed patients to be triaged to either catheter angiography or surgery (limited evidence) [43]. CT angiography may therefore be a useful tool in deciding which patients are likely to respond to endovascular management.

A study of 29 patients with acute non-variceal GI bleeding (11 upper and 18 lower) compared the diagnostic performance of endoscopy and CTA [12]. Although limited by small patient numbers, the study showed CT to be more sensitive and specific than endoscopy in identifying the site and cause of bleeding (limited evidence). The authors propose CTA as a first-line test (prior to endoscopy) in patients with GI bleeding; however, further well-designed prospective studies comparing CTA and endoscopy as initial investigations in acute lower GI bleeding are required.

The literature on the imaging of GI bleeding in children is scarce; however, there has been recent interest in the utility of CT angiography in the pediatric population. A review of 27 infants and children with lower GI bleeding found that arterial phase CT imaging identified the source of bleeding in 20 cases [44]. A small case series in 2013 described two cases of lower GI bleeding in children with causes successfully diagnosed by CT angiography [45]. While there may be a role for CTA in children with acute lower GI bleeding, further investigation is required (limited evidence).

Nuclear Medicine

Prior to the advent of CT angiography, technetium-99m-labeled red blood cell scintigraphy had been considered (along with catheter angiography) a first-line imaging test in those patients for whom endoscopy failed to identify a source of acute lower GI bleeding. The primary advantage of RBC scintigraphy is its ability to detect active bleeding rates as low as 0.1 ml/min [39], making it more sensitive to slow rates of bleeding than CT angiography and catheter angiography, which can detect bleeding at rates of 0.3 ml/min and 1 ml/min respectively [38, 40]. Technetium-99m-labeled RBC scintigraphy has been shown to be superior to technetium-99m-labeled sulfur colloid and is considered the radiopharmaceutical of choice [46].

The reported sensitivities of RBC scintigraphy for the detection of active GI bleeding vary widely, ranging from 23 to 83% (limited evidence) [46–51]. These values are based on retrospective studies using a variety of reference standards including endoscopy, angiography, and surgery. Technetium-99m RBC scans are more likely to be positive in hemodynamically unstable patients, with one study showing 62% of studies to be positive in unstable patients versus 21% in stable patients [52]. In the emergency setting, the availability of RBC scintigraphy in most institutions is limited when compared with that of CTA.

Significantly, RBC scintigraphy performs poorly when localizing the site of bleeding. A review of 162 patients undergoing RBC scans showed accurate localization of the site of bleeding in only 52% of cases (moderate evidence) [49]. Four similar smaller studies showed that RBC scintigraphy incorrectly localized the site of bleeding in 48–83% of patients [48, 53–55]. In one retrospective study of 80 patients undergoing single-photon emission computed tomography

(SPECT)-enhanced RBC scintigraphy, there were 8 false positives leading to 5 inappropriate operations [56]. A retrospective study comparing CTA and nuclear scintigraphy prior to catheter angiography found similar sensitivity and specificity between the two studies, but CTA was superior in correctly identifying the site of bleeding (moderate evidence) [41]. A prospective study performed in 2008 comparing contrast-enhanced multi-detector CT and technetium-99m RBC scintigraphy showed CT to be effective for the detection and localization of active lower GI bleeding and further showed significant disagreement between the CT and RBC scintigraphic findings (moderate evidence) [57]. Thus in the acute setting, CT is preferred over RBC scintigraphy in the imaging of lower GI bleeding.

The literature examining the role of nuclear scintigraphy in children with lower GI bleeding mainly relates to technetium-99m pertechnetate imaging for the detection of ectopic gastric mucosa in Meckel's diverticula. A systematic review of 40 such studies found technetium-99m pertechnetate imaging to have a sensitivity of 92%, specificity of 95%, positive likelihood ratio of 16.5, negative likelihood ratio of 0.15, and diagnostic odds ratio of 120.7 (strong evidence) [58]. A review of technetium-99m RBC scintigraphy in 22 children presenting with acute lower GI bleeding found it to be a sensitive but nonspecific method for detecting the bleeding source (moderate evidence) [59]. Further evidence is required to more accurately define the role of technetium-99m RBC scintigraphy in these patients.

Catheter Angiography

CT angiography has largely supplanted catheter angiography in the imaging of acute lower GI bleeding, with catheter angiography usually reserved for cases where there is intent to treat. A significant disadvantage of catheter angiography is the invasive nature of the procedure, in contrast to CTA and RBC scintigraphy. An in vitro study comparing CTA and catheter angiography found CTA to be more sensitive for the detection of slow rates of bleeding than first-order aortic branch-selective digital subtraction angiography [40]. Significant active bleeding may need to be present in order to be detectable by catheter angiography. A 2013 retrospective study showed that in 33 patients in whom CTA identified active extravasation, only 27% of the subsequent catheter angiograms were positive (limited evidence) [60]. Similarly, another 2013 retrospective study showed that only 24% of catheter angiograms were positive following a positive technetium-99m-labeled RBC scan (moderate evidence) [61]. A 1993 study evaluating the role of angiography found that in 49 patients with a history of overt non-variceal GI bleeding, 29 yielded true positive results with 16 being false negatives giving a sensitivity value of 64% [62] although note should be made of the fact that this group contained some patients with subacute presentations (limited evidence). Factors shown to increase the likelihood of a positive angiogram include hemodynamic instability, a transfusion requirement of 5 units of red blood cells or more, a hemoglobin drop of 5 g/dL or more, and a hemoglobin level of 10 g/dL or less [60, 63, 64]. Given the challenges of performing colonoscopy in unstable patients with active bleeding [15], and the increased likelihood of a positive angiogram in these cases, the American College of Radiology (ACR) Appropriateness Criteria currently recommend angiography over colonoscopy as the initial investigation of choice in unstable lower GI bleeding (insufficient evidence) [65].

A negative catheter angiogram appears to predict a low risk of rebleeding although the risk of a recurrent massive hemorrhage remains. A study that followed 75 patients for an average of 8 months after negative angiograms found that rebleeding occurred in 12 patients (16%) and in 6 of these patients (8%); this rebleeding resulted in death within 4–9 h [66]. Provocative angiography using anticoagulants and fibrinolytics has yielded some success in cases of occult GI lower bleeding [67–69] although it has largely been replaced by newer techniques such as capsule endoscopy, CT enterography and MR enterography.

Catheter angiography is not frequently used as a primary diagnostic modality in children presenting with lower GI bleeding, and the evidence relating to its utility is limited. A review of 27 such cases utilizing catheter angiography published in 1984 found that a correct diagnosis was made in 64% of patients and 36% of results were false negatives (limited evidence) [70]. Noninvasive imaging methods, particularly CT angiography, mean that the performance of diagnostic catheter angiography is now rarely undertaken, except in those cases where treatment with embolization is intended.

What Is the Most Appropriate Approach to the Radiological Management of Acute Lower GI Bleeding?

Summary of Evidence Numerous retrospective studies demonstrate the efficacy and safety of superselective microcoil embolization as a treatment in acute lower GI bleeding (moderate evidence). One randomized trial showed technetium-99m RBC scintigraphy followed by catheter angiography to be inferior to colonoscopy in localizing bleeding without a significant difference in outcomes, although intra-arterial vasopressin was used as treatment rather than superselective microcoil embolization (limited evidence) [71]. Performing CTA prior to catheter angiography has been shown to increase the ability to successfully localize the bleeding source at angiography (moderate evidence) [41]. CTA should therefore be performed prior to catheter angiography where clinical circumstances permit. Based on the current evidence, the most appropriate approach to the radiological management of acute lower GI bleeding is CTA followed by embolization when bleeding is identified.

Supporting Evidence A 2005 randomized controlled trial by Green et al. comparing urgent colonoscopy with standard care (technetium-99m RBC scintigraphy which if positive was followed by catheter angiography and subsequent expectant colonoscopy) in acute lower GI bleeding found no significant difference in patient outcomes, although a definitive source of bleeding was identified more often in the urgent colonoscopy group than in the standard care group (42% vs. 22%) [71]. This study appeared to demonstrate the superiority of colonoscopy over radiological management; however, of note superselective microcoil embolization was not performed, with a nonselective infusion of vasopressin being utilized as the transcatheter treatment (limited evidence). The widespread adoption of CTA as the imaging test of choice in acute lower GI bleeding means that the site of bleeding is now frequently known to the operator prior to commencing the angiographic procedure, thus increasing the likelihood of successful targeting of the bleeding vessel. A 2015 study showed that performing CTA prior to catheter angiography improves the localization of the source of bleeding when compared with catheter angiography alone (moderate evidence) [41]. Chang et al. showed that visualization of contrast extravasation at angiography allows targeting of the bleeding vessel directly leading to higher success rates (moderate evidence) [72]. This suggests that identifying the bleeding vessel on CTA may allow more accurate targeting at the time of embolization and higher success rates. A small retrospective review of 20 patients found that a negative CTA was associated with spontaneous cessation of bleeding, while a positive CTA allowed patients to be triaged to catheter angiography or surgery (limited evidence) [43]. For these reasons, where possible, it is suggested that CTA should be performed prior to proceeding to catheter angiography. While the previously referenced 2005 randomized controlled trial by Green et al. found colonoscopy to be superior to standard radiological investigation (nuclear scintigraphy and angiography) in localizing bleeding, CTA offers significant advantages over nuclear scintigraphy in this respect. In an ideal world, a randomized study comparing colonoscopy with CTA followed by catheter angiography would be of use, but in practice such a study is unlikely to take place.

In the hemodynamically unstable patient with active bleeding and high blood transfusion requirements, the likelihood of a positive catheter angiogram is increased [60, 63, 64] and it may be reasonable to proceed directly to angiography without a preceding CT. As previously noted, the

ACR Appropriateness Criteria on Radiological Management of Lower GI Bleeding recommend catheter angiography as the most appropriate initial intervention in these circumstances, relegating colonoscopy and CT to second line (insufficient evidence) [65], although modern multi-detector CT can be performed emergently even in the setting of hemodynamic instability.

Superselective microcoil embolization has gained widespread acceptance as a treatment of lower GI bleeding. A large number of retrospective reviews have been performed demonstrating its safety and efficacy, with reported technical success rates ranging from 73 to 100%, clinical success rates ranging from 63 to 96%, and rebleeding rates ranging from 11 to 50% (moderate evidence) [16, 61, 73–97]. Most series report ischemic complications in 3% or less of cases. Some small series have demonstrated good technical success rates with transcatheter embolization using *N*-butyl-2-cyanoacrylate (limited evidence) [98, 99]. One small recent patient cohort study found transcatheter pharmaco-induced vasospasm using epinephrine followed by vasopressin to be safe and effective in inducing hemostasis, although the exact circumstances in which this would be preferred to microcoil embolization have not yet been clarified (limited evidence) [100].

Rebleeding rates after superselective microcoil embolization are higher in the small bowel than the large bowel, probably due to its richer vascular supply (limited evidence) [97]. A meta-analysis of six series showed the rates of rebleeding to be lowest in diverticular hemorrhage, occurring in 15%, with rebleeding seen in 40% of patients with non-diverticular sources (limited evidence) [101]. Malignancy has been found to be a risk factor for rebleeding (limited evidence) [102], and one study examining tumor sources of GI bleeding demonstrated a 68% short-term success rate following embolization without any ischemic complications [103]. Studies comparing arterial embolization with surgery have not been performed. Similarly lacking are cost-effectiveness analyses comparing colonoscopy, arterial embolization and surgery in the management of acute lower GI bleeding.

What Is the Most Appropriate Imaging Modality for the Diagnosis of Acute Upper GI Bleeding Refractory to Endoscopic Treatment?

Summary of Evidence Endoscopy is currently accepted as the first-line investigation in patients presenting with acute upper GI bleeding. CTA has high diagnostic performance in identifying sources of both upper and lower GI bleeding (strong evidence) and should be performed in cases where endoscopy failed to localize or control the bleeding. One study examining the role of CTA prior to endoscopy showed that it inconsistently identified the source of bleeding but significantly shortened endoscopic procedure times (limited evidence). Further data is required before it can be recommended that CTA be performed before endoscopy. Technetium-99m RBC scintigraphy performs poorly at localizing bleeding in the upper GI tract and has no place in the diagnostic algorithm (limited evidence).

Supporting Evidence

CT Angiography

Upper GI endoscopy remains the initial investigation of choice in the presentation of acute upper GI bleeding due to its ability to provide both a diagnosis and a means of treatment. Current guidelines from the National Institute of Clinical Excellence, American Society for Gastrointestinal Endoscopy, American College of Gastroenterology, American College of Radiology, Annals of Internal Medicine Clinical Guidelines, and Scottish Intercollegiate Guidelines Network continue to recommend endoscopy as the first-line investigation [14, 104–108]. Endoscopy has previously been demonstrated to be an effective intervention with a meta-analysis of 30 studies finding a clinically important reduction in morbidity and mortality in patients with acute non-variceal upper GI hemorrhage (strong evidence) [109]. The current role of imaging in the acute setting is in those patients for whom endoscopy has failed to identify or control the bleeding source. In acute non-variceal bleeding, options for imaging are CT angiography and nuclear scintigraphy. Catheter angiography may be utilized in those cases where embolization is intended.

In the emergency setting, the objective of CT angiography following failed endoscopy is to identify the source of bleeding and to triage the patient toward further management. CTA has been shown to be effective in detecting and localizing active bleeding in the gastrointestinal tract. While initially investigated in acute lower GI bleeding, studies examining the technique have since been performed including cases of both upper and lower GI bleeding. In a meta-analysis and systematic review of 22 studies examining CTA in GI bleeding, 12 studies included patients with upper or lower GI bleeding, while 10 dealt with lower GI bleeding alone (none of the studies addressed upper GI bleeding alone) [18]. This systematic review yielded sensitivity and specificity values for CTA of 85.2% and 92.1%, respectively, and likelihood ratios for positive and negative test results of 10.8 and 0.16, respectively. Similarly high sensitivity and specificity rates for CTA were found in two earlier systematic reviews [19, 20]. CT angiography can be considered to have high diagnostic performance in detecting and localizing active upper and lower gastrointestinal hemorrhage (strong evidence).

Due to its high diagnostic performance, CTA has been proposed as a potential first-line investigation prior to endoscopy in acute upper GI bleeding. A retrospective study found that a negative CTA in acute upper GI bleeding may be falsely reassuring; Chan et al. found that in 63 patients with a negative CTA in acute upper GI bleeding, 26 patients (41%) went on to rebleed with 24 of these requiring embolization or surgery (moderate evidence) [42]. A 2014 retrospective study of 577 patients who underwent urgent endoscopy for acute upper GI bleeding compared outcomes in those who were first investigated with CT and those who were not [110]. In endoscopy-confirmed non-variceal bleeding, contrast-enhanced CT identified the source of bleeding in 55% of cases. The proposed reason for this apparently low rate of detection was the inclusion of cases with slowly bleeding lesions including esophagitis, angioectasia, and shallow ulcers. Also of note is the fact that the CT images were interpreted by endoscopists rather than radiologists. The average procedure time to endoscopic detection of the bleeding source was significantly shorter in the contrast-enhanced CT group. CT may therefore play a role as the initial test prior to endoscopy and may reasonably be requested by an endoscopist prior to endoscopy (limited evidence). A negative CTA should not prevent or delay endoscopy in these circumstances.

Studies in acute lower GI bleeding have found that performing CTA prior to catheter angiography can increase the likelihood of successfully identifying and treating the bleeding source [41, 72]. While it is now a common practice to obtain a CT angiogram prior to angiographic intervention in upper GI bleeding refractory to endoscopic treatment as part of treatment planning, there is no supporting evidence other than that extrapolated from lower GI bleeding data (insufficient evidence).

Endoscopy is the mainstay of diagnosis and treatment in patients with acute variceal upper GI bleeding [111]. CT is useful acutely in patients with refractory bleeding to assess for portal vein patency and as part of treatment planning prior to transjugular intrahepatic portosystemic shunt (TIPSS) formation or balloon-occluded retrograde transvenous obliteration (BRTO) of gastric varices [112].

Special consideration should be given to upper GI bleeding in the context of hemobilia, recent ERCP, hepatobiliary surgery, or pancreatitis. In these settings, endoscopy may have limited ability to identify and control the source of bleeding and may simply visualize bleeding from the duodenal papilla [113]. In these cases, CT is more useful than endoscopy in making a diagnosis and triaging toward further management with either transarterial embolization or surgery [114, 115]. Similarly, in patients with clinical suspicion of an aortoenteric fistula, CT is considered the first-line investigation, being preferred to endoscopy [116, 117].

Nuclear Medicine

The role of technetium-99m RBC scintigraphy in acute upper GI bleeding is limited. Although it is capable of detecting bleeding rates as low as

0.1 ml/min [39], its ability to accurately localize the source of hemorrhage has been shown to be poor (moderate evidence) [48, 49, 54, 55, 118]. Indeed, it appears to perform more poorly at localizing bleeding in the upper GI tract than in the lower GI tract. A retrospective review by Howarth et al. found that technetium-99m RBC scintigraphy accurately localized the source of foregut bleeding in only 7 of 21 cases (limited evidence) [54]. CT angiography is preferred in the acute setting, not least because of the significant logistical issues surrounding access to nuclear scintigraphy, both during the working day and out of hours.

What Is the Most Appropriate Approach to the Radiological Management of Acute Upper GI Bleeding Refractory to Endoscopic Treatment?

Summary of Evidence Superselective microcoil embolization is the initial treatment of choice in acute non-variceal upper GI bleeding refractory to endoscopic management, being preferred to surgery (moderate evidence). If treatment with embolization is intended, it should be undertaken early to improve outcomes (moderate evidence). In acute variceal upper GI bleeding, emergency transjugular intrahepatic portosystemic shunt (TIPSS) formation can be used in cases refractory to endoscopic management (moderate evidence). In both variceal and non-variceal bleeding, multiphase CT is often used for procedure planning.

Supporting Evidence CT angiography has largely replaced catheter angiography as a diagnostic modality for acute upper GI bleeding, and catheter angiography is now reserved for those cases in which treatment with embolization is intended. Upper GI endoscopy remains the initial diagnostic and therapeutic modality of choice in the emergent setting; therefore, the primary role of transcatheter arterial embolization is in those cases that are refractory to endoscopic management [107].

Numerous retrospective studies are available describing the high technical and clinical success rates of superselective microcoil embolization in acute non-variceal upper GI bleeding (moderate evidence) [72, 76, 79, 88, 98, 119–129]. One series which included patients with both upper and lower GI bleeding found that rebleeding rates after embolization were higher in those with upper GI bleeding (limited evidence) [127]. In a retrospective study comparing early and delayed embolization in patients with duodenal ulcer bleeding, the group treated early had significantly fewer deaths and ICU admissions (moderate evidence) [130]. If treatment with embolization is intended, it should therefore be undertaken early.

Given the potential roles for embolization and surgery in patients failing endoscopic management, of particular interest are studies comparing these two interventions. A retrospective study comparing embolization and surgery in these circumstances by Eriksson et al. found a clear trend toward a lower 30-day mortality rate in the embolization group compared with the surgical group (moderate evidence) [131]. In 2012 Ang et al. showed that embolization could avert the need for surgery in high-risk patients with upper GI bleeding [132]. Wong et al. examined 88 patients with bleeding peptic ulcers and showed that embolization reduced the need for surgery without increasing the overall mortality rate and was associated with fewer complications [133]. One study by Ripoll et al. in 2004 failed to demonstrate any significant differences between the two treatment groups in patients with bleeding peptic ulcers [134]. Overall, the evidence favors embolization as the treatment of choice in patients failing endoscopic management (moderate evidence).

TIPSS is an established treatment for patients with portal hypertension and variceal bleeding. The strongest evidence for TIPSS is in the secondary prevention of variceal bleeding, with numerous randomized controlled trials and meta-analyses supporting its use—a detailed review of this evidence is outside the scope of this discussion. In the setting of acute ongoing variceal hemorrhage refractory to endoscopic management, TIPSS is often employed as a salvage procedure. Numerous uncontrolled studies have shown salvage TIPSS to be effective, with a review of 15 studies using uncovered stents showing bleeding cessation rates of 90–100% and rebleeding rates of 6–16% (moderate evidence) [135, 136]. A recent randomized controlled trial comparing emergency TIPSS with emergency surgical portocaval shunt formation in refractory esophageal variceal bleeding found surgery to be superior for long-term bleeding control, encephalopathy, and survival [137]. It is worth noting however that many of the stents used in the TIPSS arm were uncovered which is no longer considered standard of care, and recent data have demonstrated superior results with polytetrafluoroethylene (PTFE)-covered stents [138]. PTFE-covered stents are now considered standard of care. A randomized controlled trial comparing TIPSS using PTFE-covered stents with surgery is required. Updated guidelines issued in 2015 by the British Society of Gastroenterology continue to recommend TIPSS or surgery as viable options for salvage therapy in uncontrolled variceal bleeding, with the choice depending on local availability [136]. Balloon-occluded retrograde transvenous obliteration (BRTO) is a procedure that has been pioneered in Japan for the treatment of gastric varices. A number of retrospective studies have shown it to be effective in the management of active gastric variceal bleeding (moderate evidence) [139–141]. In one small randomized trial with 15 patients comparing BRTO with TIPSS in active gastric variceal hemorrhage with a gastrorenal shunt, immediate bleeding control, rebleeding rates and encephalopathy were similar in both groups [142]. BRTO may be considered as an alternative to TIPSS in acute gastric variceal bleeding (limited evidence).

Take-Home Table

In Table 23.1, the diagnostic performance of imaging modalities for the diagnosis of acute lower and upper GI bleeding is highlighted and summarized.

Table 23.1 Diagnostic performance of imaging modalities for the diagnosis of acute lower and upper gastrointestinal bleeding

Imaging modalities for the diagnosis of acute lower gastrointestinal bleeding						
	Sensitivity, %	Specificity, %	Accuracy	+LR	−LR	Evidence
MDCT angiography [18]	85 (76–92)	92 (77–98)	0.94 (0.69–0.989)	10.8 (3.4–33.4)	0.16 (0.1–0.027)	Strong
Nuclear medicine Tc-99m RBC scan Adult [22–82]	23–83[a]					Limited
Nuclear medicine Tc-99m RBC scan Child [58]	92	95		16.5	0.15	Strong
Catheter angiography [62]	64 (49–78)					Limited
Imaging modalities for the diagnosis of acute upper gastrointestinal bleeding						
	Sensitivity, %	Specificity, %	Accuracy	+LR	−LR	Evidence
MDCT angiography [18]	85 (76–92)	92 (77–98)	0.94 (0.69–0.989)	10.8 (3.4–33.4)	0.16 (0.1–0.027)	Strong

Figures in brackets represent 95% confidence intervals

RBC red blood cell, *MDCT* multi-detector computed tomography, *+LR* positive likelihood ratio, *−LR* negative likelihood ratio

[a]Data based on heterogeneous results from 5 separate studies. A majority of these studies showed Tc-99m RBC scanning performs poorly at accurately localizing the site of bleeding

Take-Home Points

- CT angiography is the imaging modality of choice in acute GI bleeding.
- It has high diagnostic accuracy and can increase the likelihood of successfully localizing bleeding at catheter angiography.
- Superselective microcoil embolization is a safe and effective treatment for acute non-variceal bleeding.
- Further studies are required to investigate the role of CTA followed by embolization as the potential first-line treatment in acute lower GI bleeding.

Imaging Case Studies

Case 1

Figure 23.1a–d presents diverticular hemorrhage: a 91-year-old female with sudden massive bleeding per rectum.

Case 2

In Fig. 23.2a–d, we see upper GI hemorrhage: a 30-year-old male with hematemesis necessitating numerous blood transfusions.

Case 3

Figure 23.3 shows technetium-99m-labeled RBC scintigraphy: a 79-year-old male with bleeding per rectum without hemodynamic compromise.

Suggested Imaging Protocol

GI bleeding protocol CT angiogram:

- Non-contrast scan of the abdomen and pelvis.
- Arterial phase scan using bolus tracking at the abdominal aorta after the injection of 150 ml of 340 mg/ml iodinated contrast at 4 ml/s followed by a 50 ml saline flush.
- Portal venous phase scan acquired 35 s after the bolus-tracking trigger.
- Delayed phase scan acquired 135 s after the bolus-tracking trigger.
- The reconstructed section thickness should be 1 mm.
- The windowing of the arterial phase CT scan is adjusted at the discretion of the radiologist.

Future Research

Unanswered Clinical Questions

- CTA criteria for predicting response to endovascular management
- The role of CTA prior to endoscopy in upper GI bleeding
- Clinical outcomes and cost-effectiveness of colonoscopy versus embolization in acute lower GI bleeding
- Surgery versus PTFE-covered TIPSS in acute variceal hemorrhage not controlled at endoscopy

Clarification of Guidelines

- Clinical outcomes of CTA followed by embolization compared with embolization alone (as currently recommended by the ACR)
- CTA followed by embolization compared with colonoscopy as a first-line treatment strategy in lower GI bleeding (the ACG recommends angiography over colonoscopy in severe active bleeding)

Existing Weak Evidence of Uncertain Clinical Importance

- The role of CTA in children with acute GI bleeding

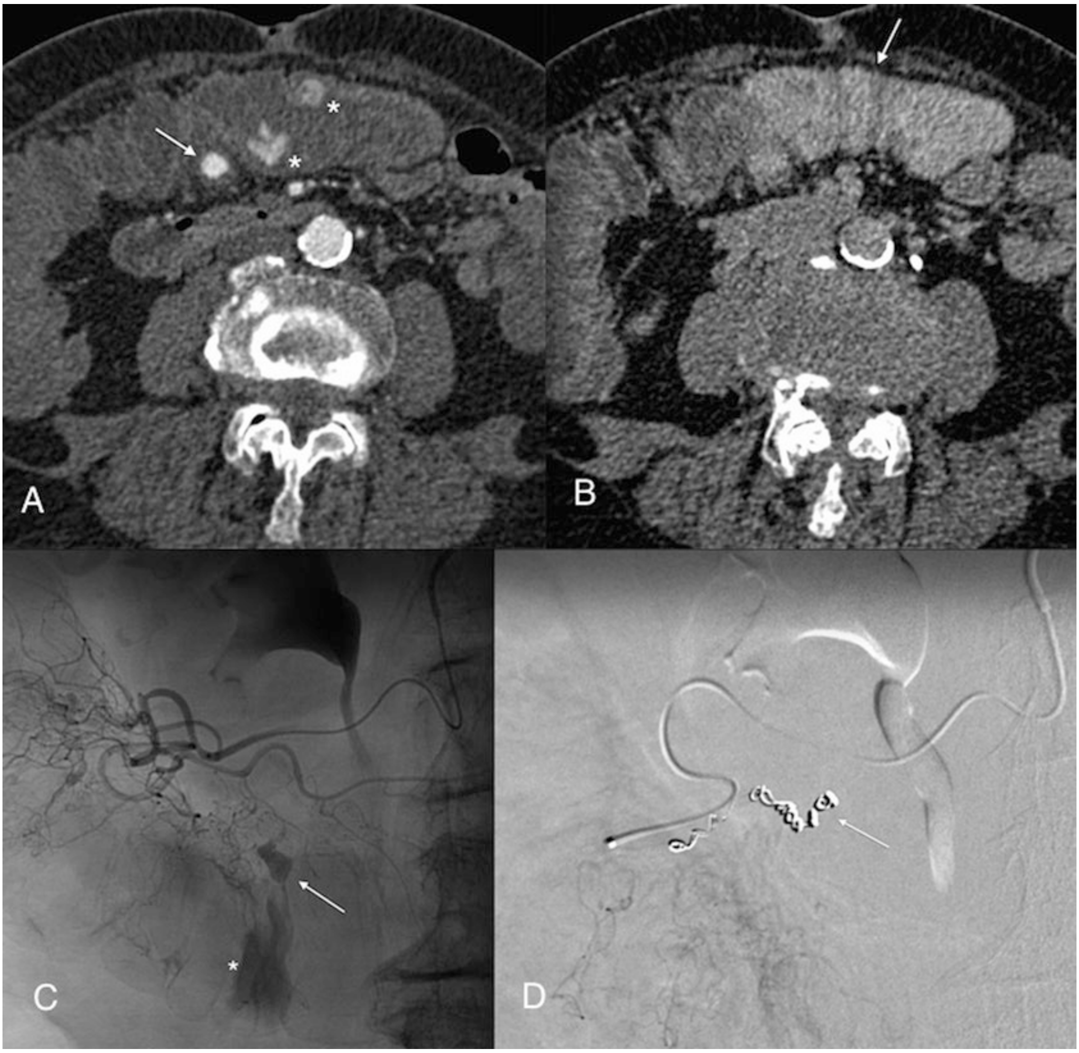

Fig. 23.1 (**a**–**d**) Diverticular hemorrhage. 91-year-old female presenting with sudden massive bleeding per rectum. There was hemodynamic instability with hypotension and tachycardia requiring multiple blood transfusions. The patient proceeded immediately to CT. (**a**) Arterial phase CT angiogram shows active extravasation into a diverticulum in the transverse colon (*arrow*) with accumulation of blood in the colonic lumen (*asterisks*). (**b**) 3-min delayed-phase CT shows significant volume acute hemorrhage in the colonic lumen (*arrow*). (**c**) Angiographic image shows bleeding from the colonic diverticulum (*arrow*) with significant active extravasation (*asterisk*). (**d**) Digital subtraction angiographic image shows coils deployed in the artery supplying the diverticulum and cessation of bleeding

Fig. 23.2 (**a**–**d**) Upper GI hemorrhage. 30-year-old male presenting with hematemesis necessitating numerous blood transfusions. Upper GI endoscopy was performed with clipping of a Dieulafoy lesion although this failed to control the bleeding. CTA was then performed. (**a**) Arterial phase CT angiogram with streak artifact from the endoscopically placed clips in the stomach (*arrow*). The source of bleeding is not directly visualized. The endoscopically placed clips allow localization of the bleeding source, and the subsequent procedure was planned accordingly. (**b**) and (**c**) Angiographic images show a rounded vascular abnormality immediately adjacent to the clips in keeping with a Dieulafoy lesion (*arrows*) being supplied by a short gastric artery from the splenic artery. (**d**) Angiographic image showing coils in the short gastric artery supplying the Dieulafoy lesion (*arrow*). There is a static column of contrast distal to the coils and no residual filling of the Dieulafoy lesion

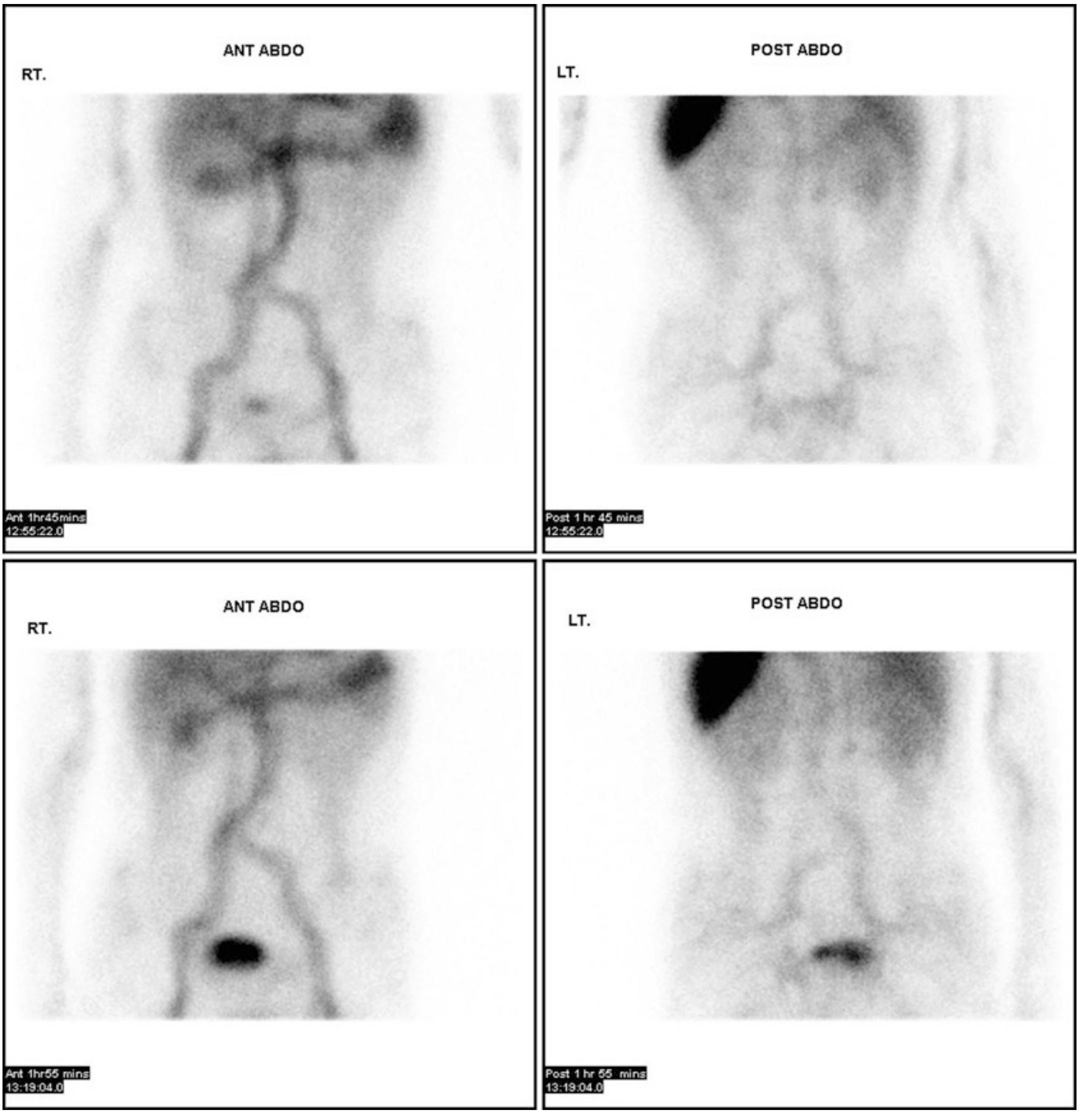

Fig. 23.3 Technetium-99m-labeled RBC scintigraphy. 79-year-old male presenting with bleeding per rectum without hemodynamic compromise. Colonoscopy showed blood throughout the colon, but no active source of bleeding was identified. No active extravasation was evident on CTA. Delayed scintigraphic images show the accumulation of labeled red cells in a horizontally oriented viscus in the upper abdomen in keeping with the transverse colon. No active bleeding was identified on the subsequent catheter angiogram

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