Chapter 9
Radiologic Diagnosis and Intervention for Gastrointestinal Bleeding

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Introduction

Acute gastrointestinal bleeding (GIB) occurs with an annual incidence of approximately 40–150 cases per 10,000 persons for upper GIB and 20–27 cases per 100,000 persons for lower GIB [1–3]. Gastrointestinal bleeding can be classified into upper or lower gastrointestinal bleeding depending on if the source is proximal or distal to the ligament of Treitz, respectively. The mortality rate for both upper and lower GIB is estimated to be around 4–10% [1–3]. There are multiple etiologies for GIB, which can be categorized generally into infectious, vascular anomalies, inflammatory disease, trauma, and malignancy (Table 9.1) [4–10].

Diagnostic and treatment approach of GIB depends on its location, severity, and etiology [3]. The first line for diagnosis and treatment when GIB is suspected is usually a gastroenterology consult for esophagoduodenoscopy (EGD) or colonoscopy. If a bleeding source is visualized, endoscopic therapy options include epinephrine injection and coaptive coagulation, hemo-clip placement, argon plasma coagulation, sclerotherapy, and band ligation, to name a few [11]. The role of radiology becomes especially important in patients whose GIB remains resistant to medical and endoscopic treatment [3]. Diagnostic imaging studies can be used to effectively localize the source of bleeding. Tests such as CT angiography, ^{99m}Tc-labeled red blood cell

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Table 9.1 Common etiologies of upper and lower GI bleeding

Upper GI bleeds	Lower GI bleeds
Esophagitis	Diverticular disease
Gastritis	Hemorrhoids
Peptic ulcer disease	Colitis: inflammatory, infectious, ischemic, radiation
Mallory-Weiss tear	Angiodysplasia
Esophageal varices	Rectal varices
Gastric varices	Polyps/post-polypectomy
Pill ulcer	Intussusception
Foreign bodies	Meckel's diverticulum
Neoplasm	Neoplasm
Coagulopathy	Coagulopathy
Traumatic	Traumatic

scintigraphy (tagged RBC scan), and digital subtraction angiography (DSA) are all options for the detection of GI bleeding, but their sensitivity is largely dependent on the rate of hemorrhage, with DSA only sensitive to rapid bleeding and tagged RBC scans most sensitive for slow bleeds. Once a source of bleeding is identified, endovascular therapeutic interventions such as transcatheter arterial embolization (TAE) can be performed in the interventional radiology suite to achieve hemostasis.

Despite the etiology, initial evaluation of patients with GIB should always begin with a history and physical examination. Focused abdominal exam and digital rectal exam should be performed in any patient with GI bleeding. Tachycardia, orthostatic hypotension, and chronic anemia are all potential signs of GI bleeding [12]. Risk factors for bleeding include anticoagulation (warfarin, NSAIDs, aspirin, corticosteroids), congenital coagulopathy, previous history of GIB, history of abdominal surgery, recent colonoscopy with polypectomy, previous abdominal or pelvic radiation, abdominal aortic aneurysm, history of alcoholism, and chronic renal or liver disease. Family or personal history of colon cancer or inflammatory bowel disease should also be noted.

In hemodynamically unstable patients, two large-bore IVs should be placed, and IV fluid resuscitation and possibly blood products should be administered rapidly to replete intravascular volume and stabilize vital signs [3]. In some patients, correction of coagulopathy may also be needed [13]. Often, diagnostic workup should be occurring simultaneously during resuscitation, to minimize morbidity and mortality associated with GIB [13–15].

Upper Gastrointestinal Bleeding

The incidence of acute upper gastrointestinal bleeding is approximately 40–150 cases per 100,000 persons per year, is twice as common in men compared to women, and increases in prevalence with age [1–3, 16]. Seventy-six percent of all gastrointestinal bleeding events are classified as upper GIB, and the mortality rate is approximately 5%. Classically, patients with upper GIB present with hematemesis or

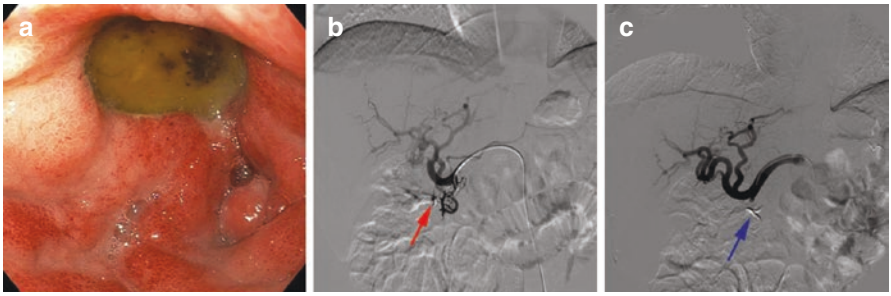

Fig. 9.1 Bleeding and intervention in a patient with peptic ulcer disease. (**a**) Endoscopic view of a duodenal ulcer, suspected source of the patient's upper GI bleed, though not actively bleeding at the time this picture was taken. (**b**) Digital subtraction gastroduodenal artery (GDA) angiography showing opacification of the proximal GDA with active extravasation at the site of ulceration (red arrow). (**c**) Digital subtraction GDA angiography images demonstrating cessation of bleeding (absence of blush) after glue embolization of the GDA, which is no longer opacified (blue arrow)

melena, though 15% of patients still present with hematochezia, indicating that the bleeding is brisk [14, 16, 17]. Gastric lavage with NG tube insertion can be performed to investigate whether upper GIB is prepyloric, but a negative result does not completely exclude it. Additionally, upper GIB distal to the pylorus will not be detected with gastric lavage. Studies estimate that approximately 25–60% of upper GIB is secondary to peptic ulcer disease (Fig. 9.1a) [16]. This is often associated with nonsteroidal anti-inflammatory (NSAID) drug use and/or *Helicobacter pylori* infection [15, 18]. If the patient has known peptic ulcer disease and is having hematemesis, EGD is always performed first to see if a bleeding ulcer can be identified and treated endoscopically. However, if there is failure in treating the bleeding gastric ulcer endoscopically, interventional radiology will commonly embolize the gastroduodenal artery (GDA), the most likely artery to be involved in supplying the ulcerated mucosa of the stomach, even in the absence of extravasation on angiography (Fig. 9.1b, c). Due to the rich collateral blood supply to the stomach, it is important to occlude the backend of the GDA in addition to its origin ("closing the back door"), as well as occluding collaterals from the pancreaticoduodenal artery and gastroepiploic arcade, which can cause back bleeding. The second most common cause of upper GIB is bleeding from varices (esophageal and gastric) [19] in the setting of cirrhosis of the liver. Additional etiologies include gastritis, esophagitis, and duodenitis; cancer (esophageal, gastric, and GIST); mechanical (Mallory-Weiss tear and trauma); vascular abnormalities (vascular ectasia, angiodysplasia, and vascular malformations); aorto-duodenal fistula; and iatrogenic causes.

Lower Gastrointestinal Bleeding

Lower GIB occurs less commonly than upper GIB with an incidence of approximately 20 cases per 100,000 persons per year but is also more common in men and older individuals [20]. Lower GIB is estimated to account for 1–2% of hospital emergencies

in the United States. Approximately, 80–85% of lower GI bleeds originate distal to the ileocecal valve, with only 0.7–9% originating from the small intestine [21]. The most common presentation of lower GIB is hematochezia. Less commonly, patients may present with melena if the source of bleeding is located in the small bowel or right colon [3]. Diverticulosis is the most common cause of painless hematochezia (40% of cases), with the incidence increasing with ages older than 65. Hemorrhoids are the most common cause of lower GIB in patients younger than 50. Other causes include inflammatory bowel disease, ischemic colitis, neoplasia, polyps, vascular malformations, post-polypectomy, and angiodysplasia [3, 12, 21, 22]. Although more than 80% of lower GIB will stop spontaneously with conservative management, 10–15% of cases eventually require endovascular intervention [23]. Overall mortality has been noted to be 2–4% [21].

Endoscopy

Endoscopy is the first choice for diagnosis and therapy in both upper and lower gastrointestinal bleeding, and therefore consultation with gastroenterology should not be delayed when a patient presents with GIB. In patients with upper GI bleed, EGD is performed; in patients with suspected lower GI bleed, colonoscopy is the procedure of choice. Colonoscopy has been shown to correctly identify the source of lower GIB in more than 75% of patients while also allowing a therapeutic modality [21]. Factors that may predict endoscopic treatment failure include patients that present with shock, hemoglobin less than 10, greater than six units of blood transfused, and significant comorbidities [3]. Additionally, lack of bowel preparation may limit the ability of colonoscopy to identify the source of bleeding, or blood may be seen within the colon lumen, but the exact site of bleeding may be difficult to identify [24].

The Role of Diagnostic Imaging Studies in the Diagnosis and Localization of Gastrointestinal Bleeding

When a patient has nondiagnostic endoscopic results or remains refractory to medical and endoscopic treatment, radiologic imaging and endovascular intervention are the next intervention of choice [3]. CT angiography and ^{99m}Tc-labeled red blood cell scintigraphy (tagged RBC scan) are noninvasive options available for the diagnosis and localization of GIB, but it is important to remember that these are diagnostic only and that bleeding will still have to be treated with subsequent endovascular or surgical intervention after localization.

Table 9.2 Comparison of imaging modalities for the detection of gastrointestinal bleeding

	CT angiography	Tagged RBC scan	DS angiography
Sensitivity	85%	95%	60%
Specificity	99%	93%	100%
Rates of bleeding detected	0.3–0.5 mL/min	0.1–0.35 mL/min	0.5–1.0 mL/min
Detection of intermittent bleeding	No	Yes	No
Therapeutic	No	No	Potentially

CT Angiography

CT angiography (CTA) is relatively noninvasive, fast and widely available, and relatively effective at detecting GIB in patients with continuous bleeding [25]. CTA can detect bleeding rates of 0.3–0.5 mL/min (Table 9.2), has a relatively low sensitivity (85–90%) [21], but a specificity of 99% and an accuracy of 97.6% in localizing both upper and lower GI bleeds. CTA exams obtained for GIB are usually three-phase studies, including unenhanced (non-contrast), arterial phase, and portal venous phase images. Slice thickness is normally thin (1 mm) and tube voltage high (120 kV) to improve the sensitivity and contrast of the study, but imaging parameters vary slightly depending on institution. On unenhanced images, focal hyperattenuation within the bowel is indicative of recent hemorrhage and may represent a "sentinel clot" [26]. On arterial phase, extravasation of free contrast (extraluminal contrast) is the hallmark of active bleeding and is used to identify/localize the source. Two cases of lower GI bleeding detected on CTA secondary to stercoral ulceration (Fig. 9.2a) and sigmoid diverticulosis (Fig. 9.3a) are shown. Furthermore, a changing appearance of the focus of extravasated contrast between the arterial and portal venous phase indicates active bleeding [27]. Because CTA detection of GIB depends on the identification of free contrast or a sentinel clot, oral contrast is withheld during this study as it can mask the source of bleeding. Again, while not therapeutic, CTA is useful to identify and localize the source of GIB and can also characterize the patient's vascular anatomy, which can be used for surgical or endovascular planning. However, certain patient factors such as contrast allergy and acute/chronic kidney disease are potential contraindications to CT angiography, which uses more contrast than conventional DSA angiography.

^{99m}Tc-Labeled RBC Nuclear Scintigraphy (Tagged RBC Scan)

In ^{99m}Tc-labeled RBC nuclear scintigraphy, erythrocytes are labeled with technetium-99m, infused into the patient, and then serial scintigraphy is performed to detect focal collections of radiolabeled material within the GI tract (i.e., sites of GI

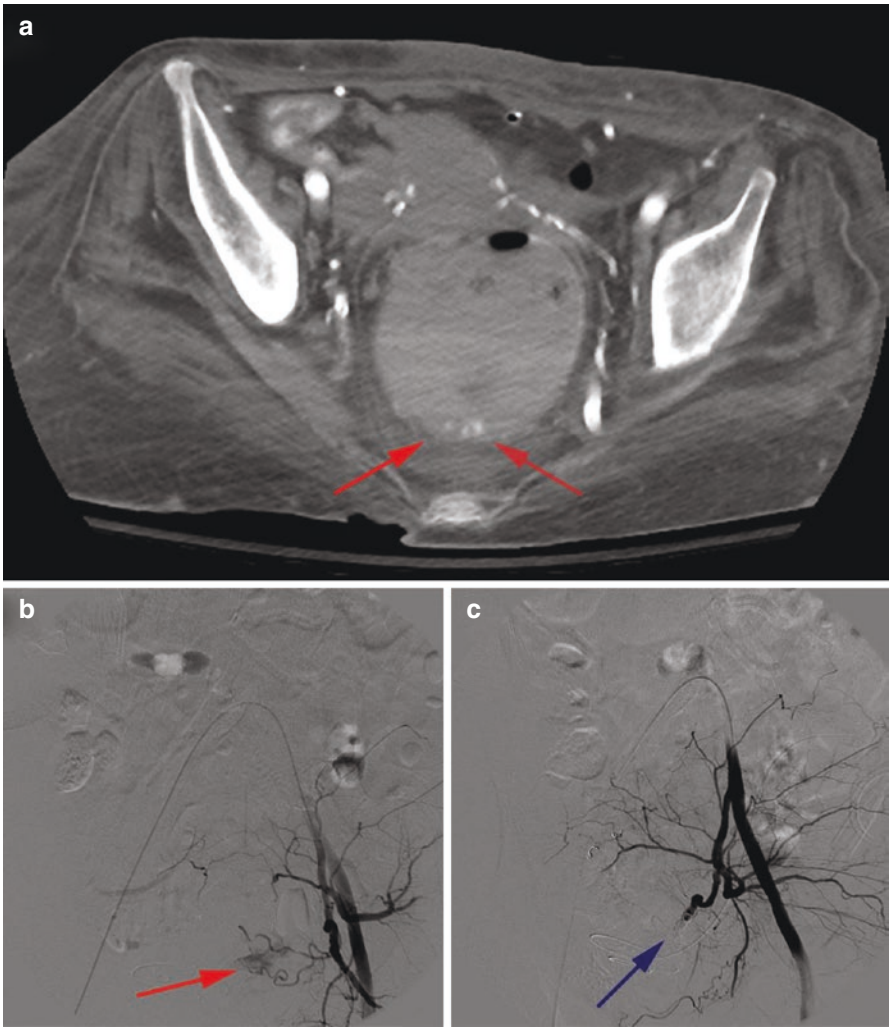

Fig. 9.2 Bleeding and intervention in a chronically constipated patient with stercoral ulcer. (**a**) CTA demonstrating active extravasation of contrast in the dependent portion of the rectum (red arrows), indicative of active lower GI bleeding. (**b**) Digital subtraction angiography images demonstrating active extravasation of contrast (red arrow) from the left middle rectal artery. (**c**) Digital subtraction angiography images demonstrating cessation of bleeding (absence of blush) after coil embolization of the left middle rectal artery (blue arrow)

bleeding). Nuclear scintigraphy is a valuable imaging modality for the detection of slow lower GI bleeding, with bleeding rates as low as 0.1–0.35 mL/min able to be detected (Table 9.2) [28]. The overall sensitivity and specificity of Tc-99m-labeled red blood cell studies are 95% and 93%, respectively [29]. Additionally, nuclear scintigraphy is advantageous in that it allows for continuous monitoring and can

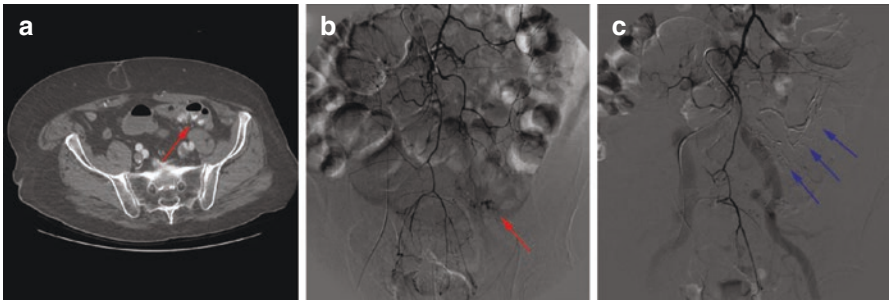

Fig. 9.3 Bleeding and intervention in a patient with diverticulosis. (**a**) CTA demonstrating active extravasation of contrast in the sigmoid colon at a diverticulum (red arrow), indicative of active lower GI bleeding. (**b**) Digital subtraction angiography images demonstrating active extravasation of contrast (red arrow) from the sigmoid branch of the inferior mesenteric artery. (**c**) Digital subtraction angiography images demonstrating cessation of bleeding (absence of blush) after Gelfoam slurry embolization into the IMA (blue arrows)

detect and localize sites of intermittent bleeding which is a common characteristic of lower GIB. The half-life of ^{99m}Tc is long so the scan can be repeated several times in a 24 hour period to evaluate sequential images [21]. Another advantage is that nuclear scintigraphy can help predict which patient will benefit from subsequent angiography. Patients with immediate blush on red blood cell scintigraphy (time to positive (TTP) less than 9 min, Fig. 9.4) are more likely to require urgent angiography, and those with delayed blush (TTP greater than 9 min) have low angiographic yield [3, 30].

Digital Subtraction Angiography

In emergent cases when patients are hemodynamically unstable, or in hospitals where CTA or nuclear scintigraphy is not available, patients with active GI bleeding who fail medical and endoscopic intervention should undergo endovascular angiographic evaluation [3]. Angiography is well suited for the detection of active and fairly brisk lower GI bleeds. Indeed, out of the imaging modalities discussed above, it is the least sensitive and requires bleeding rates of 0.5–1.0 mL/min for positive detection and localization (Table 9.2) [31, 32]. For lower GIB, angiography performed with digital subtraction has an overall sensitivity of 60% and specificity of 100% [3]. Digital subtraction angiography (DSA) is used to better visualize the vasculature by subtracting pre-contrast image from later images and effectively removing soft tissue and bones from the images (Figs. 9.2b and 9.5b); however, this technique is limited by peristalsis or patient breathing [3]. DSA is unique in that it is also potentially therapeutic at the time of diagnosis, allowing for selective embolization of the bleeding vessel. However, certain patient factors such as contrast allergy and acute/chronic kidney disease are potential contraindications to angiography.

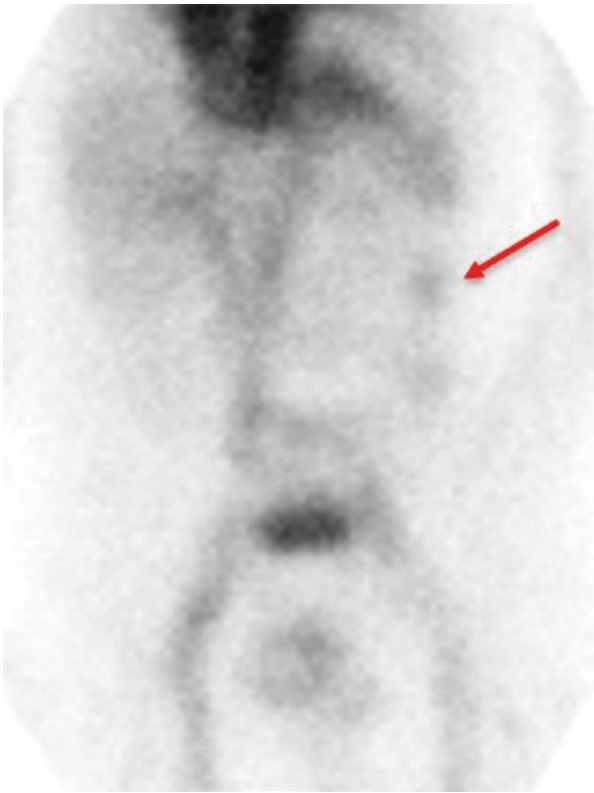

Fig. 9.4 ^{99m}Tc-labeled RBC nuclear scintigraphy (tagged RBC scan) demonstrating uptake and immediate blush in the expected region of the descending colon (red arrow), indicative of positive lower GI bleed. The patient was referred for urgent mesenteric angiography

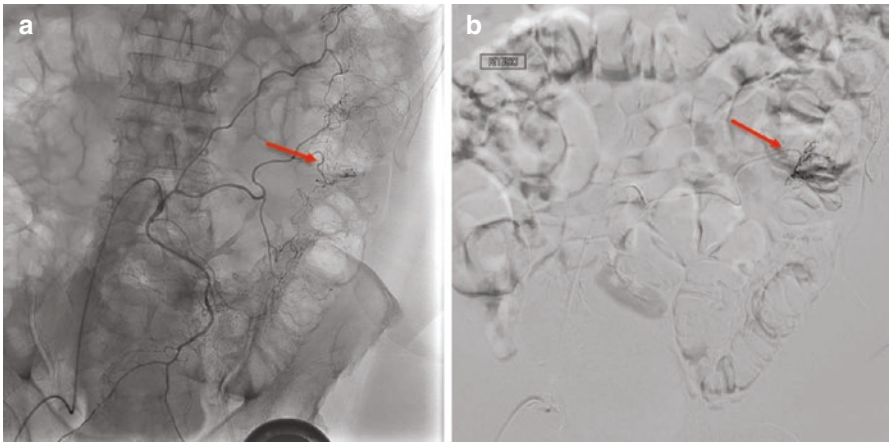

Fig. 9.5 Inferior mesenteric angiography images without (**a**) and with (**b**) digital subtraction demonstrating active extravasation of contrast (red arrows) in a subselective branch along the descending colon, indicating an active lower GI bleed

Access for endovascular angiography is gained via the common femoral artery [33, 34]. The suspected bleeding artery (based on prior imaging studies—if available) is then selectively catheterized and interrogated first. For upper GIB, the celiac, left gastric, and gastroduodenal arteries are studied. If lower GIB is suspected, the branches of the superior mesenteric artery are evaluated first (small bowel and proximal colon are evaluated), and if no source of bleeding is identified, the branches of the inferior mesenteric artery are studied (evaluates colon distal to the splenic flexure). Extravasation of contrast agent (blush) is indicative of active bleeding (Figs. 9.2b, 9.3b, and 9.5a, b) [34]. In Fig. 9.2b, a blush of active contrast extravasation from the middle rectal artery indicates an active and brisk bleed—in this case secondary to stercoral ulcer, as discussed above. In Fig. 9.3b, a blush of active contrast extravasation from the sigmoid branch of the IMA also indicates an active, brisk bleed—in this case secondary to diverticulosis, as discussed above. Positive findings include mucosal blushes with abnormal vessels suggestive of tumor, prolonged contrast spots suggestive of inflammation, and visualization of arteries and veins on the same phase of the study suggestive of an arteriovenous malformation [3]. It is important to keep in mind that active extravasation may not always be seen on angiography, but other findings during the study may suggest the source of bleeding. Examples of this include visualization of varices in unexpected locations or abnormal clusters of vessels within the bowel wall (angiodysplasia). Additionally, intermittent bleeding, venous bleeding, failure to inject the correct artery, or bleeding outside the field of view of the study are additional considerations for a negative study. Repeat examination and subselective catheterization may have to be performed if the patient continues to bleed after a negative angiogram.

Angiographic Interventions in Gastrointestinal Bleeding

As discussed above, endovascular angiography is an effective diagnostic modality for the detection of gastrointestinal bleeding, but it also has the advantage of being a therapeutic tool as well through transcatheter arterial embolization (TAE) and is a safe alternative to surgical intervention in patients who have GIB refractory to medical and endoscopic treatment [3, 35]. Using this technique, hemostasis is achieved by reducing blood flow to the bleeding vessel via injection of particles or other embolic materials (see below), thus decreasing perfusion pressure and facilitating clot formation at the site of bleeding [36, 37].

Transcatheter Arterial Embolization

TAE has been demonstrated to be a safe and effective method for controlling GIB in patients who have failed medical and endoscopic treatment, as well as in patients who are not ideal candidates for endoscopic or surgical interventions. The goal of

TAE is to embolize the bleeding vessels to reduce arterial perfusion pressure and promote clotting. As a consequence of this, one of the major potential complications of TAE is bowel ischemia/infarction. The bowel distal to the ligament of Treitz (lower GIBs) does not have a dual supply; therefore, the risk of bowel infarction is higher [37, 38]. This risk is minimized by super-selecting the most distal branch of the involved artery as possible (vasa recta, Fig. 9.6), as to reduce perfusion pressure while maintaining adequate collateral blood flow to the bowel [36]. Unlike the lower GI blood supply, there is a rich collateral network in the upper bowel (proximal to the ligament of Treitz), so bowel ischemia is less likely. In fact, there is actually a high incidence of rebleeding in upper GIB, due to this collateral supply.

Typically, a 5 French catheter would be used to access the celiac, superior mesenteric artery or inferior mesenteric artery, and a smaller coaxial 3 French microcatheter advanced through it over a 0.018 in guidewire until it is in a super-selective position (Fig. 9.7a, b). Additional potential complications of TAE include vessel perforation, dissection, and vasospasm. Once the microcatheter is in a super-selective position, embolic agents are deployed to induce clotting.

The type of embolic agent used is dependent on experience and preference, the etiology of bleeding, and availability of the agent [3]. Common agents include glue, Gelfoam, coils, PVA particles, and Amplatzer vascular plugs [39–41]. Coils are composed of a metallic component, which acts to physically occlude the vessel, and a fibrotic component that promotes clotting; they come in a variety of shapes and sizes (Fig. 9.8a, b). Figure 9.2c demonstrates successful deployment of coils (blue arrow) within the previously identified bleeding middle rectal artery (secondary to stercoral ulcer), resulting in cessation of the bleed. The advantage of using microcoils is that they can be visualized under direct fluoroscopy and they permit decreased perfusion pressure while preserving collateral flow to prevent infarction.

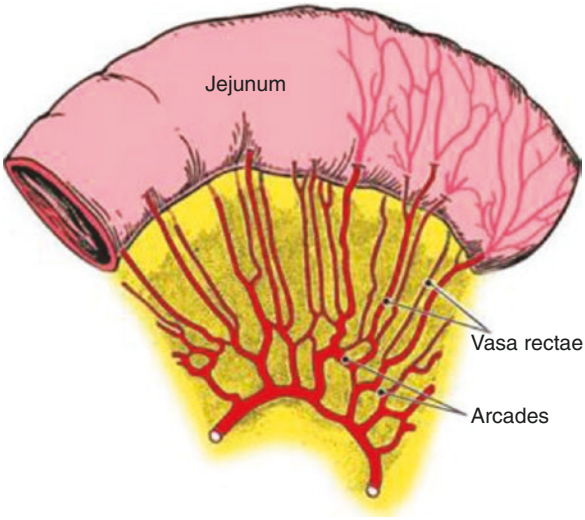

Fig. 9.6 The bowel distal to the ligament of Treitz does not have a dual supply; the vasa recta represent the terminal arterial circulation proximal to the arterioles and should be super-selected for embolization in GI bleeding to reduce perfusion pressure while maintaining adequate collateral blood flow to the bowel, minimizing the chance of bowel ischemia (Image Copyright © 2004–2013 Duke University School of Medicine)

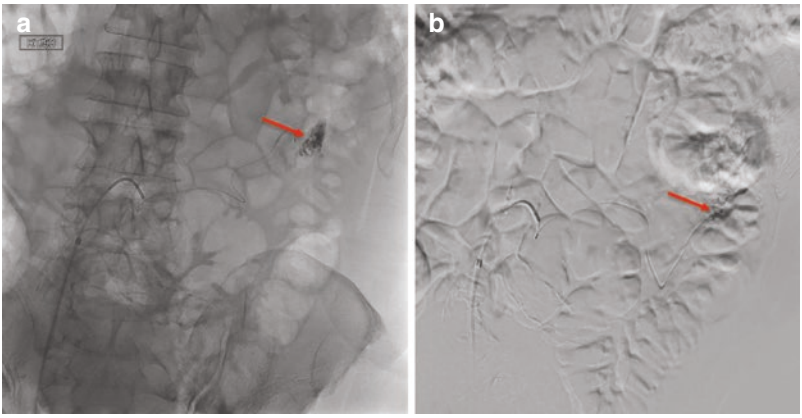

Fig. 9.7 Super-selective catheterization and angiography of the bleeding vessel shown in Fig. 9.5 without (**a**) and with (**b**) digital subtraction, demonstrating active extravasation of contrast (red arrows). 500–700 μm embospheres were utilized to embolize the small super-selective IMA branch

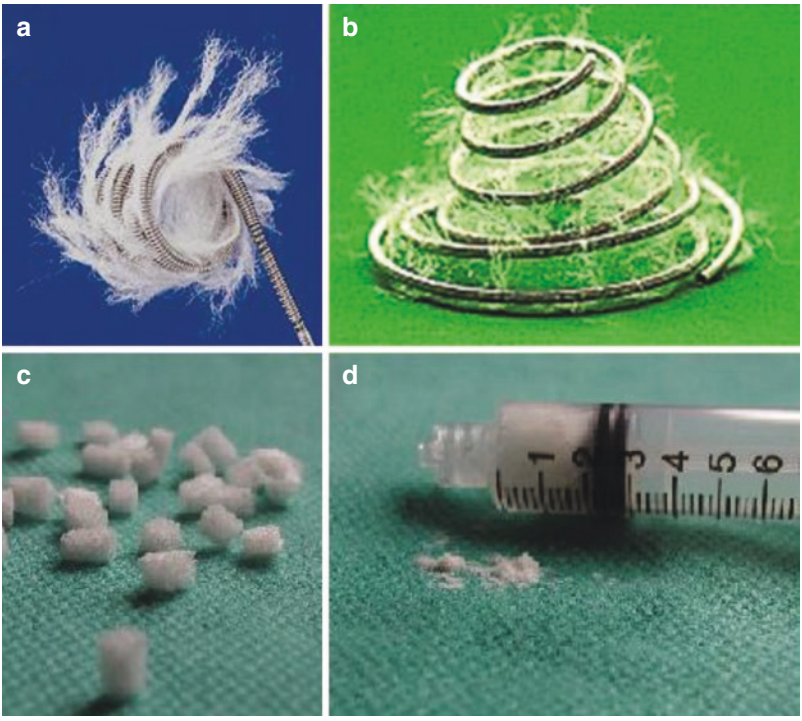

Fig. 9.8 Embolic agents. Metal coils (**a**) and (**b**) cause occlusion as a result of coil-induced thrombosis rather than mechanical occlusion of the lumen by the coil. To increase the thrombogenic effect, Dacron wool tails are attached to coils. The coils are available in many sizes and may be delivered through commonly used angiographic catheters. Gelfoam pledgets (**c**) and slurry (**d**). Gelfoam pledgets are mixed with contrast solution in a syringe forming a slurry, which is then injected slowly under fluoroscopic guidance

Gelfoam is a temporary thrombotic agent comprised of subcutaneous porcine adipose tissue that remains effective for weeks to months before recanalization occurs [3]. Gelfoam is widely available, is cost-effective, and allows future access to embolized vessels after resorption (Fig. 9.8c, d). However, a disadvantage of Gelfoam is that since it is comprised of small particulates, its placement can be unpredictable and has higher risk of bowel ischemia due to unintended distal migration and occlusion at the arteriolar level distal to the level of collateralization (Fig. 9.3c) [34]. Additionally, recanalization times after Gelfoam occlusion are often unpredictable, and therefore it is not recommended as a single embolic agent. Indeed, several studies have shown that recurrent bleeding is more likely to occur when PVA particles, Gelfoam, or coils are used alone [39, 41, 42].

Glues such as *N*-butyl-2-cyanoacrylate (NBCA) or ethylene-vinyl alcohol copolymer have several advantages including the ability to occlude vessels beyond the most distal site of microcatheter advancement (Fig. 9.1c), permanent vessel closure, the option for using ultra-microcatheters not suitable for microcoil delivery, more efficient obliteration of bleeding pseudoaneurysms with complex anatomy, and lower rebleeding rates than coils or particles [3]. However, they are significantly more expensive and pose a risk for glue reflux, nontarget embolization, bowel infarction, and future bowel stenosis [43]. Clinical success rates of embolization for upper GIB have been cited to range from 44% to 100%, whereas reported success rates for embolization of lower GIB range from 88% to 93% [35, 36, 39, 44].

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