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Gastrointestinal bleeding: The role of radiology☆

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Abstract Gastrointestinal bleeding represents a diagnostic challenge both in its acute presentation, which requires the point of bleeding to be located quickly, and in its chronic presentation, which requires repeated examinations to determine its etiology. Although the diagnosis and treatment of gastrointestinal bleeding are based on endoscopic examinations, radiological studies such as computed tomography (CT) angiography for acute bleeding or CT enterography for chronic bleeding are becoming more and more common in clinical practice, even though they have not yet been included in the clinical guidelines for gastrointestinal bleeding. CT can replace angiography as the diagnostic test of choice in acute massive gastrointestinal bleeding, and CT can complement the endoscopic capsule and scintigraphy in chronic or recurrent bleeding suspected to originate in the small bowel. Angiography is currently used to complement endoscopy for the treatment of gastrointestinal bleeding.

PALABRAS CLAVE
Hemorragia digestiva;
Angiografía por TC;
TC enterografía;
Arteriografía

Hemorragia digestiva: papel de la radiología

Resumen La hemorragia digestiva (HD) supone un problema diagnóstico tanto en su forma de presentación aguda, que requiere una rápida localización del punto de sangrado, como en la crónica, que precisa de exploraciones repetidas para determinar su etiología. El diagnóstico y tratamiento se basa en estudios endoscópicos, aunque los estudios radiológicos mediante angiografía por tomografía computarizada (TC) en la hemorragia aguda y mediante TC enterografía en la crónica son cada día más utilizados en la práctica clínica, a pesar de no estar incluidos todavía en las guías clínicas de la HD. La TC puede ser una exploración diagnóstica de primera elección en la hemorragia aguda masiva, sustituyendo a la angiografía, y una exploración diagnóstica complementaria a la cápsula endoscópica y la gammagrafía en la hemorragia crónica o recurrente cuando se sospecha un origen en el intestino delgado. La angiografía es actualmente un método terapéutico complementario a la endoscopia en el manejo de esta afección.

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Introduction

Gastrointestinal (GI) bleeding represents a serious clinical problem and a common cause of hospitalization, with a mortality rate of 6–10% for upper GI bleeding (UGIB) and of 4% for lower GI bleeding (LGIB). The study and treatment of GI bleeding require a multidisciplinary approach involving gastroenterologists, endoscopists, surgeons and radiologists. GI bleeding is self-limited in 80% of cases, requiring only supportive measures. However, the persistence of bleeding represents a diagnostic challenge to locate the site of bleeding (especially in severe bleeding) and to determine, if possible, its cause. This will allow us to select the most appropriate therapeutic approach in order to reduce the morbidity and mortality, the length of hospitalization and the transfusion requirements.

Types of gastrointestinal bleeding

Several clinical settings of GIB should be distinguished according to the source and form of presentation.

Gastrointestinal bleeding according to the source

Upper gastrointestinal bleeding

UGIB is bleeding proximal to the angle of Treitz. It accounts for 75% of GIB and can present as hematemesis or melena; however, severe hemorrhage may manifest as red blood per rectum. The placement of a nasogastric tube can help identify the source of UGIB, but this procedure should be avoided in patients with liver disease to prevent trauma to possible esophageal varices. The most common causes of UGIB are peptic ulcer disease and esophageal varices in patients with portal hypertension, but its etiology varies greatly (Table 1).

Lower gastrointestinal bleeding

LGIB is bleeding from a source between the angle of Treitz and the rectum. It accounts for about 25% of GIB and can present in the form of rectal bleeding, hematochezia or melena, depending on the volume and site of blood loss. Of the cases initially diagnosed as LGIB, up to 12% were actually UGIB, especially in cases of severe bleeding. The most common causes of LGIB are angiodysplasia and diverticulosis (Table 1), with the incidence increasing with age presumably due to the high incidence of these conditions.[1] In young patients, infectious or inflammatory conditions are the most common causes.

A new classification based on the endoscopic access to the different parts of the GI tract has been proposed recently. This classification introduces the concept of mid GI bleeding, defined as bleeding from the ampulla of Vater to the terminal ileum, inaccessible to conventional endoscopy

Table 1 Main causes of gastrointestinal bleeding.

Upper gastrointestinal bleeding	Lower gastrointestinal bleeding
Peptic ulcer:	Colonic diverticulosis
- Duodenal or gastric	Angiodysplasia
Esophageal lesions caused by reflux:	Ischemic colitis
- Esophagitis	Colon adenocarcinoma
- Esophageal ulcers	Villous and tubular adenomas
- Mallory-Weiss syndrome	Hemorrhoids
Portal hypertension:	Post-polypectomy bleeding (3% post-resection)
- Esophageal and gastric varices	
- Hypertensive gastropathy	
- Ectopic varices	Small bowel malignancies (GIST, leiomyoma, adenocarcinoma, lymphoma, metastasis)
	Crohn's disease and ulcerative colitis
	Celiac disease
Tumors:	Meckel's diverticulum
- Adenocarcinoma	Small bowel diverticula
- GIST	NSAID enteropathy
Others:	Intestinal lymphoma
- Aortoenteric fistula (to esophagus or duodenum)	Infectious enteritis (*Clostridium difficile*, *Shigella*, *Escherichia coli*, *Campylobacter*, CMV)
- Dieulafoy's lesion	Isolated rectal ulcer
- Hemobilia	Anal fissure
- Hemosuccus pancreaticus	Dieulafoy's lesion
	Vasculitis
	Endometriosis

Table 2 Obscure GI bleeding according to its origin.

Upper GIB	Lower GIB
Dieulafoy's lesion	Angiectasis
Gastric antral vascular ectasia	Small bowel tumors (adenocarcinoma, GIST, lymphoma, carcinoid tumor)
Vascular ectasias	NSAID enteropathy
Gastric or duodenal varices	Crohn's disease
Cameron's erosions (hiatal hernia)	Ectopic varices
Portal hypertensive gastropathy	Celiac disease
Peptic ulcer	Meckel's diverticulum
Hemobilia	Diverticulosis
Hemosuccus pancreaticus	Colon tumors (adenocarcinoma)
Aortoenteric fistula	

GIB, gastrointestinal bleeding.

and best investigated by double-balloon endoscopy or capsule endoscopy.[2–4]

Gastrointestinal bleeding according to the form of presentation

Visible bleeding

GI bleeding that manifests as vomiting of blood (hematemesis is vomiting of fresh blood, and ''coffee grounds'' emesis is vomiting black blood) or blood in the stool (melena is black stool and hematochezia/rectal bleeding is the passage of red blood).

Occult bleeding

Patients with occult blood in their stool detected by immunological testing (fecal occult blood test) and/or iron-deficiency anemia with no evident clinical bleeding.

Acute bleeding

Acute bleeding is classified according to the volume and rate of blood loss. Massive bleeding is defined as bleeding requiring at least 4 units of blood in 24 h, or cases with frank hemodynamic instability with systolic blood pressure <100 mmHg, hematocrit decrease >20%, heart rate >100 beats/min or hemoglobin <100 g/l.[1] Hematocrit and hemoglobin values are of little help in the initial evaluation as they are not altered until saline or plasma expanders are administered to restore volemia, producing hemodilution. Moderate bleeding is defined as bleeding that does not cause hemodynamic instability and does not require transfusion. Acute GI bleeding remains a medical emergency situation with mortality rates as high as 21–40% in patients with massive bleeding,[5] being higher in older patients, with significant comorbidity or rebleeding.[1,6]

Recurrent bleeding of unknown etiology or obscure bleeding

It is defined as GI bleeding that persists or recurs after conventional barium and endoscopic examinations with negative results[3]; however, since the role of conventional radiologic examinations is limited, obscure bleeding is usually defined as bleeding that persists after negative upper endoscopy and colonoscopy.[7] Obscure GI bleeding can be categorized into overt, in the form of melena or hematochezia (hematemesis is an uncommon manifestation), and occult, with persistently positive fecal occult blood test, iron-deficiency anemia or both.[8] A negative fecal occult blood test is indicative of chronic bleeding if associated iron-deficiency anemia is present. The most common causes of obscure bleeding are shown in Table 2.

Diagnostic techniques

Endoscopy

Esophagogastroduodenoscopy

It is considered the technique of choice for UGIB evaluation as it allows us to locate and treat the bleeding lesions (thermal coagulation, injection of epinephrine, application of clips and bands, and argon-beam coagulation). This technique has a variable sensitivity (92–98%) and specificity (30–100%),[9] although some studies have reported that in 24% of cases of acute UGIB no diagnosis can be made.[10]

Colonoscopy

It is recommended to evaluate bleeding from colon and distal ileum. This technique requires colon preparation, which may cause a 3–4 h delay in the examination. Moreover, a not far from negligible percentage of colonoscopic examinations performed (5–15%) are incomplete and some series have shown low sensitivity, reporting that colonoscopy only identifies the source of bleeding in 13% of emergency cases.[11] Sometimes the actual bleeding may hinder an appropriate examination of the mucosa and the visualization of the site of bleeding. Massive bleeding (>1 ml/min) and the lack of colon preparation can therefore determine the presence of negative results. When a bleeding site is identified, either with the depiction of the active bleeding or a visible vessel, endoscopic treatment represents an effective option with low morbidity. The exception to this indication is the patient with massive LGIB.[12]

Capsule endoscopy

Capsule endoscopy (CE) allows for the examination of the entire small bowel and the detection of gastric or colonic lesions that may have been overlooked at the initial examination.[3] The main indication of CE is bleeding of obscure etiology for which several studies have reported higher efficacy than other imaging techniques with a sensitivity of 42–80%, depending on the series.[7,13] The limitations of CE include low image resolution, risk of retention of the capsule in stenotic areas or diverticula, its costs and interobserver discrepancy.[14] CE is contraindicated in patients with pacemakers or defibrillators, previous GI surgery or suspicion of stenosis/intestinal obstruction.[8] The duration of the examination and of the review of the images makes this technique of little use in acute bleeding, especially in massive bleeding. Regarding obscure GIB, the best sensitivity is obtained in patients with active bleeding (92.3 versus 44.2% in occult bleeding).[8,15]

Balloon-assisted endoscopy

Technically, this recently described technique[16] allows for the evaluation of the entire small bowel using an antegrade, retrograde or combined approach. This method involves inflating two balloons and pleating the small bowel, and it allows for the biopsy and/or treatment of lesions.[8,17] The rate of total balloon-assisted enteroscopy varies among studies, ranging from 16% to 86%[17] with a diagnostic accuracy ranging from 55% to 80%.[7,17] On the other hand, it has a

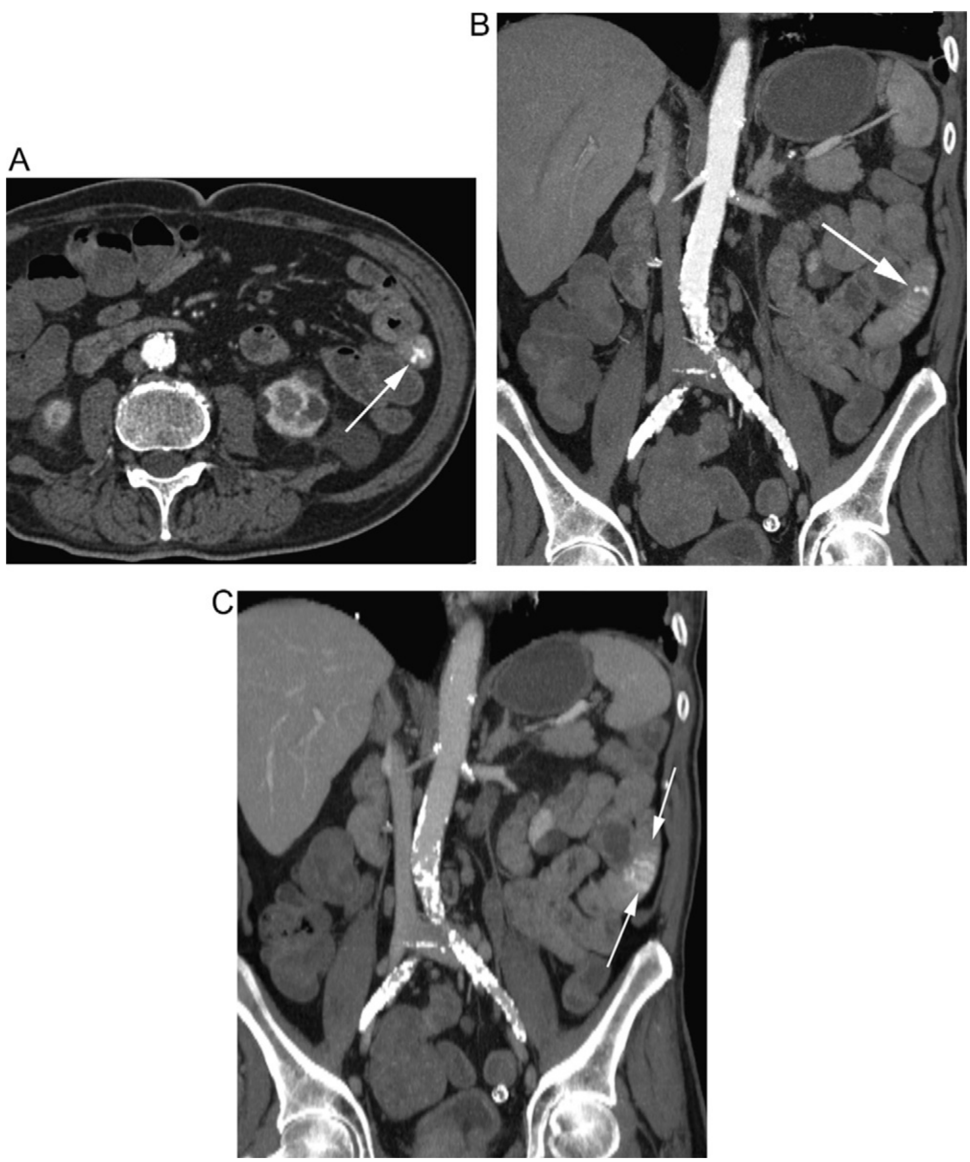

Figure 1 Patient with gastrointestinal bleeding during the postoperative period following lower extremity bypass surgery. (A) Axial CT shows jejunal ulceration with active bleeding in the ulcer bed (arrow) and endoluminal bleeding. (B) Coronal MIP shows bleeding at the ulcer site (arrow). (C) Reconstruction in the venous phase, occurring later, shows greater accumulation of extravasated contrast material and better depiction of the mucosal pattern of the jejunum (arrow). The ulcer was treated with enteroscopy with clip placement and argon. The biopsy revealed cytomegalovirus infection.

success rate of 43–81%.[18] The availability of this technique varies greatly, and as with conventional endoscopy, balloon-assisted enteroscopy also requires colonpreparation.[7]

Nuclear imaging

Scintigraphy uses technetium (^{99m}Tc)-labeled red blood cells to locate the site of bleeding. This technique can detect bleeding rates as low as 0.1–0.4 ml/min with a sensitivity of 93% and a specificity of 95%.[19] The diagnostic criteria are endoluminal accumulation of the tracer, the progressive increase of intensity and the movement of the tracer over time (due to the intestinal transit).[7] Scintigraphy is mainly used for the evaluation of LGIB, where endoscopy plays a limited role. As the tracer remains in the bloodstream after 24 h, this technique is useful in obscure overt GI bleeding with low bleeding rate, in venous and intermittent bleeding.[7,8,20,21] In contrast, it has a limited role in the localization of the site of bleeding (movement of radiotracer) with a 22% false localization rate,[22] and it does not allow characterization of the etiology.[19] Hybrid SPECT-CT improves localization of the site of bleeding.[23] Visualization of early bleeding on ^{99m}Tc-labeled red blood cell scintigraphy has been used as an indicator for angiography, increasing its accuracy,[24] while other studies refute these findings.[25] Scintigraphy has limited use in the evaluation of obscure occult bleeding.[7]

In young patients with LGIB, technetium 99m pertechnetate scintigraphy is useful in the diagnosis of Meckel's diverticulum, as the pertechnetate accumulates in the ectopic gastric mucosa of the diverticulum (present in 50% of cases) and in the mucosa of the intestinal duplications. Sensitivity for Meckel's diverticulum detection is 60–75%,[26] although the use of proton-pump inhibitors prior to the scan increases the sensitivity to 87%.[27]

Barium studies

Conventional barium studies have limited use in the evaluation of GI bleeding due to their low sensitivity.[7]

In 1985, Maglinte described the role of enteroclysis in the evaluation of occult GI bleeding,[28] which has been confirmed by several studies.[29,30] However, the diagnostic accuracy of this technique is 10–25%, being lower than CT or MR enteroclysis or enterography and than CE imaging; its role is therefore of limited value.

Ultrasound

Contrast-enhanced ultrasound allows for the detection of active bleeding, providing visualization of the extravasation of blood, especially in solid organs. It has also been proven useful in the assessment of traumatic injuries, anticoagulant

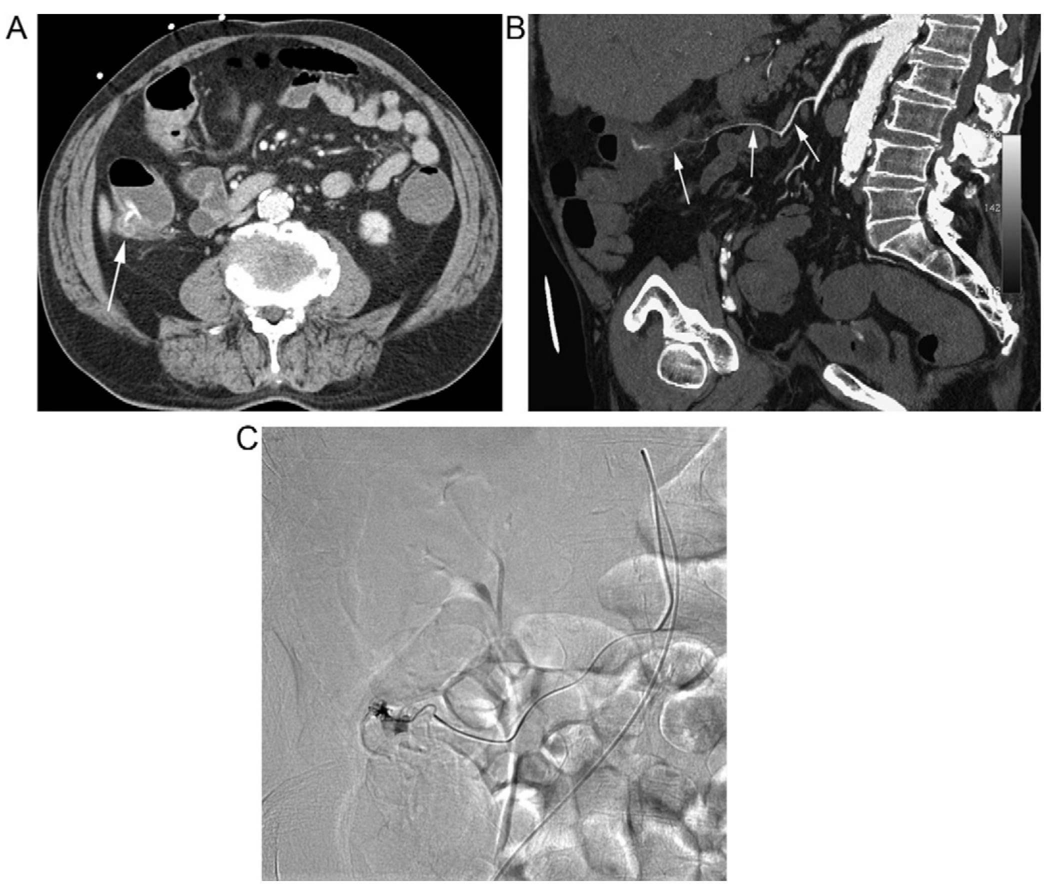

Figure 2 Patient with acute massive LGIB. (A) CT scan shows active bleeding from a diverticulum in the colon's splenic flexure (arrow). (B) Vascular reconstruction shows the vascular supply to the bleeding diverticulum (arrows) through a branch of the medial colic artery. (C) Selective angiography guided by CT findings with embolization of the bleeding vessel.

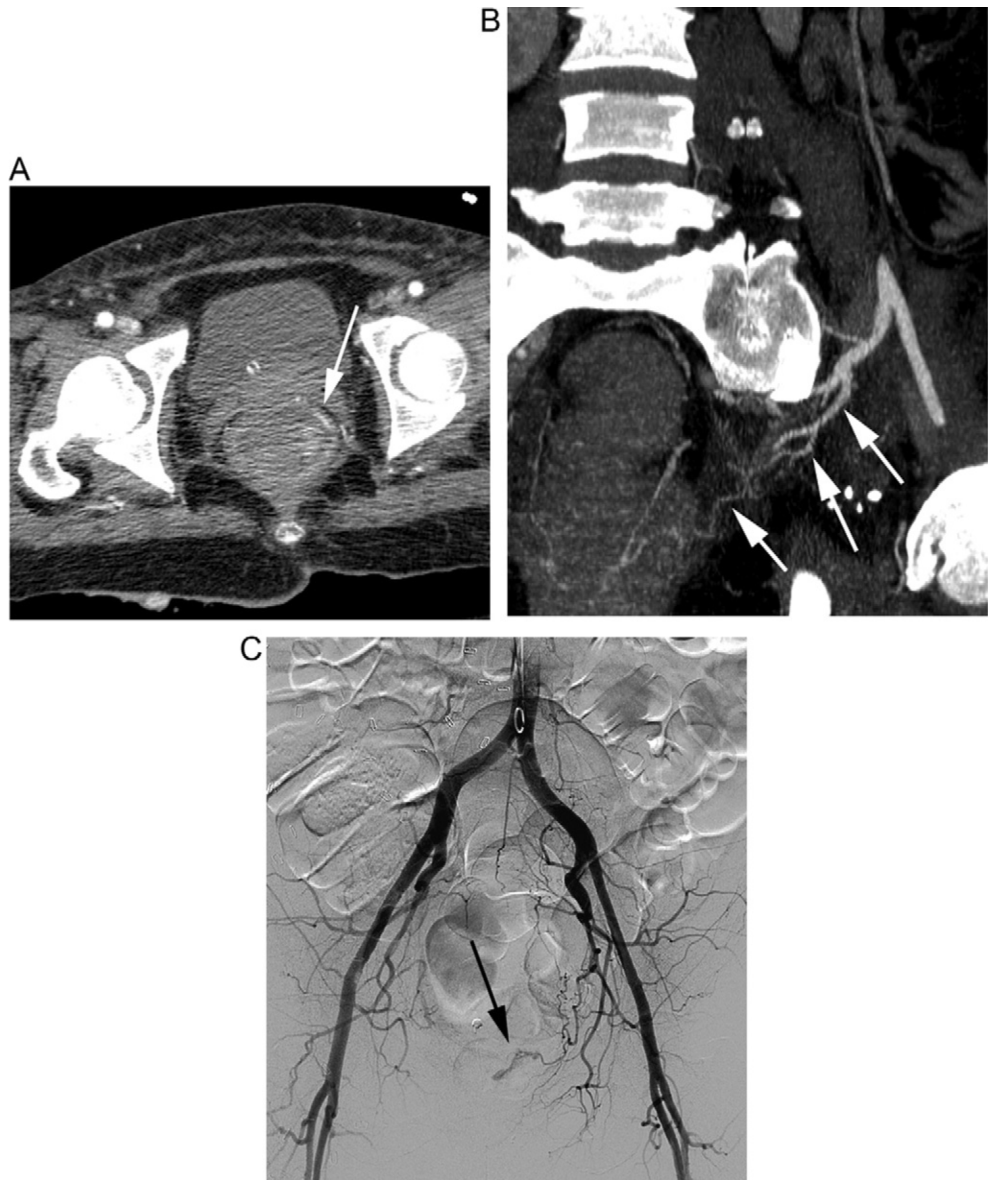

Figure 3 (A) CT scan in a patient with massive LGIB shows contrast extravasation into the left anterolateral wall of the rectum (arrow). (B) Curved reconstruction shows the bleeding source in the hypogastric branch homolateral to the bleeding (arrows). (C) The directed arteriography was performed centered at the iliac sector, obviating the need for initial evaluation of the lower mesenteric artery and confirming the source of active bleeding (arrow); selective embolization was subsequently performed (not shown).

therapy and ruptured aortic aneurysms.[31] A recent article[32] has analyzed the ability of contrast-enhanced ultrasound to detect GI bleeding in comparison with endoscopy, reporting a sensitivity and specificity of 73.7% and 97.1%, respectively. However, these results are provided by this single study, which does not evaluate the small bowel and, as pointed out by the authors, further prospective studies are needed to determine its efficacy.

Multidetector CT

Multidetector computed tomography (MDCT) is being increasingly used as this is a widely available, non-invasive and fast diagnostic technique that allows for the visualization of the entire intestinal tract and its lesions, the identification of the vascularity and possible vascular abnormalities. In addition, this technique does not require preparation in patients with acute bleeding.[5,33–35] In 1997, Ettorre et al.[36] described the usefulness of CT angiography for the detection of endoluminal extravasation of contrast agent in recurrent occult GI bleeding. However, in his study, the scanning was performed after catheterization of the abdominal aorta for contrast administration, which represents an invasive procedure. Subsequent articles demonstrated the usefulness of helical CT with IV contrast administration for the diagnosis of acute LGIB,[37–40] along with the advent of faster MDCT scanners with submillimeter collimation.[34,41]

The first prospective study that evaluated the use of 4-row MDCT[5] for the detection and localization of acute massive bleeding was published in 2006, reporting a sensitivity and specificity of 90.9% and 99%, respectively, in comparison with conventional angiography. Other articles corroborate the usefulness of MDCT in the detection of acute bleeding,[20,35,42,43] both upper and lower, especially in patients with massive bleeding, allowing for the depiction of the source of bleeding in 78% of cases (Figs. 1–7).[35,43]

Kuhle and Sheiman demonstrated in an animal model that helical CT can detect bleeding at rates as low as 0.3 ml/min, which is lower than the rate required by non-selective angiography and similar to that of scintigraphy.[44] These findings have been corroborated by recent experimental studies[45,46] that suggest the usefulness of MDCT to prevent a negative angiography and to guide therapeutic angiography in positive cases.

Specific preparation is not required in the study of acute bleeding as the administration of positive oral contrast agent may prevent visualization of the site of bleeding. This may even occur with a neutral oral contrast since the IV contrast can be diluted if is extravasated into the bowel lumen,[5,33–35] while other authors claim that bowel distension helps in the detection of active bleeding.[7,13,40] A baseline CT performed before IV contrast administration is required to depict any potential, endoluminal or mural, hyperdense material (pills, foreign bodies, stools, clips, suture material, contrast material retained in diverticula, ...) and prevent false positives after contrast administration.[5,19,20,33,35,37,39,41,42] Depiction of endoluminal blood on baseline CT scans (40–60 UH), present in as many as 50% of patients (Fig. 8),[35] may help in the localization of the site of bleeding. Delayed arterial phase imaging should be performed (bolus tracking in the aorta with 15–25 s scan delay depending on the scanner used) allowing depiction of the arterial system and providing sufficient time for the contrast to reach the bleeding lesion and to extravasate into the bowel lumen, which could not be detected on conventional arterial phase images. In general, previously published studies perform an additional venous phase scanning, allowing for the depiction of late or low-rate bleedings, progression of contrast extravasation compared to the arterial phase, a better depiction of the mucosal pattern (Fig. 1) and vascular lesions such as angiodysplasia, as well as better tumor staging.[13,34,35,42,43] However, some studies only perform arterial phase scanning since the added value of the venous phase for bleeding detection is controversial.[5,7,19,20,34] In acute GI bleeding, it is important to perform the MDCT scanning when active bleeding is suspected, since the sensitivity for the detection of extravasated contrast is considerably higher in the detection of massive bleeding (100%) than in patients with mild bleeding (14%).[35] Even when no contrast extravasation is detected, CT can help determine the source and cause of bleeding (diverticulosis, angiodysplasia, pseudoaneurysms, tumors such as GIST, polyps, colon neoplasm, intestinal inflammatory disease) and plan the most appropriate treatment (Figs. 1 and 6).

For the study of obscure GI bleeding, especially occult and overt with low bleeding rate, CT-enterography (CT-E) or CT-enteroclysis are the techniques of choice, the former being the most commonly used as no data support that one technique has yielded better results than the other.[7] Moreover, enteroclysis is better tolerated by the patient, is easier to perform and does not require a dedicated room or additional radiation for the placement of a nasojejunal tube. Neutral (density similar to water) and

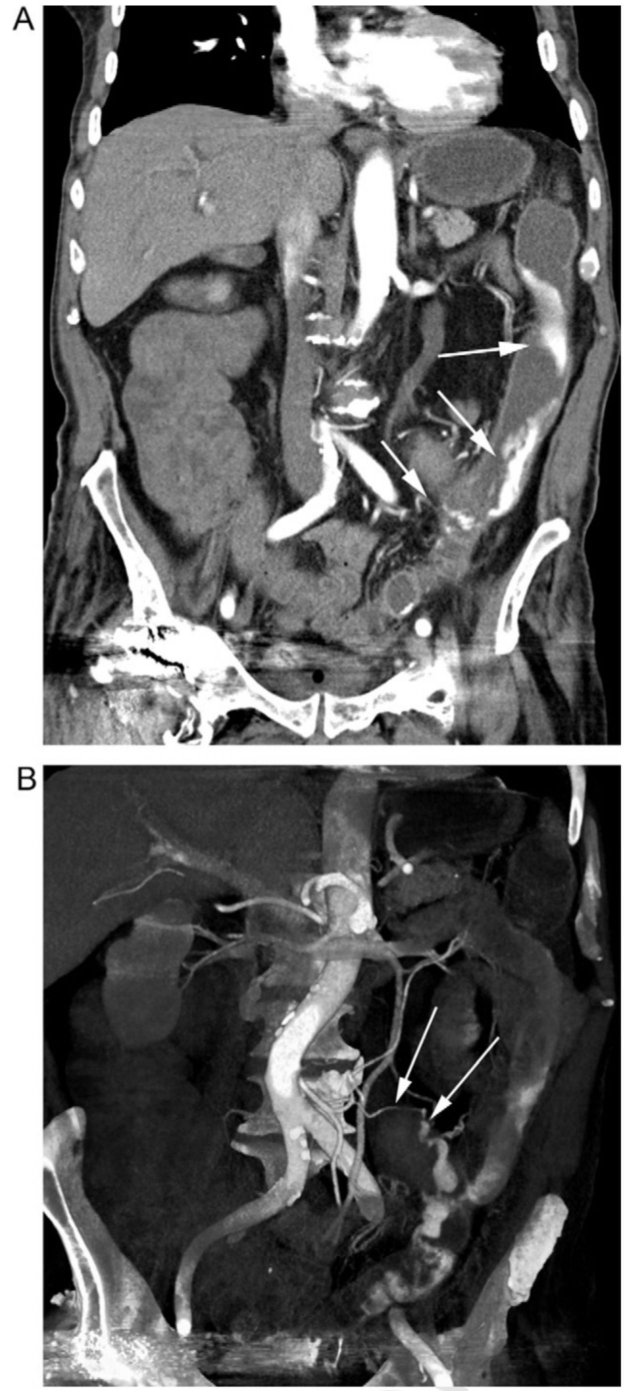

Figure 4 Patient with massive LGIB during the postoperative period following a Hartmann's procedure. (A) Coronal CT reconstruction obtained in late arterial phase shows extensive extravasation of contrast material into the left colon (arrows). (B) Volume rendering image shows the vascular origin of bleeding, located in a branch of the lower mesenteric artery (arrows).

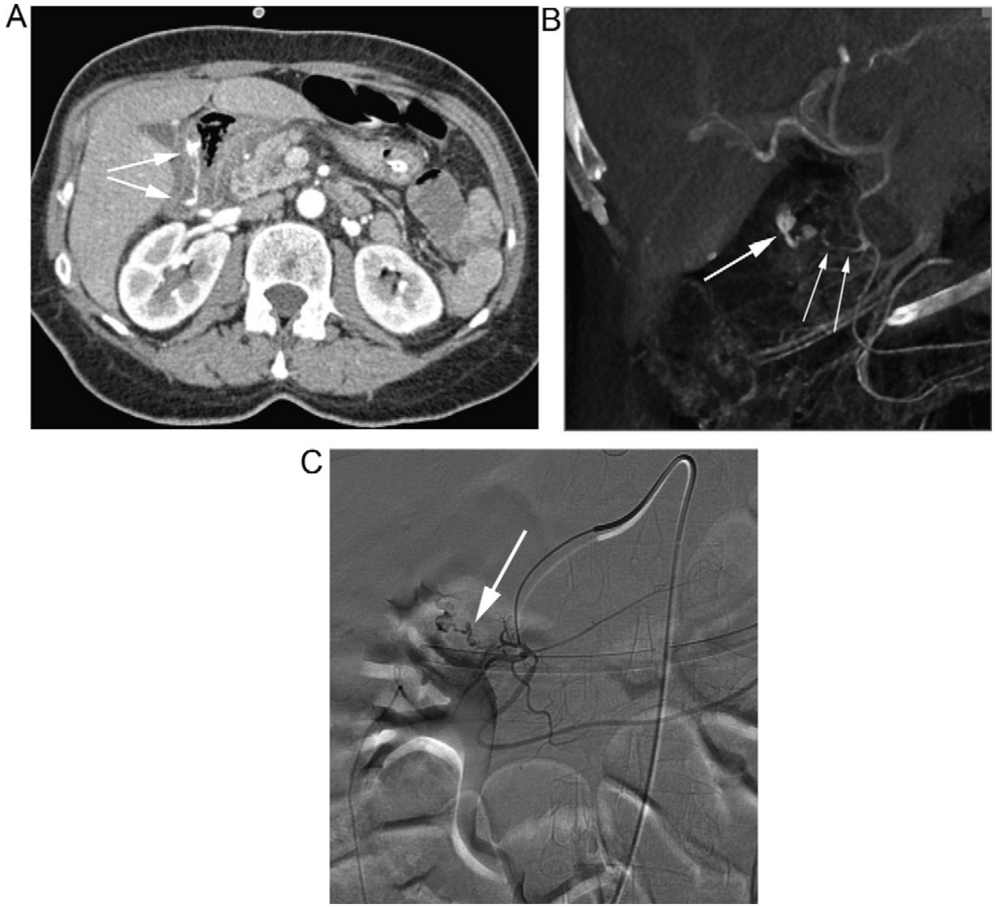

Figure 5 Patient with suspected massive LGIB. (A) TC angiogram shows active bleeding in the bulb (arrows). (B) MIP image shows the localization of the source of bleeding (thick arrow) in the branches of the gastroduodenal artery (thin arrows). (C) CT-guided angiography confirms contrast extravasation (arrow), with subsequent selective embolization.

non-resorbable (PEG, mannitol, sorbitol) enteric contrast material should be used in order to achieve appropriate distension of the bowel loops. Intravenous contrast should also be used to depict the abdominal vascular tree and the bowel wall with the acquisition of arterial, enteric and delayed phase[13] or one single phase,[47] depending on the authors. Although several studies have demonstrated the usefulness of CT in the detection of the vascular etiology of bleeding (Fig. 9), most of them are single-case or small series studies performed with different techniques,[48–50] thus assuming a lower sensitivity than CE for the detection of these lesions. Available research suggests that CT-E may complement CE,[13] which allows direct visualization of the intestinal mucosa, with higher sensitivity for depicting flat lesions.

Magnetic resonance

The usefulness of magnetic resonance (MR) imaging for the detection of active GI bleeding has been described experimentally,[51] providing even better results than scintigraphy.[52] One article showed the clinical usefulness of this technique, but it was a single-case study,[53] which along with the lower availability of MR imaging compared to MDCT makes the role of MRI in acute bleeding merely anecdotal.

There are few articles on the use of MR-enterography or MR-enteroclysis in obscure GI bleeding, most of them in the form of single-case studies.[53,54] MR imaging could have a role in young patients in whom small bowel neoplasms are a common source of obscure bleeding and where MR imaging has proven useful.[55]

Angiography

For years, angiography has been the diagnostic technique that complements endoscopy and nuclear imaging in acute GI bleeding, allowing for the detection of contrast extravasation into the bowel lumen with bleeding rates of 0.5 ml/min or greater and, sometimes, allowing for the localization of the bleeding source. Angiography has a sensitivity of 63–90% and of 58–86% for UGIB and LGIB, respectively. The only direct sign of bleeding is extravasation of contrast material into the bowel lumen. Indirect signs include visualization of a vascular bundle and an early draining vein (angiodysplasia), pseudoaneurysms, arteriovenous fistulas, vascular hyperplasia (disease), neovascularization (tumors) and extraluminal contrast filling (diverticula). Its diagnostic role has been replaced by MDCT.[19,42]

The development of catheters and microcatheters, but mainly the development of embolic materials (particles, microcoils, liquid materials with rapid polimerization, etc.), has turned angiography into a first-line modality

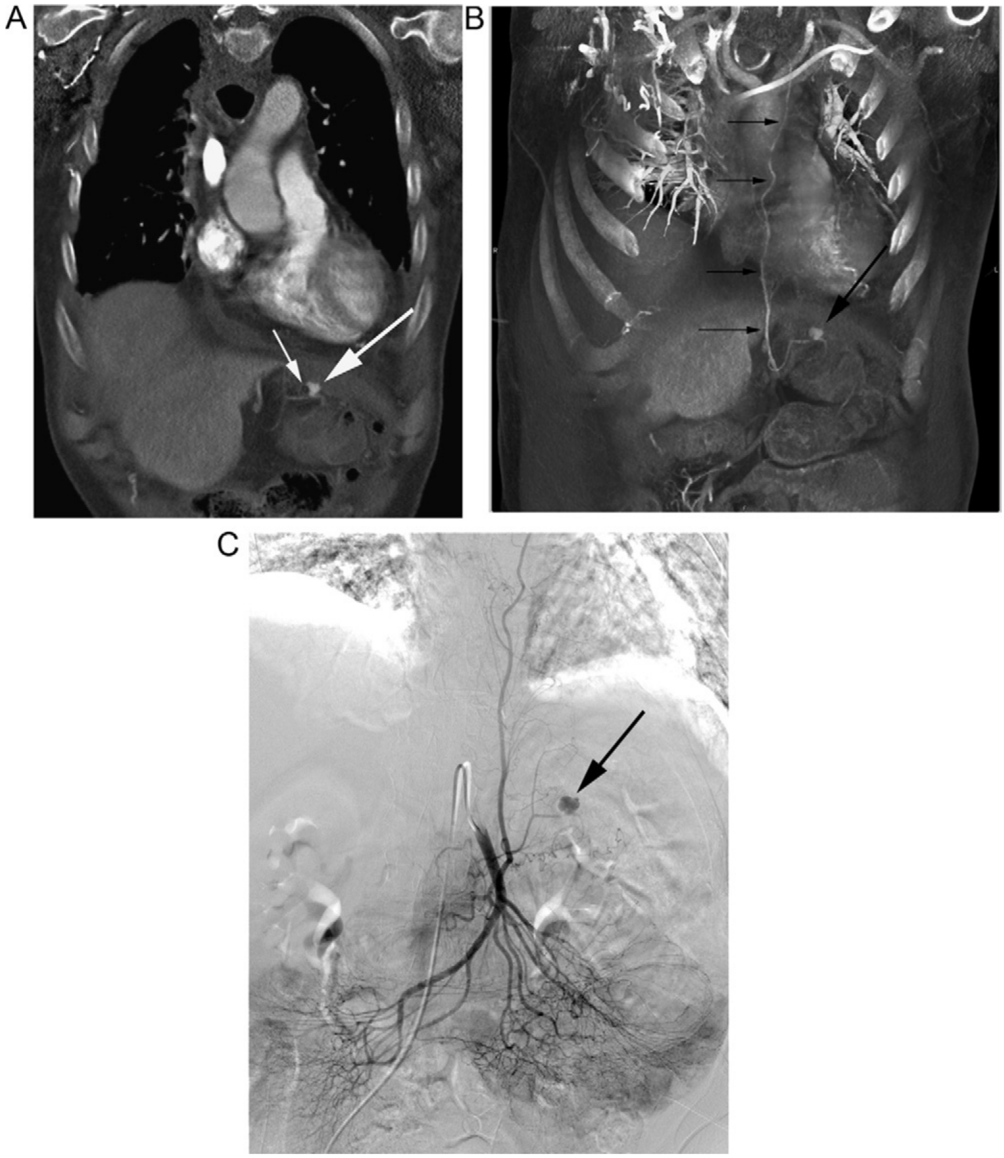

Figure 6 Patient with esophageal tumor resection and coloplasty who presents with hematemesis. (A) Coronal CT reconstruction shows a pseudoaneurysm (thick arrow) adjacent to the feeding tube (thin arrow). (B) Volume rendering image shows the pseudoaneurysm (thick arrow) arising from one of the branches of the middle colic artery (thin arrows). (C) The angiography, guided by CT findings, confirms the pseudoaneurysm (arrow), and its subsequent embolization.

for the management of these patients by using superselective embolization, especially in acute LGIB and in UGIB that cannot be controlled by endoscopy or surgery. Embolization achieves cessation of bleeding without major ischemic complications and with low rebleeding rates in 70—90% of cases,[3,21,56] especially in LGIB.[19] Postembolization complications such as intestinal stenosis are rare and asymptomatic.[57,58]

Diagnosis of gastrointestinal bleeding

Acute gastrointestinal bleeding

In acute GI bleeding, measures to stabilize the patient (resuscitation, stabilization of blood pressure and restoration of volemia) should be taken prior to diagnosis.

Endoscopy is used in the initial assessment of acute UGIB because of its high diagnostic and therapeutic efficacy. MDCT angiography is performed to determine the site and, eventually, the cause of bleeding only in those cases where endoscopy fails, especially in cases of massive blood loss (Fig. 5),[42] helping to select the most appropriate treatment for each particular case, and guiding embolization when required. Arteriography is the technique of choice for the treatment of UGIB after two failed endoscopic procedures,[59] and it has even been suggested as a treatment to control rebleeding after endoscopic treatment guided by the metallic clips placed at endoscopy, even if no active bleeding can be visualized.[60]

Colonoscopy is the initial examination in acute LGIB[3,61] but is unable to locate the site of bleeding in 25—32% of cases, and depending on the series its accuracy ranges from

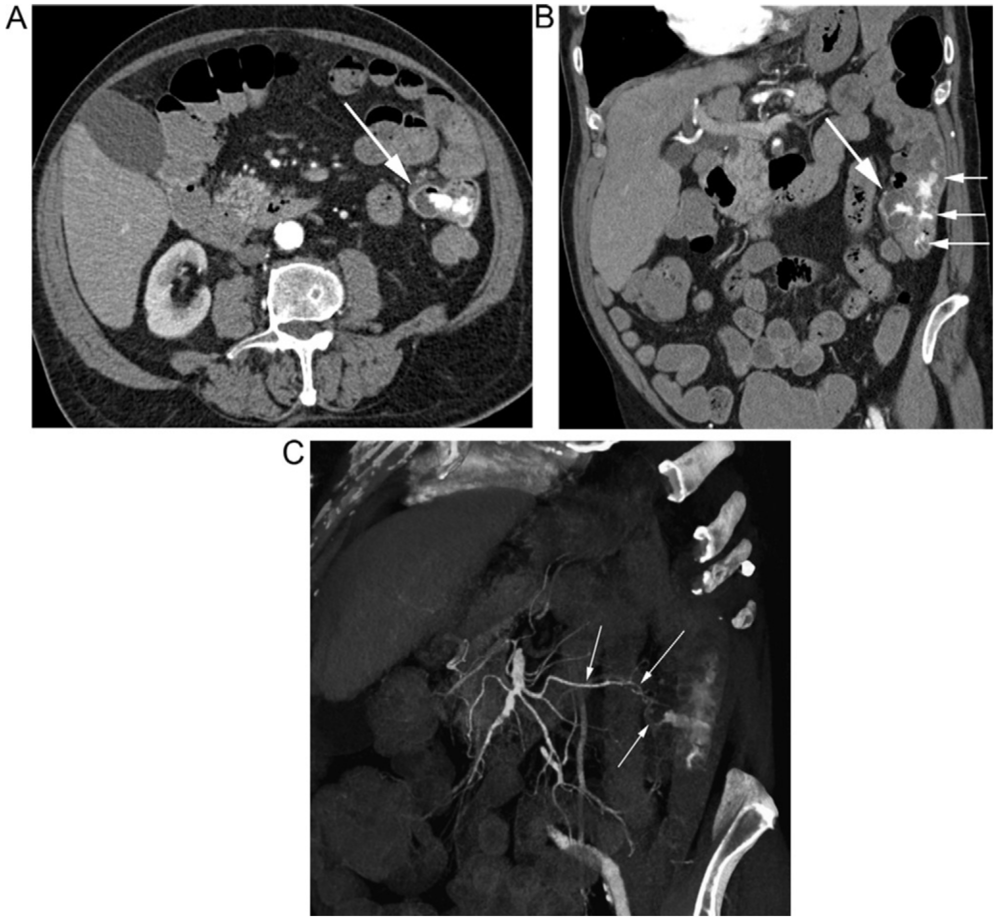

Figure 7 Patient with iron-deficiency anemia and previous endoscopic examinations with negative results presents with overt LGIB. (A) CT scans shows contrast extravasation from a jejunal diverticulum (arrow). (B) Coronal reconstruction shows the bleeding diverticulum (thick arrow), with extravasation into the bowel lumen (thin arrows). (C) Volume rendering image shows the supply to the diverticulum arising from one of the jejunal branches (arrows) of the upper mesenteric artery.

48 to 90%.[1,22,62,63] The use of colonoscopy (accepted when bleeding has stopped and colon preparation is possible) for the treatment of acute massive bleeding in an unprepared colon is controversial[5,42,64] since lesion detection rate is low.[12,64] There is no consensus, either, on whether urgent endoscopy should be performed after or without colon preparation.[1,65] In case of negative colonoscopy, with suspected small bowel bleeding, or non-conclusive colonoscopy due to the presence of stools, clots or massive bleeding, CT angiography could be useful to depict the site and etiology of the bleeding, being especially useful in massive bleeding given its high sensitivity in this clinical setting (Figs. 1—4 and 7).[66]

A CT angiography with negative findings may obviate the need of angiographic examination, reducing thus the rate of negative angiographies,[34,35,37,39] or may help determine the site of bleeding, the treatment strategy (endoscopy, angiography or surgery), and the etiology of the bleeding, with the consequent prognostic value.[7] If embolization is required, CT can guide the access (state of femoral and iliac arteries), depict abnormal vascular anatomy, localize the site and vascular source of bleeding. This will facilitate a selective angiography, resulting in a reduction in the examination time, in the volume of contrast agent and in the radiation dose received by the patient and the interventional radiologist (Figs. 2, 3, 6 and 8).[5,19,37,41] It is also useful to guide surgical procedures, limiting the surgical resection when the site of bleeding can be located, preventing thus ''blind'' segmental resection or colectomy associated with high morbidity—mortality.[39] Moreover, localization of bleeding within the small bowel may prevent unnecessary endoscopic examinations. For this reason, some authors advocate the use of CT as the first-line diagnostic modality for acute LGIB to direct patient management,[19,38,46] especially in cases of hemodynamic stability, where conservative treatment can be performed with negative CT findings, and the possibility of repeating the examination in case of recurrent bleeding. CT should also be taken into account in the initial assessment of post surgical GI bleeding as these patients are difficult to evaluate and treat by endoscopy, especially if cephalic duodenopancreatectomy or small bowel resection have been performed, with the source of bleeding probably out of reach of conventional endoscopy (Figs. 4, 6 and 8).

In a stable patient with negative colonoscopic and CT examinations, the bleeding has probably stopped and only supportive measures are required. However, even with negative results, an angiography should be performed if the

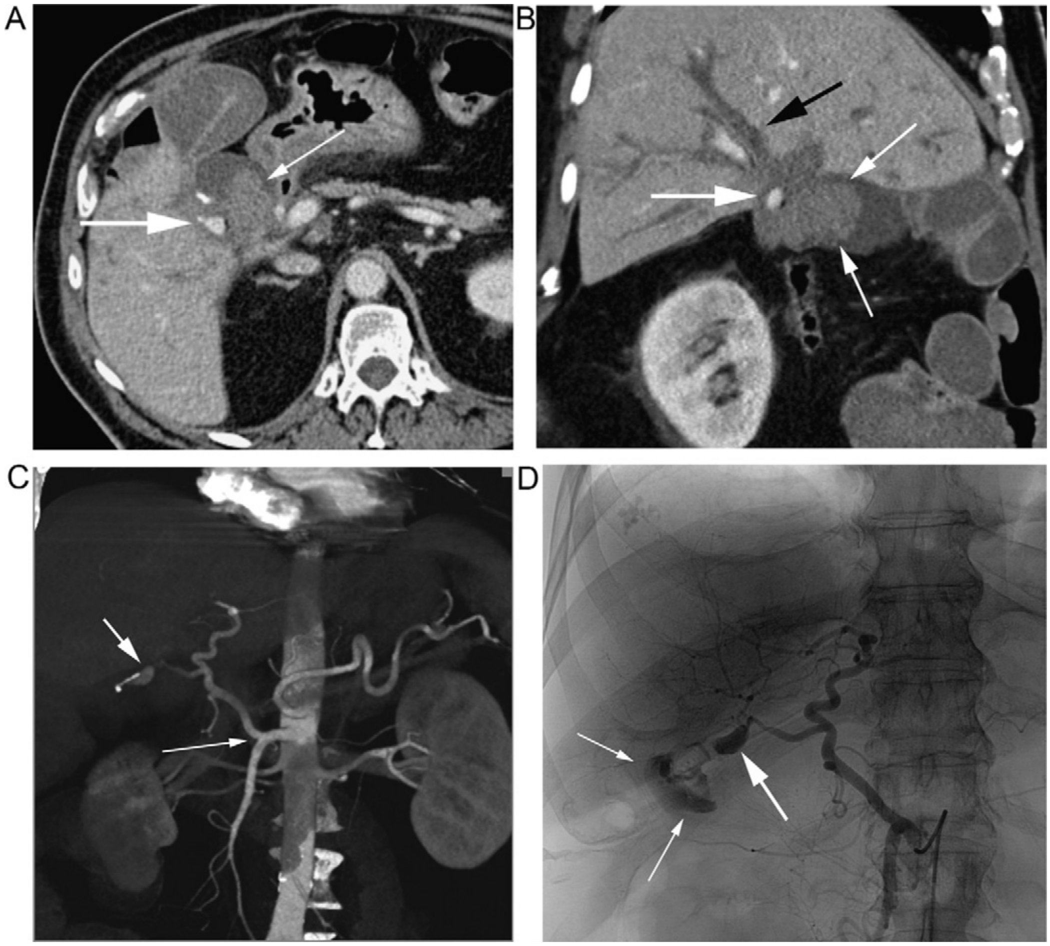

Figure 8 GI bleeding in a patient with biliary enteric shunt. (A) Axial CT scan shows clots in the jejunal loop of the shunt (thin arrow) and a pseudoaneurysmal image in the anastomosis (thick arrow). (B) Curved reconstruction shows the area of anastomosis, endoluminal clots (thin white arrows), the pseudoaneurysm (thick white arrow) and dilation of the proximal bile duct (black arrow). (C) Volume rendering image shows the hepatic artery arising from the upper mesenteric artery (thin arrow) and the pseudoaneurysm arising from the right hepatic artery (thick arrow). (D) The angiography confirms these findings (pseudoaneurysm, thick arrow) and reveals the active bleeding into the jejunal loop during the examination (thin arrows). The pseudoaneurysm was treated with coil embolization, with preservation of hepatic vascularity and cessation of the bleeding.

patient is hemodynamically unstable. Other diagnostic procedures such as CE and scintigraphy could be used if the patient remains hemodynamically stable and no diagnosis has been made.

Angiography has an important role in the treatment of this type of GI bleeding, with success and mortality rates of 81—93% and 0—7%, respectively, for massive LGIB. Several authors have therefore advocated urgent superselective embolization as the treatment of choice in patients with severe LGIB following localization of the site of bleeding on MDCT.[65,67]

Surgery should be limited to those cases in which the site of bleeding is identified and endoscopy and angiography have failed to control the bleeding. A selective segmental resection can be then performed.[65,67]

Chronic or recurrent obscure bleeding

In most cases, the cause of this type of bleeding is located in the esophagus, stomach or colon. The reasons for a negative initial evaluation include that the lesions have stopped bleeding, hypovolemia and significant anemia causing the lesions to be overlooked, intermittent and slow bleeding, and presence of clots or poor bowel preparation.[17] For this reason, on the face of initially negative findings on endoscopy, an upper endoscopy should be repeated since as many as 50% of lesions overlooked at initial endoscopy will be identify (Cameron's erosions, varices in the gastric fundus, peptic ulcer disease, angioectasias, Deulafoy's lesion or antral gastric vascular ectasia). Some authors prefer to perform an enteroscopy that can be also used to depict the proximal small bowel[35] and to treat the lesions in that localization. As for colonoscopy, only 6% of lesions are identified in the second colonoscopy, although there could be neoplasms and angioectasias overlooked at the initial study.[68]

In the face of repeated endoscopic examinations with negative results, the bleeding is assumed to originate in the small bowel (5—27% of cases)[3,69] and, in this context, we have several diagnostic tools at our disposal: CE,

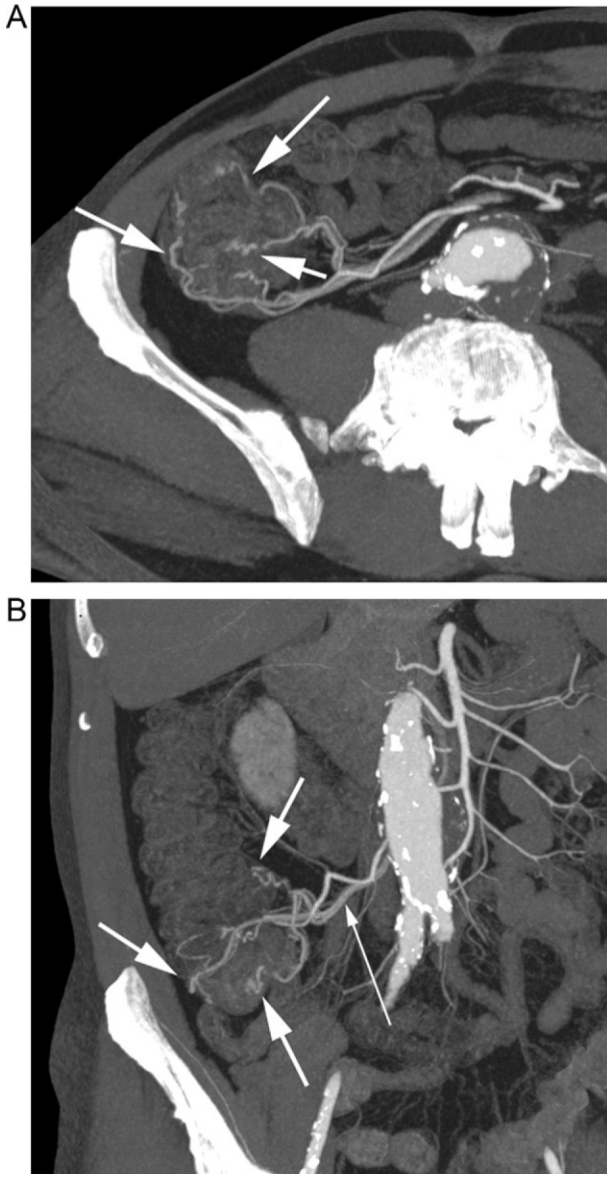

Figure 9 CT scan of a 75-year-old patient with chronic obscure GI bleeding. (A) Axial MIP image shows multiple vascular ectasias in the cecum (arrows) corresponding to angiodysplasia. (B) Coronal MIP image shows vascular dilations (thick arrows) and early drainage of the ileocecocolic vein (thin arrow).

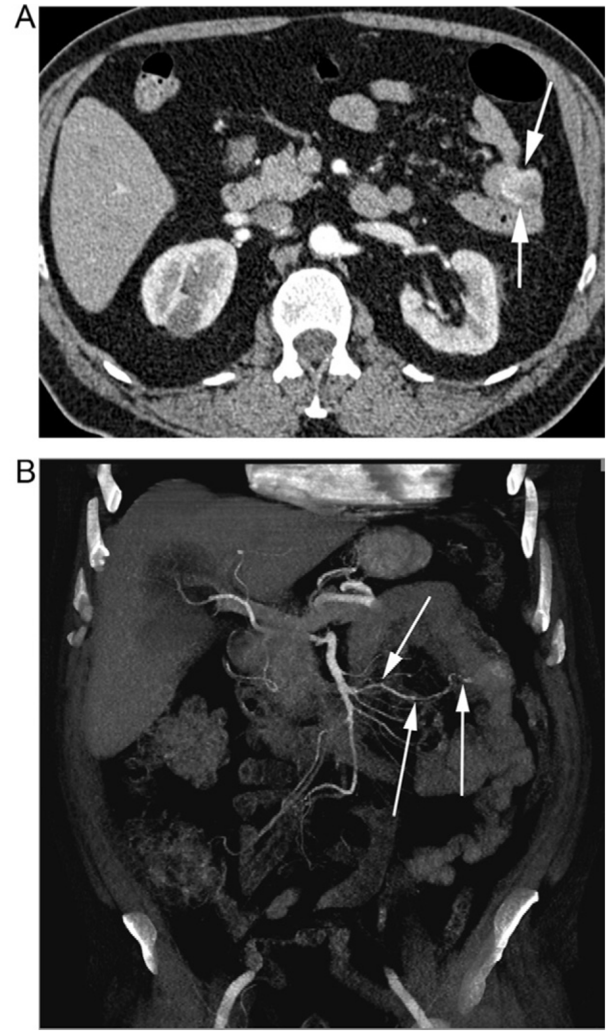

Figure 10 Patient with obscure GI bleeding. (A) CT scan shows heterogeneous hypervascular mass in the proximal jejunum (arrows). (B) Volume rendering image shows its blood supply (arrows). Surgery confirmed a jejunal GIST.

enteroscopy, labeled red blood cell scintigraphy, CT angiography, CT enterography and angiography.

In case of overt bleeding with suspected high bleeding rate, we should proceed as in acute bleeding. In case of overt bleeding at low rates or occult bleeding, CE is the diagnostic technique of choice. CE allows us to visualize the entire small bowel, to locate the lesion and to guide the treatment,[3] with a yield of 42—80% in obscure GI bleeding.[70]

MDCT enterography allows for the localization of the site of bleeding, although with much lower sensitivity than in acute bleeding or, more commonly, allows for the detection of intestinal abnormalities that may be the potential cause of the bleeding including small bowel tumors. These tumors account for 6—9% of the causes of chronic obscure GI bleeding and are the most common cause of bleeding in patients younger than 50 years (Fig. 10).[17,47] The use of CT enterography over other techniques such as CE or scintigraphy is based on the availability and experience of each institution, taking into account that they are often complementary techniques.[13,47,71,72] CE provides better diagnosis of flat lesions such as angiodysplasia and ulcerations, while CT-E offers better results in tumor detection (Fig. 10),[47,71,72] with similar yield for both techniques.[47,73]

Before CE, some authors use CT-E in obscure occult bleeding as initial diagnostic technique to rule out bowel stenosis or diverticulosis[4,7,71] that may lead to capsule retention, while other authors suggest CE as the initial diagnostic technique since angiodysplasia is the most common cause of bleeding.[4]

Labeled red blood cell scintigraphy can be used in the initial diagnosis of obscure overt bleeding if the patient is hemodynamically stable. In case of hemodynamic instability or negative scintigraphy, a CT scan is performed and an angiography if needed.[7]

Conclusion

GI bleeding often represents a diagnostic problem requiring repeated examinations that may, at times, not provide a diagnosis. Although the diagnosis and treatment are based on endoscopic studies, CT studies have proved useful in GI bleeding. Sensitivity of CT angiography is close to 100% in acute massive bleeding and it can thus be used in the initial evaluation or after a non-diagnostic endoscopy. Although the sensitivity of CT decreases considerably in moderate bleeding, this technique allows for the visualization, in a high percentage of cases, of indirect signs that may be indicative of the source and cause of bleeding. In obscure bleeding, CT-E is a technique that complements CE and scintigraphy, especially to rule out small bowel tumors in young patients. Although the place of CT-E in the diagnostic algorithm of GI bleeding is yet to be defined, probably because of the lack of prospective studies comparing this technique with endoscopic modalities, there is no doubt that it plays a complementary role to endoscopic techniques, replacing angiography as diagnostic modality.

Angiography has an important therapeutic and complementary role to endoscopy in the management of these patients, through directed examination and superselective embolization, guided by endoscopic or CT findings.

Authorship

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Conflict of interest

The authors have no conflict of interest to declare.

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