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OPINION REVIEW

Role of multidetector computed tomography angiography in non-variceal upper gastrointestinal bleeding: A comprehensive review

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Abstract

Non-variceal upper gastrointestinal bleeding (NVUGIB) is a common gastroenterological emergency associated with significant morbidity and mortality. Upper gastrointestinal endoscopy is currently recommended as the gold standard modality for both diagnosis and treatment, with computed tomography traditionally playing a limited role in the diagnosis of acute NVUGIB. Following the introduction of multidetector computed tomography (MDCT), this modality is emerging as a promising tool in the diagnosis of NVUGIB. However, to date, evidence concerning the role of MDCT in the NVUGIB diagnosis is still lacking. The aim of our study was to review the current evidence concerning the role of MDCT in the diagnosis of acute NVUGIB.

Key Words: Gastrointestinal bleeding; Upper gastrointestinal bleeding; Non-variceal upper gastrointestinal bleeding; Computed tomography; Multidetector computed tomography; Multidetector computed tomography angiography

Core Tip: Upper gastrointestinal endoscopy is currently recommended as the first-line technique for diagnosis and treatment of non-variceal upper gastrointestinal bleeding (NVUGIB). Conversely, computed tomography has a limited role in the diagnosis of acute NVUGIB. However, following the introduction of multidetector computed tomography (MDCT), this modality is emerging as a promising tool in the diagnosis of NVUGIB. Nevertheless, to date, evidence concerning the role of MDCT in the NVUGIB diagnosis is still lacking. Our study aimed to review the current evidence concerning the role of MDCT in the diagnosis of acute NVUGIB.

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INTRODUCTION

Acute upper gastrointestinal bleeding (UGIB) is the most common gastroenterological emergency with an annual incidence of 40-150/100000 population[1-3]. It is defined as hemorrhage occurring from a source located proximal to the ligament of Treitz. Based on the etiology, it is usually classified as variceal and non-variceal upper gastrointestinal bleeding (NVUGIB), with peptic ulcers, neoplasms and Mallory-Weiss syndrome being the most common causes of NVUGIB[1,2,4].

Despite marked advances in the management of acute UGIB, its mortality rate is still high ranging from 8% to 14%[5-7], and increasing up to 40% in high-risk patients[8].

Following hemodynamic stabilization, esophagogastroduodenoscopy (EGD) is currently recommended as the first-line diagnostic procedure in NVUGIB patients, allowing for simultaneous localization, characterization and hemostatic treatment in the majority of bleeding lesions[9-11]. The reported EGD sensitivity and specificity for UGIB are 92%-98% and 30%-100%, respectively[3]. However, EGD often fails to identify the exact bleeding site in case of massive UGIB (> 1 mL/min), being non-diagnostic in 10% of cases of UGIB[3,12]. Furthermore, Vreeburg *et al*[13] reported unsuccessful diagnosis at first endoscopy in 24% of acute UGIB patients, with endoscopic view impairment for excessive blood or clots in 15% of cases.

As opposed to acute lower gastrointestinal bleeding[14-16], computed tomography (CT) has currently a limited role in the diagnosis of acute UGIB and its routine adoption in the setting of acute NVUGIB is not recommended[9-11]. However, the introduction of multidetector CT (MDCT) technology has led to increased image resolution and markedly decreased scanning time, thus allowing the identification of contrast medium (CM) extravasation into the bowel lumen before contrast medium dilution. Furthermore, the ability of helical CT to detect active gastrointestinal bleeding may exceed the lower limit of 0.5 mL/min reported for mesenteric angiography and may approach the 0.2 mL/min limit of 99mTc-red blood cell scintigraphy[17]. Thus, recently, MDCT has been increasingly adopted in the diagnostic approach of most vascular diseases, and a promising role of this technique in the NVUGIB diagnosis has been suggested[18,19]. Anyway, evidence regarding the value of MDCT in NVUGIB is still limited. The aim of our study was to extensively review the current evidence with regard to the role of MDCT in the diagnosis of acute NVUGIB.

LITERATURE SEARCH

We performed a comprehensive literature search of the PubMed (MEDLINE) and EMBASE electronic databases up to July 2022, in order to identify relevant studies evaluating the role of MDCT in the diagnosis of acute NVUGIB. The medical search strategy used the terms "computed tomography", "CT", "computed tomography angiography", "CTA", "multidetector computed tomography", "MDCT", "non-variceal upper gastrointestinal bleeding", and "non-variceal upper gastrointestinal haemorrhage" in various combinations, using the Boolean operators AND, OR, and NOT. Search strategy was limited to human studies and articles written in English. Meeting abstracts, individual case reports, case series (< 5 cases), review articles, position papers, editorials, commentaries, and book chapters were excluded from our review. The reference lists of pertinent identified studies and related review articles were carefully hand-searched in order to obtain any additional eligible studies.

ROLE OF MDCT IN NVUGIB

Evidence

A total of 9 studies were included in our final analysis[20-28]. All but 3 prospective studies[20,24,25] were retrospective[21-23,26-28]. With the exception of one study comparing enhanced and unenhanced MDCT[26], in all of the remnant studies intravenous contrast-enhanced MDCT scan with at least an arterial phase acquisition was evaluated[20-25,27,28]. No CM was orally administered in any of the included studies. Main characteristics of the included studies in which MDCT was adopted in the diagnosis of acute NVUGIB are summarized in Table 1. Figures 1-3 show three cases of severe NVUGIB in which MDCT was performed immediately after EGD, providing bleeding etiology identification and thus guiding further treatment.

In 2006, Yoon *et al*[20] first prospectively evaluated the role of arterial phase MDCT in 7 patients admitted for acute massive NVUGIB in whom endoscopic examination or hemostasis failed. A high accuracy of MDCT for the detection and localization of the bleeding sites was showed.

Later on, in a small retrospective case series MDCT was able to detect the bleeding source in all cases and to identify the bleeding etiology in 9 out of 10 cases. Of note, CT provided a diagnosis in 6 patients after negative findings at angiography (n = 2) and endoscopy (n = 4). In the remaining 4 patients, CT was the initial imaging method providing a diagnosis in all 4, and no further diagnostic work-up was performed. Moreover, CM extravasation was detected in all patients with acute severe NVUGIB (7/10) and the identified NVUGIB etiology mainly included rare causes of massive NVUGIB (aortoduodenal fistula, n = 4 and arterial pseudoaneurysm, n = 4, and arteriobiliary fistula, n = 1), requiring non-endoscopic treatment[21].

In 2008, Jaeckle *et al*[22] retrospectively reported the efficacy of MDCT in 10 UGIB patients in whom upper endoscopy failed to reveal the bleeding source. In 9 out of 10 patients MDCT was able to localize the bleeding site, while active bleeding was showed in 5 cases. In the only false-negative finding, angiographic and endoscopic follow-up revealed duodenal invasion of a small pancreatic carcinoma with duodenal bleeding.

Later on, a high MDCT accuracy for the detection of acute UGIB was reported in a small retrospective case series. Of note, MDCT criteria for acute GIB not only included the identification of active CM extravasation within bowel lumen, but also the detection of mass or pathologic vessel[23].

Subsequently, a small prospective study from Italy reported an excellent sensitivity of MDCT in identifying bleeding site and etiology (100.0% and 90.9%, respectively, compared with 72.7% and 54.5%, respectively, of endoscopy). Of note, patients in whom bleeding stopped after the operative endoscopy were not included in the study, whereas EGD failure was observed in 5 out of 11 of the included patients[24].

In 2012, Sun *et al*[25] prospectively evaluated the role of tri-phasic MDCT as the initial diagnostic investigation in patients with both severe and mild acute UGIB. As similarly previously reported, criteria for positive CT were not limited to the presence of active CM extravasation within bowel lumen, but also included identification of abnormal bowel mucosal enhancement, vascular malformation, abnormally enhancing polyp or diverticulum, or tumor. MDCT was shown to be a highly accurate first-line screening modality for both detection and localization of UGIB, effectively guiding further management. However, interestingly, no CM extravasation was observed in any of the included patients with mild UGIB[25].

Subsequently, the usefulness of MDCT prior to urgent endoscopy was confirmed in a similar large retrospective study. Indeed, pre-operative MDCT showed a diagnostic accuracy for the bleeding origin detection of 57.8% (130 of 227 patients) and 19.4% (20 of 103 patients) for the enhanced and unenhanced MDCT groups, respectively, among expert radiologists. To be mentioned, the authors excluded from their study patients in whom other therapeutic modalities, such as angiography or surgery, were performed rather than urgent endoscopy due to MDCT results. Finally, the average time needed for endoscopic detection of bleeding origin in the MDCT-positive group was significantly faster (88.1 s) than that in the MDCT-negative group (155.8 s) among patients who underwent the enhanced MDCT scan ($P \leq 0.05$)[26].

Conversely, a recent large retrospective study showed that MDCT prior to endoscopy has a significantly low sensitivity for the identification of UGIB site and etiology, as compared with endoscopy. However, of note, the study did not include cases in whom EGD failed, or the endoscopic diagnosis was other than ulcer, varices, or cancer. Moreover, unstable patients were also excluded. As stated by the authors, all of the included patients were affected by mild UGIB, thus massive and rare and causes of acute UGIB were excluded from this study[27].

Intriguingly, Jono *et al*[28] compared CT findings with two well validated clinical scores to predict mortality, rebleeding and need for endoscopic therapy in NVUGIB patients. In all patients CT was performed prior to upper endoscopy. Although upper gastrointestinal (UGI) hemorrhage and UGI wall findings on CT scan were not significant in predicting mortality and rebleeding, the first CT finding better predicted the need for endoscopic therapy than both clinical Rockall score (adjusted odds ratio 10.10) and Glasgow Blatchford score (adjusted odds ratio 10.70)[28].

Table 1 Summary of studies reporting on the role of multidetector computed tomography in the diagnosis of acute Non-variceal upper gastrointestinal bleeding

Ref.	Study design	Patients, *n*	Type of CT	Inclusion criteria	Exclusion criteria	Criteria for positive CT	Reference standard	Study aim	Results
Yoon *et al*[20], 2006	P	7	4-MDCT	Patients with massive UGIB in whom endoscopic examination or hemostasis failed	-	Active GIB: Extravasation of CM with attenuation> 90 HU within bowel lumen	Angiography	Accuracy of MDCT for detection and localization of acute massive UGIB	GIB detection: TP: 4/7, FN: 2/7, FP: 1/7, TN: 0/7, GIB localization: TP: 7/7
Scheffel *et al*[21], 2007	R	10	4-, 16-, or 64-MDCT	Patients with UGIB who underwent CT in the acute phase of hemorrhage	-	Acute GIB: Active extravasation of CM within bowel lumen; or extravasated CM with attenuation > 90 HU	Surgery, angiography, endoscopy, or pathology	Ability of MDCT to identify source and etiology of acute UGIB	GIB detection: 10/10; GIB etiology identification: 9/10
Jaeckle *et al*[22], 2008	R	10	16- or 40-MDCT	Patients with UGIB in whom endoscopic examination failed to identify the bleeding source	Serum creatinine > 250 μmol/L; or iodinated CM allergy	Active GIB: Active extravasation of CM with attenuation > 90 HU within bowel lumen; or collection of hyperdense intraluminal blood with attenuation > 90 HU	Endoscopy, angiography and/or surgery	Accuracy of MDCT for detection and localization of acute UGIB	GIB detection: TP: 9/10; FN: 1/10; GIB localization: TP: 9/10; FN: 1/10
Fung *et al*[23], 2008	R	6	64-MDCT	Patients with UGIB who underwent angiography	-	Acute GIB: Mass, abnormal vessel, or active extravasation of CM within bowel lumen	Angiography	Accuracy of MDCT for detection of acute UGIB	TP: 6/6
Frattaroli *et al*[24], 2009	P	11 (1 VUGIB)	16-MDCT	Patients with severe acute UGIB following endoscopy	Hemodynamicinstability; non-severe, intermittent, or chronic GIB; or effective endoscopic hemosthasis	Acute GIB: Active extravasation of CM within bowel lumen	Endoscopy, angiography, surgery, or post-mortem findings	Ability of MDCT to identify UGIB site and etiology	GIB site identification: Sensitivity 100% (*vs* 72.7% of endoscopy); GIB etiology identification: Sensitivity 90.9% (*vs* 54.5% of endoscopy)
Sun *et al* [25], 2012	P	33	16-, 64-, or dual-source MDCT	Patients with acute UGIB who underwent; MDCT as the initial diagnostic examination	Iodinated CM allergy; pregnancy; or serum creatinine > 2.0 mg/dL	Active GIB: Active extravasation of CM with attenuation > 90 HU within bowel lumen; focal or segmental abnormal bowel mucosal enhancement; presence of a vascular malformation; polyp or diverticulum with abnormal enhancement; or tumor	Endoscopy, angiography, surgery, or pathology	Accuracy of MDCT for detection of active UGIB	TP: 25/33; FN: 3/33; TN: 5/33
Miyaoka *et al*[26],	R	330	64-MDCT	Patients with acute UGIB	Patients who underwent other therapeutic	Active GIB: Extravasation of	Endoscopy	Accuracy of MDCT for	Enhanced MDCT: 57.8%

2014				who underwent MDCT prior to urgent endoscopy	modalities rather than urgent endoscopy due to MDCT findings	CM within bowel lumen; possible bleeding: Wall thickening; focal wall enhancement; masses, varices, and aneurysms, with or without the intraluminal high-attenuation substance		detection of acute UGIB origin	(130/227); unenhanced MDCT: 19.4% (20/103)
Jono *et al* [28], 2019	R	386	16- or 64-MDCT	Patients with NVUGIB who underwent MDCT prior to urgent endoscopy	VUGIB; or no CT exam	UGI hemorrhage: Yes or no; UGI wall change: Concavity or hypertrophy	Endoscopy	OR of risks scores based on clinical data and CT findings for predicting mortality, rebleeding and need for endoscopic therapy in NVUGIB	UGI hemorrhage: Not significant in predicting mortality and rebleeding, but significant in predicting need for endoscopic therapy (OR 10.1 for RS and 10.70 for GBS); UGI wall change: Not significant in predicting mortality, rebleeding and need for endoscopic therapy
Kim *et al* [27], 2022	R	269 (53 VUGIB)	64-MDCT	Patients with acute UGIB who underwent MDCT prior to endoscopy	Execution of endoscopy 24 h after admission; endoscopic examination failure; LGIB; acute or chronic kidney injure; or iodinated CM allergy	Active bleeding: Active extravasation of CM within bowel lumen; recent bleeding: Hemorrhagic content, suspicious hematoma, and blood clots	Endoscopy	Accuracy of MDCT for identification of status, location, and etiology of UGIB	Bleeding status identification: 32.9% (active bleeding); 27.4% (recent bleeding); 94.8% (no bleeding); bleeding location identification: 60.9% (esophagus), 60.6% (stomach), 50.9% (duodenum); bleeding etiology identification: 58.3% (ulcerative bleeding), 65.9% (cancerous bleeding), 56.6% (variceal bleeding)

CT: Computed tomography; MDCT: Multidetector-row computed tomography; UGIB: Upper gastrointestinal bleeding; GIB: Gastrointestinal bleeding; CM: Contrast medium; HU: Hounsfield units; TP: True positive; FN: False negative; FP: False positive; TN: True negative; VUGIB: Variceal upper gastrointestinal bleeding; UGI: Upper gastrointestinal; OR: Odds ratio; RS: Rockall score; GBS: Glasgow-Blatchford score; LGIB: Lower gastrointestinal bleeding.

CONCLUSION

EGD is currently recommended as the first-line modality for both diagnosis and treatment of NVUGIB, with MDCT playing only a limited role in the diagnosis of NVUGIB[9-11]. However, endoscopy may fail to identify the source of UGIB, especially in case of massive hemorrhage. Furthermore, although rare, various unusual cause of UGIB may not be properly diagnosed by endoscopy and require solely endovascular or surgical treatment[29-31]. MDCT has been suggested to be a promising non-invasive, fast and widely available diagnostic tool in the diagnosis of NVUGIB, with reported high diagnostic accuracy for both detection and localization of bleeding, especially among patients with severe hemorrhage[32]. Moreover, MDCT is capable to identify the bleeding etiology, representing the gold standard diagnostic modality for most of the unusual causes of NVUGIB. Finally, as opposed to endoscopy, MDCT is capable to accurately evaluate the bleeding lesion, providing information to extraluminal abnormalities, feeding and draining vessels, and its anatomical relationship to

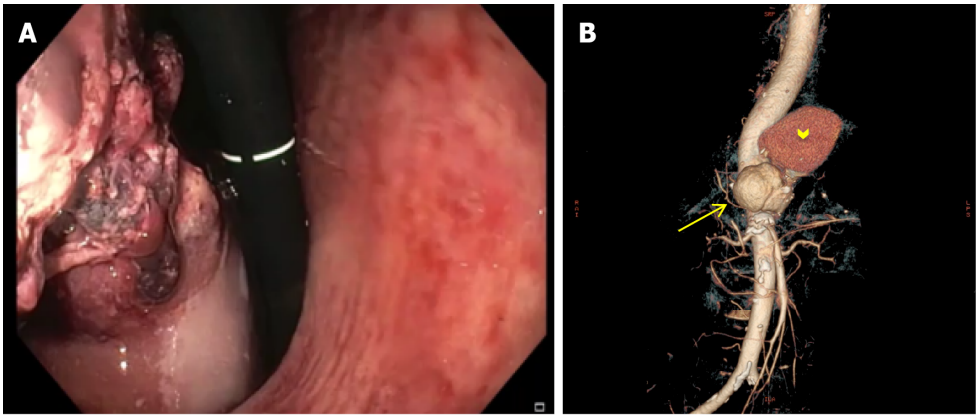

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Figure 1 Severe non-variceal upper gastrointestinal bleeding due to primary aorto-gastric fistula. A: Retroflexed endoscopic view showing gastric bulging mass partially covered by blood clots, originating from the fundus and extending to the posterior wall of the proximal body; B: Three-dimensional computed tomography angiography showing ruptured thoracoabdominal aortic aneurysm (arrow), retained by a periaortic hematoma (arrowhead).

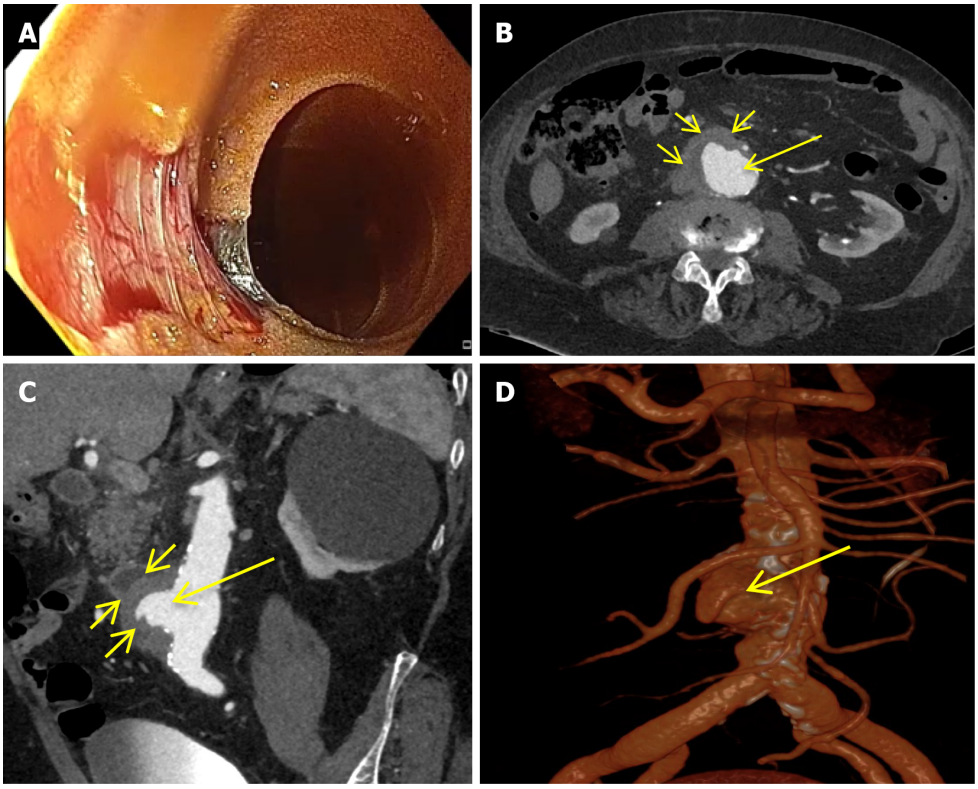

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Figure 2 Severe non-variceal upper gastrointestinal bleeding due to primary aorto-duodenal fistula. A: Esophagogastroduodenoscopy showing a large pulsating wall defect of the third duodenal portion; B-D: Axial computed tomography artery phase (B), coronal-oblique maximum intensity projection artery phase (C) and three-dimensional volume rendering reconstruction (D) showing a large outpouching from the right anterolateral wall of the abdominal aorta (B-D; long arrow) at the level of the third duodenal portion with loss of interface fat plane (B and C; short arrows), in the absence of neither air bubble within the aortic lumen and wall nor contrast medium extravasation into the duodenal lumen.

surrounding structures. Thus, MDCT has the potential to stratify patients who need earlier treatment and to assist clinicians in planning further safe, effective and tailored treatment, whether it is endoscopic, endovascular, and/or surgical.

In our opinion, MDCT angiography plays a primary role in NVUGIB patients in whom endoscopic examination fails to identify and/or to properly treat the bleeding lesion. Furthermore, in case of uncertain etiologic diagnosis at endoscopy, MDCT should be performed before treatment. Finally, across referral centers, MDCT angiography may play a role as first-line diagnostic modality in NVUGIB, especially among patients admitted for severe bleeding. Indeed, it may easily identify the bleeding

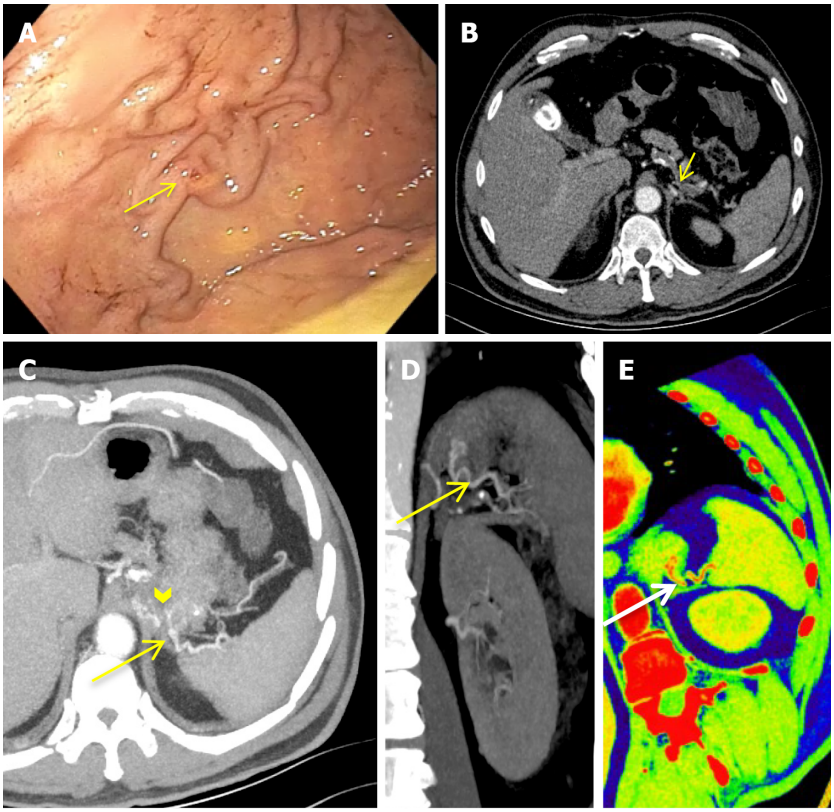

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Figure 3 Severe non variceal upper gastrointestinal bleeding due to gastric submucosal arterial collaterals secondary to splenic artery thrombosis. A: Retroflexed endoscopic view of the gastric fundus showing varicose-shaped submucosal vessels with a small erosion (arrow); B-E: Axial computed tomography dual-energy arterial phase (B) with maximum intensity projection artery phase reconstruction on axial (C) and coronal (D) multiplanar view and oblique-coronal colorimetric low keV (E) showing splenic artery thrombosis (B: short arrow) with an arterial cluster at the gastric fundus (C: arrowhead) arising from splenic artery collateral vessels (C-E: long arrow).

status, addressing the timing of treatment, and provide an etiological diagnosis of the bleeding lesion, thereby strictly directing further safe and effective management. Finally, in case of failure of endoscopic hemosthasis, emergent endovascular or surgical treatment could be directly, safely and effectively performed by the pre-alerted interventional radiologist or surgeon. However, further large prospective studies in high-volume referral centers are needed to clarify the role of MDCT in NVUGIB, especially as first-line diagnostic tool in patients affected by severe acute NVUGIB. High morbidity and mortality still associated with acute NVUGIB justify active research in this field.

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FOOTNOTES

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