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The value of multidetector-row computed tomography for localization of obscure acute gastrointestinal bleeding☆

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ABSTRACT

Purpose: There are no simple guidelines on when to perform multidetector-row computed tomography (MDCT) for diagnosis of obscure acute gastrointestinal bleeding (AGIB). We used a risk scoring system to evaluate the diagnostic power of MDCT for patients with obscure AGIB.
Materials and methods: Ninety-two patients with obscure AGIB who were referred for an MDCT scan after unsuccessful endoscopic treatment at presentation were studied. We recorded clinical data and calculated Blatchford score for each patient. Patients who required transfusion more than 500 mL of blood to maintain the vital signs were classified as high-risk patients. Two radiologists independently reviewed and categorized MDCT signs of obscure AGIB. Discordant findings were resolved by consensus. One-way ANOVA was used to compare clinical data between two groups; kappa statistics were used to estimate agreement on MDCT findings between radiologists.
Results: Of the 92 patients, 62 (67.4%) were classified as high-risk patients. Blatchford scores of high-risk patients were significantly greater than those of low-risk patients. Sensitivity for MDCT diagnosing obscure AGIB was 81% in high-risk patients, as compared with 50% in the low-risk. When used in conjunction with selection of the cut-off value of 13 in Blatchford scoring system, the sensitivity and specificity of MDCT were 70.9% and 73.7%, respectively. Contrast extravasation was the most specific sign of AGIB ($k = .87$), recognition of which would have improved diagnostic accuracy.
Conclusions: With the aid of Blatchford scoring system for evaluating the disease severity, MDCT can localize the bleeders of obscure AGIB more efficiently.

1. Introduction

Acute gastrointestinal bleeding (AGIB) is a common illness that frequently results in hospitalization. The mortality rate for AGIB has remained unchanged during the past decade and ranges from 8% to 14% [1–3]. The disease presents with symptoms that vary in clinical severity from catastrophic exsanguinating hemorrhage to insignificant bleeding superimposed on chronic anemia, with or without hemodynamic changes. Several scoring systems have been developed to evaluate the risk of mortality or rebleeding [4–8], but they do not fully incorporate recent advances in diagnostics and treatment modalities. In 2000, Blatchford and his colleagues developed a simple scoring system for early identification of patients at high risk of requiring aggressive interventions to control AGIB [8]. The Blatchford scoring system does not include an endoscopic component and consequently cannot provide information on the anatomic location of the source of bleeding in AGIB.

Upper gastrointestinal (GI) bleeding is defined as bleeding proximal to the ligament of Treitz, bleeding from the esophagus, stomach or duodenum. Lower GI bleeding originates from the small intestine or colon. As AGIB may present in various forms depending on the rate of blood loss, the origin of the bleeding is not always immediately apparent. For example, if the bleeding originates from the jejunum, patients usually initially present with tarry stools, which may be mistakenly diagnosed as upper GI bleeding. In clinical practice, an endoscopic examination is considered the first diagnostic procedure for patients with symptoms of acute upper GI bleeding. However, endoscopy is often unsuccessful in deter-

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Table 1
Blatchford risk-stratification score (range of scores 0–23).

	Points at presentation (the day of MDCT scan)					
	0	1	2	3	4	6
Hemodynamic variables						
Hemoglobin level, g/dL						
Men	≥13.0	12.0–12.9	–	10.0–11.9	–	<10.0
Women	≥12.0	10.0–11.9	–	–	–	<10.0
Lowest systolic blood pressure, mmHg	≥110	100–109	90–99	<90	–	–
Heart rate, beats/min	<100	≥100	–	–	–	–
Presence of syncope	No	–	Yes	–	–	–
Other clinical variables						
Blood urea nitrogen, mmol/l	<6.5	–	6.5–7.9	8.0–9.9	10.0–24.9	>25
Melena	No	Yes	–	–	–	–
Complicated by hepatic disease	No	–	Yes	–	–	–
Complicated by cardiac failure	No	–	Yes	–	–	–

Note: Cited in Blatchford et al.

mining the anatomical origin of bleeding when massive bleeding (>1 mL/min) occurs or when the origin of the bleeding is obscured by blood clots or is beyond the reach of the endoscope [9]. Alternative methods are required for patients for whom endoscopic treatment is unsuccessful because the origin of the bleeding is an important determinant of the type of surgical or angiographic intervention required.

Recently, several studies have been conducted to evaluate the usefulness of MDCT for localizing the site of bleeding [3,10–13], especially in patients with acute massive GI bleeding. The new-generation type of MDCT scanner is not widely used in diagnostic procedures at present. In patients who have a lesion that is not within reach of standard upper endoscopy or cholonoscopy, MDCT can allow access to the whole course of bowel loops, and thus the technique has an important role in the diagnostic approach to bleeding in these patients. However, radiologists are usually difficult to determine at which timing that MDCT is recommended to assist in diagnosing obscure AGIB. Previous canine model and in vitro studies demonstrated that conventional angiography can detect active bleeding at rates as low as 0.5 mL/min. The instantaneous bleeding rate and the total amount of blood lost are not possible to be calculated in human beings, and under the circumstance, MDCT should not to be overused.

In this study, we used a risk scoring system to determine a cut-off value for performing MDCT and tried to establish the value of MDCT for localization of obscure AGIB. We thought that this may abrogate the need for diagnostic angiographic procedures and facilitate a more efficient surgical and therapeutic angiographic intervention in patients with occult or obscure AGIB.

2. Materials and methods

2.1. Patients

This prospective study was conducted at a tertiary referral medical center from January 2007 to December 2009. Ninety-two patients who were suspected of having acute upper GI bleeding and failed to the initial endoscopic treatment were included in the study. These patients presented with melena (tarry stool) or "coffee-ground" emesis of unknown origin that had first occurred in the previous 24 h. Initial localization of the active bleeders by endoscopy was failed, and they also did not receive further push enteroscopy and balloon assisted enteroscopy. The enrolled patients (61 men and 31 women; mean age ± standard deviation [SD] = 69.0 ± 15.9 years; range = 22–97 years) were referred by our gastroenterologists for an MDCT scan (Brilliance 64; Philips, Cleveland, OH) to localize the site of the bleeding. The study was approved by the Institutional Review Board for Human Investigation, and written informed consent was obtained from all patients or from their legal representatives before the procedures involved in the study, including the doses of radiation and contrast material (CM). All procedures were explained to them.

2.2. Clinical manifestations and Blatchford scores

Demographics, clinical data and laboratory results for each patient were obtained from medical records. On the day on which MDCT was performed, we recorded vital signs and took blood samples for analysis of biochemical indices, including hemoglobin level, the international normalized ratio (INR) and prothrombin time/preprothrombin time (PT/PTT). For evaluating the disease severity in the patients with obscure AGIB, we selected Blatchford scoring system, which was primarily developed for clinical judgment the need of endoscopic intervention [8]. We calculated each patient's Blatchford scores for systolic blood pressure (SBP), heart rate, blood hemoglobin level, blood urea nitrogen (BUN) level, symptoms of melena, symptoms of shock and comorbidities (hepatic disease or cardiac failure) (Table 1). Patients who required a blood transfusion of more than 500 mL/day to maintain the vital signs were classified as high-risk patients. Patients who received a blood transfusion of 500 mL/day or less were classified as low-risk patients.

2.3. MDCT protocol for detection of obscure AGIB

The MDCT protocol for detection of obscure AGIB was as follows. MDCT was first performed without prior oral administration of water or CM. Nonenhanced MDCT scans are performed routinely at our hospital. Then, arterial phase images were obtained after intravenous administration of 60–90 mL (1.2 mL/kg body weight) of CM (iodine concentration, 350 mg/mL; Omnipaque, GE Healthcare, Norway) at a rate of 4.0–4.5 mL/s using a mechanized injector. This was followed by an injection of saline. Venous access was accomplished using an 18- or 20-gauge cubital needle. The scan delay for the arterial phase images was determined using bolus tracking with a circular region of interest positioned at the level of the abdominal aorta, and a predefined 150 Hounsfield unit (HU) enhancement threshold level was set to trigger data acquisition. The portal venous phase scan was performed 40 s after initiation of the arterial phase scan.

We used the following image parameters for MDCT scanning and reconstruction: slice thickness, 1 mm; reconstructed thickness, 5 mm; beam pitch, 1.5; tube voltage, 120 kV; and maximum tube current limited to 250 mA using dose modulation. The scanning range extended from the hepatic dome to the inferior pubic ramus. Three-dimensional maximum intensity projection (MIP)

and multiplanar reconstruction (MPR) are not routinely obtained [11]. Three-dimensional MIP and MPR images are not necessary for the diagnosis of obscure AGIB, because they provide little additional information in most cases. All MDCT images were reviewed on dedicated PACS workstations.

2.4. MDCT image reviewing

The names and record numbers of patients were electronically removed from all MDCT images before loading the cases onto a workstation for review (Extended Brilliance Workspace, Philips Healthcare). The age and sex of the patient and the date of the MDCT examination were not removed. Two gastrointestinal radiologists (W.C.C. and C.Y.Y., who had 5 years and 18 years of experience in abdominal imaging and interventional radiology, respectively) who were blinded to patient identity and surgical or angiographic diagnosis independently reviewed each MDCT image, recorded MDCT signs and noted whether the MDCT findings indicated whether the patient had AGIB or not. The radiologists knew that all patients had presented with symptoms of obscure AGIB.

MDCT signs of AGIB were classed as follows [3,10]: (a) extravasation of CM into the lumen of the bowel, (b) extravasated CM with attenuation greater than 90 HU, (c) focal dilatation of a fluid-filled bowel segment, (d) acute hematoma on an nonenhanced MDCT scan and (e) engorged mesenteric vessels. The suspected anatomic location of the origin of the AGIB was also recorded. The radiologists were also requested to decide whether the MDCT image indicated whether AGIB was present or absent. Discrepancies between the findings of the 2 radiologists were resolved by additional consensus readings, which were also used for analysis. Detection and localization of the bleeding site were based on references of the endoscopy, final surgical or angiographic findings.

2.5. Angiography and embolization technique

In our interventional radiology section, all procedures were performed in a similar fashion by the interventional radiologists. The coeliac trunk and superior mesenteric artery were routinely examined using a 4.1-F catheter (Cook Incorporated, Bloomington, IN, USA). The inferior mesenteric artery and iliac arteries were selectively checked if there was suspected bleeding in the distal colon or rectum. If indicated, we used a 2.7-F microcatheter system (Terumo Corporation, Tokyo, Japan) to approach the target vessel. Iodinated contrast medium (Ultravist, Bayer Schering Pharma AG, Berlin, Germany; iodine content, 300 mg/mL) was used.

If both MDCT and angiography had shown consistent evidence of bleeding, the target vessel was treated directly via superselective transarterial embolization. The target vessels were embolized using metallic coils (and in some cases, coils supplemented with a gelatin sponge) to the point of flow stasis. We used 0.035-in. stainless macrocoils (Cook Incorporated) or 0.018-in. platinum microcoils (Boston Scientific, Ireland) for embolization. If extravasation was not demonstrated by the angiographic procedure, the patient was treated with intra-arterial administration of vasopressin for 2 days via a catheter extending to the suspected target vessel (most commonly the gastro-duodenal artery or the superior mesenteric artery). In such cases, the suspected target vessel was selected on the basis of MDCT findings. Vasopressin administration typically began with a loading dose of 0.2 U/min, which was then increased to a maximum of 0.4 U/min, followed by tapering of the dose over 12–24 h.

2.6. Statistical analysis

Statistical analyses were performed by using software (SPSS, version 14.0, Chicago, and SAS, version 9.0, Cary, NC). Demographics and clinical information were analyzed using a one-way ANOVA test and are expressed as the mean ± SD and range for continuous variables. Categorical variables were analyzed using Person's chi-square test and are expressed as numbers of patients and percentages. $P < .05$ was considered statistically significant.

We used surgical and/or angiographic findings as the reference standard. Sensitivity and specificity of MDCT for diagnosing obscure AGIB was determined in low-risk and high-risk groups, respectively. Receiver operating characteristic (ROC) curves of Blatchford scores versus consensus MDCT diagnosis and the reference standard were compared. To minimize overall error, we identified the shortest distance on the ROC curve as the optimal cut-off value. Sensitivity and specificity of MDCT for diagnosis of obscure AGIB were then estimated after the cut-off value had been determined. Agreement between the 2 radiologists on the anatomic location of obscure AGIB and binary MDCT signs such as the presence or absence of contrast extravasation was assessed using the kappa statistic (≤0.2, slight agreement; 0.21–0.40, fair agreement; 0.41–0.60, moderate agreement; 0.61–0.80, substantial agreement; and ≥0.81, almost perfect agreement). Ninety-five percent confidence intervals were determined for each estimate of the *k* statistic.

3. Results

3.1. Clinical data of low- and high-risk patients

Of the 92 patients, 62 were classified as high-risk patients and 30 were classified as low-risk patients. In the high-risk patients ($n = 62$) with obscure AGIB if endoscopy fails to define site of bleeding and control haemorrhage, transarterial embolization has the priority as an effective means of controlling haemorrhage in our institution. However, there was still 12 patients received surgery after MDCT performed. The reasons may be individualized, and included: 3 patients showed multiple locations of extravasation on MDCT; 2 patients showed gastrointestinal tumors with active hemorrhage; 5 patients did not show definite evidence of active bleeding on MDCT; and 2 patients asked for surgery after explaining to the risks and benefits of both interventional procedures. The rest of 10 high-risk patients (or their legal representatives) refused to receive aggressive interventions (surgery or angiography), after explaining the risks of surgery and angiography. In the low-risk patients ($n = 30$) with obscure AGIB, 27 patients received angiographic intervention (diagnostic and/or therapeutic) and 3 patients received surgery. Of the 27 patients, 24 also did not show angiographic evidence of contrast extravasation.

Patient demographics and clinical information are summarized in Table 2. The most common clinical history in both the high- and low-risk groups was peptic ulcer disease ($n = 17$ and 42, respectively; 56.7% and 67.7%, respectively; $P = .3$). Three patients in the low-risk group and 12 patients in the high-risk group had comorbidity with liver disease or heart failure. Means for most of the Blatchford risk markers (lowest SBP, BUN level, hemoglobin level, heart rate and presence of shock) differed significantly between the low- and high-risk groups ($P < .05$). There was no difference ($P = .47$) in the incidence of melena (100%) or comorbidity of liver disease or cardiac failure between the 2 groups. Platelet count, PT/PTT, INR and total bilirubin level differed significantly between the 2 groups, but creatinine level did not differ. Five patients in the high-risk group had a history of chronic renal failure before MDCT was conducted; and 1 patient in the low-risk group had chronic renal failure. Eighteen patients (17 in the high-risk group and 1 in the low-risk group) developed recurrent bleeding, and 1 patient in the high-risk group developed contrast-related acute renal failure. One patient in the low-risk group (3.3%) died of post-operative complication (sepsis), and 26 patients (41.2%) in the high-risk group died despite angiographic or surgical intervention.

Table 2
Demographics and clinical information of patients with acute gastrointestinal bleeding.

Variables	Low-risk patients ($n=30$)	High-risk patients ($n=62$)	P-value[a]
Age[b], year	72.5 ± 13.9 [36–97]	67.4 ± 16.6 [22–94]	0.15
Sex (M:F)	24:6	37:25	0.06
Blood transfusion[b], mL/day	183.3 ± 245.1 [0–500]	2308.2 ± 2096.7 [500–13000]	<0.01*
History of peptic ulcer disease[c]	17 (56.7%)	42 (67.7%)	0.3
At presentation (the day of MDCT scan)			
Lowest systolic blood pressure[b], mmHg	109.3 ± 19.3 [78–183]	92.5 ± 22.1 [44–156]	<0.01*
Blood urea nitrogen[b], mmol/l	8.8 ± 5.2 [0.5–21.8]	18.6 ± 13.2 [4.3–51.8]	<0.01*
Hemoglobin[b], g/dL	8.7 ± 2.4 [4.4–14.2]	6.6 ± 1.7 [2.5–10.7]	<0.01*
Heart rate[b], beats/min	80.3 ± 15.8 [58–114]	99.2 ± 18.9 [59–152]	<0.01*
Melena[c]	30 (100%)	62 (100%)	N/A
Shock[c]	5 (16.7%)	30 (48.4%)	<0.01*
Co-morbidity (liver disease or cardiac failure)[c]	3 (10%)	12 (19.4%)	0.47
Blatchford scores[b]	9.0 ± 3.6 [1–15]	13.7 ± 3.0 [4–19]	<0.01*
Other laboratory data			
Platelet count[b], $\times 10^3/\mu l$	236.5 ± 114.9 [17–506]	133.4 ± 87.0 [20–403]	<0.01*
Prothrombin time[b], s	12.1 ± 1.1 [10.6–16.3]	13.5 ± 2.3 [9.7–22.1]	<0.01*
Preprothrombin time[b], s	28.1 ± 3.7 [24–37.4]	32.6 ± 10.6 [20.4–78.1]	0.03*
International normalized ratio[b]	1.1 ± 0.2 [0.9–2.2]	1.4 ± 0.4 [0.7–3.1]	<0.01*
Total bilirubin[b], mg/dl	1.3 ± 2.8 [0.1–15.4]	3.7 ± 5.4 [0.1–28.7]	<0.01
Creatinine[b], mg/dl	1.4 ± 1.2 [0.6–6.7]	2.0 ± 2.1 [0.2–10.6]	0.16
Outcome and follow-up			
Mortality[c]	1 (3.3%)	26 (41.2%)	<0.01*
Rebleeding[c]	1 (3.3%)	17 (27.4%)	0.01*
Contrast-related acute renal failure[c]	0 (0%)	1 (1.6%)	0.48

NA = not applicable.
[a] P values were derived from the one-way ANOVA test or Person's chi-square test.
[c] Data are expressed as no. of patients (%), unless otherwise indicated.
[b] Data are expressed as mean ± standard deviation [range], unless otherwise indicated.
* Statistically significant at the $P<0.05$ level.

3.2. Selection of a cut-off value for the Blatchford score using the ROC curve

The Blatchford score was significantly higher for the high-risk group than for the low-risk group (13.7 ± 3.0 versus 9.0 ± 3.6; $P<.01$). Sensitivity and specificity of MDCT for diagnosing obscure AGIB was 50% and 100% in low-risk patients, and 81% and 83% in high-risk patients, respectively. While comparing with Blatchford scoring system, the ROC curve (Fig. 1) revealed that a Blatchford score of 13 was the optimal cut-off point. Sensitivity, false positive rate and area under the ROC curve versus MDCT diagnosis were similar to those versus surgery/angiographic findings of obscure AGIB (Fig. 2; 0.782 versus 0.792). This implied that MDCT diagnosis of AGIB was very closely to the final diagnosis showed on surgery or angiography. With selection of the optimal cut-off value, 70.4% of cases with Blatchford scores larger than 13 could localize the obscure AGIB with the aid of MDCT, and 73.7% of cases with Blatchford scores equal to or less than 13 had no appreciable AGIB on MDCT.

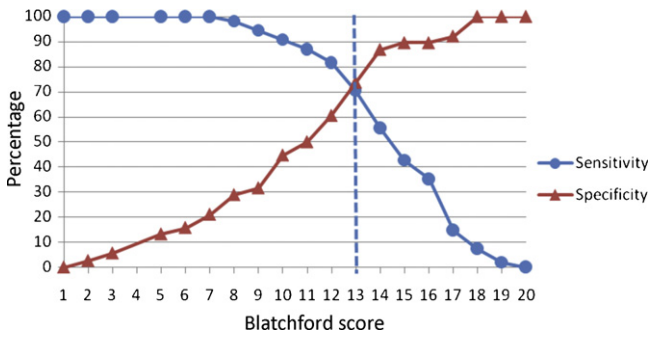

Fig. 1. Graph showed the results of the ROC curve of Blatchford scoring system versus MDCT diagnosis of obscure AGIB. The optimal cut-off value of Blatchford scores was 13.

3.3. Interobserver agreement on CT diagnosis, localization of bleeding and signs of AGIB

According to the consensus interpretation of the MDCT results, 54 patients were diagnosed with AGIB (15 with AGIB of the stomach, 15 with AGIB of the duodenum, 2 with AGIB of the gallbladder and 22 with AGIB of the small intestine); 38 patients were diagnosed as not having AGIB. There was substantial agreement between the 2 blinded radiologists in their MDCT-based diagnoses of AGIB (Table 3). There was almost perfect interobserver agreement on the location of the source of AGIB in respect of bleeding that originated in the duodenum, small intestine or gallbladder, and there was substantial agreement in respect of bleeding that originated in the stomach. Regarding MDCT signs associated with AGIB, there was almost perfect agreement between the 2 radiologists in respect of the presence of contrast extravasation in the lumen of the bowel. There was substantial interobserver agreement regarding extravasated contrast material with attenuation greater than 90 HU and acute hematoma on nonenhanced MDCT scan images. There was only fair interobserver agreement between the blinded radiologists on focal dilatation of fluid-filled bowel segments and on mesenteric vascular engorgement.

3.4. Follow-up studies and short-term outcomes

The median time from clinical presentation of obscure AGIB to completion of MDCT was 8.5 h (range, 60 min to 2 days). Obscure AGIB was associated with hemodynamic instability in 2 patients in the low-risk group and 40 patients in the high-risk group. Hemoglobin level decreased from a median of 11.1–8.7 g/dL in the low-risk group and from a median of 10.5–6.6 g/dL in the high-risk group. Twenty-seven patients (29.3%) died within 30 days. Of these, 12 died because of severe hypovolemic shock: 5 after endoscopic treatment, 6 after angiographic embolization and 1 after surgery. The other 15 patients died of associated or underlying diseases.

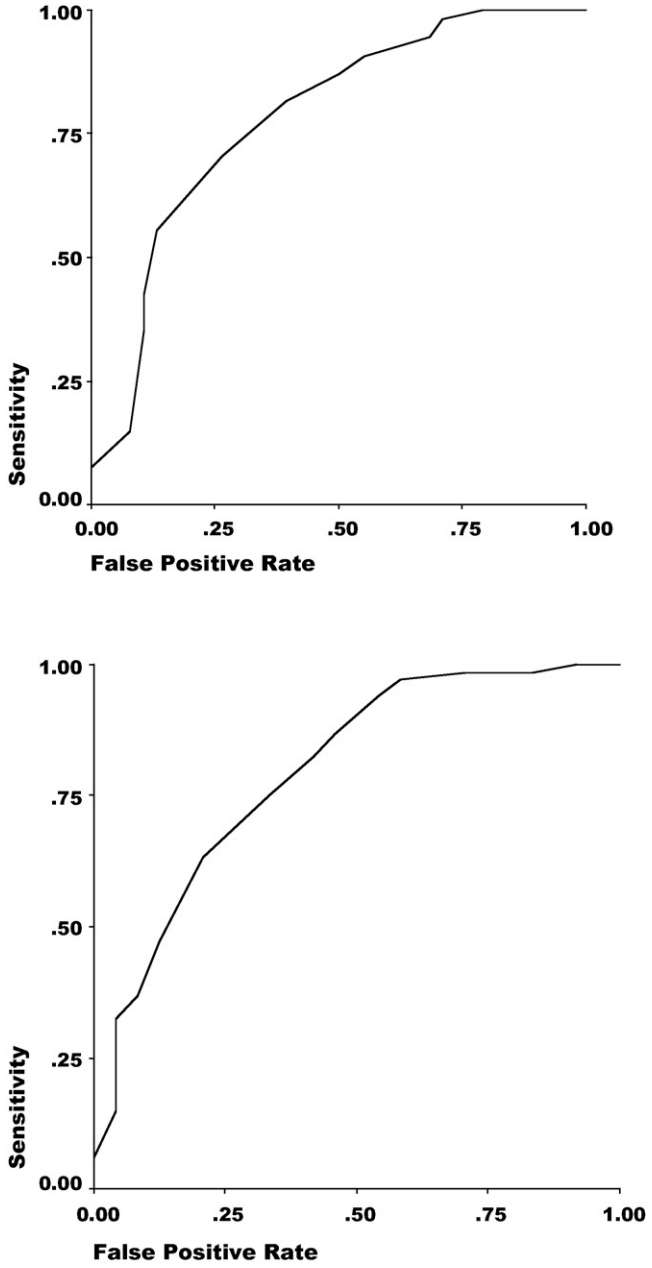

Fig. 2. (A) ROC curve of the Blatchford scores versus MDCT diagnosis of obscure AGIB. *X*-axis and *Y*-axis refer to the false positive rate and sensitivity, respectively. Area under the curve is 0.782. (B) ROC curve of the Blatchford scores versus final diagnosis of obscure AGIB using surgical and angiographic findings as the reference standard. *X*-axis and *Y*-axis refer to the false positive rate and sensitivity, respectively. Area under the curve is 0.796.

Table 3
Interobserver agreement among observers for diagnosis of acute gastrointestinal bleeding with MDCT signs.

	Radiologist 1 versus 2
MDCT diagnosis of AGIB	0.78 [0.65–0.91]
Anatomatic location	
Stomach	0.72 [0.52–0.91]
Duodenum	0.92 [0.82–1.00]
Small bowel	0.84 [0.71–0.98]
Gallbladder	1
MDCT signs of AGIB	
CM extravasation in bowel lumen	0.87 [0.76–0.97]
>90 HU extravasated CM	0.76 [0.61–0.90]
Acute hematoma on nonenhanced MDCT	0.71 [0.53–0.90]
Focal fluid–fluid bowel loops	0.36 [0.13–0.59]
Engorged mesenteric vessels	0.43 [0.17–0.69]

Note. Data are unweighted and weighted *k* statistics, with a range in parentheses.

4. Discussion

Several risk score systems have been designed to facilitate triage of patients with AGIB, most of which focus on upper GI hemorrhage [2,4–8,14]. These scoring systems involve the use of clinical and endoscopic parameters to identify patients in need of urgent intervention, predict the risk of adverse outcomes and assist in choosing appropriate treatment strategies. In contrast to other scoring systems, the Blatchford scoring system does not include an endoscopic component. According to the original report of Blatchford et al., the system was developed using data on hemodynamic status, laboratory analyses and coexisting illnesses from a cohort of 1748 patients [8]. The Blatchford scale ranges from 0 to 23, and higher scores indicate a higher risk for clinical intervention. The Blatchford scoring system has since been proven one of the most useful prognostic tools for deciding whether endoscopic examination is required [14–18].

According to Yoon et al. [3] AGIB may be intermittent even in cases of massive bleeding. We observed that patients who had ongoing AGIB usually exhibited rapid deterioration in hemoglobin levels and unstable vital signs (hypotension, tachycardia and syncope). With judgment by a risk scoring system, there is a high probability that MDCT will enable detection of the location of the site of bleeding in patients with Blatchford scores of 13 or greater (i.e., severe hypotension [SBP < 90 mmHg], tachycardia [heart rate > 100 beats per min] and syncope or severe anemia [hemoglobin level < 10 g/dL] plus more than 1 of the following: mild to severe azotemia [BUN > 6.5 mmol/L], melena or a comorbidity).

The use of MDCT angiography for diagnosis of AGIB was initially focused on the lower GI tract. In 2004 [19], Tew et al. published a retrospective study on 13 patients with acute lower GI tract bleeding who underwent 4-detector-row MDCT. They observed extravasation of contrast medium for 7 patients (54%), and all such sites were confirmed by angiography. The other 6 patients, who had negative MDCT findings, spontaneously ceased bleeding without further intervention. In their study, there were no false-positive or false-negative findings with MDCT.

In 2006, Yoon et al. conducted a prospective study of 26 patients with acute, massive GI bleeding using 4-detector-row MDCT [3]. They used MDCT to detect acute upper GI tract bleeding and, as in our study, initial endoscopic treatment was unsuccessful in their patients. They included patients who required blood transfusions of at least 4 units of blood within 24 h or had hemodynamic instability (hypotension with systolic blood pressure < 90 mmHg) in their study. The patient-based accuracy of MDCT was 88.5% (23 of 26 patients), and contrast extravasation was observed in 21 of 26 patients. They concluded that extravasation of CM with attenuation greater than 90 HU within the bowel lumen on arterial phase MDCT images is a diagnostic sign of AGIB. Yoon et al. also published two additional minor but useful MDCT findings (focal dilatation of fluid-filled bowel segments and acute hematoma on nonenhanced MDCT scan images) that were suggestive of acute, massive GI bleeding [10]. We examined these previously described MDCT signs of AGIB and found that contrast extravasation within the bowel lumen, which was present in 42 of 54 positive MDCT findings (77.8%), was the most convincing sign. Of the 42 patients, 3 were in the low-risk group and 39 were in the high-risk group (sensitivity, 50% versus 81%). We propose that the use of MDCT for diagnosing AGIB should be limited to patients with acute massive hemorrhage.

As AGIB of the small intestine is uncommon, evaluation of the small intestine not frequently indicated. Because of the location of

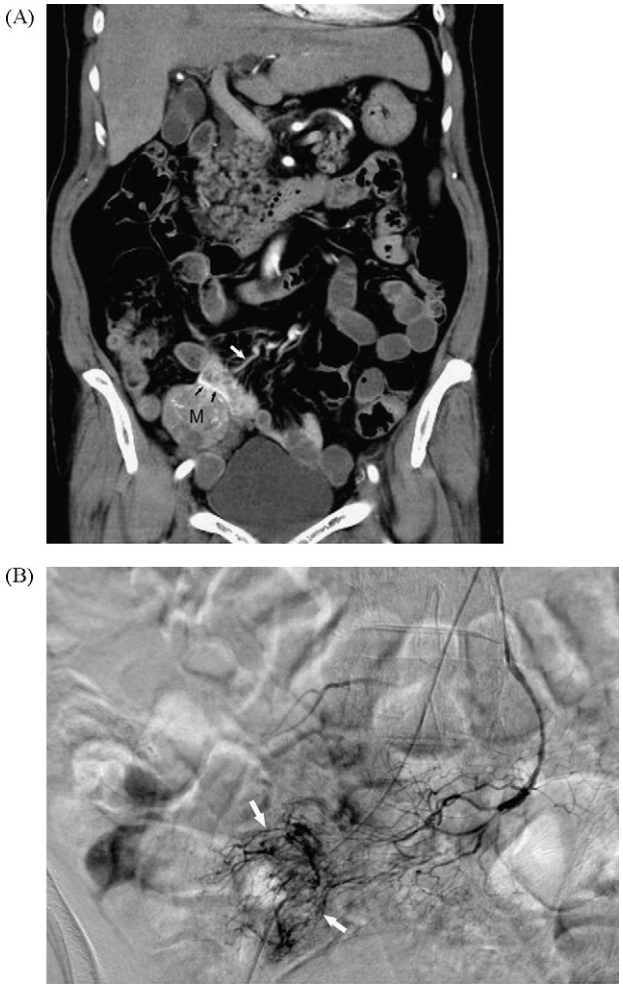

Fig. 3. A 74-year woman presented with symptoms of AGIB. The endoscopy was performed, but failed to detect the active bleeders. (A) Arterial phase CT scan on coronal plane showed a well-defined enhancing soft-tissue mass (M) over the distal ileum. Contrast was extravasated (black arrows) into the intestinal lumen. The engorged mesenteric artery (white arrow) was also evident. (B) Angiography showed a hypervascular tumor with contrast extravasation (white arrows) that corresponding to the MDCT findings. Gastrointestinal stromal tumor of the small intestine with active bleeding was confirmed after surgery.

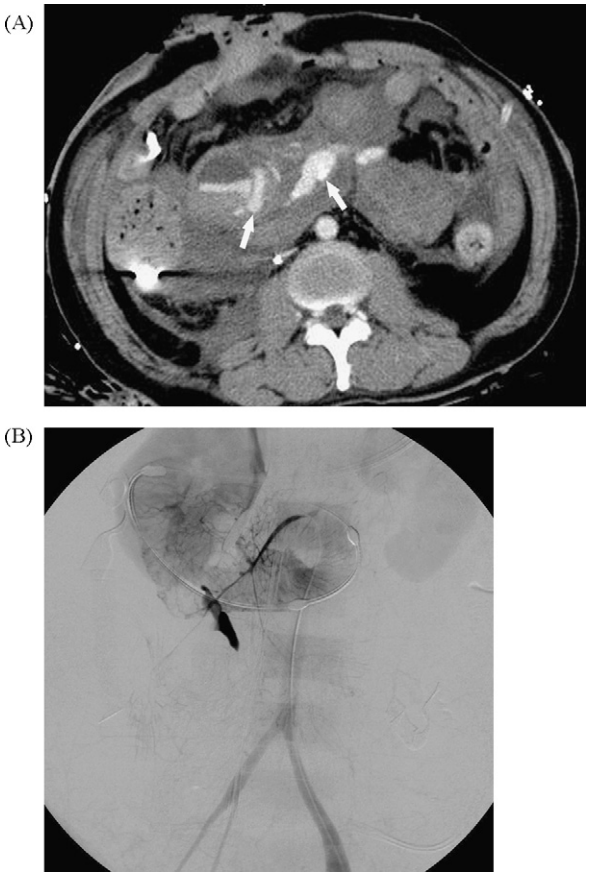

Fig. 4. A 51-year man after gastric surgery presented with unstable vital signs and symptoms of AGIB. The initial endoscopy failed to localization of the active bleeders. (A) Arterial phase CT scan on axial plane showed large amount of contrast extravasation (white arrows) into the 3rd and 4th portion of duodenum. (B) Angiography showed active bleeding of the inferior branch of gastroduodenal artery. After transarterial embolization with gelform pieces, the bleeding ceases.

the small intestine, conventional endoscopic evaluation is technically difficult and is often unsuccessful in detecting bleeding that originates at this location (Fig. 3). Several diagnostic tools have been employed to examine the small intestine. Push enteroscopy is an extension of upper endoscopy but only enables visualization of the area 15–160 cm distal to the ligament of Treitz. Capsule endoscopy is a new alternative diagnostic tool for detecting AGIB of obscure origin, but it is not available at all hospitals. This procedure takes a long time to conduct, which precludes its use with cases of acute, massive GI bleeding. The conventional radiographic method for evaluation of obscure AGIB is the barium technique, which has very low sensitivity (0–5.6%) [20,21]. In our study, 22 (23.9%) patients had an MDCT diagnosis of bleeding in the small intestine, and 10 (10.9%) patients had an MDCT diagnosis of bleeding in the 3rd and 4th portions of the duodenum that originally failed to detect on endoscopy (Fig. 4). All of these patients were in the high-risk group and had hemodynamic instability. These results show that MDCT has a high probability of detecting obscure sources of active bleeders, especially when capsule endoscopy is not indicated.

However, MDCT is a purely diagnostic modality with no therapeutic capability. Major concerns associated with the use of MDCT to diagnose AGIB are radiation exposure and the use of contrast material, which may cause allergic reactions, impair renal function or result in thyroid hyperfunction. We used a smaller volume of CM (60–90 mL) and a faster injection rate (4.0–4.5 mL/min) than previous studies [3,10–13] and found that this did not reduce the performance of 64-slice MDCT compared with other studies in which 4-slice MDCT was used. The radiation dose associated with MDCT angiography (effective dose [ED]: about 20–30 mSv) is substantially greater than that associated with conventional angiography (ED: about 8–15 mSv) [22,23]. To limit radiation exposure and reduce unnecessary use of CM, endoscopy should be performed before MDCT. When endoscopic treatment is unsuccessful, we recommend using the simplified scoring system to evaluate the severity of AGIB and to determine whether MDCT facilitates to detect AGIB. This may abrogate the need for diagnostic angiographic procedures and facilitate efficient surgical and therapeutic angiographic intervention.

Our study has several limitations. First, there was a selection bias in our study population. Patients with AGIB who had undergone a successful endoscopic treatment were not included in our study. Second, although the Blatchford scoring system is used to evaluate the disease severity of AGIB in clinical practice, AGIB may be intermediate in nature. The MDCT results could not be perfectly correlated with Blatchford scores at each moment of bleeding. If the instantaneous bleeding rate can be calculated clinically, we postulate that the bleeding rate may predict the diagnostic ability of MDCT more accurately than Blatchford scores. Third, the MDCT diagnosis of AGIB in our study was restricted to whether the patient

had AGIB or not, and no allowance was made for patients with suspected AGIB. In a few cases, subtle contrast extravasation or other equivocal MDCT findings made it difficult to assess whether the patient had AGIB or not. In addition, the criteria for MDCT signs of AGIB were subjective, and the experience of the 2 radiologists differed. This undoubtedly reduced interobserver agreement in respect of some MDCT signs, particularly identification of focal fluid-filled bowel loops and mesenteric vascular engorgement.

The results of our study indicate that the Blatchford score may be used as a risk stratification tool for identifying patients for whom MDCT is warranted to detect AGIB of obscure origin. When used in conjunction with the cut-off value of 13, this diagnostic modality could substantially decrease the frequency of unnecessary invasive procedures in low-risk patients, help to identify obscure AGIB in high-risk patients at an early stage and enable accurate therapeutic decisions to be made.

Conflict of interest

None.

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