Original Article

Comparison of diagnostic value of technetium 99m-labeled red blood cell computed single photon emission computed tomography/computed tomography (^{99m}Tc-RBC SPECT/CT) and contrast-enhanced multidetector computed tomography (MDCT) for small bowel bleeding: a retrospective study

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Background: Although small bowel bleeding is relatively rare, it is a potentially fatal disease, and its diagnosis still faces challenges. Technetium 99m-labeled red blood cell computed single photon emission computed tomography/computed tomography (^{99m}Tc-RBC SPECT/CT) and contrast-enhanced multidetector computed tomography (MDCT) are common imaging methods for diagnosing small bowel bleeding, but there have been no studies comparing their diagnostic efficacy for this purpose. This study aims to compare the diagnostic value of ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT for small bowel bleeding.

Methods: A total of 44 patients (30 males and 14 females, median age of 64 years) definitively diagnosed with small bowel bleeding and 15 non-small bowel bleeding patients (8 males and 7 females, median age of 66 years) were consecutively included in this study. All patients underwent ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT examinations at Beijing Friendship Hospital of Capital Medical University between January 2020 to September 2023. The definitive diagnosis had been made through surgery or colonoscopy, or through patient history, patient management, and clinical follow-up. We collected clinical data of the participants. ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT were reviewed in a blinded fashion for accuracy of detection of active bleeding as well as the active small bowel bleeding location.

Results: Among the 59 patients, the accuracy, sensitivity, and specificity of ^{99m}Tc-RBC SPECT were 27.3%, 93.3%, and 92.3%; for ^{99m}Tc-RBC SPECT/CT they were 76.3%, 40.5%, and 93.3%; whereas for contrast-enhanced MDCT they were 45.8%, 27.3%, and 100%, respectively. The diagnostic accuracy of ^{99m}Tc-RBC SPECT/CT for jejunal and ileal bleeding was high, at 100% and 86.4%, respectively. Meanwhile, ^{99m}Tc-RBC SPECT/CT had a higher accuracy in diagnosing more causes of small bowel bleeding. In 59 patients, the combination of ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT accurately diagnosed small bowel bleeding and provided precise localization in 50 patients, resulting in the accuracy, sensitivity, and specificity of 84.7%, 79.5%, and 100.0%, respectively.

Conclusions: ^{99m}Tc-RBC SPECT/CT has high diagnostic value in diagnosing small bowel bleeding and is superior to ^{99m}Tc-RBC SPECT and contrast-enhanced MDCT. The combination of ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT can further improve the diagnostic accuracy of diagnosis, and can accurately guide the diagnosis and treatment of small bowel bleeding.

Introduction

Gastrointestinal bleeding (GIB) is present in both the outpatient setting and the emergency department, and its incidence rate is gradually rising due to the increased use of anticoagulants and medical progress leading to extended life expectancy with potential complications (1). According to the location of GIB, it can be divided into 3 major sources: upper gastrointestinal bleeding (UGIB), lower gastrointestinal bleeding (LGIB), and small bowel bleeding (2). In 2015, the American College of Gastroenterology (ACG) guidelines defined obscure GIB as small bowel bleeding when the source cannot be found during esophagogastroduodenoscopy (EGD) and colonoscopy, and there is evidence of persistent GIB through ongoing iron deficiency, positive fecal occult blood test results, and/or significant blood loss (3). Small bowel bleeding accounts for only 10% of GIB, defined as bleeding starting anywhere between the Treitz ligament and the ileocecal valve (4). In recent years, advancements in endoscopy, video capsule endoscopy (VCE), and radiation imaging technology have enabled better identification of small bowel bleeding (5). However, the diagnosis of small bowel bleeding remains challenging; one of the challenges associated with small bowel bleeding is the difference in the range of potential lesions, which depends on the patient's age, clinical presentation, and lesion location (6).

Radiological diagnosis has important clinical value in the diagnosis of GIB (7). Contrast-enhanced multidetector computed tomography (MDCT), as an easily obtainable imaging modality in many hospitals, can quickly diagnose GIB without the need for intestinal preparation (8,9). Gastrointestinal bleeding scintigraphy (GIBS) is a non-invasive method that examines whether bleeding is active in patients with GIB, locates the site of bleeding, and estimates the amount of bleeding for prognostic purposes (10). Technetium 99m (99mTc)-labeled red blood cells (RBCs), which were the earliest and most commonly radionuclides applied, can identify active bleeding with a rate as low as 0.10 mL/min and can be acquired for up to 24 hours (11). Meanwhile, the application of single photon emission computed tomography/computed tomography (SPECT/CT) to planar imaging in GIBS can help determine the location of GIB (12,13). However, there have been few studies on the diagnostic ability of 99mTc-RBC GIBS for small bowel bleeding, and no study has analyzed its comparison with other commonly used diagnostic imaging techniques. Therefore, our study will analyze the diagnostic value of 99mTc-RBC SPECT/CT for small bowel bleeding and compare it with the diagnostic ability of contrast-enhanced MDCT. We present this article in accordance with the STARD reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-715/rc).

Methods

Patients

We retrospectively and consecutively collected patients with symptoms of overt bleeding (passing melena or hematochezia) and suspected small bowel bleeding who underwent 99mTc-RBC SPECT/CT and contrast-enhanced MDCT examination at Beijing Friendship Hospital of Capital Medical University from January 2020 to September 2023. The inclusion criteria of our study were as follows: (I) the patient presented with symptoms of overt bleeding (passing melena or hematochezia); (II) the patient completed 99mTc-RBC SPECT/CT and contrast-enhanced MDCT with an interval time of no more than 14 days; (III) complete patient clinical data. The exclusion criteria of our study were as follows: (I) the patient completed 99mTc-RBC SPECT/CT and contrast-enhanced MDCT with an interval time of more than 14 days; (II) incomplete patient clinical data; (III) poor image quality. All patients underwent contrast-enhanced MDCT first, and after confirming hemodynamic stability, 99mTc-RBC SPECT/CT was performed. According to whether patients met the diagnostic criteria (diagnostic criteria are detailed in "Definitive diagnosis"), they were divided into small bowel bleeding and non-small bowel bleeding groups. The collected clinical data included patient symptoms, medication history, disease history, hemoglobin

(HGB, g/L), and the interval between ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT examinations.

This retrospective cohort study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethical Review Board of Beijing Friendship Hospital, Capital Medical University (No. 2022-P2-380). The requirement of informed consent was waived due to the retrospective nature of the study.

Scanning and data acquisition for GIBS and contrast-enhanced MDCT

GIBS

All patients were injected with 10 mg of pyrophosphate (PYP) through the peripheral vein. After 20 minutes, 555 MBq of ^{99m}TcO$_4$ was administered intravenously through injection method, and blood flow perfusion imaging was immediately collected. Planar images of the anterior and posterior sides of the abdomen and pelvis were acquired. Initially, 60 frames were obtained consecutively for blood perfusion phase dynamic imaging at a rate of 2 s/frame (matrix size, 128×128 pixels). After blood perfusion phase dynamic imaging, 30 frames were obtained consecutively for dynamic imaging at a rate of 1 min/frame (matrix size, 128×128 pixels). The static imaging was performed at 60 minutes, and 2, 4, and 6 hours (matrix size, 256×256 pixels). SPECT data were obtained when an abnormal uptake was suspected based on the planar imaging findings. SPECT data were acquired for the region of interest (ROI; matrix size, 128×128 pixels, 6° angle steps, 20 s/frame). The acquisition parameters for CT were as follows: 130 keV, pitch 1.0, rotation time 0.6 s, and slice thickness 5.0 mm.

Contrast-enhanced MDCT

GE LightSpeed 64-layer CT scanning equipment (GE Healthcare, Chicago, IL, USA) was used. With the patient in a supine position, a scanning range from the top of the diaphragm to the level of the iliac spine was implemented. Dynamic enhanced scanning was performed after CT plain scan. Scanning parameters: tube voltage 120 kV, tube current 125–300 mA, collimator width 0.5–0.75 min, pitch 0.6–1.25, matrix 512×512, field of view 450 mm × 450 mm, rotation time 0.5 s/r, layer thickness 3–5 mm, layer spacing 3–5 mm. During enhanced scanning, contrast agent iohexol (containing 320 mg/mL of iodine; Beilu Pharmaceutical, Beijing, China) was injected into the elbow vein at a flow rate of 2.5–3 mL/s. The arterial, venous, and delay phase images were obtained by delaying the scanning for 25, 60,

and 120 seconds, respectively.

Evaluation of GIBS and contrast-enhanced MDCT

Continuous and fixed local abnormal imaging agent concentration in the area from the xiphoid process to the pubic symphysis was considered GIBS positive, and no abnormal imaging agent concentration was considered GIBS negative. The main diagnostic criteria for gastrointestinal active bleeding were as follows (meeting 4 conditions simultaneously) (14): (I) appearing outside the anatomical blood pool structure; (II) gradually dense on continuous images; (III) consistent pattern with the gut; (IV) moving in a clockwise or counterclockwise manner.

Images from contrast-enhanced MDCT were classified into 1 of the following categories: 0 Negative, negative with no identified bleeding source; P1, intermediate bleeding potential, including increased mural vessels; and P2 lesion with high bleeding potential, including inflammatory lesion, angiodysplasia, tumor, diverticulum, and active bleeding (15). Only P2 was considered contrast-enhanced MDCT positive (16). All the above scans were diagnosed by 2 physicians (with at least 5 years of professional experience) in the absence of any knowledge regarding the patient's clinical data; in the event of disputes, a senior physician (with at least 20 years of professional experience) assisted in the diagnostic process.

Definitive diagnosis

The definitive diagnosis, made through surgery or enteroscopy, was used as the main reference standard. However, for example, in a patient with an ulcer who had a history of nonsteroidal anti-inflammatory drug (NSAID) use, in a patient with enteritis who had a history of radiation exposure, or in a patient with classic angiodysplasia without recurrence or severe bleeding, the diagnosis could be made based on the history, patient management, and clinical follow-up without the need for invasive testing (16).

Statistical analysis

Qualitative data were described as number of cases and percentage [n (%)] for categorical variables and quantitative data are described as median (range) for continuous variables. We calculated sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of ^{99m}Tc RBC SPECT, ^{99m}Tc RBC SPECT/CT and contrast-
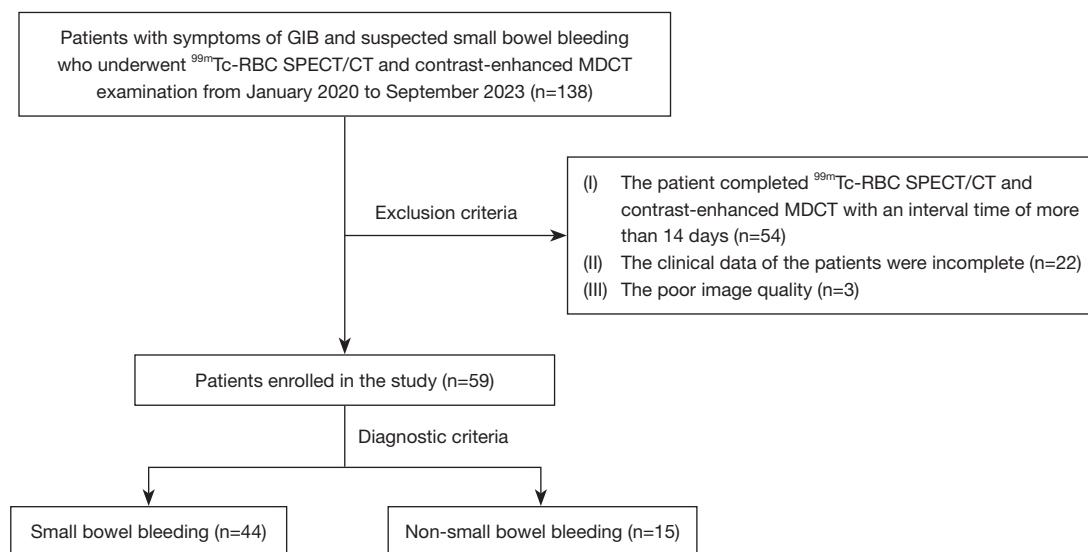
Figure 1 Flow-chart. GIB, gastrointestinal bleeding; ⁹⁹ᵐTc-RBC, technetium 99m-labeled red blood cells; SPECT/CT, single photon emission computed tomography/computed tomography; MDCT, multidetector computed tomography.

Table 1 Patient characteristics

Characteristics	Value (n=44)
Age (years)	64 (18–94)
Male:female	30 (68):14 (32)
Clinical symptoms	
Melena	24 (54.5)
Hematochezia	17 (38.6)
Both	3 (6.8)
Examination interval (days)	4 (1–14)
<3	15 (34.1)
3–7	11 (25.0)
>7	18 (40.9)
History of diseases	
Cardiovascular disease	5 (11.4)
Gastrointestinal surgery	4 (9.1)
Liver cirrhosis	1 (2.3)
Coagulation disorders	1 (2.3)
History of medication used to cause bleeding	
Aspirin	8 (18.2)
Anticoagulant	2 (4.5)
NSAIDs	1 (2.3)
Aspirin and anticoagulant	1 (2.3)
HGB (g/L)	71.5 (3–128)

Qualitative data, n (%); quantitative data, median (range). NSAIDs, nonsteroidal anti-inflammatory drugs; HGB, hemoglobin.

enhanced MDCT, respectively. The statistical analyses were conducted using the SPSS Statistics software program (version 24; IBM Corp., Armonk, NY, USA).

Results

Patient characteristics

Our study included 44 cases of definitively diagnosed small bowel bleeding for ⁹⁹ᵐTc-RBC SPECT/CT and contrast-enhanced MDCT examination (*Figure 1*). These included 30 males and 14 females, with a median age of 64 years (range, 18–94 years) (*Table 1*). All patients received emergency hemostasis treatment after admission. Among the clinical symptoms of all patients, 24 patients had melena, 17 patients had hematochezia, and 3 patients had both symptoms. Before experiencing small bowel bleeding, 12 patients had taken medication that could potentially cause bleeding: 8 patients had taken aspirin, 2 patients had taken an anticoagulant, 1 patient had taken NSAIDs, and 1 patient had taken both aspirin and an anticoagulant. There were 5 patients with a history of cardiovascular disease, 4 patients with a history of gastrointestinal surgery, 1 patient with a history of liver cirrhosis, and 1 patient with a history of coagulation disorders. The median HGB was 71.5 g/L (range, 3–128 g/L), and only 1 patient had normal HGB at admission. The median interval between ⁹⁹ᵐTc-RBC SPECT/CT and contrast-enhanced MDCT examination was 4 days (range, 1–14 days).

Among all participants, there were 15 patients with a duration of less than 3 days, 11 patients with a duration of 3–7 days, and 18 patients with a duration of more than 7 days.

In the definitive diagnosis, 21 patients were confirmed through endoscopy, 4 patients were confirmed through surgery, and 19 patients were confirmed through follow-up. Among the causes of small bowel bleeding, 4 cases were due to diverticula, 2 cases were due to ulcers, 1 case was due to small bowel inflammation, 4 cases were due to medication, 7 cases were due to tumors, 10 cases were due to small bowel vascular abnormalities, 1 case was due to postoperative abnormalities, 1 case was due to polyps, and in 11 cases, the cause of the bleeding was not identified.

Meanwhile, we collected 15 patients who were suspected of small bowel bleeding upon admission but were ultimately not definitively diagnosed with small bowel bleeding, all of whom underwent ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT examination. These patients included a total of 8 males and 7 females, with a median age of 66 years (range, 51–88 years) (*Table 1*). All patients received emergency hemostasis treatment after admission. Among the clinical symptoms of these patients, 8 patients had melena, 5 patients had hematochezia, and 2 patients had both symptoms. Before experiencing small bowel bleeding, 9 patients had taken medication that could potentially cause bleeding. This included 2 patients taking aspirin, 2 patients taking an anticoagulant, 1 patient taking NSAIDs, and 4 patients taking both aspirin and an anticoagulant. However, none of the above 9 patients had a history of ulcers, and no abnormalities were found through endoscopy. A total of 9 patients had a history of cardiovascular disease and 1 patient had a history of coagulation disorders. The median HGB was 84.00 g/L (range, 44–129 g/L). The median interval between ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT examination was 6 days (range, 1–13 days). Among all patients, there were 2 patients with a duration of less than 3 days, 8 patients with a duration of 3–7 days, and 5 patients with a duration of more than 7 days.

Diagnostic capabilities of ^{99m}Tc-RBC SPECT, ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT

Among all 44 small bowel bleeding patients, there were 8 patients with duodenal bleeding, 22 patients with jejunal bleeding, 7 patients with ileal bleeding, 2 patients with both duodenal and jejunal bleeding, 2 patients with jejunal and ileal bleeding, and 3 patients with undefined bleeding locations. The accuracy of ^{99m}Tc-RBC SPECT and ^{99m}Tc-RBC SPECT/CT in the diagnosis of duodenal bleeding was relatively low, with only 1 patient detected by these methods. The diagnostic accuracy of ^{99m}Tc-RBC SPECT/CT for jejunal and ileal bleeding was high, at 100% and 86.4%, respectively; however, ^{99m}Tc-RBC SPECT and contrast-enhanced MDCT had lower diagnostic accuracy in diagnosing jejunal (22.7% and 36.4%) and ileal bleeding (28.6% and 0.0%). In the grouping based on the cause of bleeding, compared to ^{99m}Tc-RBC SPECT and contrast-enhanced MDCT, ^{99m}Tc-RBC SPECT/CT had a higher accuracy in diagnosing more causes of small intestine bleeding, including tumors (71.4%), drugs (83.3%), diverticulum (50.0%), venous aneurysm (75.0%), angiotelectasis (100.0%), vascular malformation (66.7%), and undefined causes of bleeding (100%); however, the diagnostic rate of bleeding caused by ulcer was lower (25.0%) (details displayed in *Table 2*).

Among 44 small bowel bleeding patients, ^{99m}Tc-RBC SPECT diagnosed 16 patients, with a positive rate of 36.4% (16/44). Among them, 8 patients had small bowel bleeding lesions detected within 1 hour, and 8 patients had small bowel bleeding lesions detected within 2–6 hours. According to definitive diagnosis, 4 patients showed false positive (bleeding site). Among 16 ^{99m}Tc-RBC SPECT positive patients, 4 patients had a blood pool higher than the liver in the evaluation. Among 15 non-small bowel bleeding patients, ^{99m}Tc-RBC SPECT detected a positive lesion in 1 patient after 6 hours. The sensitivity was 27.3% [95% confidence interval (CI): 0.155–0.430], specificity was 93.3% (95% CI: 0.660–0.997), PPV was 92.3% (95% CI: 0.621–0.996), NPV was 30.4% (95% CI: 0.182–0.459), and accuracy was 44.1% (26/59) (*Table 3*). A total of 31 patients (70.5%) were diagnosed with ^{99m}Tc-RBC SPECT SPECT/CT, of which 7 patients had small bowel bleeding lesions detected within 1 hour, 21 patients had small bowel bleeding lesions detected within 2–6 hours [1 patient showed false positive (bleeding site)], and 1 patient had small bowel bleeding lesions detected 6 hours later. According to definitive diagnosis, no patients showed false positive. Among 31 ^{99m}Tc-RBC SPECT/CT positive patients, 3 patients' bleeding sites were located in the duodenum, 19 patients' bleeding sites were located in the jejunum, and 7 patients' bleeding sites were located in the ileum. Among 15 non-small bowel bleeding patients, ^{99m}Tc-RBC SPECT/CT detected a positive lesion in 1 patient 6 hours later. The sensitivity was 40.5% (95% CI: 0.546–0.827), specificity was 93.3% (95% CI: 0.660–0.997), PPV was 96.9% (95% CI: 0.820–0.998), NPV was 51.9% (95% CI: 0.324–0.708),

Table 2 Diagnostic capabilities of ^{99m}Tc-RBC SPECT, ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT in location and cause of small bowel bleeding

Characteristics	^{99m}Tc-RBC SPECT, n (%)	^{99m}Tc-RBC SPECT/CT, n (%)	Contrast-enhanced MDCT, n (%)
Location of bleeding			
Duodenum (n=8)	1 (12.5)	1 (12.5)	4 (50)
Jejunum (n=22)	5 (22.7)	19 (86.4)	8 (36.4)
Ileum (n=7)	2 (28.6)	7 (100.0)	0 (0.0)
Duodenum and jejunum (n=2)	2 (100.0)	2 (100.0)	0 (0.0)
Jejunum and ileum (n=2)	2 (100.0)	2 (100.0)	1 (50.0)
Undefined (n=3)	0 (0.0)	0 (0.0)	2 (66.7)
Cause of bleeding			
Ulcer (n=8)	1 (12.5)	2 (25.0)	3 (25.0)
Tumor (n=7)	0 (0.0)	5 (71.4)	4 (57.1)
Drug (n=6)	2 (33.3)	5 (83.3)	1 (16.7)
Diverticulum (n=4)	1 (25.0)	2 (50.0)	2 (50.0)
Venous aneurysm (n=4)	2 (50.0)	3 (75.0)	2 (50.0)
Angiotelectasis (n=3)	2 (66.7)	3 (100.0)	0 (0.0)
Vascular malformation (n=3)	1 (33.3)	2 (66.7)	0 (0.0)
Enteritis (n=1)	0 (0.0)	1 (100.0)	0 (0.0)
Postoperative anastomotic (n=1)	1 (100.0)	1 (100.0)	1 (100.0)
Coagulation disorders (n=1)	0 (0.0)	1 (100.0)	0 (0.0)
Intestinal polyp (n=1)	0 (0.0)	1 (100.0)	0 (0.0)
Unidentified (n=5)	2 (40.0)	5 (100.0)	2 (40.0)

^{99m}Tc-RBC, technetium 99m-labeled red blood cells; SPECT/CT, single photon emission computed tomography/computed tomography; MDCT, multidetector computed tomography.

and accuracy was 76.3% (45/59) (*Table 3*).

Contrast-enhanced MDCT diagnosed 16 patients, with a positive rate of 36.4% (16/44), but only 4 of the patients had active bleeding. According to definitive diagnosis, 4 patients had bleeding lesions located incorrectly, thus the accuracy rate was 27.3% (12/44). Among the 16 contrast-enhanced MDCT positive patients, 10 patients were ^{99m}Tc-RBC SPECT/CT positive; of the 31 ^{99m}Tc-RBC SPECT/CT positive patients, only 9 had positive results on contrast-enhanced MDCT. Among 15 non-small bowel bleeding patients, no positive results were found by contrast-enhanced MDCT. The sensitivity was 27.3% (95% CI: 0.155–0.430), specificity was 100.0% (95% CI: 0.747–1.000), PPV was 100.0% (95% CI: 0.699–1.000), NPV was 31.9% (95% CI: 0.195–0.473), and accuracy was 45.8% (27/59) (*Table 3*).

Among 44 small bowel bleeding patients, the combination of contrast-enhanced MDCT and ^{99m}Tc-RBC SPECT/CT accurately diagnosed small bowel bleeding and provided precise localization in 35 patients. Among 15 non-small bowel bleeding patients, no positive results were found by the combination of contrast-enhanced MDCT and ^{99m}Tc-RBC SPECT/CT. The sensitivity was 79.5% (95% CI: 0.642–0.897), specificity was 100.0% (95% CI: 0.747–1.000), PPV was 100.0% (95% CI: 0.877–1.000), NPV was 62.5% (95% CI: 0.195–0.473), and accuracy was 84.7% (50/59) (*Table 3*).

Discussion

Our study found that compared to ^{99m}Tc-RBC SPECT and contrast-enhanced MDCT, ^{99m}Tc-RBC SPECT/CT

Table 3 The sensitivity and specificity of ^{99m}Tc-RBC SPECT, ^{99m}Tc-RBC SPECT/CT, contrast-enhanced MDCT, and the combination of contrast-enhanced MDCT and ^{99m}Tc-RBC SPECT/CT

Reference standard	Positive	Negative	Total
^{99m}Tc-RBC SPECT			
Positive	12	1	13
Negative	32	14	46
Total	44	15	59
^{99m}Tc-RBC SPECT/CT			
Positive	31	1	32
Negative	13	14	27
Total	44	15	59
Contrast-enhanced MDCT			
Positive	12	0	12
Negative	32	15	44
Total	44	15	59
The combination of contrast-enhanced MDCT and ^{99m}Tc-RBC SPECT/CT			
Positive	35	0	35
Negative	9	15	24
Total	44	15	59

^{99m}Tc-RBC, technetium 99m-labeled red blood cells; SPECT/CT, single photon emission computed tomography/computed tomography; MDCT, multidetector computed tomography.

demonstrates higher diagnostic ability in the diagnosis of small bowel bleeding. Additionally, the combination of ^{99m}Tc-RBC SPECT/CT and contrast-enhanced MDCT could play a more significant role in diagnosing small bowel bleeding.

The length of the small intestine ranges from 4 to 7 meters, extending from the pylorus to the ileocecal valve, and based on structural and functional considerations, it can be divided into 3 regions: the duodenum, jejunum, and ileum (17). As a potentially life-threatening disease, small bowel bleeding accounts for 5–10% of all GIB sources (18,19). However, due to factors such as the length, curvature, causes of bleeding, and anatomical position of the small intestine, the diagnosis of small bowel bleeding is challenging and may lead to repeated examinations and poor clinical outcomes (20-22). In recent years, the continuous advancement of diagnostic technology, including videocapsule endoscopy, enteroscopy

(such as device-assisted and intraoperative enteroscopy), and radiographic techniques, has significantly improved the accuracy of diagnosing small bowel bleeding. Due to its simple operation and applicability to various types of patients, radiographic technology has become one of the main diagnostic methods for small bowel bleeding. Although CT angiography (CTA) and CT enterography (CTE) are more commonly used for diagnosing small bowel bleeding, contrast-enhanced MDCT is also utilized for clinical suspicion due to its advantages of being faster and more convenient. To date, research on MDCT in GIB has mostly focused on acute GIB (9,23,24), and has reported its good diagnostic ability. However, there has been no relevant study specifically focused on small bowel bleeding. In our study, the diagnostic accuracy of contrast-enhanced MDCT for small bowel bleeding was not high, only 36.4%. The reason may be that many patients are not acute or overt bleeding patients, and the incidence of small bowel wall lesions leading to bleeding is relatively low.

GIBS, as a non-invasive examination, is usually performed in patients suspected of occult GIB (25). GIBS is mainly suitable for obvious middle or lower GIB, and it can continuously monitor GIB for 24 hours while detecting low flow rate bleeding (11,26). Due to the half-life characteristics of ^{99m}Tc-RBC, it can ensure continuous imaging of the gastrointestinal tract for several hours, making it the preferred radiopharmaceutical for GIB. Therefore, the application of GIBS for the diagnosis of small bowel bleeding may be a potential imaging diagnostic method. However, there is currently limited study on the role of GIBS in small bowel bleeding, and most of it is reported as case reports (27-31). Dolezal *et al.* analyzed the images of 40 patients who underwent a ^{99m}Tc-RBC SPECT examination for small bowel bleeding and found that 26 patients had positive ^{99m}Tc-RBC SPECT results (32). Among 26 ^{99m}Tc-RBC SPECT positive patients, 20 were ultimately diagnosed with small bowel bleeding, and 15 of them had the correct diagnosis of the bleeding site. In our study, 44 patients were ultimately diagnosed with small bowel bleeding, with 25 patients having a clear location of bleeding. Among them, 16 patients were positive for ^{99m}Tc-RBC SPECT, but 4 patients had an incorrect location of bleeding, with a diagnostic accuracy of 31.8%. Therefore, our study demonstrated that ^{99m}Tc-RBC SPECT exhibits a diagnostic ability comparable to that of contrast-enhanced MDCT for small bowel bleeding; however, its diagnostic capability is relatively limited.

Due to the limitation of SPECT resolution, it can

affect the diagnosis and localization of lesions, especially considering the complex anatomical structure of the small bowel, which further affects its diagnosis. The combination of anatomical cross-sectional imaging modes (such as CT) and SPECT can provide more diagnostic information, thereby aiding in more accurate diagnosis. Multiple studies have previously demonstrated the added value of SPECT/CT in diagnosing GIB compared to SPECT (12,13,33). However, there is still no relevant study analyzing the diagnostic value of ⁹⁹ᵐTc-RBC SPECT/CT in the diagnosis of GIB, and its gain value compared to ⁹⁹ᵐTc-RBC SPECT. Our study had demonstrated that ⁹⁹ᵐTc-RBC SPECT/CT has high diagnostic value in small bowel bleeding (accuracy: 68.2%), which is significantly higher than that of ⁹⁹ᵐTc-RBC SPECT and contrast-enhanced MDCT, and the combination of ⁹⁹ᵐTc-RBC SPECT and CT can not only better diagnose small bowel bleeding, but also more accurately locate the bleeding location. Meanwhile, Zink *et al.* showed that contrast-enhanced MDCT was superior to ⁹⁹ᵐTc-RBC SPECT in detecting and locating active LGIB (34). In our study, compared to ⁹⁹ᵐTc-RBC SPECT and contrast-enhanced MDCT, ⁹⁹ᵐTc-RBC SPECT/CT had higher diagnostic accuracy in ascertaining different location and cause of small bowel bleeding (*Figures 2,3*). Moreover, combining contrast-enhanced MDCT with ⁹⁹ᵐTc-RBC SPECT/CT could better clarify the diagnosis and location of small bowel bleeding, for which the accuracy was 79.5%. Our study findings support that ⁹⁹ᵐTc-RBC SPECT/CT enables more accurate diagnosis for patients who suspect small bowel bleeding and are unable to undergo invasive examinations.

This study has some limitations. Firstly, this retrospective study was conducted at a single center and includes a relatively small number of patients. Secondly, 19 patients were diagnosed with small bowel bleeding through follow-up, and no clear evidence of small bowel bleeding was obtained through endoscopy or surgery. Thirdly, we only compared the diagnostic efficacy of SPECT and contrast-enhanced MDCT, without comparing them with other imaging examinations, such as CTA, catheter angiography (CA), CTE, or magnetic resonance enterography (MRE). Fourthly, ⁹⁹ᵐTc-RBC SPECT/CT still mainly relies on the subjective judgment of the nuclear medicine doctor in diagnosing small bowel bleeding, which may be influenced by the doctor's experience and lead to biased diagnostic results. Fifthly, our study, which focuses on patients with small bowel bleeding, may not account for other related conditions that could impact diagnostic accuracy. Therefore, a prospective, large sample size, multicenter study is needed to investigate the diagnostic value of ⁹⁹ᵐTc-RBC SPECT/CT in small intestine bleeding.

Conclusions

⁹⁹ᵐTc-RBC SPECT/CT has high diagnostic value in diagnosing small bowel bleeding and is superior to ⁹⁹ᵐTc-RBC SPECT and contrast-enhanced MDCT. Combining ⁹⁹ᵐTc-RBC SPECT/CT and contrast-enhanced MDCT can help physicians to diagnose small bowel bleeding more accurately and determine the location of the bleeding, especially for patients who are unable to undergo invasive examinations.
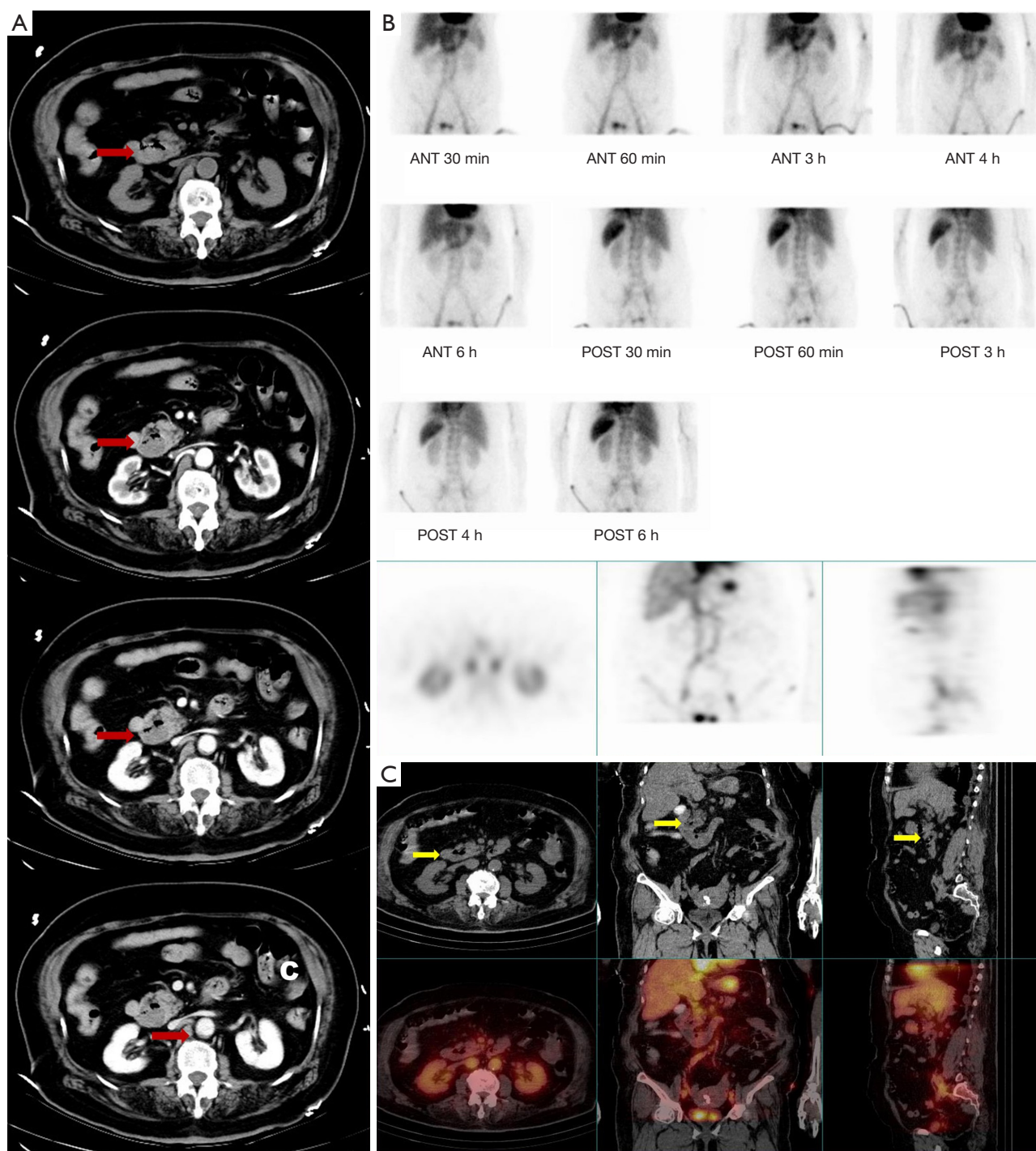
Figure 2 The patient, a 78-year-old female, was admitted to the hospital for 3 days due to melena. The patient had a documented medical history of hypertension and coronary heart disease, and was currently taking aspirin. Hemoglobin at admission was 75 g/L. (A) Contrast-enhanced MDCT showed that a diverticulum in the descending part of the duodenum (red arrows). (B) The ^{99m}Tc-RBC SPECT yielded normal results without any detected abnormalities. (C) The ^{99m}Tc-RBC SPECT/CT found a diverticulum in the descending part of the duodenum (yellow arrows), but no positive results were found. The final diagnosis of duodenal bulb ulcer bleeding was based on capsule endoscopy. ANT, anterior; POST, posterior; MDCT, multidetector computed tomography; ^{99m}Tc-RBC, technetium 99m-labeled red blood cells; SPECT/CT, single photon emission computed tomography.
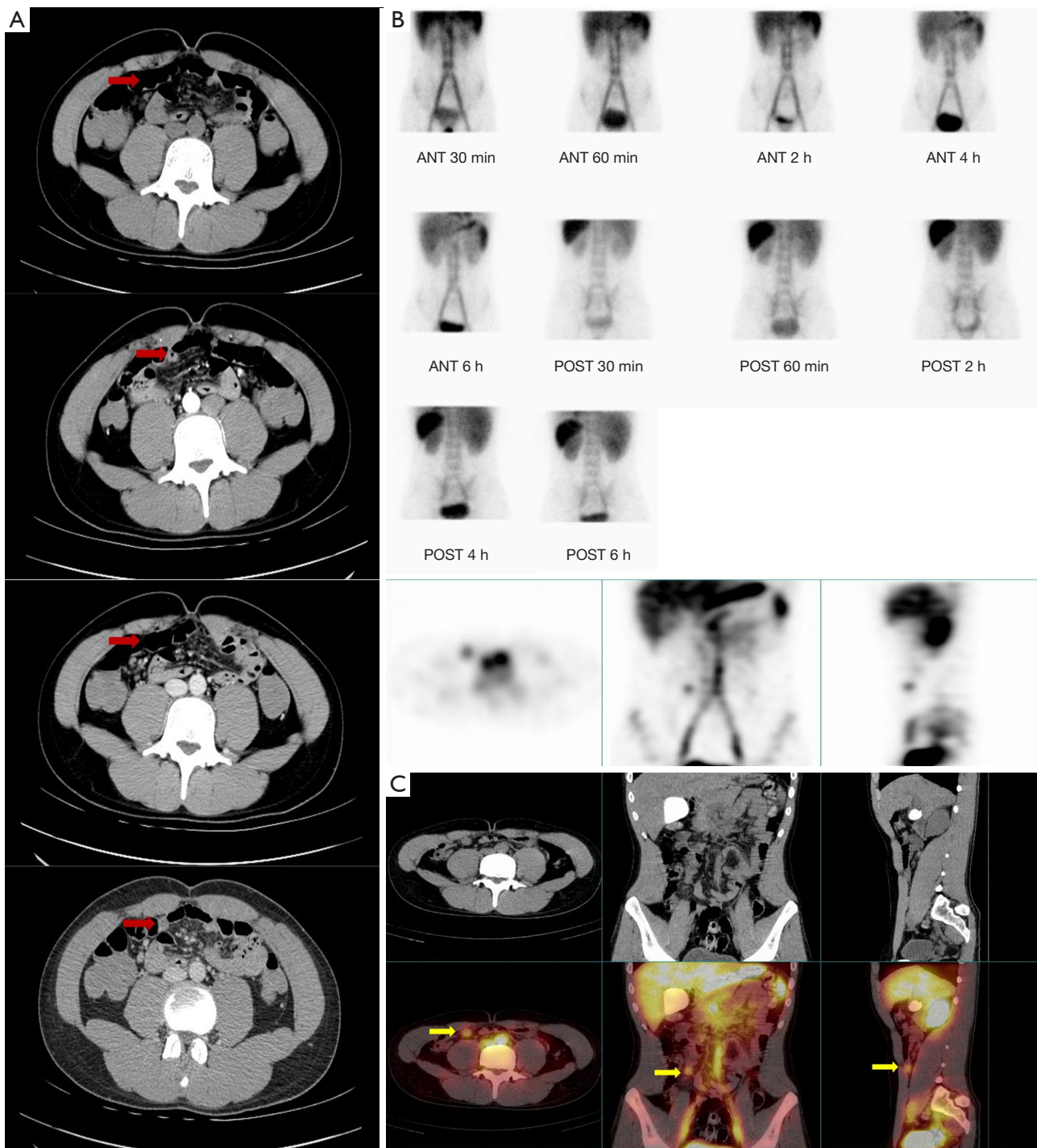
Figure 3 The patient, a 19-year-old male, was admitted to the hospital for 1 day due to melena. The patient had no previous medical history. Hemoglobin at admission was 72 g/L. No abnormalities were both found in (A) contrast-enhanced MDCT, the red arrows indicated the location of the lesion) and (B) ^{99m}Tc-RBC SPECT. (C) The ^{99m}Tc-RBC SPECT/CT found positive results in the middle ileum (yellow arrows). The final diagnosis of bleeding from Meckel's diverticulum was based on enteroscopy. ANT, anterior; POST, posterior; MDCT, multidetector computed tomography; ^{99m}Tc-RBC, technetium 99m-labeled red blood cells; SPECT/CT, single photon emission computed tomography.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://qims.amegroups. com/article/view/10.21037/qims-24-715/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims. amegroups.com/article/view/10.21037/qims-24-715/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This retrospective cohort study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethical Review Board of Beijing Friendship Hospital, Capital Medical University (No. 2022-P2-380). Due to the retrospective nature of the study, the requirement of informed consent was waived.

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