Original Article

Background suppression single-shot electrocardiogram trigger non-enhanced magnetic resonance angiography in lower extremity blood vessels: a comparative study

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Background: Background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography (BASS-TRANCE) is a recently introduced non-contrast-enhanced magnetic resonance angiography (NCE-MRA) technique. It was reported to be a practical test for the evaluation of peripheral artery disease (PAD) with an imaging performance comparable to that of the known NCE-MRA technique quiescent interval single-shot (QISS). However, its performance compared to the most commonly used diagnostic methods for digital subtraction angiography (DSA) and computed tomography angiography (CTA) remains unclear. Using DSA as the test standard, this study evaluated the image quality and clinical diagnostic accuracy of BASS-TRANCE and CTA in PAD patients.

Methods: BASS-TRANCE, CTA, and DSA were examined successively in 30 patients with PAD. Two senior physicians scored the image quality of CTA and BASS-TRANCE using the 3-point method, and the images of both were evaluated according to the 5-level stenosis evaluation method. Either paired *t*-test or Wilcoxon signed-rank test was used to compare the difference of image quality between the two groups. Using DSA results as the gold standard, the sensitivity and specificity of CTA and BASS-TRANCE for lower limb artery stenosis >50% were calculated by McNemar's test.

Results: Of 570 segments, 12 (2.1%) and 42 (7.4%) inconclusive segments were excluded from BASS-TRANCE and CTA analysis, respectively (P<0.05). The DSA results were available for 392 of the remaining segments. Among the 516 vessels with reliable image quality, there was no significant difference in scores between BASS-TRANCE {2.42 [95% confidence interval (CI): 2.36–2.47]} and CTA [2.39 (95% CI: 2.33–2.45); P>0.05]. Furthermore, BASS-TRANCE demonstrated significant efficacy in detecting vascular stenosis with a sensitivity of 92.8% and specificity of 96.1%, which were comparable to those achieved by CTA (94.9% and 96.8%, respectively).

Conclusions: As an NCE-MRA technique, BASS-TRANCE can display the lower extremity vessels in a short time; it is expected to replace CTA as a safe and effective examination method for PAD patients in the future.

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Keywords: Non-contrast-enhanced magnetic resonance angiography (NCE-MRA); lower extremity arterial disease; background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography (BASS-TRANCE)

Submitted Jun 06, 2024. Accepted for publication Dec 26, 2024. Published online Jan 22, 2025.
doi: 10.21037/qims-24-1120
View this article at: https://dx.doi.org/10.21037/qims-24-1120

Introduction

Lower extremity peripheral artery disease (PAD) affects >230 million adults worldwide. PAD is a disease of atherosclerosis involving peripheral arteries and its prevalence increases with age; patients with PAD have a 10-year mortality risk of 40%. The disease is characterized by varying degrees of luminal stenosis or occlusion, and ulcers or gangrene of the limbs may occur in severe cases. It also increases the risk of other complications such as myocardial infarction and cerebral infarction (1-3).

Early detection and evaluation of lower extremity arterial disease is essential for prevention and treatment. Ultrasound (US) and computed tomography angiography (CTA) are well-known imaging methods for screening and diagnosing arterial diseases (4). Although US has no ionizing radiation and is relatively convenient, it US relies on the subjective level of the operator and lacks an overall understanding of the vascular status. CTA provides high spatial resolution and a short scan time, and without the surgical risks associated with digital subtraction angiography (DSA), it has high accuracy in diagnosing PAD. However, the applicability of CTA is minimized in the case of severe calcification of the vessel wall, which will lead to severe calcification artifacts and thus mask the true lumen structure (5). In addition, patients undergoing CTA will be exposed to ionizing radiation and have a significantly higher risk of contrast-induced nephropathy (CIN), which is of particular concern because nearly 40% of PAD patients have significant renal dysfunction (6). Contrast-enhanced magnetic resonance angiography (CE-MRA) has also been shown to be highly accurate in detecting ≥50% of lower extremity arterial stenosis (7). Still, CE-MRA requires the use of relatively high doses of gadolinium-enhanced contrast material, which may pose a risk of nephrogenic systemic fibrosis (NSF), which may be adverse to patient interests (8,9). Considering the above factors, non-contrast-enhanced magnetic resonance angiography (NCE-MRA) is a necessary technical choice. The risk of NSF is eliminated with NCE-MRA techniques which have been developed as alternatives to CE-MRA (10,11).

Background suppression single-shot electrocardiogram (ECG) trigger non-contrast-enhanced magnetic resonance angiography (BASS-TRANCE) is a feasible magnetic resonance angiography (MRA) technique for the lower extremity, which can effectively display the lower extremity arteries (12). A recent study showed that BASS-TRANCE retains some competitiveness in vessel visualization compared with other NCE-MRA (13). It uses selective saturation pulses to suppress background and venous signals and is ECG-gated to synchronize data acquisition with maximal arterial inflow. BASS-TRANCE uses single-shot two-dimensional balanced steady-state free precession (b-SSFP) sequence for data acquisition, which can clearly delineate arteries in a short time. However, there are limited reports on BASS-TRANCE technology and no reports comparing BASS-TRANCE with CTA commonly used in clinical practice. In this study, we used DSA as the test standard to explore the differences in image quality and diagnostic accuracy between BASS-TRANCE and CTA. We present this article in accordance with the STARD reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-24-1120/rc).

Methods

Patient selection

We prospectively recruited patients with lower limb artery disease who were admitted to the Department of Interventional Vascular Surgery, the Affiliated Hospital of Binzhou Medical College from June 2023 to November 2023 (mean age: 66.8 years; aged 52–81 years), including 18 males and 12 females. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The Ethics Committee of the Affiliated Hospital of Binzhou Medical College approved this study (No. 2023 LW-185), and informed consent was provided by all patients. Randomly enrolled patients had symptoms of PAD on examination by a clinician, and all enrolled

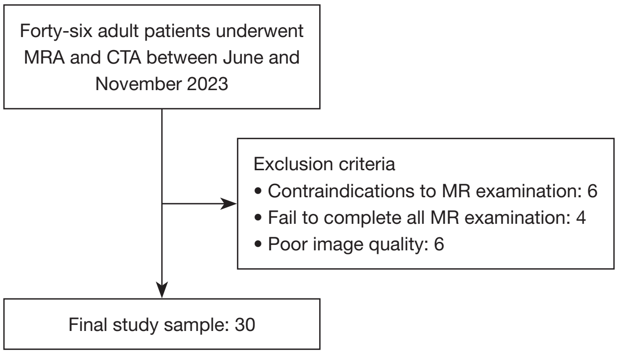

Figure 1 Flowchart of study inclusion and exclusion criteria. MRA, magnetic resonance angiography; CTA, computed tomography angiography; MR, magnetic resonance.

patients underwent MRA, CTA, and DSA. MRA and CTA are scheduled at most two days before DSA. The exclusion criteria were as follows: (I) contraindications to magnetic resonance (MR) examination; (II) failure to complete all MR examinations; and (III) poor image quality (*Figure 1*).

Magnetic resonance imaging (MRI) scheme

All data were collected using a 1.5-T MRI scanner (Philips Ingenia Ambition, Philips Healthcare, Best, Netherlands). A 32-channel body coil combined with a 16-channel integrated head and neck coil was used to cover the imaging area from the pelvis to the lower leg. Before scanning, four disposable cardiac electrodes were placed on the patient's chest and connected to a wireless electrocardiogram device triggered by electrocardiography to ensure synchronization of resting arterial inflow and data acquisition. Imaging was performed in free-breathing mode with the patient in the foot-first supine position. Six scan layers were selected to cover the imaging area from the pelvis to the lower leg, and the parameters of each scan layer were as follows: the acquisition sequence was a 2D balanced steady state free-precession sequence, the field of view (FOV), 360×273 mm^2; voxel size, 1.3×1.3×3.0 mm^3; reconstruction voxel size, 0.7×0.7×3.0 mm^3; repetition time (TR), 3.0 ms; echo time (TE), 1.4 ms; flip angle, 25°; bandwidth, 479 Hz/pixel; sensitivity encoding (SENSE) factor =2; fat suppression = spectral attenuated inversion recovery (SPAIR), venous suppression = regional saturation technique (REST) slab; delay time after the saturation pulse for imaging slice =100 ms; slice overlap =0.6 mm; trigger delay time, which was obtained by quantitative flow analysis (Q-flow). Q-flow technique is a two-dimensional phase contrast technique (2D PC) matched with ECG gating, which can obtain the trigger delay time corresponding to the fastest arterial flow velocity at the level of the abdominal aorta (14) (*Figure 2*). After the image collection, coronal maximum intensity projection (MIP) images of each station were generated by the scanner software, and all the MIP images were automatically spliced into a composite image including the entire region of interest.

CTA scheme

All CTA examinations were performed at a 256-row computed tomography (CT) scanner (Revolution CT; GE Medical, Chicago, IL, USA). The imaging coverage extended from the abdominal aorta to the toes. Injection protocol: double bolus injection, 90 mL of iodine contrast agent (350 mg/mL iohexol, Omnipaque, GE Healthcare, injection speed of 4.0–5.0 mL/s) and 40 mL of normal saline (injection speed of 4.0–5.0 mL/s) were injected through the median cubital vein (15). Bolus tracking was utilized with an application of 115 HU on the abdominal aorta to determine the scan start time. The following acquisition parameters were used: FOV set at 350 mm; pitch value set at 0.7; layer thickness set at 5 mm; detector size measuring 160 ×0.6 mm; Tube voltage set to120 kV; and tube current ranging between 200 and 450 mA. The time required was approximately 3 minutes, after which the standard reconstruction algorithm was used to reconstruct the dataset, and the thickness of the reconstructed image was 1.25 mm. Finally, dedicated workstation software (GE ADW4.7) utilizing the AutoBone XPress RUN OFF function module within Volume Viewer was used for image reconstruction to obtain three-dimensional MIP and volume rendering (VR) images depicting lower extremity vessels.

DSA scheme

DSA was performed by an experienced interventional vascular specialist using a cardiovascular imaging system (Innova IGS 530, GE Medical). A 4-F Omni Flush catheter (Angiodynamics; Terumo, Tokyo, Japan) was used to deliver contrast media. The catheter tip placement occurred above the bifurcation point of the abdominal aorta while infusing nonionic iodinated contrast medium consisting of iohexol (350 mg/mL, GE Medical); posterior anteroposterior projection imaging was conducted on lower extremity

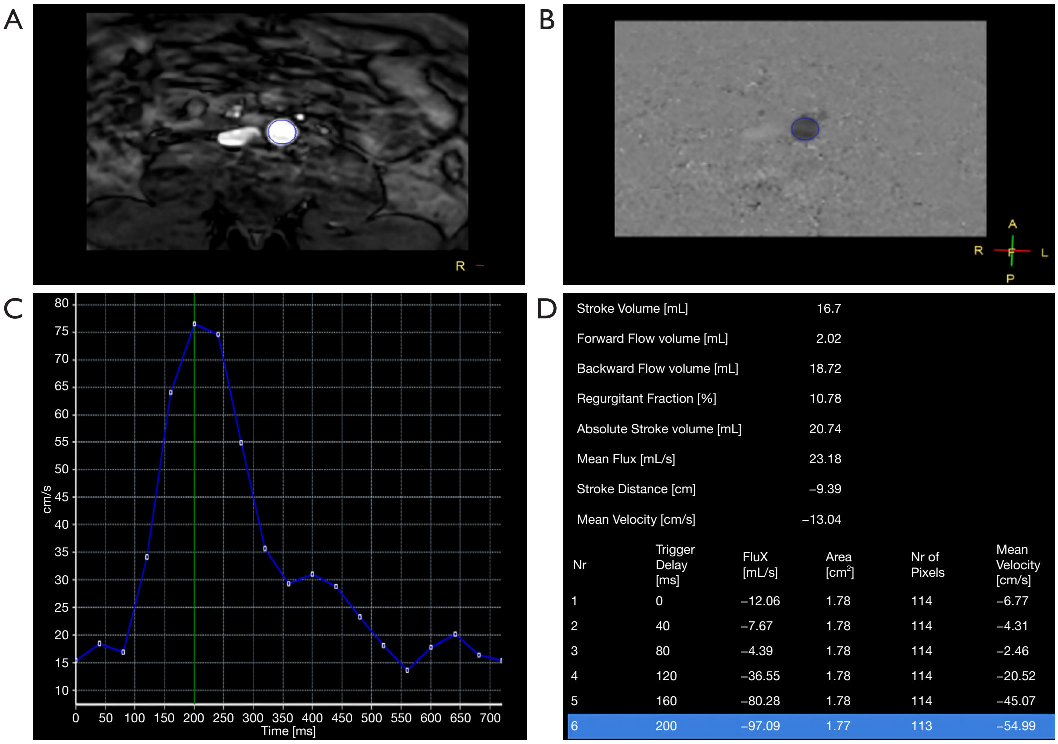

Figure 2 2D PC MRI sequence was used to evaluate the blood flow of the abdominal aorta, and the amplitude (A) and phase (B) images of 2D PC MRI are shown. The region of interest was manually delineated, and the time curve of blood flow was automatically drawn (C). The specific result value of 2D PC MRI was automatically calculated, and the trigger delay time corresponding to the maximum flow (the position of the highest point in C, corresponding to the data in row 6 in D) was used for BASS-TRANCE to scan (D). BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; 2D PC MRI, two-dimensional phase contrast magnetic resonance imaging.

arteries, a few patients underwent DSA imaging on only one side (clinically considered necessary).

Image analysis

A total of 19 vascular segments were divided (16), including distal abdominal aorta, bilateral common iliac arteries, bilateral external iliac arteries, bilateral internal iliac arteries, bilateral superficial femoral arteries, bilateral deep femoral arteries, bilateral popliteal arteries, bilateral anterior tibial arteries, bilateral posterior tibial arteries, and bilateral peroneal arteries. The overall image quality was evaluated by independent subjective scores according to a 3-point scoring standard: (I) arterial brightness was low, the edge was blurred; the branches were not displayed, there was venous contamination or vascular pulsation artifacts, and the stenosis was challenging to evaluate; (II) the arterial brightness was medium, the edge was slightly blurred; the branches were acceptable, there were slight vascular pulsation artifacts, but did not affect the diagnosis, and the degree of stenosis could be evaluated; (III) the arterial brightness was high, the edge was sharp; the branches were displayed, there was no venous contamination, no vascular pulse artifacts, and the stenosis was easy to evaluate. Examples of diagnostic values are shown in *Figures 3,4*. The degree of vascular stenosis was graded according to the following five types (17): 1 (normal), 2 (mild, stenosis <50%), 3 (moderate, stenosis between 50% and 74%), 4 (severe, stenosis between 75% and 99%), and 5 (complete occlusion). Grades 1 and 2 are insignificant and of little clinical significance. In contrast, grades 3–5 are considered to need active management, and timely and accurate diagnosis is of great significance for patient prognosis.

Image quality and stenosis were independently evaluated by two radiologists with 5–10 years of work experience, and the clinical data of the patients were unknown at the time

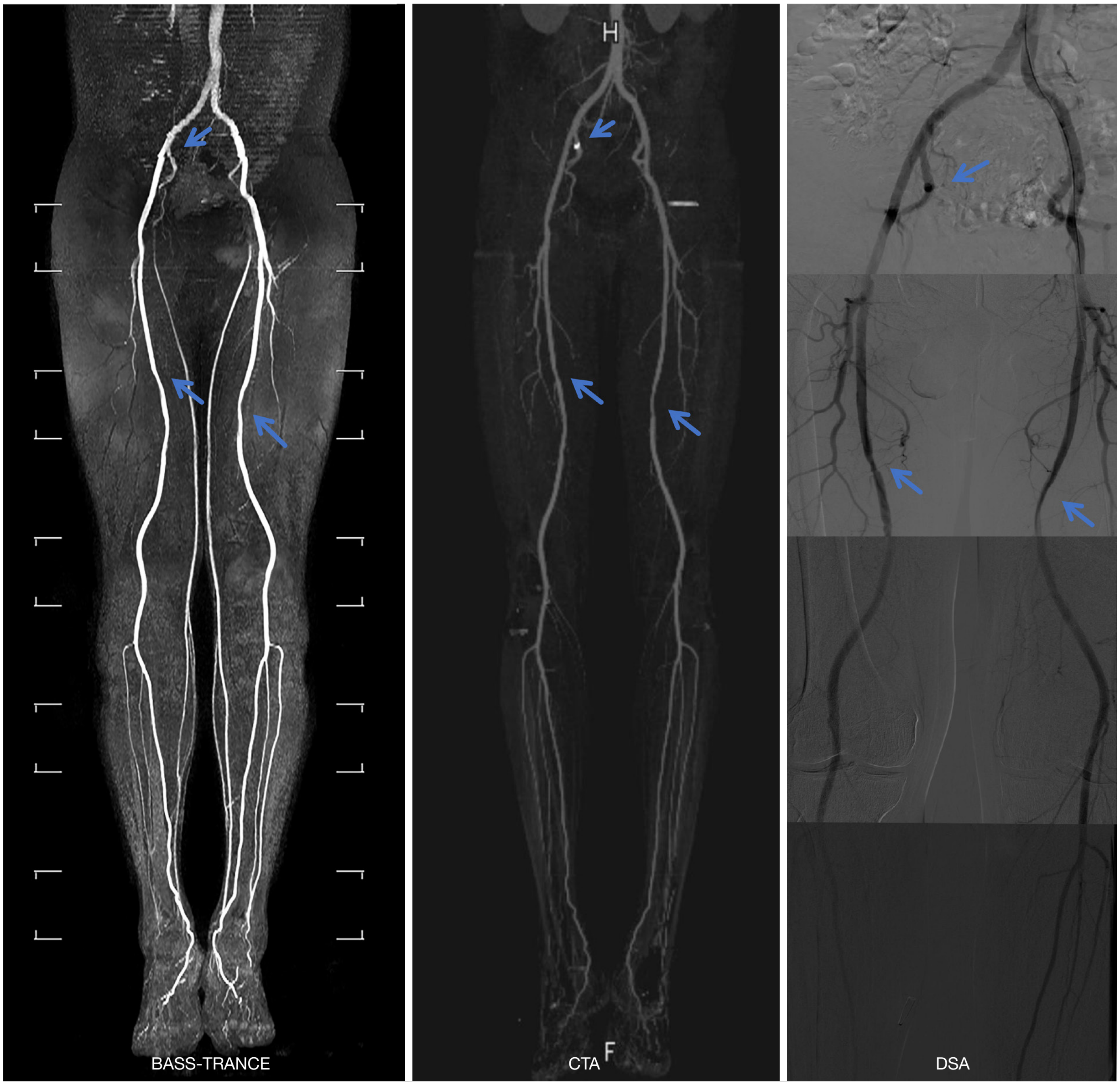

Figure 3 Corresponding BASS-TRANCE, CTA, and DSA images in same patients with PAD. The patient was a 61-year-old male. The vascular stenosis displayed on BASS-TRANCE was highly consistent with CTA and DSA (blue arrows), but the display effect of CTA was better than that of BASS-TRANCE when displaying the branches of the deep femoral artery due to the intake of contrast agent. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography; DSA, digital subtraction angiography; PAD, peripheral artery disease.

of assessment. In cases of disagreement, the corresponding results were evaluated by a third expert radiologist (with more than 10 years of experience). BASS-TRANCE and CTA datasets were evaluated separately on dedicated workstations (Philips ISP 12.0, GE Healthcare AWD 4.7). DSA images were evaluated by an interventional vascular expert with more than 10 years of experience using an image archiving and communication system (GE Healthcare AW 4.7 workstation), with unknown patient clinical data at the time of assessment.

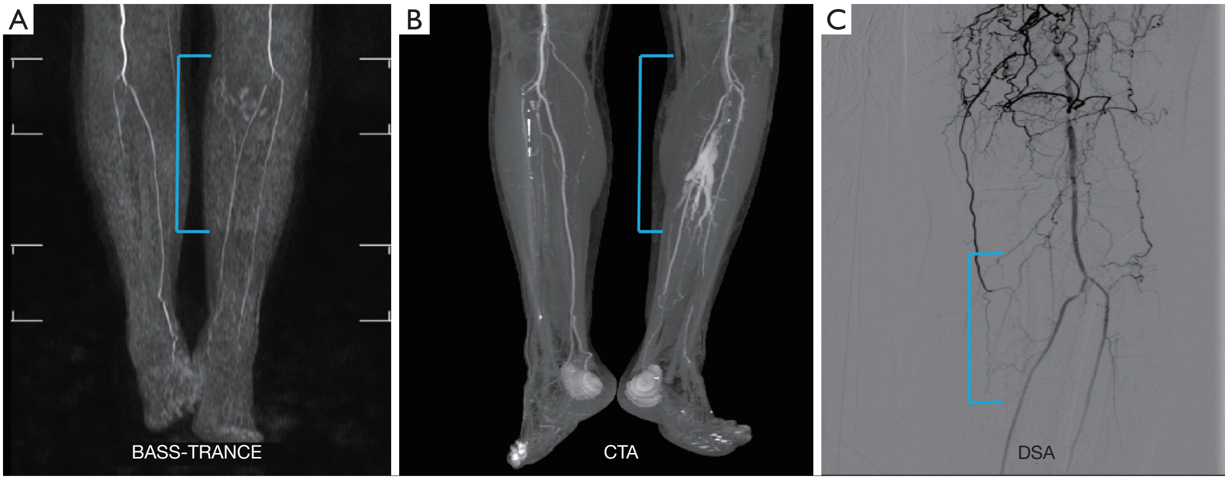

Figure 4 BASS-TRANCE, CTA and DSA comparison result of the same PAD patient, a 69-year-old woman with arteriovenous fistula. (A) BASS-TRANCE shows localized stenosis in the lower leg (solid blue line in parentheses); (B) CTA shows the vessels in the lower leg, due to the influence of venous contamination (contrast agent flowing into the arteriovenous fistula), the circulation of the corresponding blood vessels could not be accurately evaluated as BASS-TRANCE (solid blue line in parentheses); (C) the results of the final DSA display (solid blue line in parentheses) confirmed that the vascular morphology was consistent with BASS-TRANCE. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography; DSA, digital subtraction angiography; PAD, peripheral artery disease.

Statistical analysis

Statistical analyzes were performed using the statistical software SPSS 25.0 (IBM Corp., Armonk, NY, USA). Differences in subjective image quality were assessed by means of a 3-point scale provided by two physicians, and image quality was compared between BASS-TRANCE and CTA using a paired *t*-test or Wilcoxon signed-rank test to test (if the difference between the two groups of data conformed to the normal distribution, the paired *t*-test was used; if it did not, the Wilcoxon signed-rank test was used). The intra-class correlation coefficient (ICC) was used to evaluate the consistency of the subjective image quality scores between the two radiologists. In general, ICC values greater than 0.75 indicated high consistency, 0.40–0.75 indicated good consistency, and below 0.4 indicated poor consistency. Bland-Altman test was used to visualize the consistency of image quality between the two methods. Using DSA as the gold standard, McNemar's test was used to compare the sensitivity and specificity of CTA and BASS-TRANCE in detecting >50% stenosis of lower extremity arteries. Kappa statistics were used to evaluate the two methods in detecting stenosis. The agreement level was as follows: poor, $k<0.20$; acceptable, $k=0.21$ to 0.40; moderate, $k=0.41$ to 0.60; good, $k=0.61$ to 0.80; excellent, $k>0.80$. The test P value was 0.05, and $P<0.05$ was considered significantly different.

Results

Of 570 segments, 12 (2.1%) and 42 (7.4%) inconclusive segments were excluded from BASS-TRANCE and CTA analysis respectively ($P<0.05$). A total of 516 vascular segments were included in the image quality evaluation. The overall subjective image quality of BASS-TRANCE {2.42 [95% confidence interval (CI): 2.36–2.47]}, CTA [2.39 (95% CI: 2.33–2.45); P=0.584]. The interobserver agreement of BASS-TRANCE and CTA image quality scores was assessed as good and excellent [ICC =0.74 (95% CI: 0.72–0.76) and 0.80 (95% CI: 0.76–0.84), respectively]. According to the Bland–Altman test, the overall image quality of BASS-TRANCE and CTA was in good agreement (*Figure 5*).

According to the image quality score, 12 segments (2.1%) of BASS-TRANCE were considered non-diagnostic, and the accuracy analysis of BASS-TRANCE excluded the following reasons: signal loss because of severe tortuosity of blood vessels (n=7; 1.2%) and other image artifacts, including motion and susceptibility artifact (n=5; 0.9%).

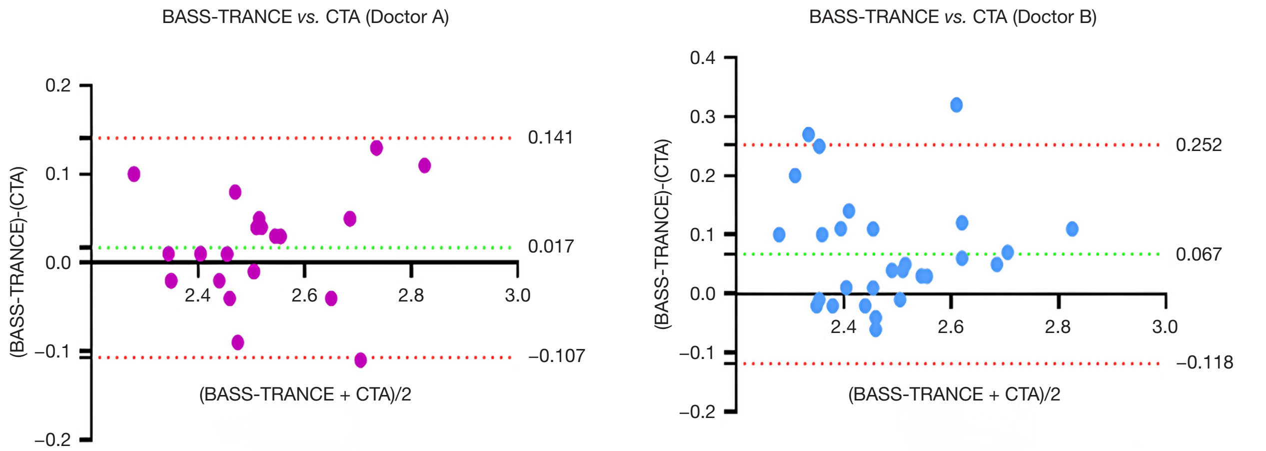

Figure 5 Rendering of Bland-Altman results comparing BASS-TRANCE and CTA images scored by two observers, respectively. Most of the parameters scored by two observers for image quality fell within the 95% consistency limit, which proved that BASS-TRANCE and CTA had good consistency in image quality. The red line represents the 95% bounds of agreement, and the green line represents the mean of the difference in scores between the two methods. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography.

Table 1 Image quality was compared between CTA and BASS-TRANCE (n=516)

Segment of blood vessels	CTA	BASS-TRANCE	P value
Distal abdominal aorta	2.83±0.46	2.90±0.30	0.433
Common iliac artery	2.29±0.64	2.38±0.55	0.325
External iliac artery	2.40±0.56	2.43±0.57	0.593
Internal iliac artery	1.86±0.50	1.90±0.48	0.573
Superficial femoral artery	2.26±0.45	2.17±0.38	0.346
Deep femoral artery	2.16±0.46	1.97±0.32*	0.012
Popliteal artery	2.56±0.56	2.63±0.49	0.489
Anterior tibial artery	2.13±0.57	2.43±0.56*	0.010
Posterior tibial artery	2.00±0.64	2.33±0.47*	0.005
Peroneal artery	2.20±0.48	2.33±0.47	0.161
Over all	2.39±0.36	2.42±0.30	0.584
Severe calcified stenotic segment	2.21±0.39	2.71±0.45*	<0.001

Data are presented as mean ± standard deviation. The n represents the frequency of all included vessel segments. The P represents the result of comparison between the two groups of BASS-TRANCE and CTA image quality. *, P<0.05 compared with CTA. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography.

In the assessment of CTA image quality, because of stent artifacts (n=6; 1.1%, compared with BASS-TRANCE, P<0.05), severe calcification (n=10; 1.7%, compared with BASS-TRANCE, P<0.05) and alienation artifacts (n=26; 4.6%), etc. Forty-two segments (7.4%; P<0.05 for comparison with BASS-TRANCE) were deemed nondiagnostic and excluded from CTA vascular analysis. *Table 1* shows the corresponding vascular segments and overall vascular image quality scores of BASS-TRANCE and CTA, respectively. MRA and CTA images of 516 segments were considered meeting the diagnostic requirements, of which 392 segments had corresponding DSA images. *Table 2* lists different stenosis severity grades frequencies according to DSA, BASS-TRANCE, and CTA. There were 51 segments (23 in BASS-TRANCE and 28 in CTA) with inconsistent results between two radiologists, and the stenosis degree was evaluated by a third imaging expert. Compared with DSA, BASS-TRANCE and CTA overestimated 8 (2.0%) and 11 (2.8%) segments of vascular segments with less than moderate stenosis (<50%), respectively. In the segments with moderate stenosis (≥50%), BASS-TRANCE and CTA underestimated 15 (3.8%) and 6 (1.5%) segments, respectively.

There was no significant difference in the detection rate of stenosis between BASS-TRANCE and CTA in assessing >50% vascular stenosis (P>0.05). *Table 3* lists the sensitivity and specificity of BASS-TRANCE and CTA for detecting

>50% stenosis. After Kappa test, BASS-TRANCE [k=0.88 (95% CI: 0.86–0.90)] and CTA [k=0.85 (95% CI: 0.84–0.86)] methods had high consistency in detecting >50% stenosis.

Discussion

The aim of this study was to investigate the image quality and diagnostic accuracy of BASS-TRANCE and CTA in lower extremity arterial imaging. Regarding overall image quality, the vascular scores of BASS-TRANCE and CTA were highly similar, but there were significant differences in some cases. For example, BASS-TRANCE image acquisition based on b-SSFP sequences sensitive to magnetic field inhomogeneity and is prone to fringe artifacts caused by external interference, especially in the pelvic region, when there is a large amount of intestinal content and gas, which often leads to a decrease in vessel sharpness. In addition, BASS-TRANCE was unsuitable for global visualization of severely stenotic tortuosity and spiral vessels. Since stenotic peripheral arteries may have different velocities, abnormal flow patterns may not cause the same flow enhancement effect as normal arteries, it may make it difficult to trigger ECG to capture flow signals, resulting in loss of blood signals and inability to develop vessels.

Table 2 Different severity classifications of stenoses (n=392)

Class of grades	DSA	BASS-TRANCE	CTA
No stenosis	74	80	69
Mild stenosis	81	84	87
Moderate stenosis	54	49	44
Severe stenosis	92	88	101
Occlusion	91	91	91

Values are presented as number. The n represents the frequency of all included vessel segments. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography; DSA, digital subtraction angiography.

CTA is superior to BASS-TRANCE in displaying small branch vessels because of the need to inject contrast agent. Still, CTA may also be faced with venous interference, which may interfere with the diagnosis. In the imaging of distal lower limb vessels (anterior tibial artery, posterior tibial artery), the image quality of MRA was sometimes significantly better than that of CTA, which may be because the distal lower limb vessels were more likely to form media calcification. The concentration of CTA contrast agent is relatively low in the distal lower limb, which will lead to blurring of the blood vessel edge and reduce the quality of the CTA image. However, MRA was not affected by the vascular contrast agent. Although decalcifications on CTA may improve the quality of vascular imaging, calcification-removal post-processing techniques could sometimes erroneously lead to significant disruptions in vascular continuity when DSA clearly shows the absence of stenosis. Therefore, we chose not to use the decalcification technique in the final CTA image analysis.

The results of stenosis grading based on BASS-TRANCE and DSA were similar regarding the ability to evaluate the degree of vascular stenosis. Close to 90% of segments were correctly graded by BASS-TRANCE, similar to CTA, suggesting that BASS-TRANCE had excellent potential for assessing stenosis severity. The MRA of the whole lower limb has a large coverage area, and the conventional MRI scanning time is longer, but BASS-TRANCE can complete the examination in about 8 minutes (these included a scout image of about 1 minute, a Q-flow scan of about 1 minute, a calibration time of 30 seconds, and BASS-TRANCE sequence scan time of less than 6 minutes). Although the total scanning time of BASS-TRANCE was longer than that of CTA, it was acceptable for most patients with lower extremity arterial disease.

Table 3 Evaluation of the diagnostic ability of BASS-TRANCE and CTA to detect >50% stenosis in lower extremity arteries compared with DSA

Mode of inspection	Sensitivity		Specificity	
	% (n/N)	95% CI, %	% (n/N)	95% CI, %
BASS-TRANCE	92.8 (220/237)	88.5–95.6	96.1 (149/155)	91.3–98.9
CTA	94.9 (225/237)	91.1–97.2	96.8 (150/155)	92.2–98.8

n represents the number of vascular segments corresponding to BASS-TRANCE or CTA; N represents the number of vascular segments corresponding to DSA. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; CTA, computed tomography angiography; DSA, digital subtraction angiography; CI, confidence interval.

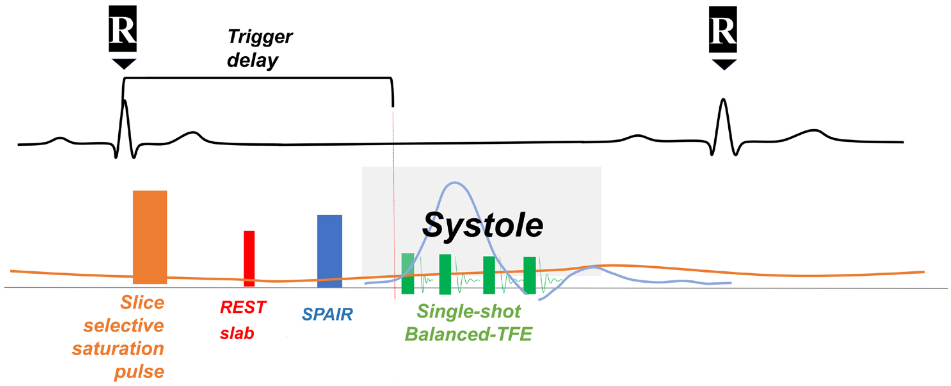

Figure 6 Sequence composition of BASS-TRANCE. BASS-TRANCE uses a selective saturation pulse and SPAIR sequence for background and fat suppression, respectively. In addition, REST slab is applied to suppress venous signals. Finally, by selecting the accurate trigger delay time, a single-shot Balanced-TFE was used to collect the signal during the systole. BASS-TRANCE, background suppression single-shot electrocardiogram trigger non-contrast-enhanced magnetic resonance angiography; SPAIR, spectral attenuated inversion recovery; REST, regional saturation technique; Balanced-TFE, balanced steady-state free precession sequence; R, electrocardiogram R wave.

Various NCE-MRA techniques have been used for the evaluation of PAD (18-21); common ones include three-dimensional fast spin echo (3D FSE) sequence (22), flow-sensitive dephasing (FSD) (23), and quiescent interval single-shot (QISS) (24). It has been reported that these NCE-MRA techniques have high diagnostic accuracy in the analysis of the degree of vascular stenosis. However, none have been widely adopted in clinical practice. For example, time of flight (TOF) was discarded due to long imaging time and poor image quality (19). 3D FSE has been shown to be able to accurately image lower extremity arteries, but this technique is complex and requires multiple parameters to be filled in and post-processing to display arterial images. In addition, 3D FSE requires a long scan time, which is intolerable for some patients. The sequence basis of FSD is different from that of 3D FSE, but in similarity with 3D FSE, FSD also needs to acquire systolic and diastolic blood flow signals and perform subtraction processing to display arteries. This operation is difficult and requires technicians to adjust multiple parameters (including systolic and diastolic delay time and first-order gradient moment), which are important for image quality. In addition, FSD also faces problems such as long scanning time (25-27). QISS was a widely used NCE-MRA (28), which could display vascular conditions in a short time, and the reported diagnostic accuracy is close to or equal to that of CE-MRA (29-31). Although the QISS and BASS-TRANCE techniques are similar, there are significant differences in implementation details. Both use radiofrequency pulses of a certain frequency to suppress background tissue and veins, and b-SSFP sequences are used for data acquisition. The difference is that QISS mainly acquires diastolic images, whereas BASS-TRANCE uses the Q-flow technique (32-34) to select data acquisition when the systolic arterial blood flow velocity is fastest. Given that arrhythmias change significantly during diastole and less during systole, data acquired by BASS-TRANCE during systole may be more helpful for the visualization of arterial signals (schematic diagram of the principle of BASS-TRANCE sequence, *Figure 6*).

BASS-TRANCE diagnostic accuracy of DSA showed that the sensitivity and specificity were 92.8% and 96.1%, respectively. This result remains highly similar to the accuracy data of the QISS technique reported by others (35,36) and slightly lower than that of CE-MRA. In addition, BASS-TRANCE, as a 2D single-shot sequence, has a certain degree of scanning time less than the traditional NCE-MRA technique applied to the lower limbs (37).

Study limitations

First, our patient population was limited to a small sample size from a university medical center; therefore, further multicenter studies were necessary to confirm the diagnostic performance of BASS-TRANCE across a broader range of patients, indications, and clinical scenarios. Second, because of differences in physical properties among various imaging tests, we did not perform objective image quality analysis based on mathematical models or algorithms. Furthermore, because BASS-TRANCE sequences use a parallel imaging technique (SENSE or PI), which may alter the spatial distribution of noise, it would be inappropriate to calculate objective image-quality measures (38). Third, due to the limited hardware equipment, we cannot directly scan and compare the effects of QISS and BASS-TRANCE images. However, QISS image information can be obtained from the corresponding references in this paper, and it can be compared and analyzed in detail with BASS-TRANCE images.

Conclusions

BASS-TRANCE, as an NCE-MRA technique, is less susceptible to calcification artifacts than CTA and can assess vascular severity in PAD patients in a short period of time. BASS-TRANCE is expected to be an effective alternative to CTA in the future, thus providing a technical solution for patients who are not suitable for contrast injection.

Acknowledgments

None.

Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-24-1120/rc

Funding: None.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-24-1120/coif). X.Z.Y. is an employee of Philips Healthcare. The other 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The Ethics Committee of the Affiliated Hospital of Binzhou Medical College approved this study (No. 2023 LW-185), and informed consent was provided by all participants.

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Cite this article as: Zhang Q, Cao H, Han XQ, Yue XZ, Wang WM, Ni LY, Cui WJ, Bao CJ, Jiang XY. Background suppression single-shot electrocardiogram trigger non-enhanced magnetic resonance angiography in lower extremity blood vessels: a comparative study. Quant Imaging Med Surg 2025;15(2):1312-1323. doi: 10.21037/qims-24-1120