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Association between CZT-SPECT myocardial blood flow and coronary stenosis: A cross-sectional study

ZHANG FANG*, WENYI CAI*, BEI CHEN*, CHUNXIANG LI, JIHONG ZHAO, ZHIQIANG TIAN, LIMEI CHEN, JU BU, ZHONGQIANG ZHAO and DIANFU LI

Department of Cardiology, People's Hospital of Jiangsu Province, The First Affiliated Hospital of Nanjing Medical University, Nanjing, Jiangsu 210029, P.R. China

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Abstract. The association between the quantitative and semi-quantitative parameters of myocardial blood flow obtained using cadmium-zinc-telluride single photon emission computed tomography (CZT-SPECT) and coronary stenosis remains unclear. Therefore, the objective of the present study was to evaluate the diagnostic value of two parameters obtained using CZT-SPECT in patients with suspected or known coronary artery disease. A total of 24 consecutive patients who underwent CZT-SPECT and coronary angiography within 3 months of each other were included in the study. To evaluate the predictive ability of the regional difference score (DS), coronary flow reserve (CFR), and the combination thereof for positive coronary stenosis at the vascular level, receiver operating characteristic (ROC) curves were plotted and the area under the curves (AUCs) were calculated. Comparisons of the reclassification ability for coronary stenosis between different parameters were assessed by calculating the net reclassification index (NRI) and the integrated discrimination improvement (IDI). The 24 participants (median age: 65 years; range: 46-79 years; 79.2% male) included in this study had a total of 72 major coronary arteries. When stenosis ≥50% was defined as the criteria for positive coronary stenosis, the AUCs and the 95% confidence interval (CI) for regional DS, CFR, and the combination of the two indices were 0.653 (CI, 0.541-0.766), 0.731 (CI, 0.610-0.852) and 0.757 (CI, 0.645-0.869), respectively. Compared with single DS, the combination of DS and CFR increased the predictive ability for positive stenosis, with an NRI of 0.197-1.060 (P<0.01) and an IDI of 0.0150-0.1391 (P<0.05). When stenosis ≥75% was considered as the criteria, the AUCs were 0.760 (CI, 0.614-0.906), 0.703 (CI, 0.550-0.855), and 0.811 (CI, 0.676-0.947), respectively. Compared with DS, CFR had an IDI of -0.3392 to -02860 (P<0.05) and the combination of DS and CFR also enhanced the predictive ability, with an NRI of 0.0313-1.0758 (P<0.01). In conclusion, both regional DS and CFR had diagnostic values for coronary stenosis, but the diagnostic abilities differed in distinguishing between different degrees of stenosis, and the efficiency was improved with a combination of DS and CFR.

Correspondence to: Dr Dianfu Li or Dr Zhongqiang Zhao, Department of Cardiology, People's Hospital of Jiangsu Province, The First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Road, Nanjing, Jiangsu 210029, P.R. China
E-mail: ldianfu@126.com
E-mail: zhaozhongqiang@jsph.org.cn

*Contributed equally

Abbreviations: CAG, coronary angiography; CAD, coronary artery disease; CFR, coronary flow reserve; CZT SPECT, cadmium-zinc-telluride single photon emission computed tomography; IDI, integrated discrimination improvement; MPI, myocardial perfusion imaging; NRI, net reclassification index; SS, stress score; RS, rest score; DS, difference score

Key words: coronary heart disease; cadmium zinc telluride; single-photon emission computed tomography; myocardial perfusion imaging; coronary flow reserve

Introduction

With the increasing prevalence of cardiovascular disease, coronary artery disease (CAD) has become a leading cause of premature morbidity and mortality worldwide (1). The diagnosis and treatment of coronary heart disease have become increasingly important. Amongst them, the assessment of plaque burden, degree of stenosis, and the resulting consequences of coronary arteries is crucial, as they are closely related to the risk of a cardiovascular event in patients (1). Single photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) is an important non-invasive imaging tool widely applied to the diagnosis, risk stratification, prognosis, and outcome assessment of CAD (2,3). Conventional SPECT MPI is typically used to diagnose CAD by visual assessment and/or semi-quantitative analysis (4), including summed stress score (SS), summed rest score (RS), and summed different score (DS; DS=SS-RS), to evaluate whether myocardial ischemia exists and the severity of myocardial ischemia (5). However, the accuracy of assessing the extent and severity of myocardial ischemia requires improvement (6). Positron emission tomography and CT (PET/CT) allow for quantitative myocardial blood flow (MBF) measurement, determination of the coronary flow reserve (CFR), and the ratio between hyperemic and baseline coronary flow, markedly improving the diagnosis of myocardial ischemia (6,7). PET/CT is therefore considered the gold standard for the non-invasive determination of both MBF and CFR (8). Nevertheless, PET/CT remains infrequently used in routine clinical practice, primarily due to the high cost of equipment and limited availability of radiopharmaceuticals.

In recent years, the emergence of the novel cardiac-specific cadmium-zinc-telluride SPECT (CZT-SPECT) method has significantly improved the performance of SPECT devices (9,10). It has been widely adopted worldwide in clinical practice due to its optimal sensitivity and spatial resolution, as well as its fast temporal resolution characteristics. CZT-SPECT enables fast and dynamic tomographic imaging for quantitative measurement of MBF (11). Furthermore, the CZT-SPECT measurements exhibit consistency with the gold standard (12,13) in diagnosing myocardial ischemia through quantitative blood flow assessment from PET, as well as with the results regarding coronary stenosis obtained from coronary angiography (CAG) (14).

As the literature on clinical applications related to MPI and CFR measurement by CZT-SPECT remains limited, the present study was designed to investigate the relationship between parameters obtained from CZT-SPECT and the level of coronary stenosis.

Patients and methods

Study population. The clinical data of 98 consecutive patients with suspected or confirmed stable CAD who successfully completed resting-load MPI and CFR measurements by CZT-SPECT at The First Affiliated Hospital of Nanjing Medical University (Nanjing, China) between March 2022 and September 2022 were retrospectively collected. Participants aged ≥18 years old who had a history of CAG assessment were included in the study (n=38). The flowchart of patient inclusion is shown in Fig. 1. Further exclusions were made for those patients who had a history of revascularization treatment (n=12) and for those who did not undergo CAG assessment 3 months before or after CZT-SPECT (n=2). After exclusions were made, 24 patients (median age: 65 years; range: 46-79 years) were eligible for inclusion in the study. The present study was approved by The Ethics Committee of People's Hospital of Jiangsu Province (The First Affiliated Hospital of Nanjing Medical University), and all patients signed an informed consent form (approval no. 2022-SR-748).

Clinical data. The clinicopathological characteristics were collected from the hospital's electronic medical record system. This information included sex, age, body mass index, past medical history, smoking history, alcohol consumption history, clinical symptoms, and admission blood pressure. The 10-year cardiovascular score was also calculated. Laboratory examination results included total cholesterol, triglycerides, low-density lipoprotein, high-density lipoprotein, and the systolic blood and diastolic blood pressure of the patients. The CAG results were used as the gold standard reference for coronary stenosis.

CZT-SPECT examination. The imaging device used was a cardiac-dedicated SPECT (D-SPECT; Spectrum Dynamics Medical Company) equipped with a CZT detector, and the radionuclide imaging agent used was ^{99}Tc-methoxy isobutyl isonitrile (Nanjing Senke Pharmaceutical Co., Ltd). Routine preparation of patients for imaging involved: Discontinued administration of cardiovascular drugs (dihydropyridine calcium antagonists and β-blockers for ≥24 h, and nitrates for ≥6 h); fasting from caffeinated beverages, tea, food, and other medications for ≥24 h; and discontinued administration of methylxanthines for ≥36 h prior to examination. The patients consumed 300 ml water before the examination (for patients with heart failure or poor diet, the water intake was reduced or eliminated and the acquisition was delayed depending on the image quality). A 'single-day' protocol of image acquisition (load after rest in the same day) or a 'two-day' protocol (rest on day 1 and load on day 2) was used. The types of imaging included: i) Rest imaging-patients were instructed to consume high-fat meals, and 40-60 min after the meal, routine resting gated tomography was performed and images were acquired for 6 min; and ii) stress imaging-at the end of rest imaging, patients had a 1-4 h interval and they were injected with ATP using an intravenous pump at 0.16 mg/kg.min for 5 min. Meanwhile, the dynamic acquisition was initiated at the peak of loading in the 3rd min, followed by rapid injection of 1,110 MBq imaging agent through a pre-buried intravenous channel for 10-15 sec, and images were acquired in list mode for 6 min. During the whole process, a 12-lead ECG was monitored in real-time. Routine stress-gated tomography was also performed 15-30 min after the end of the stress dynamic acquisition. A total of 5 ml Regadenoson (Nanjing Hailong Pharmaceutical Technology Co., Ltd.) was rapidly injected (10 sec) through a pre-built intravenous channel during the stress test, and dynamic acquisition mode was initiated 20-30 sec later.

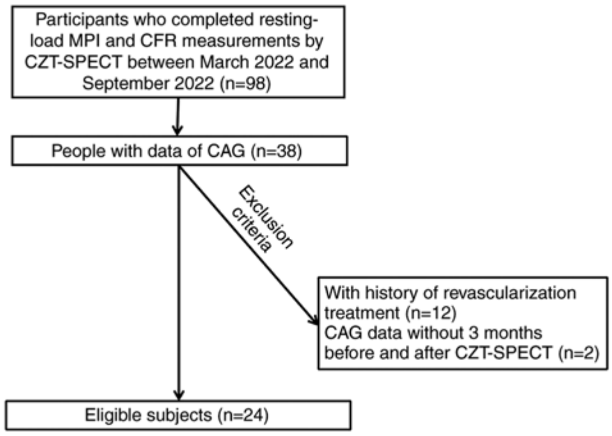

Figure 1. Flowchart of participant inclusion. CAG, coronary angiography; MPI, myocardial perfusion imaging; CZT-SPECT, cadmium-zinc-telluride single photon emission computed tomography.

Image processing. The MPI images and CFR were interpreted by two experienced nuclear medicine physicians in consultation. In case of disagreement, a third physician was consulted and provided the final decision. Quantitative parameters, including regional CFR, were automatically analyzed by image processing software (quantitative perfusion SPECT; Cedars-Sinai Medical Center; version 2017). A 17-region model and a 5-point scale of perfusion image were used to evaluate myocardial ischemia as routine (5). The 17 segments were grouped into territories of the three main coronary arteries to match the results of the CAG, including the circumflex artery (LCX), the left anterior descending artery (LAD), and the right coronary artery (RCA). The scores of the regional segments in the stress and rest images were added to create the regional semi-quantitative parameters known as the regional SS, RS, and DS.

Evaluation of CAG. CAG was performed using the standard Judkins method (15), and stenosis of coronary arteries was visually assessed by two intervention-experienced cardiologists in collaboration. The stenosis was calculated at the most severe point, and the degree of stenosis of the left main stem was considered as stenosis of both the LAD and LCX. According to the results of CAG, the coronary arteries were divided into two groups: i) The negative group with stenosis <50%; and ii) the positive group with stenosis ≥50%. In addition to this, a second approach to grouping based on a stenosis criterion of 75% was implemented.

Statistical analysis. Descriptive statistics were used to summarize the baseline data, including percentages for categorical data, means and standard deviations for normally distributed continuous data, and medians and interquartile range for skewed data. A Student's t-test was used for comparisons between the positive stenosis group and the control group.

The factors related to the degree of coronary stenosis at the vascular level were primarily investigated and the sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of DS, CFR, and DS combined with CFR for the diagnosis of positive coronary stenosis under the two stenosis criteria (50 and 75%) were calculated. The receiver operating characteristic (ROC) curves of the predictive value of DS, CFR, and the combination thereof for coronary stenosis were plotted separately, to assess the discriminative ability of the parameters. The diagnostic efficacy was also calculated based on the optimal cut-off value.

To further compare the predictive ability of semi-quantitative and quantitative parameters (continuous variable) on the degree of coronary stenosis (dichotomous variable), net reclassification improvement (NRI) and integrated discrimination index (IDI) were calculated (16). All data management and statistical analyses were conducted in R, version 4.1.2 (https://www.r-project.org/). P<0.05 was considered to indicate a statistically significant difference.

Results

Characteristics of the study population. A total of 24 patients, aged 46-79 years old, including 19 males and 5 females, with a history of hypertension in 19 patients (79.2%), diabetes mellitus in 8 patients (33.3%), stroke in 1 patient (4.2%), smoking in 11 patients (45.8), alcoholism in 3 patients (12.5%), angina in 13 patients (54.2%) and chest tightness in 18 patients (75.0%), were included in the present study, as shown in Table I. The 10-year atherosclerotic cardiovascular disease score ranged from 4.9 to 10.34. Of the total 72 major vessels of all the included patients, 34 (47.2%) had stenosis ≥50%, and 16 (22.2%) had stenosis ≥75%. A total of 57 vessel supply regions had a normal RS and 15 were abnormal; 41 regions had a normal SS and 31 were abnormal; DS was present in 27 regions and 45 regions had no change in resting load score.

Table I. Clinicopathological characteristics of the patients.

Variable	Value
Age[a], years	65, (46-79)
Male[b]	19 (79.2)
Body mass index, kg/m^2[c]	24.75±3.94
Hypertension[b]	19 (79.2)
Diabetes mellitus[b]	8 (33.3)
Stroke[b]	1 (4.2)
Smoke[b]	11 (45.8)
Consumed alcohol[b]	3 (12.5)
Angina[b]	13 (54.2)
Chest tightness[b]	18 (75.0)
10-year ASCVD risk calculation[b]	7.62±2.72

[a]Median (min-max), [b]n (%), [c]mean ± SD. ASCVD, atherosclerotic cardiovascular disease.

Clinical and CZT-SPECT parameters under the two stenosis criteria. As shown in Table II, there were no significant statistical differences in clinical indices, including systolic blood pressure, diastolic blood pressure, triglyceride, high-density lipoprotein, nor low-density lipoprotein levels. However, there was a significant difference for total cholesterol levels (P=0.029) between the two groups when 50% was used as the criterion for positive coronary stenosis. Diastolic blood pressure levels were significantly different (P=0.006) when the criterion of positive stenosis was 75%. Among the parameters obtained from CZT-SPECT, CFR was lower in the positive stenosis group under both stenosis criteria (both P<0.01), and DS was higher (both P<0.01). Under a stenosis criterion of 75%, stress coronary flow (SCF) was lower (P=0.010) while the SS was higher (P=0.036) in the positive stenosis group. There was no significant difference under the criterion of 50% (SCF, P=0.115; SS, P=0.068). The parameters measured in the resting state also did not reveal any statistically significant differences. These findings suggested that CZT-SPECT parameters might be more sensitive in detecting coronary stenosis than clinical indices, and this may potentially serve as a useful tool in the diagnosis and management of CAD.

ROC curve analysis for the diagnosis of coronary stenosis. The ROC curve analysis for diagnosing coronary stenosis (Fig. 2) demonstrated that the area under the curve (AUC) and 95% confidence intervals (CIs) of DS, CFR, and their combination were 0.653 (CI, 0.541-0.766), 0.731 (CI, 0.610-0.852), and 0.757 (CI, 0.645-0.869), respectively, under the stenotic criterion of 50%, and 0.760 (CI, 0.614-0.906), 0.703 (CI, 0.550-0.855) and 0.811 (CI, 0.676-0.947), respectively, for the stenotic criterion of 75%. The optimal cut-off value for DS was 2.50 for the two criteria and the respective cut-off values for CFR were 2.16 for the stenotic criterion of 50% and 2.08 for the stenotic criterion

Table II. Comparisons of clinical and CZT-SPECT parameters using two different coronary stenosis criteria at the vascular level.

	≥50% as the criterion for positive stenosis[d]				≥75% as the criterion for positive stenosis[d]			
Variable	Reference, n=38	Positive group, n=34	*t*	P-value	Reference, n=56	Positive group, n=16	*t*	P-value
SBP, mmHg	127.21 (15.23)	127.91 (17.02)	-0.183	0.854	126.39 (14.88)	131.56 (19.37)	-0.988	0.335
DBP, mmHg	74.37 (9.33)	77.03 (8.50)	-1.266	0.212	74.11 (8.76)	80.94 (7.89)	-2.977	0.006[b]
TC, mmol/l	3.59 (0.63)	3.25 (0.65)	2.225	0.029[a]	3.48 (0.69)	3.25 (0.51)	1.457	0.155
TG, mmol/l	1.48 (1.06)	1.36 (0.66)	0.597	0.562	1.43 (0.95)	1.38 (0.64)	0.242	0.81
HDL-C, mmol/l	1.17 (0.27)	1.07 (0.28)	1.494	0.139	1.15 (0.28)	1.02 (0.26)	1.738	0.094
LDL-C, mmol/l	2.14 (0.47)	1.95 (0.45)	1.693	0.096	2.07 (0.49)	1.97 (0.37)	0.941	0.354
SS	1.16 (2.37)	3.12 (5.68)	-1.873	0.068	1.12 (2.26)	5.44 (7.42)	-2.294	0.036[a]
RS	0.74 (2.13)	1.29 (4.73)	-0.633	0.530	0.57 (1.80)	2.50 (6.76)	-1.129	0.276
DS	0.42 (0.83)	1.82 (2.48)	-3.145	0.003[b]	0.55 (1.16)	2.94 (2.82)	-3.307	0.004[b]
SCF	1.93 (0.75)	1.67 (0.65)	1.596	0.115	1.91 (0.71)	1.42 (0.60)	2.778	0.010[b]
RCF	0.72 (0.34)	0.84 (0.29)	-1.554	0.126	0.77 (0.32)	0.78 (0.31)	-0.025	0.980
CFR	2.88 (1.06)	2.15 (0.75)	3.381	0.001[c]	2.68 (1.01)	2.02 (0.73)	2.878	0.007[b]

[a]P≤0.05, [b]P≤0.01, [c]P≤0.001. [d]Data are presented as the mean (SD). CZT-SPECT, cadmium-zinc-telluride single photon emission computed tomography; SBP, systolic pressure; DBP, diastolic pressure; TC, total cholesterol; TG, triglyceride; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SS, stress score; RS, rest score; DS, difference score; SCF, stress coronary flow; RCF, rest coronary flow; CFR, coronary flow reserve.

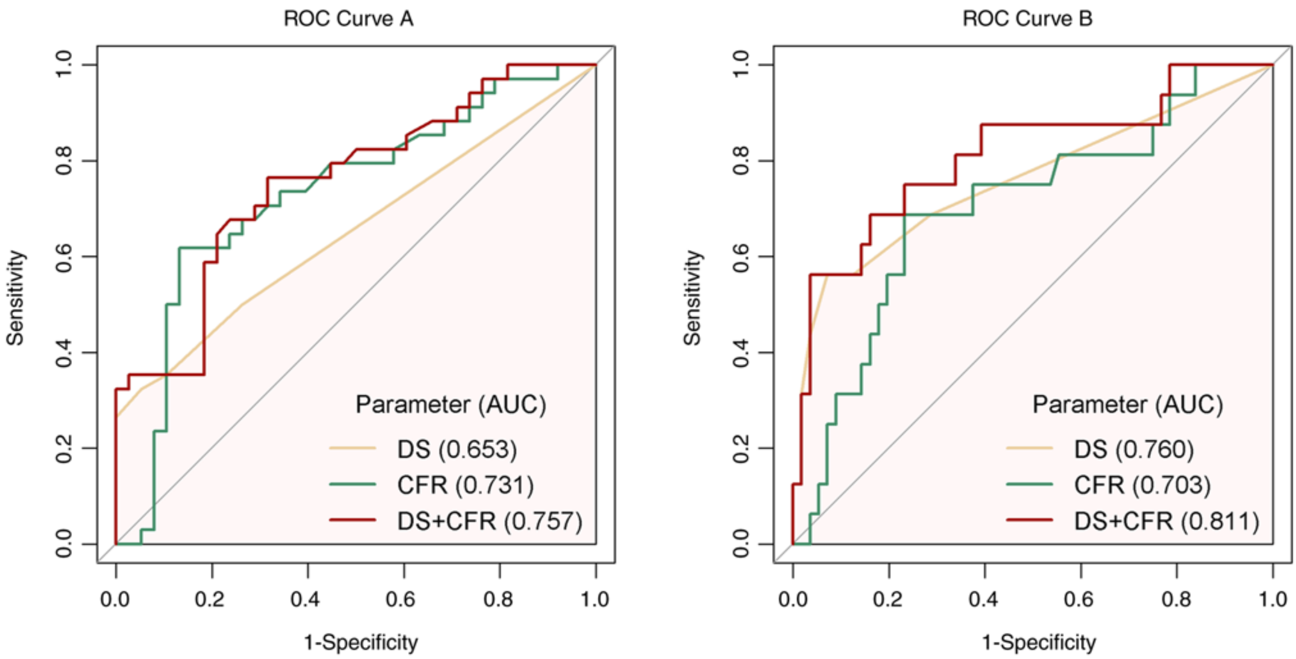

Figure 2. ROC curves for the diagnosis of coronary stenosis. ROC Curve A, ≥50% as the criterion for positive stenosis and ROC Curve B, ≥75% as the criterion for positive stenosis. ROC, receiver operating characteristic curve; AUC, arena under the curve; DS, difference score; CFR, coronary flow reserve.

of 75%. The diagnostic efficacy for the optimal cut-off value is shown in Table III. These findings suggested that a combination of DS and CFR may be a useful tool for the diagnosis of coronary stenosis, and could potentially improve the accuracy and reliability of non-invasive tests for CAD.

Reclassification and discrimination statistics for coronary stenosis. For the comparison of DS, CFR, and the combination thereof, NRI and IDI were calculated to assess the predictive ability, as shown in Table IV. Compared with DS, no statistically significant difference was found in the predictive power elevation of CFR when CAG stenosis ≥50% was defined as the positive criterion among the complete study vessels. However, CFR decreased the predictive power when the study criteria were 75%, with an IDI of -0.339 to -0286 (P<0.05). Notably, the combination of the two indices

Table III. Diagnostic efficacy of DS, CFR, and their combination for positive stenosis using two different criteria.

A, ≥50% as the criterion for positive stenosis, n=72 (%)

Parameter	Cut-off value	Sensitivity	Specificity	PPV	NPV	Accuracy
DS	2.50	32.4 (11/34)	94.7 (36/38)	84.6 (11/13)	61.0 (36/59)	65.3 (47/72)
CFR	2.16	61.8 (21/34)	86.8 (33/38)	80.8 (21/26)	71.7 (33/46)	75.0 (54/72)
DS+CFR		76.5 (26/34)	68.4 (26/38)	68.4 (26/28)	76.5 (26/44)	72.2 (52/72)

B, ≥75% as the criterion for positive stenosis, n=72 (%)

Parameter	Cut-off value	Sensitivity	Specificity	PPV	NPV	Accuracy
DS	2.50	56.2 (9/16)	92.9 (52/56)	69.2 (9/13)	88.1 (52/59)	84.7 (61/72)
CFR	2.08	68.8 (11/16)	76.8 (43/56)	45.8 (11/24)	89.6 (43/48)	75.0 (54/72)
DS+CFR		68.8 (11/16)	83.9 (47/56)	55.0 (11/20)	90.4 (47/52)	80.6 (58/72)

Cut-off values were derived from receiver operating characteristic curves. PPV, positive predictive value; NPV, negative predictive value; DS, difference score; CFR, coronary flow reserve.

Table IV. Comparison of the predictive capability of coronary artery stenosis using different parameters from CZT-SPECT.

A, ≥50% as the criterion for positive stenosis

Parameter	DS	CFR	DS+CFR
NRI	1 (ref)	0.0124 (-0.4474-0.4722)	0.6285 (0.1966-1.0604)[b]
IDI	1 (ref)	0.0126 (-0.0913-0.1165)	0.0771 (0.0150-0.1391)[a]

B, ≥75% as the criterion for positive stenosis

Parameter	DS	CFR	DS+CFR
NRI	1 (ref)	-0.3214 (-0.8706-0.2278)	0.5536 (0.0313-1.0758)[a]
IDI	1 (ref)	-0.1839 (-0.3392-0.2860)[a]	0.0171 (-0.0241-0.0584)

[a]P<0.05, [b]P<0.01. NRI, net reclassification index; IDI, integrated discrimination improvement; DS, difference score; CFR, coronary flow reserve; CZT-SPECT, cadmium-zinc-telluride single photon emission computed tomography.

increased the stenosis prediction with an NRI of 0.197-1.060 (P<0.01) and an IDI of 0.015-0.139 (P<0.05) within the 50% stenosis criteria, and an NRI of 0.031-1.076 (P<0.01) within the 75% stenosis criteria. These findings suggested that DS was not absolutely inferior to CFR for diagnostic accuracy of coronary stenosis, and the combination of DS and CFR had a higher predictive ability for the diagnosis of coronary stenosis than either DS or CFR alone.

Typical case. A 59-year-old male without a known history of hypertension or diabetes complained of typical angina after mild exertion over a period of 2 weeks. CZT-SPECT MPI in routine Regadenoson stress and rest images showed moderate myocardial ischemia only in the territory of LAD with DS=6, the quantitative flow parameter was abnormally decreased in the territory of LAD (CFR=1.24), and was almost normal in the territories of LCX (CFR=3.14) and RCA (CFR=2.45) (Fig. 3A). Invasive CAG suggested a narrowed lesion in LAD with 85% proximal limited stenosis and 70% proximal limited stenosis in the first diagonal branch, and diffuse stenosis of 50-70% in LCX, with no significant stenosis in RCA (Fig. 3B). This case highlighted the importance of early detection and diagnosis of myocardial ischemia, which can help guide appropriate treatment and management strategies. CZT-SPECT MPI can serve as a useful tool for non-invasive diagnosis and risk stratification of patients with suspected or known CAD.

Discussion

The quantitative flow parameters and the semi-quantitative flow parameters are important in the diagnosis and treatment of

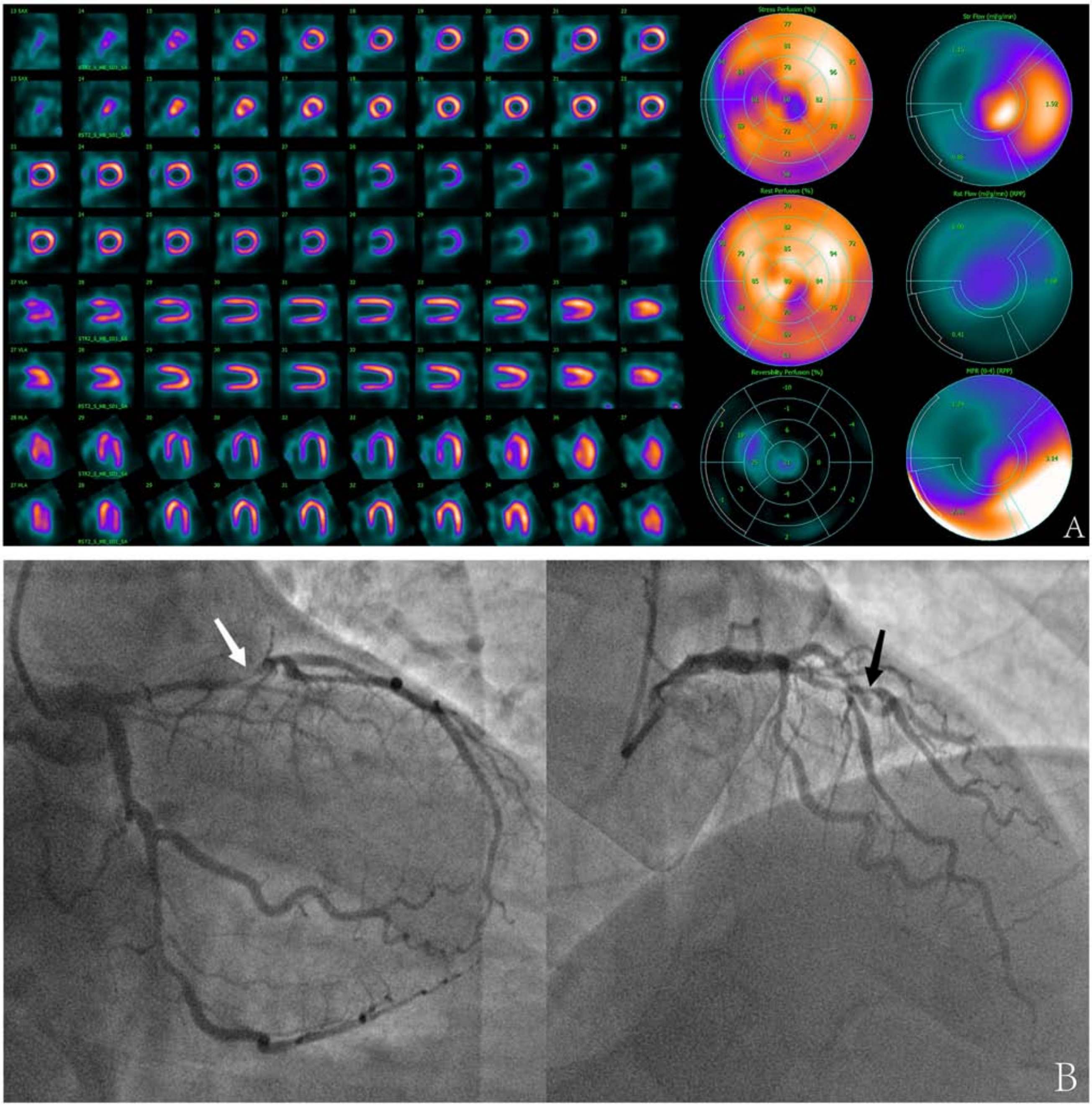

Figure 3. Myocardial functional perfusion imaging and coronary angiography for a typical case. (A) Myocardial functional perfusion imaging. (B) Coronary angiography images.

CAD and have been extensively studied (1,2,5,10). This study focused on the concordance of these parameters measured using the advanced cardiac-specific CZT-SPECT method with coronary stenosis and their clinical values in CAD. Other potential clinical parameters should not theoretically reflect the degree of coronary stenosis since they do not directly correlate with coronary stenosis and may be confounded by medications, which are consistent with our findings.

The present study demonstrated the significant value of CZT-SPECT MFPI in diagnosing and treating coronary heart disease. As the difference between CFR and DS were statistically significant under both stenosis criteria, the comparative analysis of their diagnostic ability for positive stenosis was performed. When considering coronary artery stenosis ≥50% as a positive outcome, the diagnostic value of CFR for coronary stenosis was comparable to DS, and the combination of the two indices increased the predictive power compared with DS alone. When the positive stenosis was defined as ≥75%, CFR was inferior to DS. However, the combination of the two indices improved the predictive power.

Advanced CZT-SPECT can obtain continuous and dynamic tomographic data acquisition, which increases the accuracy and convenience of quantitative MBF measurements and greatly compensates for the shortcomings of conventional SPECT. Its excellent agreement with PET/CT in quantifying MBF has led to its increasing use in clinical practice (12,13). In a healthy coronary system, peak blood flow under stress can increase up to more than three times than that at rest.

Gould *et al* (17) first demonstrated the relationship between CFR and the degree of coronary stenosis in 1974, suggesting that CFR is barely affected in coronary stenosis <50%, but decreases significantly in more severe stenosis, primarily due to the reduction in stress blood flow. Therefore, it was hypothesized that DS, the difference between stress and rest measurements, may be more valuable than other MPI indices, which was also confirmed by the results of the present study.

The assessment of the severity of coronary stenosis can currently be discussed under two aspects: Anatomical and functional. In clinical practice, a coronary angiographic finding of 50% coronary stenosis is typically defined as the threshold for the diagnosis of CAD, and a finding of coronary stenosis >70% is considered severe stenosis, which may seriously affect the blood fluid dynamics of the coronary artery. Thus, stenosis >70% is typically regarded as the stenosis reference standard for performing interventional therapy for patients with CAD, and treatment modalities for stenosis between these two criteria require a combination of clinical evidence of ischemia to make the final decision (18). Given the aforementioned guidelines, the present study was conducted under two stenotic reference standards and it was found that both DS and CFR were associated with the coronary stenosis of CAG.

A previous study that examined the left ventricular blood flow as a whole concluded that quantitative parameters obtained with CZT-SPECT presented certain diagnostic values for CAD and demonstrated an improved ability compared with semi-quantitative indicators (19). Another study demonstrated that individuals with abnormal MPI after classification by the CAD Prognostic Index had a decreased CFR compared with healthy individuals [2.01 (CI, 1.48-2.77) vs. 2.94 (CI, 2.38-3.64); P=0.002], and ROC analysis indicated that the overall best critical value of CFR for high-risk CAD was 2.08 and the regional value was 2.2 (20). One study analyzed 91 patients with suspected or confirmed CAD who had undergone CAG and CZT-SPECT and found that MFR was lower in the coronary group (stenosis ≥70%) than in the control group (1.96±0.7 vs. 2.74±0.9; P<0.05) and the best cut-off value for CFR was 2.1 (21). The results of the present study were comparable to these previous studies and the ROC analysis also demonstrated favorable diagnostic efficiency. In addition, studies have demonstrated that CFR may improve the diagnostic efficacy of SPECT MPI semi-quantitative parameters for CAD (19,22), and the overall diagnostic efficacy of quantitative myocardial flow analysis was higher than that of semi-quantitative analysis, which is consistent with the findings of the present study. However, the results of the present study suggested that the diagnostic value of DS was overall improved compared with that of CFR at the stenosis criterion of 75%, unlike in one previous study (19). It was indicated in the present study that when evaluating coronary arteries with potentially severe stenosis, DS was more likely to be an appropriate non-invasive index due to its higher efficacy and lower cost than CFR, which may shed light on current clinical decisions of diagnosis and therapy. Finally, it was further demonstrated that the power to jointly diagnose was best.

The present study has some limitations. Coronary microvascular disease or collateral circulation may lead to inconsistencies amongst coronary stenosis, DS, and CFR (23). Additionally, stenosis of the coronary branch vessels was not considered here. Given the limited sample size of the present study, sex differences could not be demonstrated as in a previous study (24).

In conclusion, both the DS obtained with traditional MPI and the CFR obtained with CZT-SPECT had certain diagnostic values for coronary artery stenosis. DS was better than CFR in predicting severe coronary stenosis, and the combined diagnostic effect of DS and CFR was the best.

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Availability of data and materials

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Authors' contributions

ZF and WC conceived the study and wrote the manuscript. BC, CL and JZ performed the statistical analysis. ZT, LC and JB collected the data. DL and ZZ developed the concept and methodology of the present study, provided guidance and revised the manuscript.

Ethics approval and consent to participate

The present study was approved by The Ethics Committee of People's Hospital of Jiangsu Province (The First Affiliated Hospital of Nanjing Medical University), and all patients signed an informed consent form (approval no. 2022-SR-748).

Patient consent for publication

All patients provided a form giving informed consent.

Competing interests

The authors declare that they have no competing interests.

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