Correlation between Myocardial Scintigraphy and CT Angiography in the Evaluation of Coronary Disease

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Abstract

Background: Coronary multidetector CT angiography (CTA) has shown good accuracy for detection of coronary stenosis. Although this is a promising technique for the evaluation of CAD, its correlation with the functional expression of the disease is not yet well established.

Objective: To evaluate whether the presence of CAD and the degree of coronary stenosis assessed by CT angiography are associated with changes in the Myocardial Perfusion Scintigraphy (MPS).

Methods: This is a retrospective observational study, which included 99 consecutive patients with known or suspected CAD. MPS and CTA were conducted. We compared the presence of perfusion defects by MPS with the presence of CAD and the degree of luminal obstruction by CTA. For statistical analysis, Student's t-test, ANOVA, and Chi-square (or Fisher's exact test for n <5) tests were used. Multivariate analysis was performed using logistic regression: the level of significance was 5%.

Results: Mean age was 62 ± 11.4 years, with 46 (71.7%) men. The variable analysis was performed per patient (n = 99) and per coronary irrigation territory (n = 297). Of the 67 territories that had significant CAD by CTA, 44.8% had abnormal MPS. Considering the degree of stenosis, abnormal MPS was present in 18.7% of the territories with no significant stenosis, 45.28% of the territories with moderate stenosis, and 42.8% of the territories with severe injuries.

Conclusions: CTA is a good method for exclusion of CAD. However, its use to evaluate the severity of stenosis and its functional impact has not shown good correlation (Arq Bras Cardiol. 2013;100(3):238-245).

Keywords: Coronary Disease / diagnosis; Computed Tomography; Heart / radionuclide imaging.

Introduction

Despite major advances in the understanding of the pathophysiology of cardiovascular diseases and the creation of new diagnostic methods, Coronary Artery Disease (CAD) still remains, even in the 21st century, as a major cause of death in Brazil and in the world[1,2]. Although primary prevention is a priority for modern medicine, it is also necessary to develop complementary diagnostic tools that may aid in the early identification of CAD, since early treatment is crucial for modifying the prognosis.

Currently, coronary angiography is the standard method of reference for the diagnosis of CAD; however, new noninvasive imaging methods, such as coronary multidetector CT angiography (CTA), have proven to be a reliable alternative for the diagnosis of this disease. Since this technique began to be utilized in clinical practice, there has been a rapid evolution in the quality of the images obtained, allowing the expansion of the clinical application of this method, whose accuracy, specificity and sensitivity for detecting coronary artery stenosis had already been well established in the literature[2-7]. However, it is important to note that similarly to the invasive coronary angiography, this method identifies the anatomic stenosis of the coronary arteries, but does not allow a functional evaluation of the lesions.

Among the methods for assesssing the functional impact of obstructive coronary lesions, Myocardial Perfusion Scintigraphy (MPS) stands out for its high accuracy in detecting myocardial ischemia; it is also a powerful tool to predict the risk of future coronary events, enabling a stratification of patient risk to guide therapeutic management decisions[8,9].

Although CTA is a promising technique for assessing CAD, its correlation with the functional expression of the disease is not well established and needs to be investigated. Therefore, the objective of this study was to evaluate whether the existence of CAD and the degree of coronary stenosis assessed by CTA are associated with changes in MPS.

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Methods

We conducted an observational retrospective study, which included consecutive patients with suspected or known CAD who underwent CTA and MPS from August 2006 to September 2009, with an interval of less than 90 days between the two procedures. The indication of the procedures was determined by the attending physician, and the analysis of these indications was not among the objectives of this study. We used as data sources the medical history records of the Nuclear Medicine Service of the Pró-Cardíaco Hospital and the medical records of the patients. The study excluded patients with a history of prior CABG and those with incomplete data records. The project was approved by the Research Ethics Committee of the Pró-Cardíaco Hospital (Rio de Janeiro) under registration number 412.

We studied the following characteristics: gender, age, risk factors for CAD (hypertension, dyslipidemia, smoking habit, physical inactivity, diabetes, family history, obesity), and prior CAD (acute myocardial infarction, percutaneous transluminal coronary angioplasty and coronary obstructive lesions with reduction greater than 50% diameter).

Objective

The following scintigraphic variables were evaluated: type of stress used, number of segments showing reversible (ischemia) and fixed (fibrosis) perfusion defects by qualitative and quantitative data analysis softwares (QPS-Cedars Cinai and Emory Cardiac Toolbox); evaluation of global and segmental contractility and ejection fraction by gated SPECT. The segmentation model used was the 17-segment model[10]. Scintigraphy tests with reversible or fixed perfusion defects were classified as abnormal.

All MPS tests were conducted at the Nuclear Medicine Service of the Pró-Cardíaco Hospital in Rio de Janeiro, in a Siemens Anger-type digital tomographic scintillation camera (Single Photon Emission Computed Tomography), using an E-Cam double detector with low power and high resolution collimator.

The results obtained by scintigraphy were compared with the presence of coronary artery disease (significant CAD: ≥ 50% luminal obstruction; not significant CAD: < 50% luminal obstruction) and the degree of stenosis (not significant: <50%; moderate: 50%-70%; severe: > 70%) assessed by CTA.

CTA tests were performed in a GE Healthcare's LightSpeed® VCT 64-slice CT Scanner. Patients received from 5 to 20 mg of intravenous metoprolol to control Heart Rate (HR), obtaining an average HR of 70 bpm. Calcium scoring was analyzed through prospectively triggered conventional data acquisition and a collimation of 3 mm. In the angiographic analysis; we used prospectively or retrospectively triggered helical acquisition, according to the HR and the weight of the patient, with 0.625 mm collimation and the injection of 80 ml of non-ionic iodinated contrast with a flow rate of 5.0 ml/s.[20] A total of 20 cardiac phases were reconstructed, and the phase with the least cardiac motion at the level of the coronary arteries was selected. For the analysis, we used axial imaging sources, multiplanar reformatting, and three-dimensional curves and reconstructions per volume rendering, in an ADW4.3 workstation (GE Healthcare).

The analysis was performed per patient (n = 99) and coronary irrigation territory (n = 297). Statistical analysis was performed using the SPSS software version 17. Continuous variables were presented in the form of mean and standard deviation. We used the Student's t-test for the means of these variables, and ANOVA analysis of variance. For categorical variables, we used the chi-square test or Fisher's exact test for n < 5. Multivariate analysis was performed using logistic regression, and the level of significance was 5%.

Results

The study included 99 patients with a mean age of 62 ± 11.4 years: 71.7% were male; 6% had a history of myocardial infarction; 18% had previous coronary angioplasty with stenting. Of the total sample, 47% reported chest pain as the main reason for the examination; myocardial perfusion scintigraphy was the first method used in 66% of patients. The interval between tests was 12.4 ± 17.5 days. The type of stress used in scintigraphy was pharmacological in 52 patients, and physical in 47 patients. The other baseline characteristics of the study population are shown in Table 1.

Analyzing each patient by coronary territory, we obtained 297 territories, corresponding to 297 segments. An abnormal MPS was found in 73 segments (24.57%). Of the segments evaluated, 230 showed not significant CAD. Of these, 43 (18.7%) had an abnormal MPS, as shown in Chart 1-A. Of the 67 segments that showed significant CAD, 30 (44.8%) had abnormal MPS (Chart 1-B).

Chart 2 shows the distribution of scintigraphic changes according to the severity of coronary stenosis. An abnormal MPS was present in 18.7% (n = 43) of the territories with no significant stenosis, in 45.28% (n = 24) of the territories with moderate stenosis, and in 42.8% (n = 6) of the territories with severe injuries. There was a significant association of the presence of abnormal MPS in lesions with stenosis above 50% and in lesions with stenosis above 70%.

The Positive Predictive Value (PPV) of CTA for abnormal MPS was 44.8%, and the Negative Predictive Value (NPV) was 81.3%. The sensitivity and specificity of CTA were, respectively, 41.1% and 83.5%.

Analyzing the scintigrams per patient, regarding the possible variables that could explain the presence of scintigraphic changes, we found that, in the univariate analysis (Table 2), a history of hypertension (p = 0.01) and a history of previous angioplasty (p = 0.04) were significantly associated with an abnormal MPS. The presence of significant CAD by CTA (p = 0.01) also showed a correlation with the presence of an abnormal MPS. According to the multivariate logistic regression (Table 3), the presence of significant lesions on CTA was the only variable independently associated with the presence of abnormal MPS (p = 0.018).

Table 1 - General characteristics of the study population

Characteristics	n
Total Number of Patients	99 (100%)
Male	71 (71.7%)
Female	28 (28.3%)
Hypertension	56 (56.5%)
Dyslipidemia	48 (48.5%)
Smoking habit	15 (15.1%)
Sedentary	45 (45.4%)
Diabetes	15 (15.1%)
Family history of CAD	43 (43.4%)
Obesity	38 (38.4%)
Previous AMI	6 (6%)
PTCA	18 (18.2%)
Exertion	47 (47.5%)
Significant CAD*	77 (77.8%)

CAD: coronary artery disease; AMI: acute myocardial infarction; PTCA: percutaneous transluminal coronary angioplasty; (*) ≥ 50% coronary luminal narrowing was considered as a significant CAD.

Figure 1 shows the CTA of one of the patients in our series: Male patient aged 66 years, asymptomatic, with an exercise stress test showing isolated ECG changes at peak exercise (he reached 10 METS in the ramp protocol), was referred for CTA. The tomographic images (Figure 1) showed the presence of an obstructive lesion in the anterior descending artery, immediately after the emergence of the first diagonal artery. As the patient had excellent functional capacity and was asymptomatic, he was referred for stress and rest scintigraphy to quantify the area of ischemia. He underwent a physical stress similar to the previous, and in the evaluation of the perfusion images (Figure 2), a restricted perfusion defect (<5% of the left ventricular myocardial mass) was observed in the interventricular septum. There were no contractile changes in post-stress gated SPECT scintigraphic images. The patient was clinically managed and has been monitored for more than two years, remaining asymptomatic, with no events.

Discussion

The presence of myocardial ischemia is an important prognostic information. Patients who have significant areas of ischemia have a poor prognosis when maintained in clinical treatment[11]. Coronary stenoses are the major causes of myocardial ischemia, and their detection by morphological examination is essential in defining the therapeutic strategy. However, several studies have shown that there is a binary relationship between the existence of coronary stenoses with more than 50% diameter narrowing and the presence of ischemia[12].

In our study, we compared the results of CTA with those of MPS in patients with known or suspected CAD, and the main conclusion was that the presence of obstructive lesions (> 50%) has low predictive value for identifying myocardial ischemia using MPS: only 44.8% of the territories with moderate or severe injuries by CTA showed abnormal MPS. This finding is similar to that obtained by Schuijf et al.[12] who demonstrated a correlation between significant CAD by CTA and abnormal MPS in only 45% (33 of 73) of the patients analyzed. Similar results have been reproduced by other authors in the literature[13-15]. This discrepancy between the methods is partly attributed to CTA limitations in showing the physiological effects of coronary stenosis. By using the severity of coronary stenosis we are limited to only one of the variables that determine the atherosclerotic coronary resistance, neglecting important aspects such as length, shape and eccentricity, and the presence of

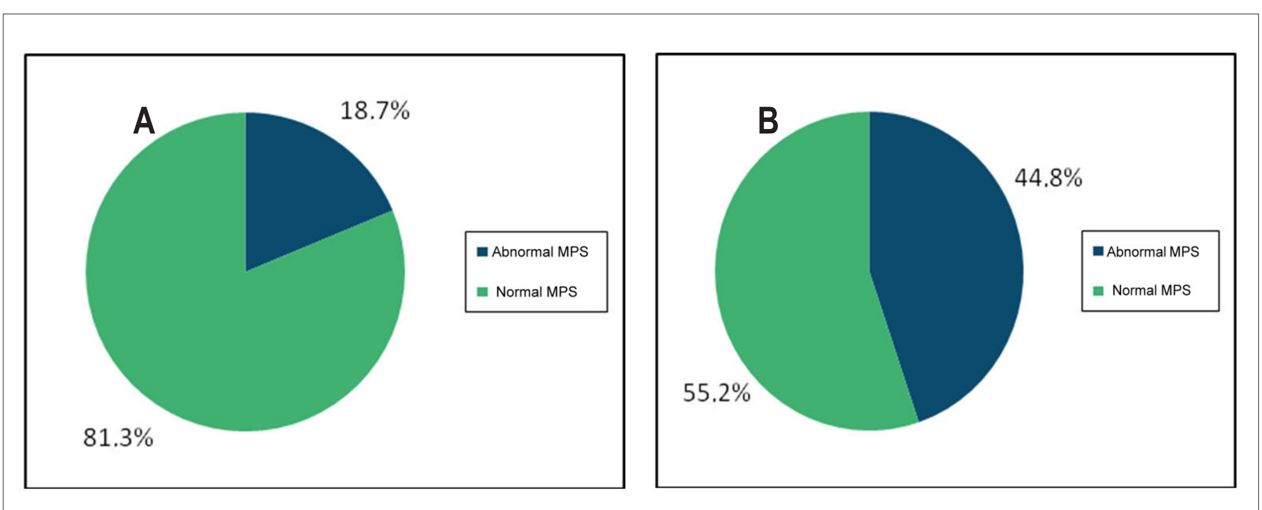

Chart 1: *A - Distribution of segments with changed and normal Myocardial Perfusion Scintigraphy (MPS) among segments with not significant CAD (luminal obstruction < 50%) by coronary CT angiography. B - Distribution of segments with changed and normal MPS among segments with significant CAD (luminal obstruction ≥ 50%) by coronary CT angiography.*

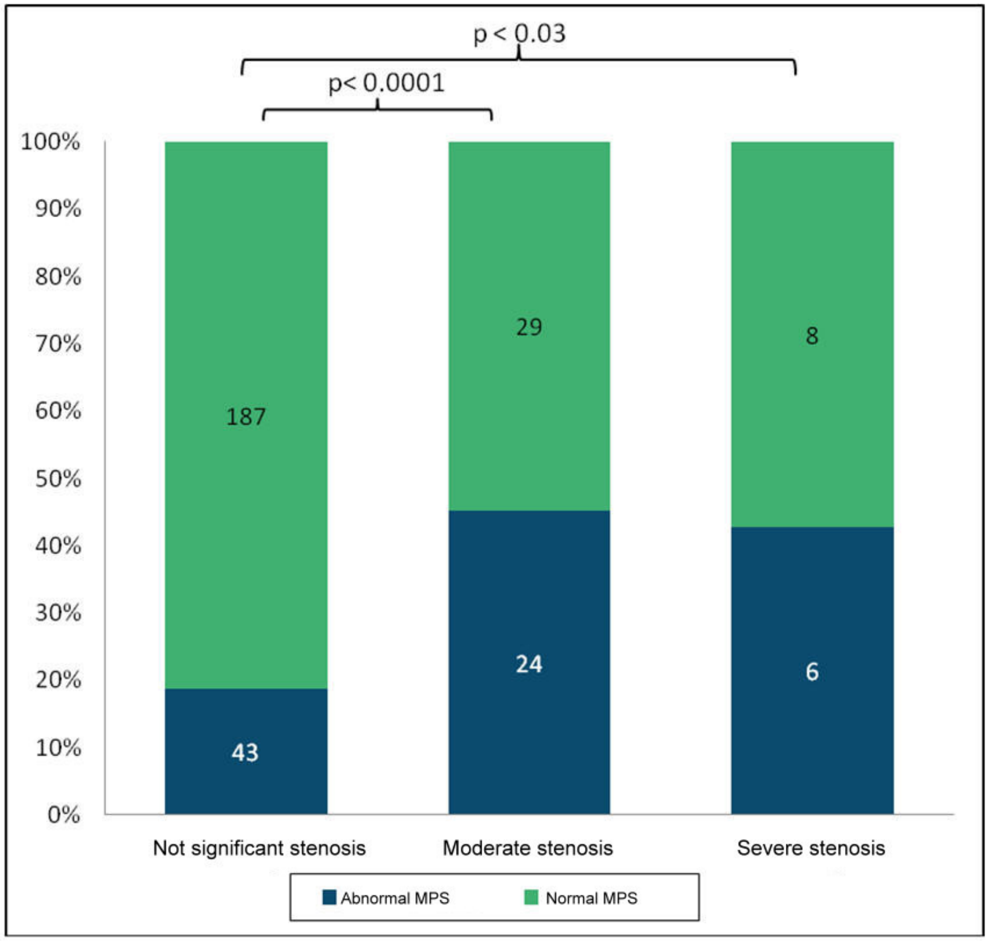

Chart 2 - *Distribution of abnormal scintigraphic (abnormal MPS and normal MPS) according to the severity of coronary stenosis.*

Table 2 - Univariate analysis of patients with correlation between patient baseline characteristics and the presence of abnormal MPS

Characteristics	Abnormal MPS	Normal MPS	Statistical Significance
Age (years)	61 ± 12	62 ± 10	ns
Male	39	32	ns
Female	12	16	ns
Hypertension	35	21	0.01
Dyslipidemia	25	23	ns
Smoking habit	8	7	ns
Sedentarism	26	19	ns
Diabetes	11	4	0.06
Family history of CAD	24	19	ns
Obesity	23	15	ns
Previous AMI	5	1	ns
PTCA	13	5	0.04
Exertion	37	37	ns
Significant CAD	32	14	0,01

CAD: coronary artery disease; AMI: acute myocardial infarction; PTCA: percutaneous transluminal coronary angioplasty; ns: no significant.

Table 3 - Multivariate analysis

Model	Coefficients*						
	Non standardized coefficients		Standardized coefficients	t	Sig	Confidence interval	
	B	Standard Error	Beta			Lower Limit	Upper Limit
1 (constant)	0.340	0.481		0.707	0.482	-0.616	1.296
Age	-0.003	0.005	-0.077	-0.664	0.509	-0.014	0.007
Gender	0.127	0.121	0.114	1.050	0.297	-0.114	0.368
Hypertension	0.165	0.117	0.164	1.404	0.164	-0.069	0.398
Diabetes	0.264	0.147	0.185	1.793	0.077	-0.029	0.556
Smoking habit	0.063	0.148	0.045	0.423	0.673	-0.232	0.358
Dyslipidemia	0.094	0.114	-0.094	-0.826	0.411	-0.320	0.132
FH of CAD	0.135	0.115	0.134	1.180	0.241	-0.093	0.364
Obesity	0.040	0.138	0.039	0.291	0.772	-0.234	0.314
BMI	-0.002	0.014	-0.019	-0.146	0.884	-0.029	0.025
Sedentarism	0.069	0.113	0.069	0.621	0.542	-0.156	0.295
Previous AMI	0.244	0.265	0.118	0.923	0.359	-0.282	0.771
Previous STENT	0.019	0.172	0.014	0.111	0.912	-0.323	0.361
Sig CAD	0.264	0.109	0.262	2.417	0.018	0.047	0.480

(*)Dependent variable: MPS.

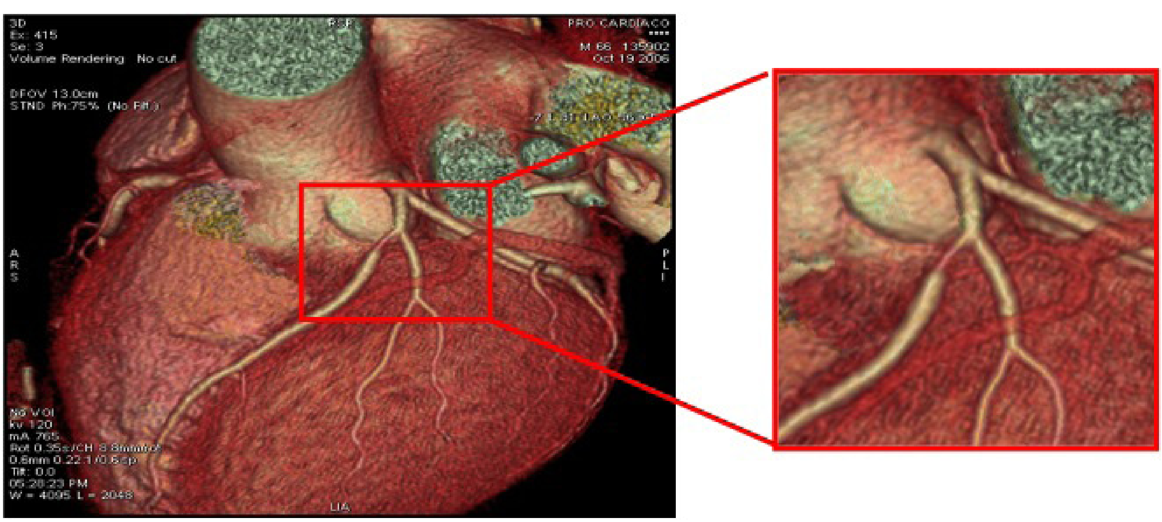

Figure 1 - *CT angiogram of a 66 year-old, male, asymptomatic patient. An obstructive lesion in the left anterior descending artery is highlighted.*

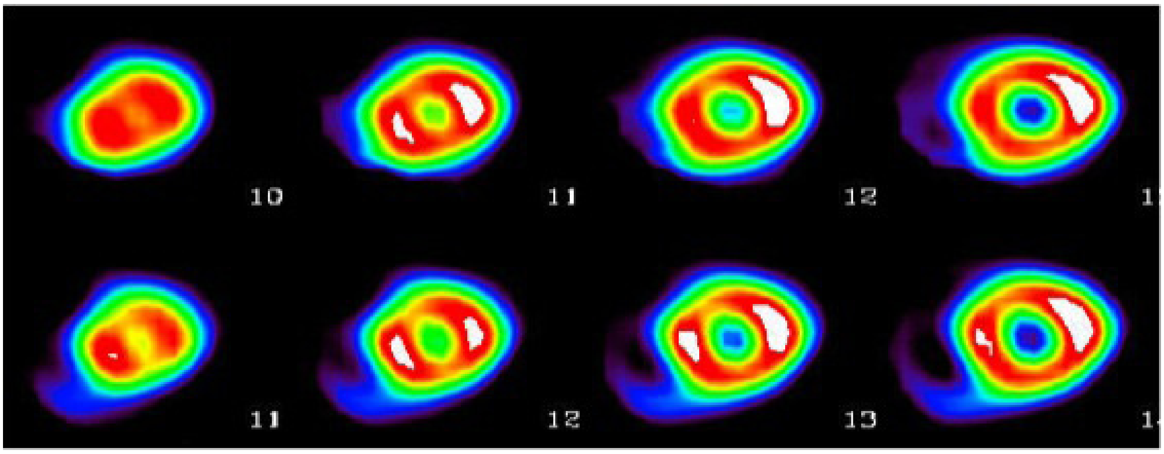

Figure 2 - *Rest-stress myocardial perfusion scintigraphy, short-axis projections, of the same patient in Figure 1. A discrete reversible septal defect is observed. The patient was maintained on medication treatment.*

stenoses in series, which significantly affect blood flow. Furthermore, vascular tone, integrity of microcirculation and collateral circulation, which are not assessed by morphological methods such as CT angiography, can contribute significantly to scintigraphic and functional findings.

The annual incidence of death or myocardial infarction in patients with normal myocardial scintigraphy is less than 1%, as demonstrated by numerous studies and meta-analyses[16]. Revascularization in patients who present no ischemia may be of little clinical benefit, or be even counterproductive, as demonstrated by the DEFER[17] study. In patients in whom there was no functional significance, there is safety in not performing an intervention. Therefore, this anatomofunctional discordance impacts not only in diagnosis, but also in decision-making regarding revascularization. The recent publication of the FAME study brought enough attention to this issue, in this study, the assessment of the functional significance of coronary lesions by invasive Fractional Flow Reserve (FFR), which can detect with great accuracy the presence of visual functional discordance[18]. The FAME researchers observed that for all patients with triple artery in catheterization, in only 14% of them all lesions had functional significance (assessed by FFR) and, most importantly, 9% of patients had no stenosis with functional significance. In a total of 1329 coronary lesions with more than 50% stenosis (with significant obstruction), only 816 lesions (61%) had functional significance, according to FFR[18].

CTA is an excellent method for exclusion of CAD, a fact confirmed in our study, which found that the majority of coronary territories with no significant injury also present normal MPS (NPV: 81%). Similar results were found by other investigators[12-15,19], who found this same good accuracy of CTA to exclude ischemia. This suggests that in patients with less than 50% coronary stenosis, there should be no necessity for performing additional functional tests.

Through CTA the assessment of the severity of coronary stenosis is not very precise, for it has lower spatial resolution than the invasive coronary angiography[20,21], which implies an inability to specify the degree of stenosis in a manner similar to the latter examination. This may have been responsible for the inability to demonstrate differences between the frequency of perfusion changes in patients with moderate stenosis (50% – 70%) compared to patients with severe stenosis (> 70%): 45.3% and 42 8%, respectively. However, some groups have obtained different results from those found in other studies, in which most patients with severe stenosis present abnormal MPS. Probably, this difference is due to the small number of patients with severe stenosis included in our study (n = 14).

The case series review was retrospective, which may have limited the ability to obtain clinical information; however, as all tests were performed at the same institution, a correlation was determined between the data obtained in both tests. Another significant limitation was that patients often had been referred to the second examination from the result of the first, which may have contributed to the increase in the number of discordant cases between techniques, since the clinical findings added to the first exam could still be associated with diagnostic uncertainty. The cases with strongly positive or clearly normal test results are rarely referred for further examinations as part of a noninvasive diagnostic strategy. However, one of the merits of the study was the evaluation of the use of these strategies in a real world situation.

Conclusions

CTA proved useful in excluding the diagnosis of CAD, but its accuracy in assessing the severity of lesions is unsatisfactory. To this end, MPS has shown in several studies to be quite accurate. It is concluded, therefore, that CTA and MPS provide supplemental information about CAD, the former on morphological aspects, and the latter on functional aspects. How both techniques can be integrated into clinical practice is not yet fully understood.

In our study, by including consecutive patients, we obtained a sample that is similar to that seen in everyday clinical practice, which attaches great relevance to our results.

Author contributions

Concepção e desenho da pesquisa: Azevedo JC, Rochitte CE, Mesquita ET, Mesquita CT; Obtenção de dados: Azevedo JC, Ferreira Junior DS, Vieira FC, Prezotti LS, Simões LS, Nacif MS, Oliveira Junior AC, Mesquita CT; Análise e interpretação dos dados: Azevedo JC, Ferreira Junior DS, Vieira FC, Prezotti LS, Simões LS, Nacif MS, Oliveira Junior AC, Mesquita ET, Mesquita CT; Análise estatística: Azevedo JC, Ferreira Junior DS, Vieira FC, Prezotti LS, Simões LS, Mesquita ET, Mesquita CT; Redação do manuscrito: Azevedo JC, Ferreira Junior DS, Vieira FC, Prezotti LS, Simões LS, Mesquita CT; Revisão crítica do manuscrito quanto ao conteúdo intelectual: Azevedo JC, Nacif MS, Rochitte CE, Oliveira Junior AC, Mesquita ET, Mesquita CT.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any post-graduation program.

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