Concordance between myocardial perfusion scan assessed by SPECT and fractional flow reserve findings for detection of significant ischemia

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Abstract *Background:* Myocardial Perfusion Imaging (MPI) plays an imperative role in the diagnosis of myocardial ischemia. On the other hand, fractional flow reserve (FFR) has a number of distinctive characteristics that make it particularly appropriate for the functional assessment of coronary artery stenosis. The present study aimed to assess concordance of MPI with SPECT and FFR findings for detection of significant ischemia.

Methods: Forty-five consecutive patients who were candidate for coronary angiography were included into the study and underwent MPI with SPECT. Ischemia was considered significant if the presence of stress induced-ischemia in a wide myocardial area ($\geqslant 10\%$) or stress segmental score indicates multiple vascular territories with abnormalities in MPI with SPECT, or if FFR < 0.75.

Results: There was a significant concordance between FFR and MPI with SPECT techniques for detecting ischemia in involved LAD territory (kappa = 0.565, p < 0.001), in LCX territory (kappa = 0.815, p < 0.001), and in RCA territory (kappa = 0.776, p < 0.001). Comparing diagnostic value of SPECT with FFR, as gold standard for detection of ischemia, for LAD involvement, SPECT had sensitivity, specificity, PPV, NPV, and accuracy of 66.7%, 71.0%, 30.8%, 91.7%, and 70.3%, for LCX involvement 100%, 60.0%, 33.4%, 100%, and 66.7% and for RCA involvement, 100%, 60.0%, 20.0%, 100%, and 70.0%, respectively.

Conclusion: FFR and MPI with SPECT techniques showed significant concordance for detection of myocardial ischemia, regardless of the type of diseased coronary arteries. In this context, SPECT has high sensitivity and NPV for detection of ischemia compared with FFR.

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1. Introduction

Coronary artery disease (CAD) is one of the most common causes of death worldwide, and it is the second most frequent cause of emergency department visits. Diagnosing myocardial ischemia prior to a heart attack is crucial because ischemic

heart disease is responsible for approximately 14% of all deaths worldwide.[1–5]

Nuclear imaging plays an essential role in the diagnosis of myocardial ischemia as well as other cardiovascular diseases. The nuclear myocardial scan is one of the best initial imaging studies for the detection of myocardial ischemia.[6] Currently, nuclear myocardial scans encompass both perfusion and gated wall motion images. Scanning is performed for 3 reasons: (1) to aid in the diagnosis of CAD, (2) to stratify the risk in patients with known CAD, and (3) to evaluate the patient's response to therapy for CAD. The indications for gated myocardial perfusion single-photon emission computed tomography (SPECT) are based on its prognostic value, cost, and feasibility in virtually all patients. The prognostic value is exceptional.[5,6] Although SPECT is more expensive than stress echocardiography, it has a better negative predictive value.[7–9]

Fractional flow reserve (FFR) is defined as the ratio of the maximal blood flow measured in a stenotic vessel to the normal maximal flow in the same vessel, which represents the fraction of maximum flow that can still be maintained despite the presence of the stenosis.[10] FFR has a number of exclusive characteristics that make it particularly appropriate for the functional assessment of coronary stenosis and subsequent clinical decision making in the catheterization laboratory.[11,12]

For determining significant coronary artery involvement, both SPECT and FFR methods can be used. SPECT method can reveal cardiac ischemia with a high sensitivity; in addition, FFR had a high specificity to determine ischemia. Thus, the concordance between the two techniques can help to discriminate ischemia from normal cardiac condition. Therefore, the present study aimed to assess concordance of MPI with SPECT and Fractional FFR for detection of significant ischemia.

2. Methods and materials

In this cross-sectional study, forty-five consecutive patients with chronic stable angina who were candidates for coronary angiography were included in the study and underwent MPI with SPECT; 2-day protocol was performed and attenuation correction and ECG analysis were applied; for all patients pharmacologic stress with dipyridamole was introduced. Ischemia was considered significant if the presence of stress induced-ischemia in a wide myocardial area ($\geqslant 10\%$) or stress segmental score indicating multiple vascular territories with abnormalities in MPI with SPECT was detected, or if FFR was less than 0.8. The results of SPECT and FFR were compared in each vascular territory. Hyperemia was achieved for all patients with adenosine. One experienced physician who was blinded to angiography results interpreted all MPI results; the intraobserver variability for MPI results was calculated 0.90(0.76–0.97). Results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by frequency (percentage) for categorical variables. The results of SPECT were compared with those of FFR as the gold standard following calculation of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV). The area under the receiver-operating characteristic (ROC) curve was used to determine FFR value to discriminate ischemic from non-ischemic conditions. Moreover, the concordance between the two procedures was assessed using Kappa value. For the statistical analysis, the statistical software SPSS version 19.0 for windows (SPSS Inc., Chicago, IL) was used. P values less than 0.05 were considered statistically significant.

3. Results

Overall, 45 patients were assessed with the mean age 59.07 ± 1.12 years and male gender distribution of 57.8%. Among all included patients, 28.9% had family history of coronary disease, 22.2% were smoker, 42.2% were diabetics, 51.1% were hypertensive, and 57.8% had history of dyslipidemia. In angiography report, 37.8% had single-vessel disease, 44.4% had two-vessel disease, and 17.8% had three-vessel disease.

Regarding results of FFR in each involved vessel, for LAD vessel, FFR was negative in 69.9%, positive in 13.3%, and not performed in 17.8%; for LCX vessel, FFR was negative in 11.1%, positive in 2.2%, and not performed in 86.7%; and for RCA vessel, FFR was negative in 22.2%, positive in 2.2%, and not performed in 75.6%.

With respect to the results of SPECT, for LAD artery, 53.3% had negative result and 28.9% had positive result; for LCX artery, 6.7% had negative result and 6.7% had positive result; and for RCA vessel, 13.3% had negative result and 11.1% had positive result.

There was a strong concordance between FFR and SPECT techniques for detecting ischemia in involved LAD artery (kappa = 0.565, $p < 0.001$), in LCX artery (kappa = 0.815, $p < 0.001$), and in RCA artery (kappa = 0.776, $p < 0.001$). Comparing diagnostic value of SPECT with FFR, as the gold standard for detection of ischemia, for LAD involvement, SPECT had sensitivity, specificity, PPV, NPV, and accuracy of 66.7%, 71.0%, 30.8%, 91.7%, and 70.3%; for LCX involvement, SPECT had sensitivity, specificity, PPV, NPV, and accuracy of 100%, 60.0%, 33.4%, 100%, and 66.7% and for RCA involvement, SPECT had a sensitivity, specificity, PPV, NPV, and accuracy of 100%, 60.0%, 20.0%, 100%, and 70.0%, respectively.

4. Discussion

As previously described, SPECT technique has a high sensitivity for detection of ischemic area with a high safety and limited radiation to the patients.[5,6] On the other hand, FFR has been well known as an accurate, but invasive method for diagnosing myocardial ischemia; however, the use of this method may be accompanied with notable patients' displeasure. In this context, obtaining a good concordance between these two techniques can result in replacing FFR by SPECT which leads to increased patients' satisfaction. The present study conducted to examine this concordance between the two methods and showed a high agreement between them regardless of the type of involved coronary vessels. In this regard, SPECT method was shown to have high sensitivity and high NPV for detecting ischemia with sensitivity ranged 66.7–100%, and NPV ranged 91.7–100%. The result of the study regarding high diagnostic value of SPECT compared with FFR is consistent with most previous studies. In one study, the summarized sensitivity and specificity of SPETC were 77% (95% confidence interval

[CI], 70–83%) and 77% (95%CI, 67–84%) by reviewing 13 manuscripts in a meta-analysis, indicating a moderate diagnostic value for SPECT.[13] Another investigation revealed a concordance of 69% between angiography, FFR, and SPECT.[14] As a result of an interesting study, sensitivity, specificity, and negative and positive predictive values of summed difference score (SDS) and summed stress score (SSS) as the main indices of SPECT for the detection ischemia, in comparison with FFR values lower than 0.75 in the target vessels, as the gold standard, were 80%, 76%, 53%, and 92%, respectively, and 70%, 93%, 78%, and 90%, respectively, in patients without prior myocardial infarction; and 57%, 50%, 67%, and 40%, respectively, and 100%, 50%, 78%, and 100%, respectively, in patients with prior myocardial infarction.[15] However, another study found a weak agreement between these two techniques with an agreement value of 0.14.[16]

In a comprehensive study, sensitivity and specificity were 77% (95% confidence interval [CI], 70–83%) and 77% (95% CI, 67–84%) for myocardial perfusion SPECT in comparison with FFR as a standard. Vessel-level pooled sensitivity was 66% (95%CI, 57–74%) and specificity was 81% (95%CI, 70–89%). The overall diagnostic performance of MPS was intermediate. The area under the summary receiver operating characteristic (sROC) curve was 0.83.[17]

Our study was a single center study and was relatively distinctive in its time; Myocardial Perfusion Imaging is a non-invasive modality; however, we enrolled only the patients who were fully agreed after comprehensive clarification of the study for them. So, it was inevitable that a part of our candidate patients were not included in the study. This Study could be as a pilot study and new window for future large and multicenter investigations which will reveal more detailed results. Moreover, appreciated clinical and systematic reviews could be published from results of several centers.

5. Conclusion

FFR and MPI with SPECT techniques showed significant concordance for detection of myocardial ischemia, regardless of the type of diseased coronary arteries. In this context, SPECT has high sensitivity and NPV for detection of ischemia compared with FFR. Studies with large sample size are recommended for future to show more detailed and obvious concordance.

Conflict of interest

The authors declare that they have no conflict of interest.

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