Diagnostic Accuracy Assessment of ST-Segment Displacements, Chest Pain and Stress Myocardial Perfusion Imaging Exercise Test in Coronary Stenosis Compared with Angiography Findings

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Abstract

Introduction- Nowadays, myocardial perfusion imaging (MPI) plays an important role in the early diagnosis of patients with coronary artery disease (CAD). This study sought to assess the performance of MPI alongside chest pain and ST-segment changes during the stress test by comparison with angiography in the diagnosis of coronary artery stenosis. To that end, the accuracy of these modalities in terms of sensitivity and specificity and the degree of greement between their results in the diagnosis of coronary artery stenosis were evaluated.

Methods and Materials- The study population, selected from those with known or suspected CAD, was comprised of 85 patients (67 males) at a mean age of 53.7 ± 9.6 years. All the patients were subjected to SPECT imaging of the blood supply to the heart muscle during a two-day state of stress (either pharmacologically with Dipyridamole or through exercise test) and during rest via the injection of 99m Tc - MIBI. ST-segment changes during stress as well as clinical symptoms were recorded. All the patients underwent coronary angiography within two weeks, and coronary artery stenosis >50% was considered positive. Finally, the results of chest pain, ECG changes, and MPI for the evaluation of coronary artery involvement were compared with those of angiography as the gold standard.

Results-Of the 85 patients, who underwent angiography, 10 patients had normal coronary angiography, 22 single-vessel disease, 28 two-vessel disease, and 25 three-vessel disease. ST-segment depression and ST-segment elevation were observed in 40 and 6 patients, respectively. The ECG had sensitivity of 57% and specificity of 70% in the diagnosis of coronary artery stenosis. Fifteen patients had chest pain during stress; all of them had coronary involvement according to angiography. Of the 70 patients with no chest pain, coronary angiography was positive in 62 cases; accordingly, chest pain had sensitivity of 20% and specificity of 100% in the diagnosis of coronary artery stenosis. There were 80 patients with abnormal MPI, including 387 fixed and reversible defects. Therefore, MPI had sensitivity of 79%, specificity of 70%, and diagnostic accuracy of 76% in the diagnosis of coronary artery stenosis.

Conclusion- MPI enjoyed higher diagnostic accuracy and agreement coefficient than did chest pain and ST-segment changes in the diagnosis of coronary artery stenosis.Given the acceptable results of MPI in the diagnosis of coronary artery stenosis, this modality could be valuable in the management of CAD patients ***(Iranian Heart Journal 2011; 12 (4):30-36*).**

Keywords: ST-segment changes■ Myocardial perfusion ■Chest Pain■ Coronary stenosis■ Angiography

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Coronary artery disease (CAD) is a major cause of death worldwide. CAD is a complex degenerative disease which gradually progresses with age. In America, the cardiovascular disease mortality is up to one million each year, half of which is due to ischemic heart disease caused by atherosclerosis [1-4]. Atherosclerosis reduces the diameter of coronary arteries and then reduces the myocardial perfusion[5]. Today, the cardiovascular disease mortality due to atherosclerosis has risen significantly, as attested to by the more precise assessment of risk factors via recent advances in diagnostic modalities [1-4]. Over the past two decades, the exercise stress test with myocardial perfusion imaging (MPI) has played an important role in the diagnosis of atherosclerosis disease. Single Photon Emission Computed Tomography (SPECT) depicts the three-dimensional distribution of radiopharmaceutical tracers in the body, and MPI is viewed in the reorientation and reconstruction of horizontal long-axis, vertical long-axis, and short-axis slices[8-6]. Several factors can affect MPI, including the type of the stress imaging test protocol, the time of imaging in relation to the radiotracer injection, and the interval between injection and imaging. MPI can be used for myocardial ischemia diagnosis, prognosis, risk stratification, and it can also evaluate the outcome of thrombolytic therapies such as percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass graft surgery (CABG)[9].

Several studies have assessed the accuracy of diagnostic procedures such as chest pain and ST-segment changes during stress testing in the diagnosis of CAD.[12-10]

Recent developments in computer technology and software for myocardial perfusion have led to advances in SPECT imaging. The present study sought to assess the diagnostic accuracy of myocardial perfusion scintigraphy in the non-invasive diagnosis of coronary artery stenosis and compare the results with angiography as the gold standard.

Materials and Methods

Patients

This clinical study included 85 patients (67 males and 18 females) at a mean age of 53.7 ± 9.6 years. The patients were selected from those with known or suspected CAD. All the patients had coronary angiography within 2 weeks. In this study, the exclusion criteria included all patients with myocardial perfusion images containing disturbing extra-cardiac activity and motion artefacts. The important clinical factors of the patients, including blood pressure, triglyceride, cholesterol, blood sugar, smoking, stress testing results, and angiography results, were recorded. The study was performed in the Nuclear Medicine and Molecular Imaging Department of Rajaei Cardiovascular, Medical and Research Center, affiliated with Tehran University of Medical Sciences. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all the patients.

SPECT imaging

SPECT imaging was acquired with DST Xli Sopha with double-head 90-degree and high-resolution, low-energy collimator. Detectors' rotation was 45 degrees right anterior-oblique (RAO) to 45 degrees left posterior-oblique (LPO) using detector rotation 180-degree orbit with the step and shoot mode. Symmetric 20% energy window with photo-peak at 140 keV of ^{99m}Tc was selected. Imaging matrix size was determined at 64 × 64 (pixel size = 0.66) and the magnification factor was 1.33. MPI SPECT was performed using a two-day stress (either pharmacologically with Dipyridamole or via exercise) and rest protocol for all the patients through the injection of 20 mCi ^{99m}Tc-MIBI. ST-segment changes during stress and clinical symptoms were registered. In this study, the indices of chest pain, ECG changes, and myocardial perfusion were compared to evaluate CAD. Angiographic findings were

employed as the gold standard for the assessment of coronary artery stenosis. All patients with stenosis ≥50% were considered positive.

Statistical analysis

The sampling method in the present study was convenience sampling of the patients with known or suspected CAD who were referred to our department for MPI or stress test, all within one year. Using the true positive, false positive, true negative, and false negative results of the diagnostic modalities, their respective sensitivity, specificity, and diagnostic accuracy were calculated. To investigate the agreement between the results of MPI, angiography, ECG, and chest pain, the Cohen kappa statistic using SPSS software was used.

Results

Of the 85 patients, 10 had normal coronary angiography, 22 had single-vessel disease (SVD), 28 two-vessel disease (2VD), and 25 three-vessel disease (3VD). ST-segment depression was detected in 40 patients, and 6 patients had ST-segment elevation. The ECG had sensitivity of 57% and specificity of 70% in the diagnosis of coronary artery stenosis.

Based on the results of coronary angiography, 15 patients had chest pain during stress, and 70 patients had no chest pain. Coronary angiography was positive in 62 cases. Chest pain had sensitivity of 20% and specificity of 100% in the diagnosis of coronary artery stenosis. Eighty patients had abnormal myocardial perfusion, including 387 fixed and reversible defects. Therefore, MPI had sensitivity of 79%, specificity of 70%, and diagnostic accuracy of 76% in the diagnosis of coronary artery stenosis. (Table I).

According to the polar map into three vascular territories, sensitivity and specificity were 91% and 47% for the left anterior descending (LAD) artery, 91% and 67% for the left circumflex (LCX) artery, and 80% and 69% for the right coronary artery (RCA) (Table II).

Table I. Demographic and clinical characteristics of patients in this study

	Data
Patient (n)	85
Sex (Male/Female)	67/18
Age (Years)	53.7 ± 9.6
Weight (kg)	72.7 ± 11
High (cm)	167 ± 8.4
Coronary Risk Factors, n (%)	
Diabetes (%)	14 (16.5)
Smoking (%)	24 (28.12)
Triglyceride (%)	21 (24.7)
Hypercholesterolemia (%)	22 (25.9)
Family (%)	10 (11.8)
Hypertension (%)	27 (31.18)
Angiography: (abnormal/normal)	75/10
Coronary disease:	
1-Vessel Disease (%)	22 (26)
2-Vessel Disease (%)	28 (33)
3-Vessel Disease (%)	25 (29)
LAD (%)	70 (82)
RCA (%)	40 (47)
LCX (%)	43 (51)
Stress Test:	
Exercise	54
Dipyridamole	31
CHEST PAIN (%)	
With Chest Pain In Stress (%)	15
Without Chest Pain In Stress (%)	70

The results of the evaluation showed that there was insignificant agreement between chest pain and the findings of angiography in the diagnosis of coronary artery stenosis. There was a significant coefficient of consistency between the ST- segment changes and MPI in the diagnosis of coronary artery stenosis compared with the results of angiography. MPI had a better agreement

(0.508) compared with the ST-segment changes (0.448).

Table II. Results of sensitivity, specificity and diagnostic accuracy of ST-segment, chest pain and MPI in the diagnosis of coronary artery stenosis

	Sensitivity	Specificity	Accuracy	Kappa	P Value
ST Segment Changes	57%	70%	54%	0.448	0.000
Chest Pain (%)	20%	100%	30%	0.056	NS
Myocardial Perfusion	91%	47%	83%	0.461	0.000
LAD	80%	70%	75%	0.485	0.000
RCA	67%	90%	71%	0.578	0.000
LCX					
Average	79%	70%	76%	0.508	-

Results of sensitivity, specificity, and diagnostic accuracy showed that despite the comparable specificity for the diagnosis of coronary artery stenosis, the diagnostic accuracy of MPI was higher in comparison with ST-segment changes. Table 2 shows the high sensitivity MPI (79%) compared with ST-segment changes (57%). With respect to the use of MPI in the diagnosis of coronary artery stenosis, the LCX had higher agreement than did the LAD and RCA, whereas it had less sensitivity, which resulted in lower accuracy (71% for the LCX, 75% for RCA and 83% for LAD compared with MPI) (Table II). Fig. A-1 and B-1, respectively, depict normal and abnormal myocardial perfusion images.

Discussion

Angiography as invasive method is the gold standard method for the determination of coronary artery stenosis. In the present study, angiography was performed according to the standard protocol within a two-week period after MPI. Of course this method has some limitations. The main purpose of this study was to assess the diagnostic accuracy and coefficient of agreement in MPI SPECT as a non-invasive method for the determination of coronary artery stenosis.

A

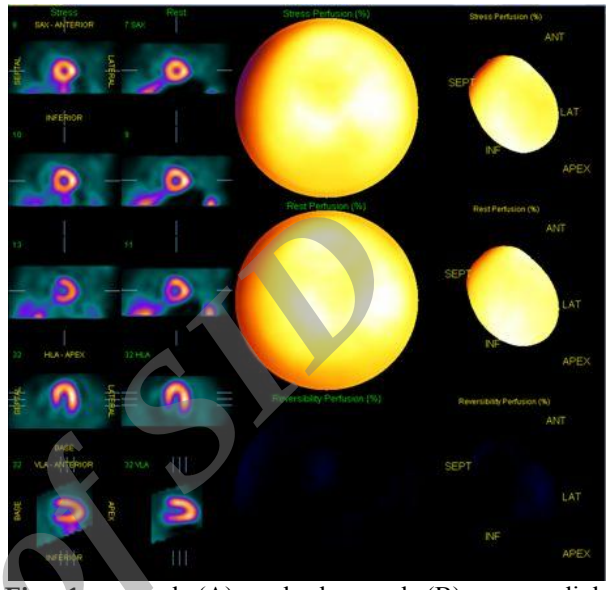
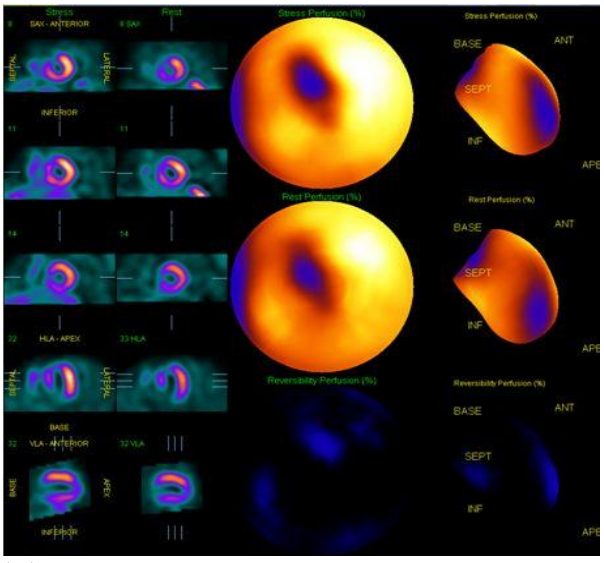


Fig. 1. normal (A) and abnormal (B) myocardial perfusion images.



(B)

Our results showed the sensitivity and specificity for the left anterior descending (LAD) artery were 91% and 47%, for the left circumflex (LCX) artery 91% and 67%, and for the right coronary artery (RCA) 80% and

69%, respectively; and the average sensitivity, specificity, and accuracy of MPI in the diagnosis of coronary artery stenosis were 79%, 70%, and 76%, respectively. Our case selection was not suitable to assess specificity because all the referred patients had a symptom and sign of ischemic heart disease. We know that some patients with a normal coronary have ischemic heart disease (IHD) such as endothelial dysfunction, coronary spasm, and insufficient coronary flow reserve. MPI is a sensitivity method for all IHD (with CAD and other causes of ischemia). On the other hand, our study was performed with a relatively old generation of the SPECT gamma camera and software. Today, new SPECT/CT gamma cameras with new software have more ability to determine the global and regional myocardial function (ejection fraction, end-diastole volume, end-systole volume, wall motion, wall thickness and thickening, phase analysis for assessment of dyssynchrony and quantitative perfusion defects such as sum stress score, and sum rest score).

However, some studies have shown different results. For example, in a study by Santoro et al. (1998) at the Institute of Cardiology in Italy on 235 patients, 95% sensitivity and specificity of 76% were reported[13]. In comparison with our results, although the sensitivity and specificity were higher, the difference in sensitivity is more noticeable. In another study, Elhendy et al. (2002) assessed the diagnostic accuracy of MPI dobutamine stress in 1208 patients with CAD: sensitivity, specificity, and accuracy were 85%, 72%, and 83%, respectively.[14] Giorgetti et al. (2007) evaluated the diagnostic accuracy of myocardial gated SPECT in 120 patients with CAD and reported that sensitivity, specificity and accuracy were 78%, 72%, and 80%, respectively. [15] Finally, Sato et al. in 2008 assessed the accuracy of the diagnosis of CAD over 70% using Coronary Angiography Computed Tomography (ACT) in comparison to MPI in 104 patients with CAD were respectively the sensitivity and specificity of 79%, 96% of CTA compared to 88% and 83%.[16] In the study of Shin and et al. (2009) on 368 patients with diagnostic accuracy of CAD 50% and 70% using by prone MPI were respectively the sensitivity and specificity of 88%, 61% in the stenosis of coronary artery 50% and 92 %, 55% in the stenosis of coronary artery over 70%.[18]

On the other hand, Castell Conesa et al. (1997) studied 149 patients with coronary artery stenosis greater than 50%. They considered the diagnostic accuracy of the scan separately in three coronary arteries. Their results showed that the scan sensitivity and specificity were 85% and 74% for the LAD, 79% and 85% for the RCA, and 45% and 96% for the LCX, respectively.[7] The Institute of Cardiology in Italy studied 235 patients with coronary artery stenosis greater than 50%. According to the type of the coronary artery separately, the sensitivity of the scans with the LAD was 71%, specificity 94%, sensitivity and specificity for the RCA 73% and 81%, sensitivity and specificity for the LCX 61% and 96%.[13] In addition, Elherdy et al. (2006) studied 88 female patients with coronary artery stenosis: the diagnostic accuracy of the scan separately in all the three coronary arteries was considered. Their results showed that the scan sensitivity, specificity, and accuracy for the LAD was 82%, 84% and 83%, for RCA 77%, 84% and 81%, for LCX 74%, 80% and 78% and the average sensitivity, specificity and accuracy of 78%, 82% and 81%, respectively.[17]

Regarding the results of other studies, our investigation had accurate and acceptable results. As was mentioned above, all the cases were suspected or known CAD.

One important piece of software in MPI is quantitative perfusion SPECT (QPS). Parsad et al. (2010) evaluated ischemic area via the Change method in 997 patients with QGS and the sensitivity, specificity and accuracy were 90%, 81% and 85%, respectively[19]. With respect to the MPI result with new software and machine, today, for more accurate findings we need to use validation software

such as Cedars QPS, QGS, Emorry Tool Bax, and 4DMSPECT. Fortunately, all of the new machines (SPECT/CT) and new pieces of software are available in our department.

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