Original

Investigation Myocardial Perfusion Scan Parameters and Walls Motion in Patients undergoing Cardiac Surgery

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ABSTRACT

Background: Coronary heart disease the most prevalent form of cardiovascular disease, results from the blockage of blood flow through arteries. The Myocardial Perfusion Scan (MPS) is considered a non-invasive method to assess the heart condition and provides valuable information, such as End Diastolic Volume (EDV), End Systolic Volume (ESV), Ejection Fraction (EF), Lung to Heart Ratio (LHR), and Transient Ischemic Dilatation (TID).

Objective: This study aimed to investigate changes in gated heart scan parameters to diagnose patients, who are candidates for heart surgery.

Material and Methods: In this descriptive cross-sectional study, 40 patients who are candidates for heart surgery were enrolled to evaluate the relation between the parameters of the gated heart scan and the amount of ischemic area of the heart. After scanning the patients, TID, ESV, LHR, and EF and also the movements of the heart walls are examined and analyzed in these patients.

Results: According to the results of the one-sample t-test showing a significant difference between the parameters, the results were within the normal range (*P*-value<0.0001). Additionally, all patients showed changes in cardiac output and wall movement issues.

Conclusion: The evaluation of Myocardial Perfusion Scan (MPS) and gated heart scan parameters can provide an effective method for diagnosing patients who may require heart surgery.

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Keywords

Cardiovascular Disease; Coronary Heart Disease; Myocardial Perfusion Imaging; Gated Heart Scan Parameters; Nuclear Medicine

Introduction

The most Common Cardiovascular Disease (CVD) is coronary heart disease, caused by the blockage of blood in the arteries due to the deposition of fat and cholesterol in the walls of the arteries [1]. CVD occurs when a patient has one or more of the signs, symptoms, or complications of an inadequate blood supply to the myocardium. The cause of this disease is often due to obstruction of the coronary arteries of the epicardium due to atherosclerosis [2]. In 2019, CVDs accounted for approximately 32% of all deaths, while heart attacks and strokes were responsible for 85% of those deaths.

Although conventional non-invasive diagnostic methods are widely used like Electrocardiogram (ECG) and cardiac biomarkers, false-negative results of these tests cause misdiagnosis of CVDs, especially acute myocardial infractions. During the last decades, the development of imaging facilities, such as acute rest Myocardial Perfusion Scan (MPS), stress echocardiography, Electron Beam Computerized Tomography (EBCT), cardiac Magnetic Resonance Imaging (MRI), and Multi-detector Computerized Tomography (MDCT) has enabled the cardiologists to diagnose and treat the cardiovascular diseases by the cardiovascular system [3, 4].

MPS, as a non-invasive type of nuclear scanning for diagnosing CADs, helps patients without a history of myocardial infarction (MI) and also assesses the amount of living, healthy tissue remaining in the heart muscle of elderly patients or those with a previous history of myocardial infarction [5].

However, in patients experiencing acute chest pain, traditional cardiac biomarkers may not be sufficient as they are time-dependent and may only rise several hours after myocyte necrosis, MPS can show abnormality during impaired myocardial perfusion caused by plaque rupture or coronary artery occlusion [6]. Additionally, myocardial viability, one of the crucial results of MPS, can determine the prognosis and type of treatment of patients with cardiac disease. Therefore, MPS is an optimal scanning method for ischemia or infarction diagnosis among patients at low-to-intermediate risk based on clinical and ECG findings [6].

To assess myocardial viability, MPS with nitrate-augmented Tc-99m sestamibi is a common and available method. Blood perfusion, cell membrane integrity, and membrane potential (mitochondrial function) are the markers of viability detected by the absorption and retention of sestamibi [7-9]. MPS is also done with the Gated method providing information on End Diastolic Volume (EDV), End Systolic Volume (ESV), Ejection Fraction (EF), Lung to Heart Ratio (LHR), and Transient Ischemic Dilatation (TID). Further, TID is a quantitative parameter in diagnosing patients with severe coronary artery stenosis and determining the prognosis of patients suspected of coronary artery stenosis [10,11].

Tillisch et al. reported that the viability is related to the contractile function recovery of the heart after coronary revascularization [12]. Gregoire et al. showed that MPS with Tc-99m had 96% sensitivity in myocardial ischemia detection compared to 35% sensitivity of ECG [13]. While various studies examine coronary artery circulation, Tc-99m MIBI is commonly used due to its faster blood clearance, reduced pulmonary and hepatic absorption, and ability to produce higher quality images [1, 14]. Hanoush et al. conducted a study to analyze the accuracy of prediction and diagnosis of cardiac perfusion imaging and its impact on patient management in a cardiovascular nuclear laboratory [15]. Fad et al. conducted a study on 64 patients to evaluate the value of myocardial perfusion imaging in distinguishing cardiomyopathy from the ischemic form of heart disease. This study also showed that the perfusion scan's sensitivity, specificity, and positive and negative predictive value were 94%, 94%, 96%, and 92%, respectively [16].

This study aimed to investigate the relationship between the numerical amount of the gated method parameters, such as EDV, ESV, EF, LHR, and TID, and the movements of the heart walls in patients enrolled in this study in comparison with a normal range.

Material and Methods

In this descriptive cross-sectional study, 40 patients were enrolled in the Nuclear Medicine Center, Namazi Hospital, Shiraz, Iran. The ethics committee of Shiraz University of Medical Sciences approved this study. The declaration of Helsinki was considered in all phases of the research, and written informed consent was obtained from the patients. The patients are included who underwent viability scans within one month after approval of the study. After scanning the patients, the parameters of the gated heart scan and the movements of the heart walls are examined and analyzed in these patients. The gated-method heart scan parameters, such as EF, ESV, EDV, and TID numerically displayed by the heart scan software (OASIS Nuclear Medicine Workstation overview). The patients were instructed to refrain from taking beta-blockers for 48 h, discontinue consumption of tea, coffee, and soft drinks 24 h prior to the test, fast for at least 4 h before the scan, and continue their medications (except methyl xanthines). The one-day stress-rest Tc-99m tetrofosmin protocol is used—symptom-limited treadmill exercise, or regadenoson 400 mcg IV, induced stress among patients. In the stress phase, the electrocardiogram, blood pressure, and heart rate are recorded at rest, and dipyridamole at an approximate dose of 0.56 mg/kg is injected intravenously within 4 min with ECG monitoring and 4 min after injection. ECG, blood pressure, and heart rate are re-recorded, and the signs and symptoms of patients and radiopharmaceuticals are prescribed. In the case of dipyridamole side effects, intravenous aminophylline is administered at an approximate dose of 100 mg. A weight-adjusted dose of Tc-99m tetrofosmin (250 to 400 MBq during stress and 750 to 1200 MBq at rest) was intravenously administered. The patients who had significant perfusion defects on the stress acquisition received sublingual glyceryl nitrate before rest injection to improve the assessment of viability.

Clinical signs, including chest pain, sweating, dyspnea, and palpitations are criteria for a positive dipyridamole test. It is important to note that dipyridamole alone, without ischemia, can cause these signs and symptoms as adverse effects. Therefore, the appearance of the mentioned symptoms in the interpretation of the test is valuable when it is accompanied by four types of electrocardiograph changes: a) the occurrence of cardiac arrhythmias (primarily ventricular arrhythmias), b) the development of new conduction disturbances, c) the emergence of ischemic T-wave in derivations that did not exist before, and d) ST segment changes are in the following three forms: ST elevation, Horizontal ST depression, and downward upsloping ST depression. It is worth noting that the patient's risk of developing IHD can be assessed based on the severity of electrocardiogram changes.

Statistical Analysis

After scanning the patients, the parameters of the Gated heart scan, namely, EDV, ESV, EF, LHR, and TID, which are numerically calculated by the software, and the movements of heart walls were examined and analyzed by OASIS workstation Software. The obtained data were analyzed using the SPSS software version 22.

Paired Student's t-test or Mann-Whitney U-test were used to compare stress and rest acquisitions. Categorical and original variables were reported as frequency (percentage).

Patients were grouped into ungated rest volume deciles to determine the upper limits of TID; the upper limits were then calculated within each group as mean+1.96 STD. Bartlett's test assessed the homogeneity of TID variance within each decile. The regression model of the TID upper limits and rest ungated volume association was determined using the Gauss-Newton method.

Results

This study was performed on 40 participants in Namazi Hospital, Shiraz, Iran. The demographic and contextual information of participants is shown in Tables 1 and 2. The mean and standard deviation of the age was 63.22±11.94 years. The results showed that the frequency of females and males was equal (50%, 20 subjects), and the mean and standard deviation of TID was 0.96±0.063, which was lower than the normal population. Furthermore, the mean and standard deviation of LHR was 1.03±1.30. According to the results, the frequency of hyper dynamic SV was 20 (50%). Moreover, differences in ejection fraction criterion among patients with heart failure are reported in Table 2. In the male patients, 35% have moderately abnormal EF. In the female patients, 25% have moderately abnormal, and 5% have severely abnormal EF, as shown in Table 2.

The One-Sample t-test showed a significant difference between TID, SV, LHR, and EF with normal ranges (according to *P*-value<0.0001), as shown in Table 3.

Discussion

Invasive coronary angiography is the gold

Table 1: Frequency distribution and mean and standard deviation of primary variables in participant

Variable		Mean±SD/N (%)
Age		63.22±11.94
Sex	Female	20(50%)
	Male	20(50%)
TID: Transient ischemic dilatation (Normal range 1.19-1.23)		0.96±0.063
SV (Stroke Volume)	Hyper dynamic=greater than 70%	20(50)
	Normal=50% to 70% (midpoint 60%)	4(10)
	Mild dysfunction=40% to 49% (midpoint 45%)	0
	Moderate dysfunction=30% to 39% (midpoint 35%)	16(40)
LHR: lung to heart ratio (Normal range More than 1.14)		1.03±1.30

SD: Standard Division

Table 2: Fraction Ejection criterion among the patients

Subject	Normal	Abnormal		
		Mild	Moderate	Severe
Male population (%)	2(10)	11(55)	7(35)	0
Female population (%)	2(10)	12(60)	5(25)	1(5)

Table 3: Difference between Transient Ischemic Dilatation (TID), Stroke Volume (SV), Lung to heart ratio (LHR), and Ejection Fraction (EF) with normal ranges in participant

Variable	Mean±SD	Mean Difference	T	*P*-Value
TID	0.96±0.63	-0.238	-23.92	0.0001
SV	90.08±15.60	25.07	10.16	0.0001
LHR	1.03±1.30	-0.36	-1.77	0.0001
EF	44.58±7.69	-15.42	-12.67	0.0001

TID: Transient Ischemic Dilatation, SV: Stroke Volume, LHR: Lung to Heart Ratio, EF: Ejection Fraction, SD: Standard Division standard for the diagnosis of CAD. However, guidelines recommend non-invasive imaging to select patients who need an invasive procedure [17, 18]. Gated myocardial perfusion SPECT is a highly sensitive MPS, used to detect coronary artery stenosis [19].

TID presence indicates widespread or severe coronary artery disease, due to extensive subendocardial ischemia [20]. There is only diastolic dysfunction in the early stages of CAD; however, in more advanced diseases, there is also systolic dysfunction (heart contractile dysfunction with LVEF ≤40 percent), resulting in hypotension, heart failure, and dangerous arrhythmias [21]. The difference between EDV and ESV is used to measure stroke volume. The main parameter of the left ventricular systolic function is the Left Ventricular Ejection Fraction (LVEF). The fraction of chamber volume ejected in systole (stroke volume) to the volume of blood in the ventricle at the end of diastole is referred to as LVEF. LVEF is calculated as follows [22].

$$LVEF = \left(\frac{SV}{EDV}\right) \times 100 \qquad (1)$$

A meta-analyze showed the diagnostic sensitivity and specificity of MPS scans were 87% and 73%, respectively [19].

A study among 90 patients under hemodialysis demonstrated that left ventricular mechanical dyssynchrony and perfusion scores assessed by SPECT were independent predictors of major adverse cardiac events [23].

Hage FG et al. [24] conducted a study of 246 ischemic cardiomyopathy patients to define the role of viability assessment by MPI on the management and outcome of the patients. They reported that in patients with a smaller area of nonviable myocardium, the survival after coronary revascularization was better, as a one percent increase in the size of nonviable myocardium was associated with a five percent increase in the risk of death. In addition, LVEF was an independent predictive factor of mortality as a one percent decrease in LVEF increased three percent of mortality risk [24].

In addition, myocardial viability is a factor considered when deciding whether to begin medical therapy or perform coronary revascularization [24]. Patients with viable myocardium typically have better outcomes with coronary revascularization compared to medical therapy. Conversely, there is no significant difference in outcomes between coronary revascularization and medical therapy for patients with nonviable myocardium [24-27].

In a study on 182 subjects, patients with significant myocardial viability had a lower risk of myocardial infarction, cardiac hospitalization, and cardiac death one year after coronary revascularization [28]. In contrast, Beanlands et al. showed that there was not any difference in outcome between patients who underwent viability assessment and those who did not [29]. According to the results obtained in this study, the importance of cardiac perfusion scans was well-defined in heart surgery candidates.

In this study, the values of important parameters, such as EF, TID, SV, and LHR were examined, and their values were significantly different from the normal range. Changes in cardiac output and wall movement problems were observed in all patients. Therefore, MPS is considered an effective method for patients with heart surgery candidates.

Correction of the TID parameter based on the difference in myocardial volume between the two stages of stress and rest can improve the prognostic value of this parameter to some extent and reduce false positives. This plan is necessary to evaluate the gate system and viability scan in patients who are candidates for heart surgery and to increase the surgeon's physiological information on heart tissue.

Significant limitations of cardiac perfusion scans are their dependency on the experience and accuracy of the person interpreting the movements of the walls and their thickness.

Conclusion

This study examined essential parameters, such as TID, SV, LHR, and EF, and their values significantly differed from the normal range. The results are justifiable considering the damage to the heart's vascular, muscular, and valvular tissues in patients with 2 or 3 vascular diseases and are candidates for heart surgery. Wall thickness and valvular problems are the main changes in left ventricular volume. Statistically, the changes in the studied parameters compared to the normal state of the heart were quite significant and warned of the need for immediate action.

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Authors' Contribution

MM. Movahedi was involved in the supervision, investigation, and editing of the manuscript. H. Aryanfar participated in methodology, data collection, analyses, and writing the manuscript. M. Atefi was involved in conceptualization, methodology, validation, and writing the manuscript. A. Tavakoli Golpaygani was involved in conceptualization and investigation. F. Gheisari participated in supervision and conceptualization. T. Mahmoudi was involved in the investigation, validation, and editing of the manuscript. All authors read the final version of the manuscript and approved it.

Ethical Approval

This study was approved by the Shiraz University of Medical Sciences Institutional Review Board (IRB) (IR.SUMS.MED.REC.1400.267) and followed the tenets of the Declaration of Helsinki.

Informed Consent

The declaration of Helsinki was considered in all phases of the research, and written informed consent was obtained from the patients.

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Conflict of Interest

None

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