Original Article

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Characterization of Heart Disease Using Radionuclide myocardial Perfusion Imaging

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Abstract

Background: The clinical utility of radiotracer study of heart in nuclear cardiology must be considered in the context of other cardiac diagnostic procedures. Accordingly. this study aimed is to determine the pattern of heart diseases detected by technetium Sestamibi (Tc^{99m}). **Subjects and Methods:** This study included Fifty patients 34 male (68%), 16 female (32%), age mean ± SD (57± 10 years) and ranged from 39-82 years, were referred for MPI were presenting as known or suspected ischemic heart disease , it was done in Elnilen diagnostic center nuclear medicine department. Each patient underwent Tc^{99m} -sestamibi studies, which were performed according to one day protocol. **Results:** Fifty patients were enrolled in the study, The results of this study revealed that EF , and weight as 54.16, 69.92 respectively**,** Distribution of Uptake and Viability of the patients, Poor Uptake (24%), Normal (40%), No (8%), Reduce (28%) and No (54%), Small(6%), Normal(40%)**,** SPECT images revealed ischemia of the apical, anteroapical, apicoseptal, and septal walls. Gated SPECT illustrated significant deterioration in the left ventricular ejection fraction (LVEF), in seven cases wall motion, and systolic wall thickening obtained with rest gated SPECT. **Conclusion:** The MPI has an excellent value to detect coronary stenosis, The diagnosis of coronary artery disease remains common application of MPI, but it is increasingly being used for the diagnosis of acute MI, risk stratification after infarction, and assessment of viable myocardium in patients with chronic coronary artery disease.

Keywords: Myocardial Perfusion Imaging (MPI); Myocardial viability; Radiopharmaceutical; Coronary artery disease; Diagnostic value; Imaging modalities; Single photon emission computed tomography (SPECT).

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Introduction

Myocardial perfusion imaging (MPI) using single-photon emission computer tomography (SPECT) commonly used).[1]

Cardiovascular disease is the leading cause of morbidity and mortality in different countries. The most common cause of Ischemic Heart Disease is narrowing of coronary arteries, a process called as atherosclerosis.[2] Chronic injury to vascular endothelium is caused mainly by a disturbance in the pattern of blood flow in certain parts of arterial trees, such as bending points and areas near branching vessels. Local shear forces, which are probably enhanced in hypertension, several factors including hypercholesterolemia, advanced glycation end products in diabetes (particularly insulin dependent, chemical irritants in tobacco smoke circulating vasoactive amines, immune complexes and infections may potentiate chronic endothelial injury leading to accumulation of lipids and monocytes (macrophages).[3]

Ischemic heart disease may present as silent or acute myocardial infarction, unstable angina, stable angina, non Q wave myocardial infarction, Q wave myocardial infarction or sudden death from ventricular fibrillation or cardiac failure. Acute myocardial infarction is most dreaded and cardiac arrhythmia is most dangerous complication of atherosclerotic narrowing of coronary arteries.[4] Recently Tc^{99m} agents including hexakis- isonitriles, boronic acid adducts and diphosphine (Tetrofosmin), sestamibi and teboroxime have been approved for clinical use in humans. Tc^{99m} tetrofosmin is a lyophilic, cationic diphosphine developed for myocardial perfusion imaging in humans.[5] Studies have shown that it has excellent early myocardial uptake and a relatively slow clearance (approximately 1% at 2 hours). This study focuses on the determination of the pattern of ischemic changes by technetium tetrofosmin.

Coronary artery disease (CAD) remains the leading cause of mortality and morbidity in Western countries.[6] Invasive coronary angiography is currently the gold standard for diagnosis and treatment of CAD; however, it is an invasive procedure associated with risks and complications.[7] Moreover, it is reported that around 20% to 40% of all diagnostic invasive coronary angiography procedures were performed for diagnostic purposes without any interventional procedures being applied.[8-10] Thus, investigation of less invasive imaging modalities is important for reducing or avoiding the use of invasive

coronary angiography examinations.[11]

Conventional noninvasive methods of evaluation of individuals with suspected CAD have relied on functional testing by an array of modalities, including exercise treadmill testing, stress echocardiography and myocardial perfusion imaging (MPI) with single-photon emission computed tomography (SPECT),[12] or positron emission tomography (PET).[13]

Myocardial perfusion imaging with SPECT is a widely established method for non-invasive evaluation of coronary artery stenosis.[14] However, the most important applications of SPECT are in the diagnosis of CAD, prediction of disease prognosis, selection of patients for revascularization and assessment of acute coronary syndromes. Moreover, SPECT holds special value in some particular patient subgroups.[15, 16]

Generally speaking, the sensitivity of stress SPECT for detecting angiographically -defined CAD is consistently above 70%, but in the better-designed studies, it is within the range of 85-90%.[17, 18]

Despite promising results reported in the literature[19, 20], the diagnostic value of SPECT and PET to detect CAD has not been well established. This is mainly because the diagnostic accuracy reported by

these studies is variable and the radiopharmaceuticals used in these studies are different.

The purpose of this study was to evaluate the value of SPECT in the diagnosis of heart diseases.

Subjects and Methods

Study Population

Fifty consecutive patients with suspected or known heart diseases,(34 males and 16 females)over a period of two years (December 2012 to December 2013) were enrolled in this study at Elnilen diagnostic center-nuclear medicine department. All cases underwent MPI.

The exclusion criteria

Were as follows: frequent premature beat, contraindications for the iodinated contrast agent, serious coronary calcification and motion artifacts affecting measures of stenosis. All patients gave formal written consent approved by our Institution Ethics Committee.

Gamma camera

(SIEMENS, MIE, SNTROM)accessory for the above model of Gamma camera, the specifications of which as follows:

1. Detector

All MIE Gamma Camera Systems consist of the same detector unit that is in use in the Siemens- or GE Gamma Camera System, and we claim substantial equivalence, The detector is consists of NaI(Tl) scintillation crystal with size of Large Field of View: 390 mm Narrow detector flange for close positioning Counterbalanced stand offers limitless positioning capabilities with wheelchairs, stress tables or gurneys.

finally, by one frame of 900 seconds, amounting to a total

2. Gantry

The Orbiter coupled with the SCINTRON IV computer is virtually a new system. All camera functions are controlled by a single workstation. This gantry optimizes space and minimizes service problems. Options include: A wide variety of collimators (any two are included), Whole body, and film format. An EPSON printer is standard.

3. Collimators

The above model of Gamma camera, can apply these types of collimators as follows: LEGP, LEHR, LEUHR, HEGP as shown in Figure [1].

Figure 1: A grey scale image of theanterio-posterior and transverse diameters measurementof the prostate gland (A-B is anterio-posteriordiameter and C-D is transverse diameter)

^{99}Mo-^{99}mTc Generator

(MONROL\A\TR\G41476EBZE-KOCAZL\ TURKY with initial activity 354 mci and 15gBq volume) used at the EL-NILINE nuclear medicine center.

MPI

1. Imaging Acquisition. All patients underwent electrocardiography-gated MPI protocol. Exercise stress/rest gated MPIs were performed on a SPECT scanner(Siemens).

Each patient underwent Tc^{99m} Sestamibi stress and rest studies. Tc^{99m} Sestamibi study was performed according to protocol which is as follows. The acquisition for stress gated-SPECT study was performed about one h after injection. Rest studies started acquisition about 1.5 h after injection by using the same amount of doses. The acquisition parameters were listed as follows: a low-energy, high-resolution collimator; a 20% symmetric window at 140 keV; a 64 × 64 matrix; an elliptic orbit with step-and-shoot acquisition at 6◦ intervals over 180◦ from the right anterior oblique 45◦ to left posterior oblique 45◦; 25 sd well time per stop. Acquisitions were gated as the follows:

Sequence of serially acquired images typically consists of 12 frames of 10 seconds each, followed by two frames of 30 seconds each, followed by one frame of 60 seconds, and,

acquisition time of 19 minutes.1–3 The final, 900-second

transaxial image data set is reoriented into short and long axis slices of the left ventricular myocardium Images will be obtained over a 180° orbit from the right anterior oblique 45° view to the left posterior oblique 45° view, using a dual-head, variable-angle gamma camera equipped with ultra-high-resolution collimators

Image Reconstruction and Interpretation.

All data were transferred to the workstation and reconstructed using an iterative reconstruction algorithm. Images were reconstructed into short axial, horizontal axial, and vertical long axial sections. At the same time, polar maps, wall motion, and wall thickening were obtained using a special software package. The left ventricular myocardium was divided into segments

The results of MPIs were divided into two categories: negative MPI, defined as having homogenous radioactive distributions in myocardium and no defective segments noticed for both stress and rest scans; positive MPI.

Left ventricular function

Some studies have demonstrated that gated SPECT evaluation of ejection fraction (EF), regional wall motion and wall thickening was accurate, and gated SPECT could be considered as an effective substitute modality of radionuclide ventriculography for the assessment of left ventricular function.

Statistical Analysis

Continuous data are expressed as mean ± SD. Student's *t*-test was used as appropriate to compare continuous data. Correlation between percent ^{99m}Tc-sestamibi activity and percent viable myocardium was performed by least-squares linear regression analysis.

Results

Baseline Characteristics

The objective of this part of study is to determine the pattern of heart diseases detected by technetium Sestamibi (Tc^{99m}).

Baseline Characteristics: 50 patients (34 men, 16women; mean age, 57± 10 years) were enrolled in the study, The mean of the age, EF, and weight as 57.08, 54.16, 69.92 respectively [Table 1].

Table 1: Patient characteristics, age, EF, weight

Statistics	Age	EF	WT
Mean	57.08	54.16	69.92
Median	55.00	62.00	71.00
Std. Deviation	10.27	23.68	8.09
Range	43	85	45
Minimum	39	15	50
Maximum	82	100	95

EF stands for ejection fraction, WT stands for weight

Table 2: Distribution of perfusion of patients

IHD	Frequency	Percentages%
Positive	19	38
Negative	31	62
Total	50	100

Table 3: Distribution of Uptake and Viability of the patients

Distribution of Uptake	Frequency	%	Viability	Frequency	%
Poor Uptake	12	24	No	27	54
Normal	20	40	Small	3	6
No	4	8	Normal	20	40
Reduce	14	28			

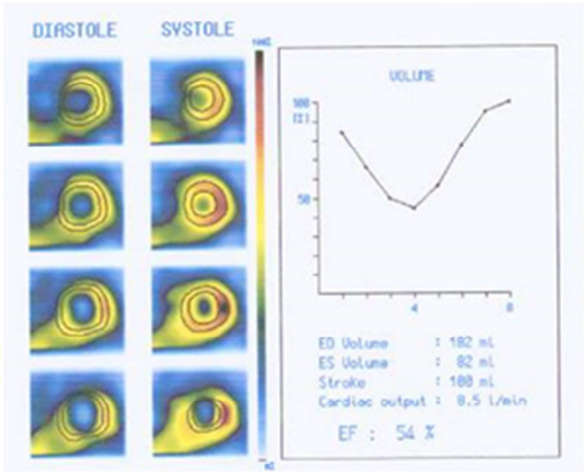

Figure 2: Figure (2) SPECT MPI study at rest showedmarkedly reduced uptake at the apex, mid anterior wall, mid anterior septum,Quantification of EF, regional myocardial wall motion, and thickening from gated myocardial perfusion.) Myocardial contours displayingendocardial and epicardial surfaces overlying end-diastolic (ED) and end-systolic (ES) frames display short-axis images

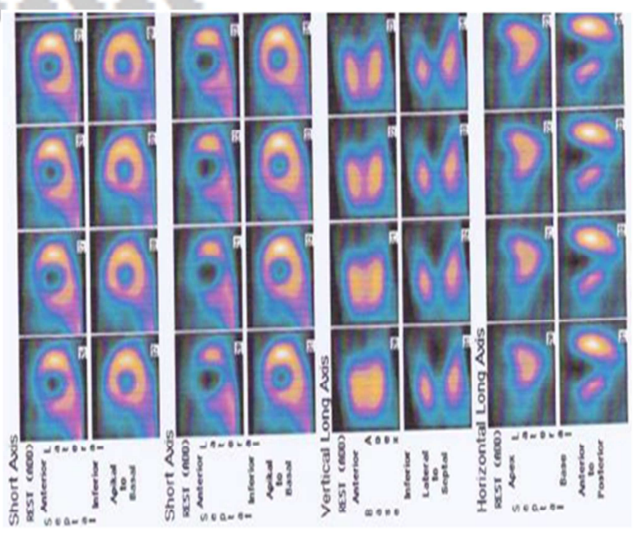

Figure 3: Figure (3). Left ventricular wall motion and systolic function can be analyzed with an ECG-gated study. EDV, ESV, and EF are calculated and displayed (circled)

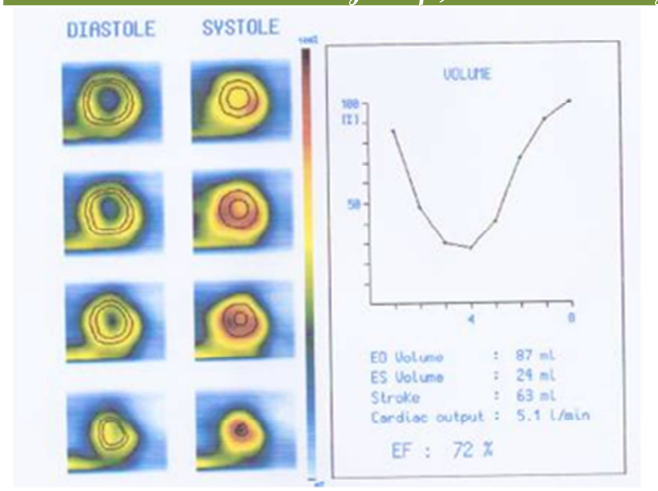

Figure 4: SPECT MPI study at stress showed no significant reduction in tracer uptake at maximum hyperemia.

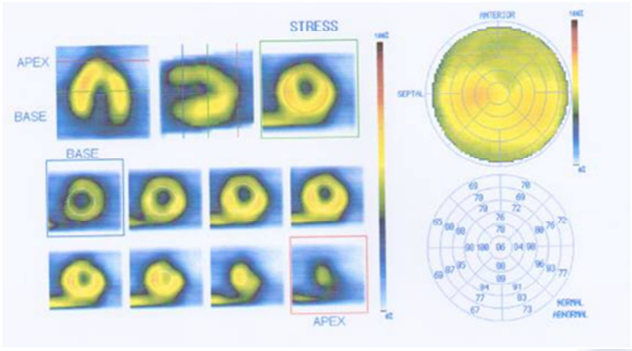

Figure 5: Gated SPECT showed good contractility at all segments.

Discussion

Assessment of myocardial viability in patients with coronary artery disease and depressed left ventricular function plays an important role in the decision to refer these patients for coronary revascularization. Earlier studies suggested that ^{99m}Tc-sestamibi was not a good viability agent.[24,25] However, a substantial body of evidence now indicates that ^{99m}Tc-sestamibi may also be a good viability marker.[21-23] Also, experimental studies have shown that mitochondrial function and sarcolemmal integrity are crucial for the uptake and retention of ^{99m}Tc-sestamibi,[26-28] thus establishing a link between the tracer kinetics, preserved myocardial metabolism, and myocyte viability.

The study was undertaken to determine the pattern of perfusion defects in ischemic heart disease patients. Imaging was done using SestamibiTc^{99m} in patients suffering from heart disease. Myocardial perfusion scans can localize the obstructed coronary vessel(s) via localizing the extent of the heart muscle area with reduced blood flow. It also provides information about the heart's pumping function, and identify areas of the heart muscle that are scarred from a heart attack.

Fifty patients were enrolled in the study, The results of this study revealed that ejection fraction (EF) , and weight as 54.16, 69.92 respectively [Table 1], Distribution of perfusion of patients, Negative (62%) [Table 2], Distribution of Uptake and Viability of the patients, Poor Uptake (24%), Normal (40%), No (8%), Reduce (28%) and No (54%), Small (6%), Normal (40%), [Table 3], SPECT images revealed ischemia of the apical, anteroapical, apicoseptal, and septal walls. Gated SPECT illustrated significant deterioration in the left ventricular ejection fraction (LVEF), in seven cases wall motion, and systolic wall thickening obtained with rest gated SPECT.

In the study by Xiang et al, perfusion abnormalities were seen in myocardial segments corresponding to 25 vascular territories of a total of 51 vessels with 50% luminal narrowing in 22 patients (sensitivity 49%), whereas increased ^{18}FDG uptake was seen in 34 vascular territories (sensitivity 67%, P=0.008).[29]

Another study by Samady et al. demonstrated the significant correlation between Tc^{99m} uptake at rest and unipolar voltage and normalized unipolar voltage for all myocardial segments.[30] Current nuclear techniques appear to be highly sensitive for the detection of myocardial viability in a synergic myocardium.[31]

This study revealed that an excellent ability of MPI using SPECT for detecting cardiac diseases [Figures 2-5]. In all patients with flow-limiting coronary stenosis (i.e., stenosis that were associated with myocardial ischemia as evidenced by MPI) this method help providers more fully incorporate clinical evidence into their decision-making process.

A shortcoming of our study was the limited number of study participants.

Conclusion

Ischemia and defects were more common in an inferior wall and fixed the defect in a left ventricular apex. Current myocardial perfusion imaging agents appear to be highly sensitive for the detection of myocardial viability in a synergic myocardium.

This study recommended that the combined non-invasive approach with CTA and MPI in patients with known or suspected CAD has an excellent accuracy to detect flow-limiting coronary stenoses compared with the gold standard of QCA combined with MPI and may be used as a gatekeeper for CA and revascularization procedures.

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