Original Research Article

Comparison of five different modalities in diagnosis of coronary artery disease

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Abstract: This is a hospital based study comparing the five most common diagnostic modalities for coronary artery disease, ECG, ETT, Rest and Stress Echo, 99mTc-MIBI, and Angiography, taking Angiography as the gold standard. Seventeen patients were included in the study, 16 were males and one was female. In each patient, corresponding resting and stress ^{99m}Tc-MIBI images were evaluated for direct comparison. Data analysis was done qualitatively (visual analysis) by three independent nuclear physicians (1). Echocardiography and angiography were performed and analyzed by a cardiologist. (2). Place of Study: Nuclear Medicine, Oncology, and Radiotherapy Institute (NORI), Islam Abad, Pakistan. (3). ECG sensitivity was found to be relatively low (60%) compared to the others. Echo sensitivity was 82.4%. Stress induced a significant improvement in sensitivity of both ECG and Echo. 99mTc-MIBI sensitivity and specificity obtained were comparable to those of Angiography. In addition, the localization ability for diseased coronary arteries by the different modalities was also investigated in which ECG and Echo showed fair results for localization of LAD problems, average results for RCA and poor results for LCx. 99mTc-MIBI showed good results for LAD, excellent results for RCA, and below average results for LCx artery diseases.

Keywords: Nuclear Medicine, Oncology, Radiotherapy Institute, Exercise Tolerance Test, Coronary Artery Disease, Left Anterior Descending Artery, Right Coronary Artery , Left Circumflex Artery

INTRODUCTION

Coronary artery disease (CAD) is a leading cause of death in both developing and developed countries [1, 2]. The first description of the symptoms of coronary artery disease was written in 1768 by William Heber den, an English physician. Dr. Heber den coined the term "angina pectoris''—from the Latin, angere, which means to strangle or distress, and pectoris, "of the chest''—and his classic description still holds true today.

It is important to choose the most suitable diagnostic modality in the specific patient to save time lapse to intervention. There are many tests in use for the diagnosis of CAD and each of them has different merits. The purpose of this study was to study and compare five of the most commonly used investigation modalities in diagnosis of CAD, that were, ECG, ETT, Angiography, Rest and Stress Echo and ^{99m}Tc-MIBI.

Most centers prefer physical exercise for stress in myocardial perfusion imaging but people who are unable to tolerate an exercise test because of orthopedic problems or impaired leg circulation can be effectively tested using 99mTc-MIBI combined with coronary vasodilators such as dipyridamole (Presenting). Dipyridamole causes the coronary arteries to dilate (as they should to satisfy the increased demand for oxygenated blood created by exertion) and thus increases the blood flow. If there are blockages in an artery, the increase of flow does not occur and a "cold spot" is imaged. This test compares favorably with exercise 99mTc-MIBI imaging. Another diagnostic tool, multigated acquisition scans (MUGA), which uses the radioisotope technetium as well, can also provide information on the size and contraction pattern of the left ventricle. Contraction abnormalities that are induced by exercise can indicate coronary artery disease. Ischemic or infarcted (dead, due to a heart attack) regions of the heart usually contract abnormally.

Portions of the heart can be seen using echocardiography. The echocardiogram is a useful diagnostic tool for determining impaired function and increased thickness of the walls of the left ventricle as well as for helping to rule out other cardiac problems such as valve disease. As with the MUGA, abnormalities in ventricular contraction (wall motion abnormalities) can be documented by the echocardiogram during exercise or pharmacologic

stimulation. An electrocardiogram [ECG] and other tests suggest that a patient risks damage to a considerable portion of the heart muscle (for example, the patient who has marked ECG changes after only a few minutes of a stress test). Certain severe anatomic subsets of coronary artery disease (as shown using coronary angiography) are better treated with coronary bypass surgery.

In third world countries with a few health infrastructure, all these modalities are not available up to now , and also there was not rich literature delivered from third world regarding the CAD, so this study seem to be an effort that will contribute to this field of science.

MATERIALS AND METHODS

Seventeen patients were included in the study, 16 were males and one was female. All patients were having anginal symptoms and 6 of them required admission in intensive care units (ICU). All patients were referred to NORI from cardiology departments of different hospitals for stress/rest ^{99m}Tc-MIBI myocardial perfusion study. All patients referred for myocardial perfusion scintigraphy were included in the study. Patients who were diagnosed to be having CAD were referred for angiography.

Patient Preparation:

Patients fasted for 6 hours at least, to minimize gall bladder activity. They stopped cardiac medications like, beta blockers, nitrates, ACE inhibitors, etc., for an average of 24 hours (patients on long acting beta blockers were instructed to stop medication 24-48 hours before the test).

Protocols

Two days stress/rest study was performed in which exercise was according to modified Bruce protocol with bicycle ergometer. Dose range was 555-740 MBqs for each study. Single head, SOPHA camera with SPECT facility was used for imaging all patients under the same protocol. Multiple displays were used for subjective visual analysis. Echocardiograms were taken by a cardiologist before commencement of exercise and at its peak. Patients were ambulatory and remain in resting state for 30 minutes before imaging.

Data Analysis

In each patient, corresponding resting and stress ^{99m}Tc-MIBI images were evaluated for direct comparison.

Data analysis was done qualitatively (visual analysis) by three independent nuclear physicians.

Echocardiography was performed and analyzed by a cardiologist.

For analysis of angiography, the enclosed report from the cardiologist was used.in add to that Microsoft EXCEL was used in data analysis purpose.

RESULTS

A total of 17 patients were included in the study, 16 were males and one was female. Minimum and maximum ages were 33 and 65 years respectively with a mean age of 47.76 ± 6.91. There were two normal individuals (11.76%) and 15 abnormal ones (88.24%). Out of the 15 abnormal cases, 12 (80%) were smokers, 7 (46.67%) were hypertensives, and 3 (20%) were diabetics table 1.

Table 1: Values of statistical parameters for the different modalities

parameter	ECG(Rest)	ETT	ECHO	^{99m}Tc-MIBI	ANGIO
SENSITIVITY	60.0%	73.3%	82.4%	100%	100%
SPECIFICITY	100%	100%	100%	100%	100%
PVPT	1	1	1	1	1
PVNT	0.25	0.33	0.67	1	1

PVPT = predictive value of the positive test
PVNT = predictive value of the negative test
ETT = Exercise tolerance test
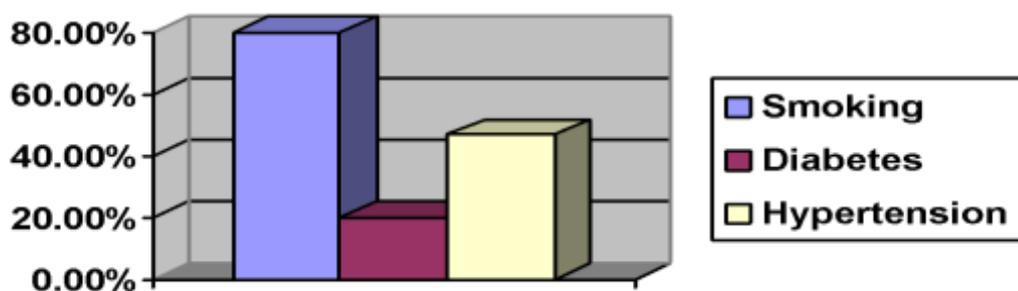
Fig. 1: Percentage of risk factors among patients

Electrocardiography (ECG) and Exercise Tolerance Test (ETT):

In comparison between stress and rest ECG findings, it was noticed that there was increase in diagnostic sensitivity caused by exercise.

Echocardiography

It was noticed that exercise induced a significant change in ejection fraction and fraction shortening, but the change in the other echo parameters was less significant.
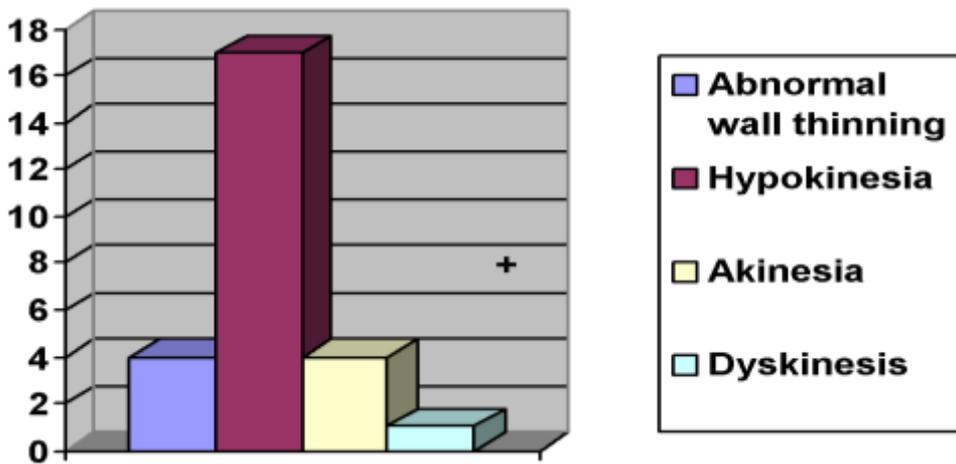

Fig-2: Percentage of occurrence of different Echo. Abnormalities

^{99m}Tc- Sestamibi

Table 1 showed the results of patients undergoing ^{99m}Tc- Sestamibi SPECT scan, and its sensitivity, specificity, and predictive values. It can be noticed easily that these results are the same as results of angiography.

Coronary Angiography

It was taken as a gold standard for all other tests. Table 2 shows the data of patients concerning number of vessels involved in each patient and the percentage of each category,
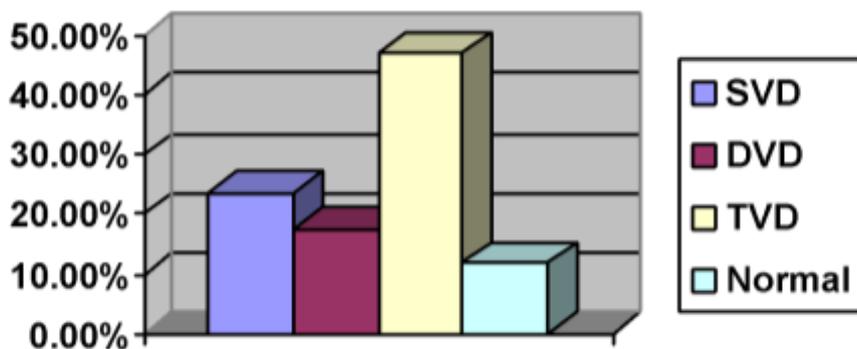

Fig-3: Percentage of number of vessels involved.

Table 2: Percentage localization ability

Artery Diseased	ECG	Echocardiography	^{m}Tc-MIBI^{99}	Angiography
LAD	%61.54 (13/8)	%53.85 (13/7)	%84.62 (13/11)	%100 (12/12)
LCx	36.36 (11/4)	%18.18 (11/2)	%45.45 (11/5)	%100 (11/11)
RCA	%50 (10/5)	%50 (10/5)	%100 (10/10)	%100 (10/10)

DISCUSSION

Each of the five investigation modalities tested was proved to have advantages as well as disadvantages and thus they differ in importance according to the magnitude of benefit that can be achieved from each.

ECG

From our study results, it can be noticed that resting ECG sensitivity is relatively low (66.6%) as compared with the other test techniques. This is quite consistent with the finding that, resting ECG can be normal in patients with angina due to coronary heart disease (one, two, or even three vessel coronary involvement) [6]. Even patients with a history of severe angina may show ST-T abnormalities only during chest pain, and in this study most of our patients did not present with chest pain. Also the abnormal Q-waves indicating prior myocardial infarction may attenuate or even disappear over time [7].

The specificity and predictive value of positive ECG (table 1) came to be very high (100%) and 1 respectively, and that is apparently unrealistic which could be attributed to the small number of normal cases (only two) which is discussed further below. But the predictive value of negative ECG came to be low (0.25), which can be predicted from the discussion above about its relatively low sensitivity especially in the patients not presenting with chest pain.

When comparing with the other test techniques, one can notice that ECG is relatively cheaper than the others in addition to that it can have a prognostic value.

Localization of an infarct by ECG (anterior Vs. inferior), correlates well with localization of lesions in a particular coronary artery by angiography (LAD Vs RCA) (table 3).

It was found that the differential localization ability of ECG is better for ischemic or infarcted areas supplied by LAD (table 3) more than the other two arteries, and this could be related to the proximity of anterior and septal walls of left ventricular myocardium to the ECG leads, and therefore they are easily influenced by any problem arising in those two walls. All patients with ECG evidence of MI has been found to have more than one coronary artery involvement.

Exercise Tolerance Test (ETT):

The diagnostic aim of stress testing is to induce a controlled, temporary ischemic state, under clinical and ECG observation.

It was noticed from the study that exercise testing increased the diagnostic sensitivity of ECG, and (to some extent) echocardiography through induction of myocardial ischemia, an abnormal ejection fraction, or an abnormal fraction shortening.

The test showed a sensitivity of 75% for diagnosis of CAD, which is relatively good and could be regarded as an indication of success of the Bruce protocol and its suitability to the patient population tested.

Its specificity value came to be 100% which is an unrealistically high value, but that is attributable to the small number of normal cases (only two). Because all of the patients were referred to the angiography department after they underwent the other test modalities and proved to be abnormal, with the exception of those two normal cases who underwent coronary angiography because of that; one of them had an stent operation to dilate his stenosed coronary artery, and was referred for confirmation of operation success and adequacy of coronary circulation, and the other was a hospital officer from the high risk group, diabetic, hypertensive, and a heavy smoker, and was referred for confirmation or exclusion of CAD after an attack of chest pain.

The predictive value of positive test was high (table1), and that was because of the fact; the study was a hospital-based and almost all of patients included in the study were diseased (only two normal cases), and therefore there was a very high chance for any tested positive patient to be from the diseased group. But the predictive value of a negative test was found to be low (0.25), and that is true for the same reasons discussed above if we considered the reversed relation between the two formulae.

Echocardiography

The sensitivity for CAD detection with echocardiography came to be (82.4%) (Table 1), which is good and within the range reported in the texts of 75%-85% [13-17]. But the specificity came to be very high (100%) which is clinically unrealistic and higher than specificity in previous studies which was reported to be in the 90% range [13-17].

This variation could be attributed to that; there were only two normal patients according to which the specificity was calculated. Also the decision to have these patients undergo angiography was influenced by abnormal results on their nuclear cardiology studies, and there were many additional patients with normal nuclear cardiology studies who did not undergo coronary angiography and were therefore not included in the estimates of specificity.

It was observed from study results that there is some correlation between wall motion abnormality (WMA) detected by echocardiography and perfusion defects detected by ^{99m}Tc-MIBI in most cases, in that the WMA coincides with one or more of the defects that were detected by ^{99m}Tc-MIBI radionuclide study for the same patient. Thus echocardiography appeared to underestimate the actual abnormality.

⁹⁹ᵐTc-MIBI

Sensitivity of rest/ stress ⁹⁹ᵐTc-MIBI in detection of CAD, was found to be 100% which may be a bit higher than what is reported (about 90%) by Maddahi [Maddahi *et al.;* Am J Cardiology.1990], but that could be due to the relatively small study population.

Specificity was also found to be much higher (100%) than the value reported by Maddahi in the study mentioned (about 80%), and that was due to the same reasons mentioned above (for ETT).

The predictive value of a positive test was found to be high, and that was a good result if we considered the relatively small study population and therefore, causes of false positive results have little chance to appear. Also the predictive value of a negative test was found to be good.

Localization ability for area supplied by the stenosed vessel was found to be good especially for right coronary artery and left anterior descending artery, 100% and 82% respectively. But its localization ability for stenosed left circumflex territory was found to be less (only about 45%), and we couldn't find an explanation for that.

The advantage of rest/stress ⁹⁹ᵐTc-MIBI imaging over the others is that it is relatively cheap, less invasive than angiography, and has a superior sensitivity over echocardiography, ECG, and ETT. Its drawbacks are that it is less specific i.e. it cannot differentiate the new from old infarction or scarred and fibrotic tissue. Also the radiation dose the patient receives although small it should be put into consideration. Generally ⁹⁹ᵐTc-MIBI in this study showed excellent results, and comparatively was proved to be the first diagnostic choice in many aspects.

Coronary Angiography

In our study coronary angiography was taken as the gold standard and the last investigation line after the patient had undergone all the other tests. And this might be the cause of our relatively small study population due to its high cost and the risk of complications.

LAD was found to have the most frequent involvement which agrees well with the known information found in texts [4]. The coronary angiography is apparently has the highest sensitivity and specificity in diagnosis of CAD, but its high cost, invasiveness, radiation dose, and risk of complications lead to the relatively less use of this valuable test.

CONCLUSION

Each of the five modalities studied, has its own advantages and disadvantages. Resting ECG remains the most simple and cheap but its sensitivity although good, was less than that of the other four. Especially it was less sensitive in between the ischemic attacks. Also its localization ability is less dependable in areas other than anterior wall and septum. ETT increased the diagnostic accuracy of ECG but its role in echocardiography was less marked. Echocardiography although the safest, less invasive, and relatively showed good results, but these results were inferior to both 99mTc-MIBI and coronary angiography, having a large margin of personal error, and also it had many limitations especially with stress echo. 99mTc-MIBI showed excellent results that were identical to the results of coronary angiography. Its localization ability for stenosed or occluded artery tributaries was good and comparable with coronary angiography concerning LAD and RCA especially with the latter for which it was 100% sensitive, but its localization results for stenosed LCx was not up to the mark. Its drawbacks were its inability to distinguish between new and old infarction, scar or fibrosis. Also the radiation hazard although minimal but must be taken into consideration. Coronary angiography was taken as a gold standard, and although no mortality or other complication related to it was reported, but its high cost was the main drawback that lead to the relatively limited number of our study population. Smoking as expected showed strong correlation with CAD incidence.

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