REVIEW ARTICLE

# STRESS TESTING IS AN IMPORTANT DIAGNOSTIC TOOL IN DETECTING CORONARY ARTERY DISEASE

**Muhammad Inam Qureshi[1], Afzal Qasim[2], Darshan Kumar[2], Muhammad Umar Khan[2]**

[1]Karachi Institute of Heart Disease, Karachi and [2]Dow International Medical College, Dow University Health Sciences, OJHA Campus, Karachi, Pakistan

## ABSTRACT

Among many other causes of death, cardiovascular disease is the most common cause of death in developing countries including Pakistan. Management strategies for cardiovascular disease are constantly developing. These strategies are becoming more and more complicated so physicians should pay attention that they are using suitable diagnostic measures to optimize patient care for example, as progress in the development of effectual methods of myocardial revascularization leads to more minimally invasive and noninvasive procedures, there is a greater need to estimate the possibility of a patient having coronary artery disease by means of noninvasive cardiac testing. Stress testing is a time tested and noninvasive diagnostic technique which plays an important role in the investigation of coronary artery disease. The present piece of work reviews the use of stress testing in the assessment of patients with suspected ischemic heart disease, including the use of risk factor analysis to assess a patient's candidature for noninvasive testing. The indispensable methodology of performing a stress test is reviewed.

**KEY WORDS:** Myocardial Revascularization; Stress testing; Coronary Artery ; Coronary Artery Disease.

**This article may be cited as:** Qureshi MI, Qasim A, Kumar D, Khan MU. Stress testing is an important diagnostic tool in detecting coronary artery disease. Gomal J Med Sci 2015; 13: 193-6.

## INTRODUCTION

There is no doubt in this fact that coronary artery disease (CAD) is the major single cause of death both in developed and developing countries including Pakistan.[1] while it is also worldwide fact that patients with coronary artery disease are not a uniform cluster so they must be considered individually. They differ very much in their clinical status including extent of coronary artery disease, left ventricular dysfunction, potential for myocardial ischemia, and presence of cardiac arrhythmias.[2] Some of the patients with coronary artery disease have had prior cardiac events like myocardial infarction, cardiac arrest or treatments for example coronary artery bypass graft surgery, percutaneous transluminal coronary angioplasty, or other coronary artery interventions. Many patients have additional medical disorders including hypertension, peripheral vascular disease, valvular heart disease, chronic obstructive pulmonary disease, and diabetes mellitus.[3] Increased levels of low-density lipoprotein (LDL) cholesterol and depressed levels of high-density lipoprotein (HDL) cholesterol are key risk factors for the development of coronary artery disease. Exercise stress testing has received much attentionin recent years with the principal focus of interest beingits predictive power.[4] Among asymptomatic individuals,those with an abnormal ECG response during exercise have a substantially higher risk of developing manifest coronary heart disease than those with a normal ECG response. Exercise testing is now used almost routinely by many as apart of the evaluation of patients with angina pectoris or chest pain thought to represent angina, before cardiac catheterization and coronary angiography. These data provide a new opportunity to examine the relation between exercise parameters, singly or in combination, and the angiographic findings.[5] They also provide an opportunity to examine the prognostic value of exercise parameters inpatients with known and quantified anatomic disease of thecoronary arteries. The best screening test for CAD depends on a patient's probability for CAD, ECG findings, and exercise capacity.[2] Patients with low probability of CAD can be managed by diagnosing and treating noncardiac causes of chest pain. If diagnostic testing is desired in low-risk individuals, Exercise stress test is a reasonable choice since it is cost-effective and noninvasive. The addition of cardiac imaging lends incremental insight for detection of CAD, most markedly for patients at intermediate probability for CAD.[6] Exercise or dobutamine stress

**Corresponding Author:**
Dr. Muhammad Inam Qureshi
Assistant Professor of Cardiology
Karachi Institute of Heart Disease (KIHD)
Karachi, Pakistan
E-mail: danishin101@gmail.com

echocardiography may be a good compromise of sensitivity and specificity for CAD, and is cost-effective by usual medical economic analysis.[7]

## DISCUSSION

Usually the chest pain allied with myocardial ischemia is linked with exercise which is retrosternal or left parasternal in location and this pain radiates to the left shoulder or arm which can be resolves with nitroglycerin or rest.[7] If a patient has chest pain then it is the first step in establishing the diagnosis. A comprehensive history including the estimation of coronary risk factors may allow a physician to stratify patients with chest pain into levels of low, intermediate, or high likelihood of having obstructive CAD.[2,3] This knowledge of physician will help him in suggesting that what type of diagnostic test is suitable for a particular patient.

Smoking, hypertension, hyperlipidemia, diabetes mellitus, family history of premature coronary artery disease and physical inactivity are well known major cardiac risk factors.[4] The presence of chest pain is distinguishing feature of myocardial ischemia and if the patient has three or more major cardiac risk factors suggest the high prospect of CAD in a patient while pain with one or two risk factors decreases that chance to intermediate and the absence of risk factors in a patient with characteristic chest pain decreases the likelihood of CAD to low.[8] Charisma of unusual chest pain in a patient with or without risk factors generally represents low to low-intermediate possibility for the existence of significant CAD.[9] It is a common observation that noninvasive cardiac testing plays an important role in evaluating a patient for CAD and for referral for coronary angiography.[5-7] But it is most important that the perception of pretest possibility should be kept in mind when interpreting the results of noninvasive testing. It is found in literature that the most precise and correct results of noninvasive testing are obtained in patients with intermediate possibility of having significant coronary artery disease based on history and risk-factor evaluation.[10] In patients with low pretest possibility, the number of false-positive results on noninvasive testing tends to be higher. In patients with high pretest possibility the number of false-negative results may be higher. Patients with high pretest possibility should consequently go through coronary angiography yet with a negative result on noninvasive testing.[11] Patients with low pretest possibility may not have to go through cardiac stress testing unless symptoms become progressive.[6-8]

The unique type of noninvasive cardiac testing is exercise stress testing with electrocardiogram (ECG) monitoring which is extensively used and is very suitable for patients as it is frequently performed in the office of cardiologist.[12] Following are the indications and appropriate clinical settings for this form of testing. a) Patient has chest pain and an intermediate pretest possibility of CAD. b) Patient previously evaluated and has possible or known CAD or but has a change in clinical status. c) Patient has persistent symptoms of ischemia after revascularization. d) Patient has known or suspected exercise-induced arrhythmias For evaluation of medical therapy and assessment of prognosis in post-MI patients who do not have hypotension or recurrent chest pain (symptom limited at 2-3 weeks or at 4-7 days followed by symptom limited at 3-6 weeks) For identification of suitable settings in patients with rate adaptive pacemakers. The process of exercise stress testing can be accomplished by either treadmill or cycle ergometry but the fact is that treadmills are mostly used.[13] It must be noted that there are a number of standard treadmill protocols that can be tailored for patients to reach the endpoint of 85% to 100% maximum predicted heart rate while the Bruce protocol is most widely used and popular.[12] This protocol consists of a maximum of eight 3-minute stages with incremental increases in speed and incline.[9] Highest predicted heart rate is calculated by subtracting the patient's age from the number 220 and exercise capacity is then reported in minutes or sometimes in estimated metabolic equivalents of oxygen consumption (METs). METs imitate the actual metabolic disbursement during exercise and can be compared among different patient populations. A test is considered sufficient if at least 6 METs have been achieved.[13] The patient is constantly monitored through ECG while heart rate and blood pressure are strictly observed.The exercise testing is stopped when the patient reaches the target heart rate (a percentage of the predicted maximum heart rate) b) or develop symptoms c) develop significant ECG changes.

All those patients with positive results of stress testing are frequently suggested to undergo coronary angiography to ascertain exact diagnosis. Patients with equivocal or nondiagnostic stress test results may be recommended for radionuclide or echocardiographic stress testing before a final decision regarding coronary angiography is made.[14] It is a matter of facts that baseline ECG abnormalities make elucidation of exercise ECG difficult so necessitating performance of radionuclide or echocardiographic stress testing. It is also good to perform exercise stress testing without certain medications, such as β-antagonists, calcium channel blockers, or nitrates, in order to avoid false negative results and allow the patient to reach the target heart rate. However a stress test may be performed while a patient is on medications in order to assess exercise capacity and adequacy of therapy inpatients with previously diagnosed CAD. Overall, exercise stress testing is a safe procedure.[15]

It is a routine procedure that radionuclide imaging may be supplementary to regular ECG exercise stress testing on the treadmill. It can also be performed with pharmacological agents substituting for exercise. Following are the indications and appropriate clinical settings for radionuclide cardiac imaging, a) patient has chest pain with 1 or more of the following resting ECG changes: bundle branch blocks, left ventricular hypertrophy, early repolarization abnormalities, b) patient has chest pain and cannot exercise, c) for evaluation after equivocal exercise stress test in patients with intermediate probability of CAD, d) for evaluation of the correlation between coronary stenosis and myocardial ischemia, e) to assess myocardial viability in patients after MI or revascularization and f) to assess existence of preoperative medical risk.[16]

Two main isotopes are used: Thallium Th 201 and TechnetiumTc 99 m.[13,14] The advantages of technetium, which is given in combination with its carrier, sestamibi, is that the quality of imaging is better and the imaging itself takes less time than with thallium.[12] When a full ECG exercise stress test is performed, these agents are injected at 1 minute prior to the end of exercise in order to allow tracer to circulate at maximal heart rate and be distributed within myocardium. Scintigraphic images of cardiac perfusion are then acquired. The most popular method of imaging is the single photon emission computed tomography (SPECT). A gamma camera collects data from multiple views, and its computer produces images for interpretation by the physician. Imaging is repeated, with isotope reinfusion, after the patient has rested. Both immediate poststress and resting images are then compared.[17] The presence of a perfusion defect on both stress and resting images indicates irreversible ischemia i.e old myocardial infarction whereas the presence of a perfusion defect on stress images but not on resting images suggests reversible ischemia i.e coronary stenosis with viable myocardium.[13-16]

It is noted that standard sensitivity of radionuclide myocardial imaging is about 90%, while specificity is76%.[13-16] Radiation dose is minimal, and there are virtually no undesirable effects from appropriately injected isotope. These studies are quite costly due to the high equipment cost, isotope cost, personnel work,and physician-interpretation fees. In many hospitals the ECG part of the test is interpreted by a cardiologist or an internist, and the scintigraphic imaging portion is read by a radiologist. In some laboratories, the cardiologist reads both parts.

Now-a-days the most important method for stress echocardiography is the newest method of noninvasive testing to detect CAD. Usually indications for stress echocardiography are similar to radionuclide imaging[18] especially it is important and valuable test in women having higher numbers of false-positive results of exercise stress testing.[19]

The principle of the test is that an ischemic myocardial wall becomes hypokinetic. First of all baseline echocardiography is performed with judgment for any regional wall-motion abnormalities. The detection of such wall-motion abnormalities suggests earlier infarction.[19] After that the patient exercises on the treadmill according to the standard exercise stress test protocol. After the termination of this exercise another set of echocardiographic images is taken. Resting and poststress pictures are compared and evaluated for the presence of exercise induced wall-motion abnormalities which indicate reversible ischemia. The information obtained from this test also includes that obtained from regular ECG stress testing, because stress test on the treadmill is an essential part of the procedure.[20]

Some of the patient cannot exercise therefore a pharmacologic agent which is usually dobutamine is commonly used to simulate stress,[20,21] as a result of its optimistic inotropic and chronotropic effects, dobutamine may induce wall-motion abnormalities in segments of the myocardium supplied by diseased coronary artery, thus simulating stress caused by the standard exercise. Echocardiographic imaging is applied in order to detect these abnormalities.[22] Usually baseline and post-dobutamine sonograms are fairly analyzed. On the other hand, dipyridamole may be used in pharmacologic stress echocardiography but it is less frequently used because the mechanism of action is based on perfusion changes rather than straight effects on myocardial contractility.[22] Stress echocardiography is easy to perform and is available at most noninvasive cardiac laboratories. Usually the cost is less than that of radionuclide imaging because of the equipment and materials are not so costly. In this case the quality of echocardiographic imaging is the most important limiting factor. It is also very important to note that in patients with chronic obstructive pulmonary disease or in obese patients the acoustic window is limited,consequently, exact assessment of regional wall-motion abnormalities may not be possible but echocardiographic contrast materials may offer some help to overcome this barrier. The sensitivity of stress echocardiography in detecting coronaryartery disease is approximately 90% with similar specificity.[18–21]

## CONCLUSION

Stress testing is an important diagnostic tool in detecting CAD. Standard stress testing involves treadmill exercise to produce stress. Pharmacologic stress testing can be performed in patients unable to exercise. Stress testing is cost-effective for patients with intermediate or low-intermediate clinical probability of having CAD. Cardiac catheterization remains the gold standard of diagnosis. However, the noninvasiveness, cost-effectiveness, and prognostic value of stress testing are the major reasons why these tests are used in the initial evaluation of patients with suspected CAD. Also, newer imaging techniques like magneticresonance imaging and electron beam computed tomography may play an important role in diagnosing CAD in the near future.

## REFERENCES


1. Detry JM, Kapita BM, Cosyns J. Diagnostic value of history and maximal exercise electrocardiography in men and women suspected of coronary heart disease. Circulation 1977: 56: 756-61.
2. Ellestad MH, Thomas L, Ong R, Loh J. The predictive value of the time course of ST segment depression during exercise testing in patients referred for coronary angiograms. Am Heart J 1992: 123: 904-8.
3. McElroy K, Alvarado MI, Hayward PG. Exercise stress testing for the pediatric patient with burns: a preliminary report. J Burn Care Rehabil1992: 13: 236-8.
4. Beller GA. Radionuclide exercise testing for coronary artery disease. CardiolClin1984: 2: 367-78.
5. Marwick TH, Anderson T, Williams MJ. Exercise echocardiography is an accurate and cost-efficient technique for detection of coronary artery disease in women. J Am Coll Cardiol1995: 26: 335-41.
6. Previtali M,Lanzarini L, Fetiveau R. Comparison of dobutamine stress echocardiography, dipyridamole stress echocardiography and exercise stress testing for diagnosis of coronary artery disease. Am J Cardiol1993: 72: 865-70.
7. LaarmanGJ, Niemyer MG, van der Wall EE. Dipyridamole thallium testing: noncardiac side effects, cardiac effects, electrocardiographic changes and hemodynamic changes after dipyridamole infusion with and without exercise. Int J Cardiol 1988: 20: 231-8.
8. Garber AM, Solomon NA. Cost effectiveness of alternative test strategies for the diagnosis of coronary artery disease. Ann Intern Med 1999: 130: 719-28.
9. Fiorino AS. Electron-beam computed tomography, coronary artery calcium, and evaluation of patients with coronary artery disease. Ann Intern Med 1998: 128: 839-47.
10. Ortolani P, Marzocchi A, Marrozzini C. Clinical comparison of “normal-hours” vs “off-hours” percutaneous coronary interventions for ST-elevation myocardialinfarction. Am Heart J 2007: 154: 366-72.
11. Pryor DB, Harrell FEJ, Lee KL. Estimating the likelihood of significant coronary artery disease. Am J Med 1983: 75: 771-80.
12. Diamond GA, Forrester JS. Analysis of probability as an aid in the clinical diagnosis of coronary-artery disease. N Engl J Med 1979: 300: 1350-8.
13. Detrano R, Gianrossi R, Froelicher V. The diagnostic accuracy of the exerciseelectrocardiogram: a meta-analysis of 22 years of research. Prog Cardiovasc Dis 1989: 32: 173-206.
14. Marwick TH, Case C, Vasey C. Prediction of mortality by exerciseechocardiography: a strategy for combination with the duke treadmill score. Circulation 2001: 103: 2566-71.
15. Stratmann HG, Tamesis BR, Younis LT, et al. Prognostic value of dipyridamoletechnetium-99m sestamibi myocardial tomography in patients with stable chest pain who are unable to exercise. Am J Cardiol 1994: 73: 647-52.
16. Mark DB, Shaw L, Harrell FEJ, et al. Prognostic value of a treadmill exercise score in outpatients with suspected coronary artery disease. N Engl J Med 1991: 325: 849-53.
17. Yamada H, Do D, Morise A, Atwood JE, Froelicher VF. Review of studies using ultivariable analysis of clinical and exercise testdata to predict angiographic coronary artery disease. Prog Cardiovasc Dis 1997: 39: 457-81.
18. Weiner DA, Ryan TJ, McCabe CH. Exercise stress testing:correlations among history of angina, ST-segment response andprevalence of coronary-artery disease in the coronary artery surgerystudy. N Engl J Med 1979: 301: 230-5.
19. Gohlke H, Samek L, Betz P, Roskamm H. Exercise testing provides additional prognostic information in angiographically defined subgroups of patients with coronary artery disease. Circulation 1983: 68: 979-85.
20. Hammermeister KE, DeRouen TA, Dodge HT. Variables predictive of survival in patients with coronary disease: selection by univariate and multivariate analyses from the clinical, electrocardiographic, exercise, arteriographic, and quantitative angiographic evaluations. Circulation 1979: 59: 421-30.
21. Morrow K, Morris CK, Froelicher VF.Prediction of cardiovascular death in men undergoing noninvasive evaluation forcoronary artery disease. Ann Intern Med 1993: 118: 689-95.
22. Williams MJ, Marwick TH, O’Gorman D, Foale RA. Comparison of exercise echocardiography with an exercise score to diagnose coronary artery disease in women. Am J Cardiol 1994: 74: 435-8.



CONFLICT OF INTEREST
Authors declare no conflict of interest.
GRANT SUPPORT AND FINANCIAL DISCLOSURE
None declared.