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Let's Get Physical- Myocardial Stress Tests: A Student's Perspective

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Abstract

Myocardial perfusion imaging is a routine study that helps to see if the blood flow to the heart muscle is normal or abnormal. There are three parts to myocardium imaging; the resting scan with the radioactive tracer, the stressing of the myocardium, and the stress scan with the radioactive tracer. With the resting scan, a radioactive tracer is injected into the patient to obtain the first set of images of the myocardium at rest. After the rest scan, comes the stressing of the myocardium. There are two different ways to stress the myocardium for the stress test. The first way is to have the patient exercise on a treadmill following a specific exercise protocol, and the second method is to use a pharmacologic stressing agent if the patient cannot exercise. Pharmacologic stress agents produce coronary artery vasodilation and increased myocardial blood flow. During exercise stress, the heart rate should preferably reach 85% of the maximum heart rate and the patient should be symptomatic or fatigued, the technologist injects the patient with the radioactive tracer at peak stress and then obtains a second set of stress images . Of the two different ways to stress the myocardium, the physical stressor is preferred to pharmacologic stress testing in conjunction with myocardial perfusion imaging.

Let's Get Physical- Myocardial Stress Tests: A Student's Perspective

During my clinical rotations, I participated in many myocardial rest/stress tests. It seemed that many of the patients were scheduled for pharmacologic stress instead of walking on the treadmill, which led me to question which method is the better stressor to produce the best myocardial perfusion stress images? A myocardial perfusion test is a type of nuclear medicine scan used to image a patient's heart before and after exercise. The main goal of this test is to determine the adequacy of blood flow to the myocardium (*1*). The reason it is called a perfusion test is that it can show how the myocardium is perfused with blood.

Clinical Indications

A patient could need a stress test for various reasons such as for the detection and evaluation of coronary artery disease (CAD), risk stratification of post-myocardial infarction patients, risk stratification before noncardiac surgery in patients with known CAD or those with high-risk factors, and to evaluate the efficacy of therapeutic interventions (*2*). Contraindications for doing a physical or treadmill stress test include patients experiencing chest pain, a patient who has a documented acute myocardial infarction within 2-4 days of the test, extremely high blood pressure or arrhythmias, a medically unstable patient or noncardiac physical limitations (*3*).

Patients unable to perform adequate exercise stress might be candidates for pharmacologic stress (*4*). There are several scenarios where pharmacologic stress is preferred over exercise stress such as in patients unable to exercise at 4 to 6 minutes or obtain 5 metabolic equivalents (METs) on the treadmill, patients with a blunted heart rate response on the treadmill, patients taking beta-blockers, and patients with a left bundle branch their EKG. Contraindications for doing a pharmacologic myocardial stress test might be if a patient is not

NPO for 4-12 hours before the exam, if the patient consumed caffeine or medications containing theophylline, patients with 2nd- or 3rd-degree heart block, patients with bronchospastic lung diseases, among many other reasons (*2*).

Protocol

My clinical site used Technetium-99m (99mTc) tetrofosmin. Tetrofosmin is a lipophilic cationic perfusion tracer that accumulates in the myocardium in proportion to blood flow (*5*). 99mTc has a short half-life of 6 hours which makes it ideal for patient use. Studies in normal volunteers have demonstrated rapid myocardial uptake of the Tc99m tetrofosmin, and rapid blood, liver and lung clearances. Uptake in the myocardium reaches a maximum of about 1.2% of the injected dose at 5 minutes and approximately 1% of the injected dose at 2 hours (*3*).

In figure 1, the process for the testing starts with the resting part of the rest/stress test. The technologist injects the patient with 296-444 MBq of 99mTc-tetrofosmin, and the patient waits for 30 to 60 minutes (*6*) before the first of the two scans. Once this scan is completed, usually 15 to 25 minutes, the patient goes to the Stress Lab. This is where the patient can either be stressed physically or pharmacologically.

For a physical stress test, the patient walks/runs on a treadmill following a graded protocol. The most common protocol used is the Bruce Protocol (*6*). In table 1, the protocol starts slowly with a small incline and gradually gets faster and steeper. Once the patient has symptoms or is fatigued and their heart rate reaches 85% of their maximum heart rate – which equals (220 – Patient's age) x 0.85) (*3*) – the patient is then injected with the second of the two 99mTc-tetrofosmin doses and continues to exercise for another minute. The stress dose should be 3 times more than the resting dose and should be in the range of 888-1332 MBq. The exercise gradually slows to a walk, the patient then sits down, and rests for 10 minutes or so while their

EKG, heart rate, and blood pressure return to baseline. The second set of images is performed after 15 minutes.

As mentioned above, if the patient is unable to adequately walk on a treadmill a pharmacologic stress is performed. For a pharmacological stress test, the patient is injected with a coronary vasodilator. Vasodilators dilate blood vessels, which allows blood to flow more easily. Vasodilators do not increase the heart to 85% of the maximum heart rate – which is required for an adequate stress test but unfortunately they come with some side effects that the regular treadmill stressor does not. Side effects can include dyspnea, headache, and flushing (*6*).

My clinical site used regadenoson, which is an A2A receptor agonist that causes coronary vasodilation that is commonly used in pharmacologic stress testing (*7*). It comes as a prefilled syringe containing 0.4 mg of regadenoson in a 5-mL volume and is administered as a rapid bolus (Figure 2). It is quickly followed by a saline flush. It causes an increase in heart rate and a decrease in blood pressure. Poststress imaging is 30 minutes after the pharmacologic stressing (*8*). Usually caffeinated beverages can relieve most side effects and if needed, aminophylline can be administered for more severe side effects (*6*). Patients with serious heart conditions such as a 2nd or 3rd degree AV (atrioventricular) block should not be given this medication.

Results

The second set of perfusion images is compared to the first set of images to see if there are differences between the two scans. Normal results demonstrate heterogeneous uptake throughout the myocardium of the left ventricle on both sets of images. For abnormal results, there can be a defect in both stress and rest scans, which would indicate infarction, or there could be a defect on the stress scan but not on the rest scan which indicates reversible ischemia.

Physical vs. Pharmacologic Stress Comparison

Exercise stress has several benefits over pharmacologic stress. The patient's exercise capacity and the level of exercise which provokes symptoms can be assessed (*4*). Exercise stress provides hemodynamic information. Image quality is better with exercise stress as there is less hepatic uptake of the radioactive tracer. Comparative studies have shown similar cardiac scintigraphic patterns and overall diagnostic accuracy for both (*6*). Results of studies over the years suggest that myocardial perfusion scintigraphy has an approximate sensitivity of 87% and specificity of 80% (*7*).

Conclusion

Despite the similar scintigraphic patterns and diagnostic accuracy shown in comparative studies, physical stress testing is preferred. Physical stress is a true depiction of how the myocardium reacts in reality; since stressing the heart in daily life is achieved by actual physical strain on the heart; and not really by using vasodilating drugs. Physical stress testing should always be considered first unless contraindicated. Despite the fact that physical stress testing is the best way to achieve optimal results, there is a place for pharmacologic stress when the patient cannot or should not perform physical stress.

References

1. Fogoros R. What You Should Know About The Nuclear Stress Test. [online] Verywell Health. Available at: https://www.verywellhealth.com/nuclear-stress-test-overview-4172096. Published November 18, 2019. Accessed March 10, 2020
2. Shackett P. *Nuclear Medicine Technology: Procedures And Quick Reference*. 2nd ed. Baltimore: Wolters Kluwer; 2009: 66-78.
3. Myoview (Kit for the Preparation of Technetium Tc99m Tetrofosmin injection)[package insert]. Oslo, Norway: GE Healthcare AS. 2011.
4. Pagnanelli R. Pharmacologic stress testing with myocardial perfusion imaging. *J Nucl Med Technol.* 2017;45(4): 249-252.
5. Saha G. *Fundamentals Of Nuclear Pharmacy*. 7th ed. Cha Switzerland: Springer; 2018: 312-323.
6. Waterstram-Rich K, Gilmore D.. *Nuclear Medicine And PET/CT*. 8th ed. St. Louis: Elsevier; 2017: 490-517.
7. Ziessman H, Fahey F, O'Malley J, Thrall J. *Nuclear Medicine*. 4th ed. Philadelphia: Elsevier Saunders; 2014: 380-389, 405.
8. Farrell, MB. Myocardial Perfusion Imaging 2016: Quality, Safety, and Dose Optimization. *J Nucl Med Technol.* 2016: 44(4): 270-271.
9. Farrell M, Mantel E, Basso D, Thomas K, Kerr B. *Quick-Reference Protocol Manual for Nuclear Medicine Technologists.* Reston: Society of Nuclear Medicine and Molecular Imaging Inc. 2014. 17-108.

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Figure 1. 99mTc Rest/Stress Myocardial Perfusion Protocol. Reprinted from (*8*)

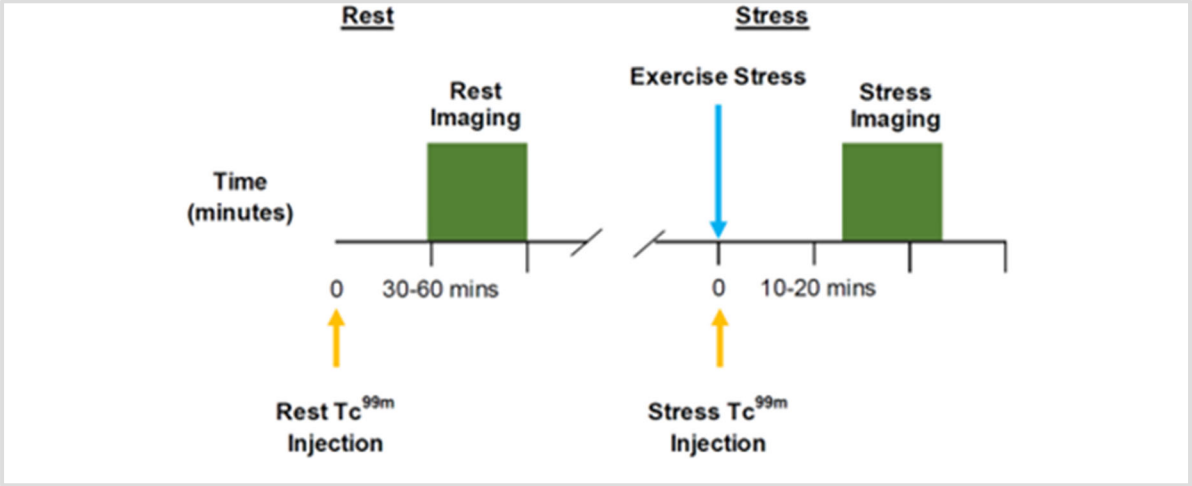

Table 1. Bruce Protocol (*6)*

Stage	Minutes	% grade	km/h	mph	METS
1	3	10	2.7	1.7	5
2	6	12	4.0	2.5	7
3	9	14	5.4	3.4	10
4	12	16	6.7	4.2	13
5	15	18	8.0	5.0	15
6	18	20	8.8	5.5	18
7	21	22	9.6	6.0	20

Figure 2. Regadenoson Vasodilator Stress Protocol. Repriuted from *(8)*.