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

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Myocardial perfusion imaging is a routine study that helps determine whether blood flow to the heart muscle is normal or abnormal. There are 3 parts to myocardial imaging: a resting scan with a radioactive tracer, stressing of the myocardium, and a stress scan with a radioactive tracer. For the resting scan, a radioactive tracer is injected into the patient to obtain a set of images of the myocardium at rest. After the resting scan comes stressing of the myocardium. There are 2 different ways to stress the myocardium. The first is to have the patient exercise on a treadmill following a specific exercise protocol, and the second is to use a pharmacologic stressing agent if the patient cannot exercise. Pharmacologic stressing 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 images. Of the 2 different ways to stress the myocardium, physical stress is preferred to pharmacologic stress.

Key Words: cardiology; cardiac; myocardial perfusion stress scan; student

J Nucl Med Technol 2020; 48:136–138
DOI: 10.2967/jnmt.120.244947

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, leading 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.

Received Mar. 11, 2020; revision accepted Apr. 9, 2020.
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Published online Apr. 10, 2020.

CLINICAL INDICATIONS

A patient may need a stress test for various reasons, such as detection and evaluation of coronary artery disease, risk stratification after myocardial infarction, risk stratification before noncardiac surgery if there is known coronary artery disease or high-risk factors, and evaluation of the efficacy of therapeutic interventions (*2*). Contraindications to a physical or treadmill stress test include chest pain, a documented acute myocardial infarction within 2–4 d of the test, extremely high blood pressure or arrhythmias, medical instability, and noncardiac physical limitations (*3*).

Patients unable to perform adequate exercise might be candidates for pharmacologic stress (*4*). There are several scenarios in which pharmacologic stress is preferred over exercise stress, such as an inability to exercise for 4–6 min or to obtain 5 metabolic equivalents on the treadmill, a blunted heart rate response on the treadmill, use of β-blockers, and a left bundle branch blockage seen on the electrocardiograph. Pharmacologic myocardial stress testing is contraindicated if a patient has eaten or drank anything during the 4–12 h before the test, consumed caffeine or medications containing theophylline, has a second- or third-degree heart block, or has a bronchospastic lung disease, among many other reasons (*2*).

PROTOCOL

My clinical site uses ^{99m}Tc-tetrofosmin for myocardial perfusion imaging. Tetrofosmin is a lipophilic cationic perfusion tracer that accumulates in the myocardium in proportion to blood flow (*5*). ^{99m}Technetium (^{99m}Tc) has a short half-life of 6 h, which makes it ideal for patient use. Studies on healthy volunteers have demonstrated rapid myocardial uptake of ^{99m}Tc-tetrofosmin and rapid blood, liver, and lung clearance. Uptake in the myocardium reaches a maximum of about 1.2% of the injected dose at 5 min and approximately 1% of the injected dose at 2 h (*3*).

The rest–stress test starts with the resting part (Fig. 1). The technologist injects the patient with 296–444 MBq of ^{99m}Tc-tetrofosmin, and the patient waits for 30–60 min (*6*) before undergoing the resting scan. Once this scan is completed, usually in 15–25 min, the patient goes to the stress lab. This is where the patient can be stressed either physically or pharmacologically.

For a physical stress test, the patient walks or runs on a treadmill following a graded protocol. The most commonly

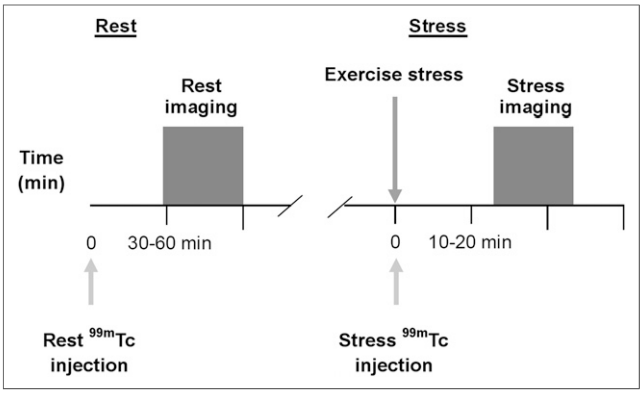

FIGURE 1. ^{99m}Tc rest–stress myocardial perfusion protocol. (Adapted from (*8*).)

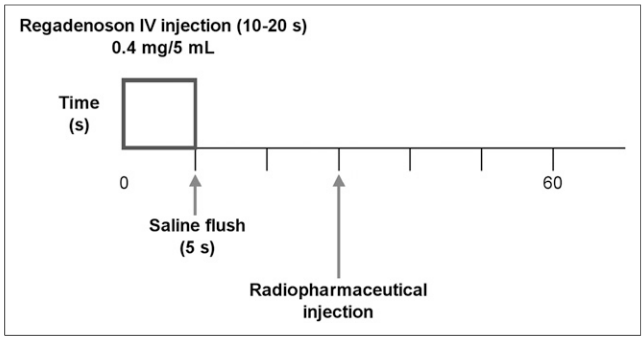

FIGURE 2. Regadenoson vasodilator stress protocol. IV = intravenous. (Adapted from (*8*).)

applied protocol is the Bruce protocol (Table 1) (*6*). It starts slowly with a small incline and gradually gets faster and steeper. Once the patient has symptoms or is fatigued and the heart rate reaches 85% of the maximum heart rate—which equals (220 – patient's age) × 0.85 (*3*)—the patient is injected with a second dose of ^{99m}Tc-tetrofosmin and continues to exercise for another minute. This stress dose should be 3 times the resting dose and in the range of 888–1,332 MBq. The patient is gradually slowed to a walk and then sits and rests for 10 min or so while the electrocardiography trace, heart rate, and blood pressure return to baseline. The stress test is performed 15 min after the 10 min has elapsed.

If the patient cannot adequately walk on a treadmill, pharmacologic stress is performed, in which the patient is injected with a coronary vasodilator. Vasodilators dilate blood vessels, allowing blood to flow more easily. Vasodilators do not increase the heart rate to 85% of the patient's maximum heart rate as the exercise stress test does, and unfortunately they come with some side effects. These can include dyspnea, headache, and flushing (*6*).

My clinical site used regadenoson, which is an A_{2A} receptor agonist that causes coronary vasodilation and 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 (Fig. 2) quickly followed by a saline flush. It causes an increase in heart rate and a decrease in blood pressure. Poststress imaging is performed 30 min after the pharmacologic stressing (*8*).

TABLE 1
Bruce Protocol (*6*)

Stage	Minutes	% grade	km/h	mph	Metabolic equivalents
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

Caffeinated beverages can usually relieve most side effects; if they are more severe, aminophylline can be administered (*6*). Patients with serious heart conditions such as a second- or third-degree atrioventricular block should not be given this medication.

INTERPRETATION OF RESULTS

The second set of perfusion images is compared with the first to see if they differ. The results are considered normal if there is heterogeneous uptake throughout the myocardium of the left ventricle on both sets. The results are considered abnormal if a defect is seen on both the stress and the rest scans, indicating infarction, or if a defect is seen on the stress scan but not on the rest scan, indicating reversible ischemia.

Exercise stress has several benefits over pharmacologic stress. The patient's exercise capacity and the level of exercise that 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 a similar cardiac scintigraphic pattern and overall diagnostic accuracy for both (*6*). The results of studies over the years suggest that myocardial perfusion scintigraphy has an approximate sensitivity of 87% and specificity of 80% (*7*).

CONCLUSION

Although comparative studies have shown a similarity in scintigraphic pattern and diagnostic accuracy between physical and pharmacologic stress testing, physical stress testing is preferred. Physical stress is a true depiction of how the myocardium reacts in reality, because in daily life, the heart is stressed by actual physical strain and not by vasodilating drugs. Unless contraindicated, physical stress testing should always be the first choice. However, there is a place for pharmacologic stress testing when the patient cannot or should not undergo physical stress.

DISCLOSURE

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENT

I thank Catherine M. Bloor, RT (N), Lina Agha, CMNT, PET, and Mary Beth Farrell, CNMT, NCT, FSNMMI-TS, for their help, guidance, and support.

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