



# Radiology Rounds

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## Nuclear Cardiology Stress Tests for Coronary Artery Disease

- **Exercise ECG without imaging should be the first choice for evaluation of coronary artery disease (CAD) when patient can exercise on a treadmill to 85% of maximum predicted heart rate and**
  - resting ECG is normal or has minor abnormalities
  - unstable myocardial infarction (MI) has been ruled out
  - risk of adverse effects from exercise is low to intermediate
- **Cardiac stress myocardial perfusion SPECT is indicated:**
  - when baseline ECG suggests that exercise ECG would be nondiagnostic or uninterpretable for ischemia
  - when clinical presentation and exercise ECG indicates at least an intermediate likelihood of CAD
  - for preoperative evaluation of those with known high coronary risk factors
  - for management of known cardiac disease
- **Physical exercise stress myocardial perfusion SPECT is recommended if patient can exercise to 85% of maximum predicted heart rate; otherwise pharmacological stress myocardial perfusion SPECT should be ordered.**

When patients present with chest pain, clinical examination and patient history are fundamental to determine the probable cause of pain and the selection of appropriate tests to confirm clinical suspicions. In the case of myocardial ischemia due to coronary artery disease (CAD), the patient often but not always presents with the classical symptoms, chest tightness and left arm pain. However, cardiac symptoms may be similar to indigestion, muscle spasm, or other non-specific complaints. Nevertheless, other causes of chest pain that do not have cardiac origin, including pulmonary embolism, pneumothorax and aortic dissection must always be considered.

If CAD is suspected after these initial examinations and MI or severe unstable angina has been ruled out along with other dangerous but non cardiac causes of chest pain, the next step is exercise ECG (exercise treadmill test, ETT), provided that the patient is able to exercise well enough to reach 85% of maximum predicted heart rate (HR; 200-age is 100% of the patient maximum predicted HR) and has a normal resting ECG or has only minor ECG abnormalities that will not interfere with interpretation of the exercise ECG (See Box 2).

### (Box 1) Contraindications for Nuclear Cardiology Stress Test

<b>Absolute</b>	<ul style="list-style-type: none"> <li>Acute myocardial infarction</li> <li>Severe aortic stenosis</li> <li>Severe reaction to stress agent</li> <li>Severe pulmonary hypertension</li> <li>Obstructive hypertrophic cardiomyopathy</li> <li>Combination of low EF (20%) and documented recent VF/VT</li> <li>Cocaine within 24 hours</li> <li>Pregnancy</li> <li>Unstable angina</li> </ul>
<b>Relative</b>	<ul style="list-style-type: none"> <li>Severe Mitral stenosis</li> <li>Hypertension (&gt;180/100 mm Hg)</li> <li>Hypotension (&lt;90 mm Hg, systolic)</li> <li>Tachycardia (&gt;120/min)</li> <li>Wheezing, bronchospasm</li> <li>Unable to communicate</li> <li>Acute illness such as pericarditis, pulmonary embolus, infection, fever</li> </ul>

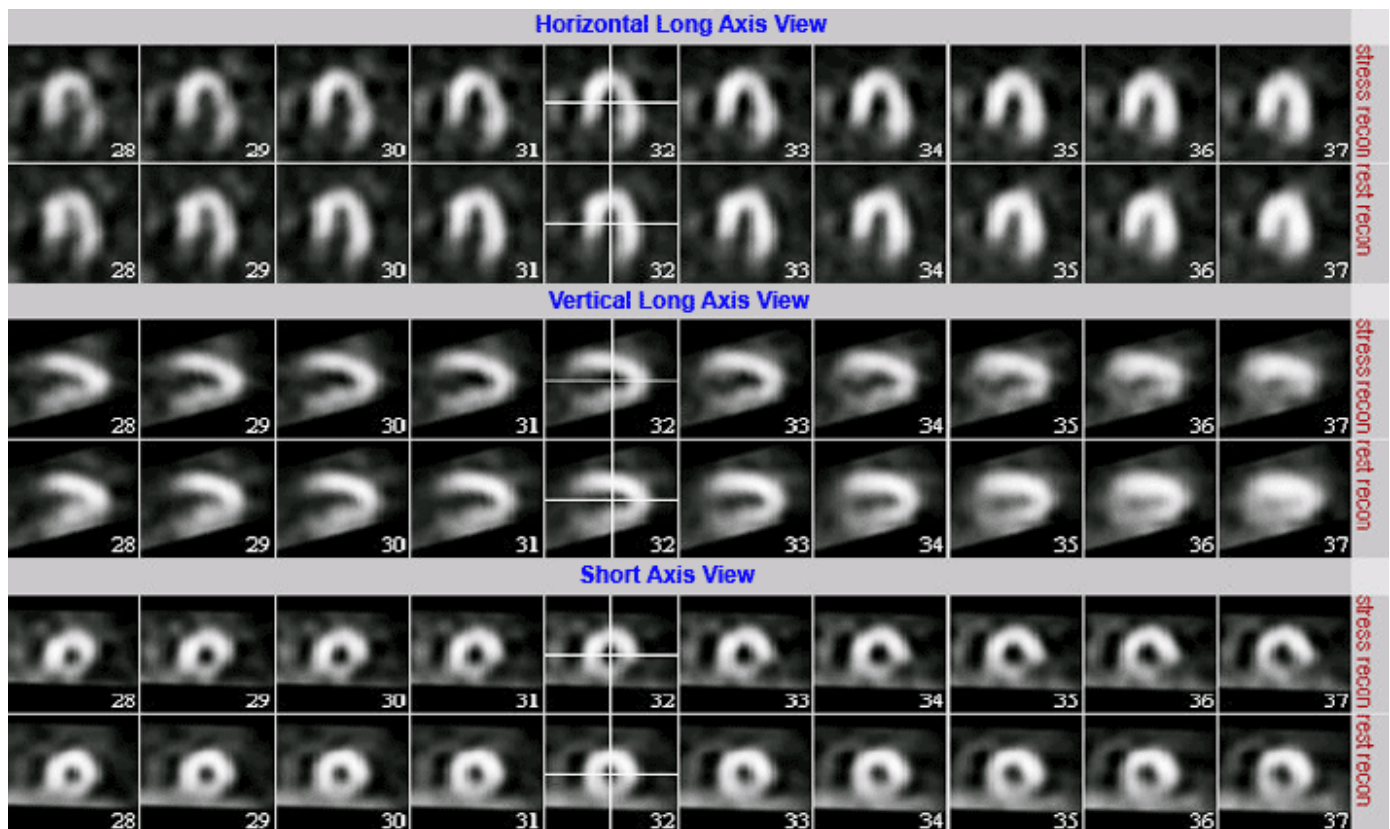
## Myocardial Perfusion Imaging SPECT (MPI SPECT)

Although nuclear cardiology is both time consuming and expensive, MPI SPECT is valuable for the clarification of a suspected false positive (or negative) exercise ECG. It is also a valuable test for patients with an intermediate likelihood of coronary artery disease if the patient is unable or unwilling to perform an exercise ECG. MPI SPECT has major utility to define the extent and location of disease, determine the physiological significance of known coronary stenoses, evaluate a particular vascular territory, and to risk stratify a patient with known or suspected CAD once an unstable acute coronary syndrome has been excluded. Therefore, MPI SPECT is well established for prognostic evaluation of these patients.

MPI SPECT is also valuable for the management of patients with cardiac disease, for example, to assess viability and to guide the selection of by-pass graft or PCI (percutaneous coronary intervention) region. In addition, the left ventricular ejection fraction, which is obtained as an integral part of the MPI SPECT study, is an important determinant of long-term prognosis and can be used to evaluate symptoms such as shortness-of-breath, fatigue, and poor exercise tolerance.

Nuclear cardiology images show the distribution of a radioactive agent, such as  $^{99m}\text{Tc}$ -Sestamibi. Since the amount of radioactivity is roughly proportional to regional blood flow, nuclear cardiology images show variations in blood flow in the myocardial regions that are under-perfused relative to other regions and may be the cause of myocardial ischemia. Additional information on cardiac function, such as ventricular motion and ejection fraction, can be obtained when cardiac gating is used to synchronize image acquisition to the cardiac cycle.

In most cases, blood flow is adequate in the resting state but not during exercise or physiological stress because diseased blood vessels are unable to dilate further in response to increased energy demand. Therefore, nuclear cardiology images are acquired both under stress and rest conditions to unmask the reserve capacity of the coronary blood vessels. However, resting SPECT MPI may be ordered as a separate stand-alone study (i.e. rest gated MIBI) to assess left ventricular ejection fraction, regional contraction and myocardial viability (not for ischemia).



MPI SPECT findings consistent with inferior and inferolateral ischemia with an incomplete infarction in these areas.



## Patient Preparation

Since  $\beta$ -blockers slow the heart rate and the stress test is designed to increase heart rate, it is preferable that  $\beta$ -blockers be withdrawn prior to cardiac stress myocardial perfusion SPECT to ensure that arterial pressure increases appropriately with exercise if the test is ordered for diagnostic purposes. The patient should be warned to reduce his/her level of exertion and his/her physician must, of course, determine that it is safe and appropriate to do so. Unfortunately, sudden withdrawal of  $\beta$ -blockers may cause a surge in blood pressure, which could result in test cancellation. Therefore physicians should withdraw them slowly and monitor blood pressure to be certain that the patient can complete a stress test. Other anti-hypertensive medications may be continued to avoid excess hypertension at the time of the test. Anti-anginal agents may be continued with the referring physician's approval. If physicians want to establish the effectiveness of medication, they may continue the medication to evaluate the symptoms and ischemic territory and size with stress test MPI SPECT. Patients should not consume any caffeine or chocolate 24 hours prior to the test and should not eat, drink, or smoke for 12 hours prior to the test. Therefore, diabetics, in consultation with their PCP or endocrinologist, should adjust their insulin and other anti-diabetic medication accordingly.

## Test Procedure

The procedure begins with an intravenous injection of radionuclide contrast agent with the patient at rest. Twenty to thirty minutes later, when the radionuclide is distributed throughout the body, the patient is imaged with a gamma camera for a period of 20-30 minutes to obtain baseline cardiac images. If an exercise stress test is to be done, the patient will be taken to a treadmill and asked to exercise while their ECG is monitored. One minute before the patient has reached his or her limit or HR has reached 85% of the predicted maximum, a second dose of radionuclide contrast is injected and exercise continued for one more minute. After another 30 minute wait for the radionuclide to equilibrate, the patient is imaged for a second time to obtain stress myocardial images.

If a pharmacological agent is used to induce coronary dilation, the second injection of radionuclide contrast is injected at 10 minutes after injection of dipyridamole or 2 minutes into the infusion of intravenous adenosine. The stress images are obtained after radionuclide equilibration, as above. The total time for the procedure is 3 – 3.5 hours.

A radiologist and cardiologist will examine the series of SPECT images in the short axis, the horizontal long axis, and the vertical long axis to assess perfusion defects. In addition, the cardiac-gated SPECT images may be reconstructed into cine loops, which are used to assess regional ventricular wall motion, ejection fraction, and, indirectly, myocardial viability.

## Myocardial Perfusion Imaging PET (MPI PET)

MPI PET can be performed when MPI SPECT is equivocal or likely to be uninterpretable because of obesity. PET is a quantitative modality because tracer kinetic models can be applied to the data and attenuation artifacts largely avoided. It can therefore help detect false negative or positive MPI SPECT results. MPI PET should be ordered with prior consultation of a nuclear cardiologist.

### (Box 3) Possible Complications of Stress Test

<b>Exercise</b>	Chest pain, 20% Cardiac event, 0.01-0.02% Death, 0.002% or 1/50,000 Accidental fall Pulmonary edema
<b>Pharmacological (adenosine)</b>	Chest pain, 20-40% Some degree of AV block, 3-18% Bradycardia, 12% Nausea, 5% Drop in BP, 3-5% Bronchospasm, 0.2% Cardiac event, death, <1%

## Scheduling

Appointment for nuclear cardiology examinations may be scheduled by calling 617-643-1552 or through the Radiology Order Entry system, <http://mghroe/>. Weekend scheduling should be made directly by calling the on call nuclear cardiologist at 617-726-9292.

## Further Information

Further information may be found on the [Nuclear Cardiology website](#). For questions, please contact [James Scott, M.D.](#), Associate Professor of Radiology at [scott@helix.mgh.harvard.edu](mailto:scott@helix.mgh.harvard.edu).

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