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# imaging update

CARDIAC NUCLEAR MEDICINE



Queensland  
Diagnostic Imaging

# MYOCARDIAL PERFUSION IMAGING WITH THALLIUM AND SESTAMIBI

Myocardial perfusion imaging (MPI) using thallium or sestamibi is an accurate means of detecting reversible myocardial ischaemia or previous myocardial infarction. It is useful for detection of coronary artery disease in patients with chest pain or other suspicious symptoms. It also may be used to assess the functional significance of proven coronary artery disease because the severity, extent and location of ischaemia can be determined. Stress echocardiography is the major competing modality. Studies have shown similar accuracy of MPI and stress echo for detecting whether coronary artery disease is present or absent. However, MPI has been shown to out-perform stress echo for correctly identifying patients with multi-vessel coronary artery disease. Identifying these higher risk patients is an important goal of non-invasive cardiac assessment. At the other end of the spectrum, A normal MPI scan predicts excellent short-term prognosis with less than 1% annual risk of cardiac related death or infarction.

## INTRODUCTION

Thallium and sestamibi scans depict myocardial perfusion and viability. Two sets of images are acquired: stress and resting images. The stress image is performed following tracer injection during a standard exercise stress test or an infusion of dipyridamole (Persantin) or dobutamine. These drugs, like exercise act to induce vasodilatation and increase blood flow in the coronary circulation. Persantin and exercise are frequently combined. A fixed perfusion defect is a defect seen on the stress image that remains unchanged on the resting image and denotes myocardial scar due to previous infarction. A reversible defect is one seen on the stress scan that normalizes on the resting image and denotes reversible myocardial ischaemia due to a critical coronary stenosis.

Images are acquired using Single Photon Emission Computed Tomography (SPECT) to display all segments of the left ventricle as multiple slices in three planes (figures 1 and 2). ECG-gated SPECT is a relatively new technique giving cine images of left ventricular wall motion and allows calculation of ejection fraction adding function to perfusion information (figure 3).

## INDICATIONS

Myocardial perfusion imaging (MPI) is a valuable tool for diagnosis of coronary artery disease in patients presenting with chest pain or other suspicious symptoms (see table 1). It is indicated when a standard maximal exercise stress test (MEST) is not feasible, or has been reported as submaximal, equivocal or non-diagnostic. It should be noted that left bundle branch block on a resting ECG renders a standard MEST uninterpretable and necessitates going directly to MPI (or

other imaging). Left ventricular hypertrophy or digoxin therapy very commonly give false-positive MEST and it is reasonable to perform MPI as the initial test in these patients as well.

Patients with intermediate likelihood of coronary artery disease after a MEST are also candidates for MPI. This often applies when there is a mismatch between clinical factors and MEST findings. For example, a 60 year old man with exertional chest pain but negative MEST or a 45 year old woman with atypical chest pain and a positive MEST could both have MPI to clarify their diagnosis. It is well recognised that the standard MEST has quite low diagnostic accuracy and false-positive and false-negative results are common.

MPI can also be ordered (usually by a cardiologist) when there is proven coronary artery disease, for example to determine the functional significance of an angiographic lesion or to determine which of two or more is the "culprit" lesion. Thallium is also used to assess myocardial viability when there is left ventricular dysfunction after a myocardial infarction.

MPI has also proven value for determining prognosis and risk stratification. It is often very useful in pre-operative risk evaluation in patients undergoing non-cardiac surgery.

## CONTRAINDICATIONS

Contra-indications are given in table 2. It is rare that a referred patient cannot be stressed safely by selecting one of the methods available. It should be stressed however that unstable angina pectoris (UAP) is one clinical setting where MPI using exercise, Persantin or dobutamine can be dangerous. A history of unstable symptoms such rapid worsening of angina, angina of

recent sudden onset or a strong suspicion of angina at rest should be referred urgently to a cardiologist or hospital emergency department.

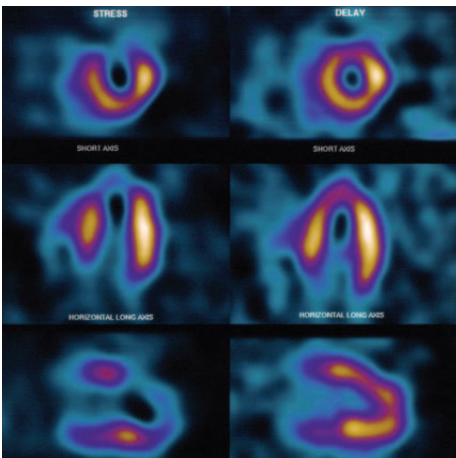
## RISKS AND ADVERSE REACTIONS

Maximal treadmill exercise carries a 1 in 10,000 risk of death and 3 in 10,000 of non-fatal myocardial infarction or other serious complications. Persantin or dobutamine infusion have similar risks. Minor adverse symptoms of Persantin such as headache, flushing, lightheadedness or nausea are common but are reversed very rapidly (within seconds) with I.V. aminophylline. Persantin may also cause bronchospasm in asthmatic subjects. The radiation dose is slightly more than a chest CT scan for sestamibi and approximately twice that of a chest CT for thallium. Allergic reactions to thallium or sestamibi are virtually unknown. Allergic reactions to Persantin occur occasionally.

## EXERCISE, PERSANTIN OR DOBUTAMINE?

We routinely combine maximal treadmill exercise with Persantin in nearly all patients unless there is a contra-indication. The rationale is to maximize coronary hyperaemia, minimize Persantin side-effects and to obtain useful clinical information from the MEST component. Dobutamine infusion is time consuming and we use this infrequently. Clearly the optimal method will be dictated by factors such as contra-indications, ability to exercise and regular medications that may block the actions of Persantin or dobutamine. All these issues are reviewed by the nuclear medicine physician prior to the test.

Fig 1



Thallium SPECT stress and rest images. Tomographic slices showing a reversible perfusion defect.

## THALLIUM OR SESTAMIBI?

For routine indications this should not be an important consideration for the referring doctor and the two agents can be considered equivalent. Sestamibi is a newer technetium based agent with radio-active properties favourable for image quality but also has some theoretical disadvantages compared to thallium. Clinical trials where thallium and sestamibi have been used in the in the same patients have failed to show any significant difference in performance for detection of coronary artery disease. We routinely use thallium at St. Andrew's and Allamanda Hospitals and a combined thallium-sestamibi protocol at Holy Spirit Northside Hospital.

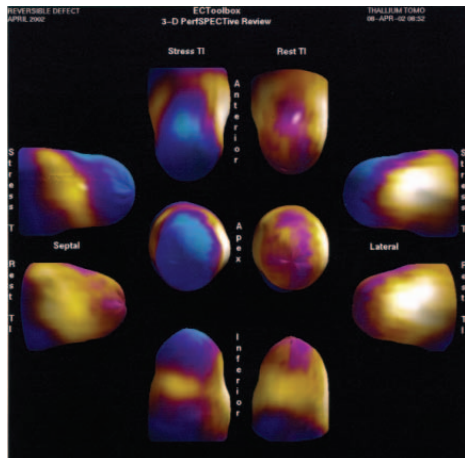
## WHAT CAN THE PATIENT EXPECT?

Patient preparation is given in table 3. Typically, a stress test is followed immediately by a stress-scan then a second resting scan is performed 4 hours later. Each scan takes approximately 20minutes and the whole test occupies most of one day (although the patient can leave the department between scans). The pharmacological agents used are reversed rapidly in the stress room so patients should feel normal and may drive after the test. IV cannulation and ECG monitoring are used during the stress test.

## A SPECIAL NOTE

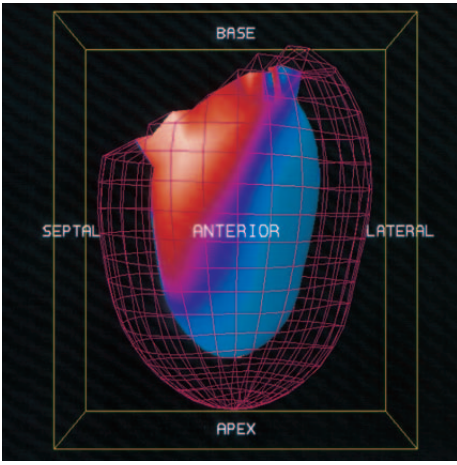
If the patient has had a recent MEST elsewhere it is useful to include the exercise duration and peak heart rate on the referral form. This helps us to optimally time the isotope injection during exercise.

Fig 2



3D representation of left ventricular perfusion during stress and rest (same patient as Figure 1).

Fig 3



ECG-gated SPECT used to assess left ventricular wall motion and ejection fraction.

## HOW ACCURATE IS THE TEST?

Accuracy is high for detection of CAD although sensitivity is better than specificity (see table 4). A major cause of reduced specificity is related to "photon attenuation artefacts" - false defects on the scan caused by structures such as the breast or diaphragm overlying the heart. These are usually mild defects and can often be anticipated by knowing the patient's size and body habitus. Recently, gated-SPECT has improved our ability to recognise attenuation artefacts.

## THE POWERFUL PROGNOSTIC VALUE OF A NORMAL SCAN

Irrespective of its ability to predict angiographic CAD, MPI is a powerful predictor of prognosis in its own right. This is especially true when the scan result is normal. It has been shown that the risk of death or non-fatal myocardial is less than 1% per year after a normal MPI scan based on more than 7500 patients studied. This "warranty" probably lasts for 2 to 3 years - i.e. the time it takes for new coronary lesions to develop or old ones to progress. A normal MPI scan implies exceedingly low short-term risk even in patients with CAD demonstrated on angiogram.

## MYOCARDIAL PERFUSION IMAGING OR STRESS ECHO?

Stress echocardiography (stress echo) has recently emerged as an alternative to MPI. Advantages of stress echo are that it is quicker to perform, cheaper and does not involve radiation. However, stress echo does have limitations when compared to MPI for detecting some forms of coronary artery disease. Stress echo has been shown to be less likely to correctly identify high-risk patients with multivessel coronary artery disease. It is also relatively insensitive for detecting single vessel disease of the left circumflex coronary artery and has difficulty in detecting reversible ischaemia superimposed on previous infarction. Correct detection of multivessel disease is an important goal for non-invasive myocardial imaging because it allows these patients to be prioritized for coronary angiography and intervention. In approximately 5% of patients stress echo cannot be performed due to inadequate image quality - usually due to obesity or chronic obstructive pulmonary disease.

## WHERE ARE THESE PROCEDURES PERFORMED?

Currently MPI is performed within QDI at:

Department of Nuclear Medicine and Cardiology  
St Andrews' Hospital  
Wickham Terrace, Brisbane  
(ph) 38390822

Department of Nuclear Medicine and Cardiology  
Allamanda Hospital  
Southport  
(ph) 55325044

QDI Holy Spirit Northside  
Chernside  
(ph) 532564011

The procedures are performed by Nuclear Medicine Physicians Dr John Arnold, Dr David Carseldine, Dr Frederick Khafagi, Dr Tanvir Rahman and Dr David Rose.

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# Key Points in the Clinical Use of Myocardial Perfusion Imaging (MPI)

**TABLE 1: Indications for MPI for diagnosis of coronary artery disease**

<p>Patient unable to exercise effectively for standard maximal exercise stress (MEST)</p> <ul style="list-style-type: none"> <li>Severe hip or knee arthritis</li> <li>Claudication</li> <li>Previous CVA</li> </ul>
<p>Resting ECG abnormalities leading to uninterpretable ST segments</p> <ul style="list-style-type: none"> <li>Left bundle branch block (LBBB)</li> <li>Permanent pacemaker</li> </ul>
<p>To clarify diagnosis after a MEST when</p> <ol style="list-style-type: none"> <li>a. Inadequate cardiac workload</li> <li>b. Equivocal ST segment changes</li> <li>c. Non-diagnostic ECG: ST depression in the setting of             <ol style="list-style-type: none"> <li>(i) Left ventricular hypertrophy (LVH)</li> <li>(ii) Digoxin therapy</li> <li>(iii) Right bundle branch block (RBBB) and ST changes confined to leads V1 to V3</li> </ol> </li> </ol>
<p>Intermediate likelihood of coronary artery disease based on clinical history and MEST results:</p> <ol style="list-style-type: none"> <li>a. High clinical suspicion, negative ST segments (? False-negative)</li> <li>b. Low clinical suspicion, positive ST segments (? False-positive)</li> <li>c. Any combination of age, sex, pattern of symptoms, risk factors and MEST data where the diagnosis of CAD remains in doubt.</li> </ol>

**TABLE 2: Contraindications**

<p>Treadmill exercise</p> <ul style="list-style-type: none"> <li>Unstable angina pectoris</li> <li>Severe aortic stenosis</li> <li>Severe left main coronary artery stenosis</li> <li>Severe systemic or pulmonary hypertension</li> <li>Inflammation or infection of the heart (myocarditis, pericarditis, endocarditis)</li> <li>Malignant arrhythmias</li> </ul>
<p>Dipyridamole</p> <ul style="list-style-type: none"> <li>Moderate or Severe Asthma or COPD with recent exacerbation</li> <li>Second or third degree AV block or Sick Sinus Syndrome without a pacemaker</li> </ul>
<p>Dobutamine</p> <ul style="list-style-type: none"> <li>Same as for exercise</li> <li>Atrial fibrillation/flutter</li> <li>Aortic aneurysms &gt; 5cm (relative contraindication)</li> </ul>

**TABLE 3: Patient Preparation**

<p>Fast for 4 hours (medications can be taken with water)</p>
<p>No caffeine (coffee, tea, cola) for 24 hours</p>
<p>Do not stop beta-blockers or other cardiovascular medications</p>
<p>Withhold oral theophylline or dipyridamole (Persantin, Asasantin) for 24hr if possible</p>
<p>Wear or bring appropriate clothes and shoes for treadmill exercise</p>
<p>Patient to bring a list of current medications</p>

**TABLE 4: Important Statistics for MPI with SPECT**

Sensitivity*	93%
Specificity*	77%
<p>Annual risk of cardiac death or non-fatal MI after a normal scan &lt;1%</p>	
<p>* Sensitivity is the percentage of patients with significant coronary disease who have a positive scan. Specificity is the percentage without significant disease who have a negative scan. These are average values for exercise thallium from the literature compared to coronary angiography as the gold standard. A significant angiographic lesion was defined as a 50% or 70% stenosis depending on the study.</p>	

Enquiries should be directed in the first instance to **QDI Information Officer**  
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