Nuclear cardiology in the clinical setting

Nuclear cardiology has made great strides in the past three decades.

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During the past three decades, the most rapidly growing areas of nuclear cardiology have been stress myocardial perfusion imaging single photon emission computed tomography (MPI SPECT) and positron emission tomography (PET) for the diagnosis and prognosis of patients with known or suspected coronary artery disease (CAD).

A stress ECG has a relatively low sensitivity and specificity. MPI is both more sensitive and specific than an exercise ECG for diagnosing CAD. Maximal benefit is observed in patients with intermediate probability of the disease, and in those with non-diagnostic ECGs.

Uses of MPI include:
- diagnosis of CAD
- identification of the site of ischaemia
- quantification of the extent and severity of impaired coronary flow reserve
- evaluation of acute ischaemic syndromes
- evaluation before surgery
- prognostic assessment of CAD patients
- assessment of tissue viability.

MPI is indicated to exclude or diagnose CAD in patients with suspected CAD, and as a screening test in those with intermediate CAD or at high risk of CAD. The latter includes patients with familial hyperlipidaemia, type II diabetes mellitus, family history of CAD, as well as those with atypical symptoms of ischaemic heart disease undergoing surgery and who are at high risk of developing peri- or postoperative cardiovascular events, e.g. those with peripheral vascular disease, aortic aneurysm, acute chest pain and the elderly.

In patients with CAD with congestive heart failure, it is important to identify viable myocardium.

Patients with a high probability of developing coronary heart disease require imaging to help in the planning of appropriate management rather than for diagnosis. MPI is particularly valuable to confirm silent myocardial ischaemia or infarction.

Multiple non-coronary causes of ST-segment depression that can render the stress ECG uninterpretable are:
- digitalis
- severe hypertension
- severe aortic stenosis
- anaemia
- severe hypoxia

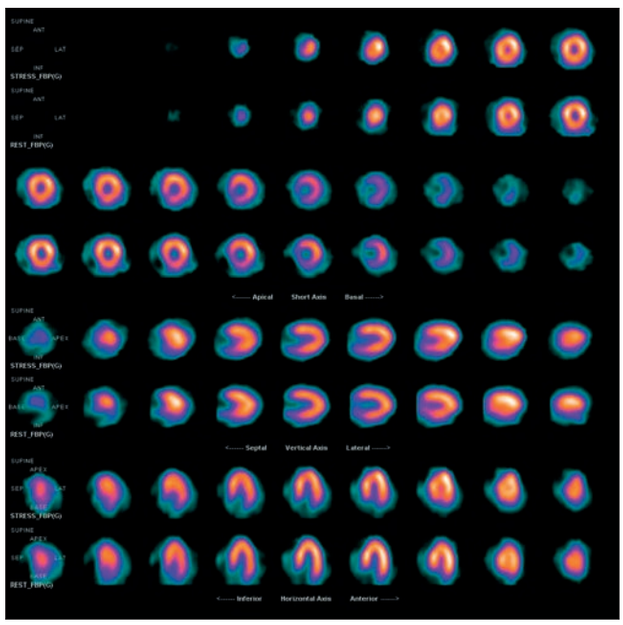

Fig 1. A normal myocardial perfusion scan (MPI). The upper row shows the stress images and the bottom row the rest images, in the short axis, long axis vertical and long axis horizontal views.

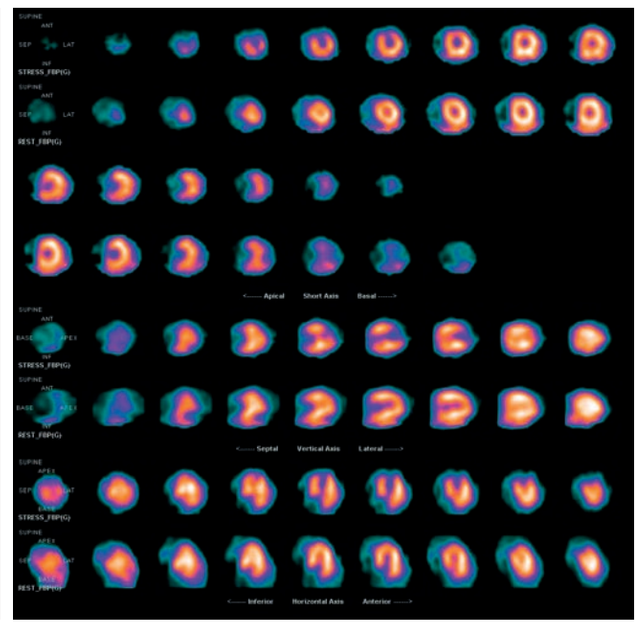

Fig. 2. Myocardial perfusion imaging (MPI), showing severe ischaemia in the apical and apical-anterior segments.

- left ventricular hypertrophy
- glucose load
- hypokalaemia
- mitral valve prolapse
- IV conduction disturbance
- supraventricular tachyarrhythmias
- cardiomyopathy
- sudden excessive exercise
- hyperventilation
- severe volume or pressure overload.

In the abovementioned cases, MPI can contribute in clarifying the presence or absence of ischaemia.

Patients with a high probability of developing coronary heart disease require imaging to help in the planning of appropriate management rather than for diagnosis.

In patients with confirmed CAD, MPI is indicated in:

- Evaluation of the functional significance of a coronary lesion. The extent and severity of the stress perfusion defect is closely related to subsequent cardiac events. It is therefore important to determine the size, severity and reversibility of a stress-induced perfusion defect. Functional criteria provide more accurate characterisation of stenosis severity than angiographic criteria. The presence of an angiographic lesion does not necessarily mean that it is responsible for the patient's symptoms.
- Risk stratification and prognosis evaluation.
- Detection of 'high-risk' CAD.
- Post-infarction risk stratification. Detection of ischaemia, either at the site of injury or in a different region, detection of myocardial viability in the infarcted region, and flow-function relationship (from gated SPECT).
- Deciding on long-term medical management versus revascularisation in patients with stable angina.
- Detection of restenosis after revascularisation, percutaneous transluminal coronary angioplasty (PTCA), stents or coronary artery bypass graft (CABG).
- Detection of residual ischaemia while planning multiple PTCAs.
- Post-CABG evaluation in suspected graft occlusion or for routine assessment.
- Thallium-201, and technetium-99m radio-labelled lipophilic compounds such as sestamibi and tetrofosmin – most commonly used for MPI SPECT.

There are multiple contraindications to a physical stress test:

- poor motivation to exercise
- poor exercise capacity due to non-cardiac endpoints (such as fatigue or shortness of breath)
- beta-blocking drugs that limit heart rate response
- left bundle-branch block
- fewer than 5 days after a myocardial infarction
- peripheral arteriosclerotic vascular disease
- disabling arthritis
- history of stroke
- orthopaedic problems (e.g. low back pain)
- chronic pulmonary disease
- amputation of an extremity.

In these cases, exercise can be replaced by pharmacological stress by administering vasodilators, e.g. adenosine or dipyridamole, or inotropic agents, e.g. dobutamine. The sensitivity and specificity of the pharmacological and physical stress tests are equivalent.

According to the American Society of Nuclear Cardiology, the overall risk of hard adverse events (death or non-fatal myocardial infarction) in an individual with a normal perfusion scan is <1% for a period of 12 months, independent of age, gender, symptoms, history of CAD, presence of CAD, isotope or imaging technique used (Fig. 1).[1] If the perfusion scan is abnormal, the risk of adverse events increases in proportion to the affected area.[2-12]

Fixed and reversible perfusion defects can predict hard events. However, patients with extensive stress-induced ischaemia are at higher risk (Fig. 2).[3-6, 8, 9, 11, 13-15]

Post-stress left ventricular ejction fraction (LVEF), as measured by gated SPECT, provides significant information in addition to the extent and severity of perfusion defects in the prediction of cardiac death.[10]

In patients with CAD and congestive heart failure, it is important to identify viable myocardium. Ventricular function and symptoms may improve with revascularisation therapy in patients with significant hibernating or stunned myocardial tissue. In addition, patients with viable myocardium are at greater risk of hard events than those without viability when treated medically and not referred for revascularisation. MPI SPECT with thallium-201, Tc-99m sestamibi or tetrafosmin and PET imaging with F-18 flourodeoxyglucose (FDG) have an essential role in localising viable myocardium.[16-19]

A stress ECG has a relatively low sensitivity and specificity. MPI is both more sensitive and more specific than exercise ECG for the diagnosis of CAD.

Currently, the clinical approach is based on identifying patients who are at risk for cardiac death and non-fatal myocardial infarction rather than those with anatomical coronary disease. MPI therefore plays a fundamental part in the diagnosis and risk stratification of these patients.[2]

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Summary

- A stress ECG, with its relatively low sensitivity and specificity, may not be sufficient to evaluate patients with known or suspected ischaemic heart disease.
- MPI SPECT is both more sensitive and specific than a stress ECG in the diagnosis and risk stratification of patients with significant CAD and may act as a gatekeeper for coronary angiography.
- There is extensive literature to show that patients with normal MPI are at very low risk of hard cardiac events (death or non-fatal myocardial infarction) for 1 year and even 2 years after the test. However, the risk increases linearly with the degree of ischaemia.
- Post-stress LVEF provides significant information on the extent and severity of the perfusion defect on risk prediction. In patients with ischaemic heart disease and congestive heart failure, MPI SPECT is an extremely valuable tool to identify and quantify viable myocardial tissue.