Investigating hibernating myocardium

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Hibernating myocardium (HM) arises from repeated episodes of ischaemia, due to reduced subendocardial blood flow, and leads to dysfunctional myocardial movement. HM can be found in various conditions, including stable or unstable angina, acute myocardial infarction, LV dysfunction with or without congestive cardiac failure, anomalous left coronary artery from the pulmonary artery, LV aneurysm, aborted sudden death and valve disease with LV dysfunction.

Revascularisation of hibernating myocardium can improve regional and global LV systolic function, and reverse remodelling, with a subsequent increase in survival rate. Given these possible gains, patients with the conditions mentioned may benefit from prompt assessment. There are myriad potential investigations to diagnose this condition. This article looks at the choice of cardiac imaging.

Imaging used for the investigation of HM

Echo and SPECT

The first investigation for potential HM should be echocardiogram. This allows assessment of wall thickness, wall movement with strain indices, dilation of ventricles and LV end-diastolic volume (LVEDV) and LV ejection fraction (LVEF). In those with severe LV dysfunction where LVEDV is greater than two times the normal upper limit or if there are ≥4 ventricular segments with scar, there is minimal chance of LV function recovery. If LVED wall thickness is ≤0.5-0.6cm and is associated with akinesis or severe dyskinesis, there is a <5% chance of recovery, though this rises to ≥50% if the wall thickness is >5-6mm.

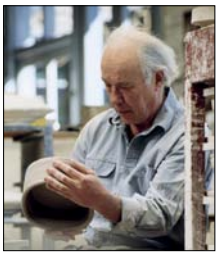
Low dose dobutamine echocardiography (LDDE) can be used to look at the contractile reserve of the myocardium and has a sensitivity of between 75-80% and a specificity of 80-85%. LDDE is best used in combination with other imaging, and a combination of wall thickness and LDDE gives a sensitivity of 88% and specificity of 77% for chance of functional recovery. LDDE with SPECT gives a similar degree of accuracy.

LDDE is more operator dependent than SPECT and can be difficult in large patients and those with COPD (due to difficulty obtaining good acoustic windows).

Stress myocardial perfusion SPECT using radionuclide perfusion agents has excellent sensitivity for prediction of regional functional improvement with revascularisation (80-90%), however specificity is 54-80%, based on current knowledge. For recovery of function, stress-redistribution-reinjection thallium scanning gives negative and positive predictive accuracy of between 80-90%.

Due to the nature of the study, SPECT is more sensitive than LDDE for detecting viable myocardium; however LDDE is more specific for predicting recovery of myocardial function post-revascularisation. For this reason it is recommended that both imaging techniques are used in potential candidates. If there is any evidence of reversibility, an attempt at revascularisation is appropriate. If there is no evidence for reversibility, further imaging may be required to try and prove this and both echocardiography and SPECT are Medicare funded.

Case Study



Mr DD presented to the ED with symptoms and signs of minor left sided stroke (subsequently proven on brain MRI) and excessive tiredness over the last year. His past medical history included inferior MI in 1994, which matched ECG findings. Echocardiogram demonstrated moderate global LV systolic dysfunction and left ventricular ejection fraction (LVEF) 37%.

Stress myocardial single photon emission computed tomography (SPECT) showed evidence of a large inferior and lateral infarct and a small region of reversibility at the mid inferoseptal wall. Myocardial positron emission tomography (PET) using ^{18}F-2-fluoro-2-deoxyglucose demonstrated a large region of perfusion-metabolic mismatch in the inferior and lateral left ventricular walls i.e. normal or increased metabolism in an area of poor or absent perfusion (see figures: SPECT perfusion slices are above the corresponding FDG metabolism slices). This was in keeping with significant hibernating myocardium in the inferolateral wall and was highly predictive of myocardial viability or a high likelihood of improved cardiac function following revascularisation.

A repeat echocardiogram 3.5 months after coronary stenting showed only mild global LV systolic dysfunction, and the LV ejection fraction had improved to 50%. The patient was feeling well and able to get through the working week without any difficulty.

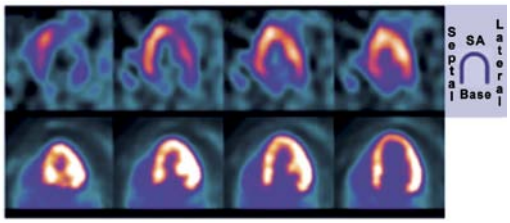


Figure 1: PET mismatch in the lateral wall (perfusion top row; metabolism bottom row).

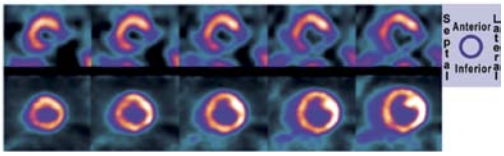


Figure 2: PET mismatch in the inferolateral wall (perfusion top row; metabolism bottom row).

PET and CMR

Due to relative ischaemia in hibernating myocardium, ATP is produced from glucose preferentially. The glucose substitute ^{18}F-2-fluoro-2-deoxyglucose is taken up by myocardial cells but due to it being a poor substrate for glycogen synthesis and glycolysis, it remains within the cell. The concentration of ^{18}F in the tissue then provides qualitative data on rates of glucose utilisation.

PET is remarkably accurate in cardiac imaging; the positive predictive value for recovery of function post-revascularisation is 85%, while the negative predictive value is even higher at 92%.

In areas of hibernating myocardium there is almost always a significant degree of scar tissue. Gadolinium chelates are an extracellular and interstitial contrast agent used in cardiac magnetic resonance imaging (CMRI) and tend to collect in areas of scar, and non-viable tissue. The accuracy for CMRI in identifying viable tissue is comparably high with PET-FDG, and its sensitivity is 88%, specificity 87% and positive predictive value 92%. When combined with dobutamine, CMR sensitivity is 89% and specificity 94% in identifying LV functional recovery. Either PET or CMRI are helpful in identifying areas of HM not identified by LDDE and SPECT. FDG PET for assessment of myocardial viability is approved by Medicare, however CMRI is not. ■

Learning Points

1. The conditions in which HM may occur:
   - stable or unstable angina
   - acute myocardial infarction
   - LV dysfunction +/- congestive cardiac failure
   - ALCAPA
   - LV aneurysm
   - aborted sudden death
   - valve disease with LV dysfunction
2. A step-wise approach should be taken with regards to imaging in patients with cardiac dysfunction:
   - Standard echo +/-
   - LDDE and SPECT +/-
   - PET and CMR
3. Relatively small changes in LVEF can lead to improvement in morbidity and mortality.
4. Investigation for reversible cardiac dysfunction can bring rewards.