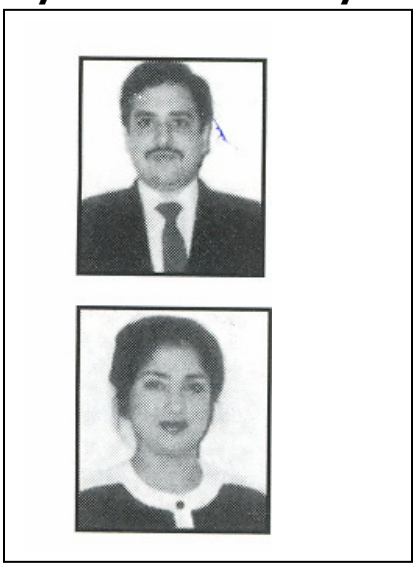
Myocardial Viability



Anand U Kulkarni MD DM

Rachana A Kulkarni MD

East Brunswick, New Jersey

Over the past two to three decades significant advances have been made in therapy of coronary artery diseases. This has lead to a fall in the death rate from coronary artery disease. The improved survival has been associated with increased incidence of congestive heart failure. Assessment of myocardial viability is important in this population to determine the best modality of treatment. In the past myocardium was either alive and hence functioning or dead and non-functioning. Now we know that systolic contractile dysfunction can occur despite preservation of myocardial cellular metabolism and thus viability. The viable myocardium in non-contractile regions is either stunned or hibernating.

Stunned myocardium: When a coronary artery is occluded then resultant ischemia leads to wall motion abnormality onset of wall motion abnormality is immediate with onset of ischemia. Once ischemia is relieved resolution of wall motion abnormality may not be immediate. It may take hours or days to recover. The state of prolonged regional wall motion abnormality following a sublethal episode of ischemia has been described as stunned myocardium.

Hibernating myocardium: Hibernating myocardium is a chronic process caused by long standing partial reduction in resting coronary blood flow. In this scenario there may be no chest pain, No EKG changes but there may be diminished left ventricular function. In contrast to

scarred myocardium hibernating myocardium has potential to recover contractile function, often rapidly after revascularization.

Stunned and hibernating myocardium are thus two distinct entities albeit with some overlaps in one segment of myocardium there may be normal, scarred myocardium plus stunned and hibernating myocardium. It is felt that hibernating is secondary to chronic reduced blood flow to a level where myocardium is live but not with same degree of contractility. It is also argued that hibernating myocardium may be due to repetitive episodes of stunning. Repetitive ischaemia may be due to abnormal vasomotion or due to increased oxygen demand for example due to increased physical activity.

In the scenario of coronary artery disease and presence of LV dysfunction it is important to assess viability to judiciously use our resources. If significant viability is present, revascularisation with either PCI or CABG may be considered. In absence of viability medical therapy would be appropriate. Thus only patients with viable myocardium would be exposed to risks and costs of interventions for possible benefit.

APPROACHES TO DETECT VIABLE MYOCARDIUM :

Clinically, EKG and angiographic assessment are often not helpful in differentiating scarred from dysfunctional but viable myocardium. Nuclear imaging techniques use myocardial perfusion and metabolism to assess viability. While PET scanning is used to assess metabolism, SPECT imaging with agents such as Thallium – 201 or Technetitium – 99m is used for assessment of perfusion.

SPECT IMAGING

Single photon imaging can be done with radionuclides which are commercially easily available. Tl-201, Tc99m are examples of some of the common radionuclides used. Although TC99m sestamibi can be used for viability assessment, Tl-201 has been more extensively studied.

In a typical stress test patient is stressed using treadmill/dipiridamole/adenosine or dobutamine. At peak of exercise or stress Tl-201 is injected. Once Tl-201 is injected it is important to begin imaging immediately. Images are obtained with a gamma camera. Patient is asked to come back between three to four hours and redistribution imaging is done at that time.

Thallium 201 is potassium analog and is taken up by myocardium. The initial uptake depends myocardial blood flow and myocardial extraction of thallium – 201. This requires that the cell be viable. Redistribution of Thallium – 201 begins within minutes. There is a constant exchange between myocardium and blood pool. Thus areas with good uptake give out thallium – 201, areas with low perfusion now starts getting more Tl-201 or they give out Tl-201 more slowly. This redistribution leads to equalization of thallium – 201 counts or resolution of a defect.

When interpreting a nuclear stress test thus we have a set of pictures at peak of stress and another set of redistribution at rest. Various myocardial segments are identified on these scans. If a segment has uptake on stress and redistribution, it is considered normal. If a defect is seen on stress and not seen on redistribution scans, it is indicative of ischemia and that segment is viable. If a defect is seen on stress scan as well as rest scans it is called a fixed defect and is indicative infarct and in past were considered indicative of non-viability.

It is important to remember that all fixed defect do not represent scar as 30-40% of such defect, improve after revascularisation, thus indicating that even in those fixed defects there is a viable myocardium. Thus additional measures are needed to detect viability in such fixed defects.

Quantitative assessment: Persistent defects which are mild showing only 25-50% reduction in counts are indicative of viability.

Late 24 hour Redistribution imaging: When a defect is seen on stress images and on 2.5-4 hour images; late 24 hour redistribution imaging can be undertaken. Studies have shown usefulness of this technique in correctly assessing viability in areas that would otherwise be called scar. A major limitation is sub optimal count statistics after 24 hours . This leads to poor quality images.

Reinjection Protocol: An alternative to 24 hour delayed redistribution imaging is the reinjection of second dose of Thallium 201 after acquiring 2.5-4 hour redistribution images. Thus images are taken on stress, 4 hour later and then again after reinjection . A defect seen on stress and on 4 hour imaging but not seen on imaging after reinjection is indicative of viability. Several groups have shown that

uptake after reinjection is as sensitive as PET imaging for myocardial viability.

The 2.5-4 hour redistribution images should not be excluded because some defects that demonstrate redistribution at 4 hours will revert to persistent defects after reinjection . Magnitude of defects seen on post-stress image is reduced on 4-hour redistribution image. Magnitude of defect increases again after reinjection. This is seen when there is a diminution in resting coronary blood flow and defect pattern seen after reinjection represents the resting flow reduction. About 25% of defects will be wrongly called nonreversible if 4 hour redistribution imaging is not performed before reinjection.

Thus the sequence of post-stress, 4 hour redistribution and reinjection imaging is currently accepted as the most appropriate protocol for detection of defect reversibility.

This sequence appears to be as sensitive as PET imaging with FDG to differentiate between ischemia and scar.

Rest-Redistribution Th201 Imaging: Stress test protocol may not always be appropriate in all patient subsets. In patient with severe LV dysfunction, the question sometimes is whether to revascularise or to perform cardiac transplant. These patients may be critically ill, on pressors, ventilator or TABP. In many patients cardiac catheterization and angiographic data may already be available. Exercise stress test is not necessary in this subset. In this subset of patients a rest-redistribution protocol is helpful. Imaging is initially done after injection of Th201 and again 4 hour later. There may be resting hypo-perfusion in certain segments and hence perfusion abnormalities may be present. Four hour later imaging is done again and these segments may show reversal. The segments with reversibility on Rest-redistribution improve with revascularization. Rest-redistribution protocol has good specificity but is not a sensitive index.

Positron Emisson Tomography – PET

Sophisticated imaging techniques like PET imaging may be the most sensitive noninvasive approach for identifying viability in asynergic myocardium and is considered by many to be the gold standard for viability detection.

A number of tracers are available for PET imaging. 18F deoxy-glucose commonly called as FDG is used for glucose metabolism. 11C palmitate is used for fatty acid metabolism and 11C

acetate can be used for overall oxidative metabolism. Agents for perfusion imaging are 13N ammonia, 15-0 labelled water or 82Rb. The most common technique utilizes N13 ammonia as perfusion agent and FDG as a metabolic marker of glucose utilization.

In a zone of myocardial asynergy if FDG uptake is seen, it indicates presence of glycolysis and hence viability. A myocardial segment is considered to be irreversibly injured on PET scan when decreased perfusion is matched with decreased FDG uptake. Presence of a mismatch pattern when intact FDG uptake occurs in presence of decreased perfusion is indicative of viability.

PET imaging of blood flow and metabolism is useful for preoperative evaluation in patients with marked LV dysfunction. The major limitation for PET scan is its expense. PET scan is not easily available due to unavailability of tracers. Many of the PET tracers require cyclotron generation on premises.

Thus in summary, assessment of myocardial viability is important to decide need for revascularization. Nuclear techniques with SPECT or PET imaging can provide very important data, which would be clinically useful. Although PET imaging is an excellent techniques for demonstrating myocardial viability, its general use is limited by its expense and unavailability of tracers. Th201 is more easily available and provides very useful data when a proper protocol is used.