Myocardial Viability: Cardiac MRI or PET

Ali Ahmad MD, FACC.
Director of non-invasive cardiovascular imaging services
Mercy Health Physicians, Toledo OH

Disclosure

• None
Definition of viable myocardium

- Viable = Alive, Salvageable or able to regain function.

- Viable cardiomyocytes? Myocardial segment/s?

- Viable myocardium: Myocardial segments with reduced function that often appear dysfunctional on imaging studies. These segments are capable of functional recovery, either spontaneously or after the offending insult – usually ischemia – is removed by revascularization.

Basic concepts

- Viable myocardium is dysfunctional but alive

- Myocardial scars are dysfunctional and non-viable

- Stunned myocardium is dysfunctional and capable of spontaneous recovery

- Hibernating myocardium is dysfunctional and ischemic and revascularization may lead to functional recovery.
Problems with these definitions

- This is an oversimplification.

- Not all myocardial scars are full thickness and the degree of transmurality would determine the degree of functional recovery with revascularization.

- Techniques that are very sensitive in detecting viable myocardium may not translate into functional recovery after revascularization.

- Functional recovery is the ‘gold standard’ of myocardial viability assessment

Histopathologic Characteristics

1. Loss of contractile proteins (sarcomeres).

2. Glycogen-rich perinuclear zones adjacent to areas of numerous small mitochondria.

3. Substantial loss of sarcoplasmic reticulum.

4. Nuclear changes with heterochromatin distributed evenly over the nucleoplasm.

5. Downregulation of beta adrenergic adenylyl cyclase.

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Assessment of Viability

- Dobutamine Stress Echo/MRI (Contractile Reserve).
- Myocardial Contrast Echo (Microcirculatory integrity)
- SPECT imaging using Tc labelled compounds (Intact Mitochondria).
- SPECT imaging using Thallium 201 (Cell membrane integrity).
- PET-FDG (Myocardial glucose utilization).
- Cardiac MRI (Scar detection and Contractile reserve).

Why PET

- The most well-studied method: Compares perfusion and metabolism of the heart.
- Very high energy output allows for clear imaging, less interobserver and intra-observer variation.
- Can be combined with CT to better identification of soft tissue artifact.
- Absolute blood flow can be measure.
- Predictive of outcomes
Limitations

- Lower specificity to dob.echo & MRI
- Cannot differentiate b/w endocardial and epicardial viability
- High cost
- Limited availability

Data on PET

For predicting segmental functional recovery, the pooled data showed

- Sensitivity of 93%
- Specificity of 58%
Positron Emission and Annihilation

Example of PET Imaging
PET Tracers versus SPECT

![Graph showing the relationship between tracer uptake and myocardial blood flow.]

PET Tracers

**Perfusion Agents**
- Rubidium-82
- N-13 Ammonia
- O-15 Water

**Metabolic Agents**
- F-18 Fluorodeoxyglucose
PET Perfusion Agents

<table>
<thead>
<tr>
<th>AGENT</th>
<th>1/2-LIFE</th>
<th>DOSE</th>
<th>MEAN POSITRON RANGE</th>
<th>PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>O-15 Water</td>
<td>2.0 min</td>
<td>60–100 mCi</td>
<td>1.1 mm</td>
<td>Cyclotron</td>
</tr>
<tr>
<td>N-13 Ammonia</td>
<td>9.8 min</td>
<td>7–20 mCi</td>
<td>0.7 mm</td>
<td>Cyclotron</td>
</tr>
<tr>
<td>Rb-82</td>
<td>75 sec</td>
<td>20–60 mCi</td>
<td>2.4 mm</td>
<td>Generator</td>
</tr>
</tbody>
</table>

Metabolic imaging

- The myocardium typically uses 2/3 fatty acid oxidation and 1/3 glucose to meet its energy needs.

- During ischemia, energy production is shifted from fatty acid oxidation to glucose which may contribute up to 70% of the total energy production.

- Uptake of glucose increases in the post-prandial state. So usually the patient is asked to fast for 6 hours followed by administration of a glucose load (25-100g) to stimulate natural insulin production.
Metabolic imaging

• $^{18}$F-FDG is a glucose analog

• Initial uptake is comparable to glucose uptake

• After phosphorylation, it remained trapped in the myocyte and cannot be further metabolized and therefore becomes a strong signal for imaging

PET Viability Interpretation

- Areas that are well perfused with metabolic activity are viable

- Flow metabolism mismatch-reduced perfusion with intact metabolism: hibernating viable myocardium

- Flow metabolism match-impaired FDG uptake with reduced perfusion-scar
PET Viability Interpretation

Cardiac MRI for Viability

- Preserved wall thickness >5.5mm correlated with PET viability

- Dobutamine cine MRI
  - Improved thickening>2mm by low dose dobutamine CMR
  - Higher accuracy than dobutamine echo
  - Monitoring difficult

- Delayed enhancement MRI (DEMRI)
Mechanism of Late Gadolinium Enhancement in infarcted or scarred tissue

Scarring begins at sub-endocardial surface and extends toward the epicardium

Transmural extent of infarct used to determine viability of each segment.

Likelihood of functional improvement inversely related to TEI

78% with no delayed hyperenhancement improved, only 2% with >75% TEI improved (Kim RJ et al; NEJM 2000)
SSFP cines imaging

Delayed Enhanced imaging
SSFP cines imaging

Delayed Enhanced imaging
Non-transmural infarction

Cardiac MR
Cardiac CMR

Advantages

- Accurate assessment of extent of scar
- Superior spatial resolution
- Simultaneous assessment of perfusion, function and viability
- Good imaging windows
Disadvantages

- High cost, limited availability
- Longer time
- Contraindicated with implanted ferromagnetic objects
- Gadolinium contraindicated in CKD with GFR<30ml/min
- Claustrophobia, Breathholding required

Data on MRI

- Using a cutoff value of 25% transmurality of scar tissue, the sensitivity and specificity were 86% and 61% to predict improvement of function
- Using 50%, the sensitivity and specificity were 97% and 44%
- Using 75%, sensitivity and specificity would be 100% and 15%, respectively

Kim RJ et al, NEJM, 2000;343:1445–53
DHE to predict the result of revascularization

Kim, Wu, Rafael, et al., NEJM 2000;343:1445-1453

DHE to Predict SCD in ICM

Assessment of Myocardial Scarring Improves Risk Stratification in Patients Evaluated for Cardiac Defibrillator Implantation

Igor Klem, MD,* Jonathan W. Weinsaft, MD,* Tristram D. Bahmson, MD,‡ Don Hegland, MD,* Han W. Kim, MD,* Brenda Hayes, BS,* Michele A. Parker, MS,* Robert M. Judd, PhD,*‡ Raymond J. Kim, MD*‡
Durham, North Carolina
DHE to Predict SCD in ICM

PARR2

- EF ≤ 35% considered for revascularization, transplant, or HF work-up with high suspicion of CAD.
- Randomized patients to a PET-guided therapy or “standard care” (no PET).
- Imaging physicians issued a therapy recommendation based on PET findings and treating physicians then made a decision regarding revascularization.
- Patients in the standard care arm had no PET, but could have another viability test, which was performed in 138 of 209 (66%) patients.
- Primary outcome: composite of cardiac death, myocardial infarction, or recurrent cardiac hospitalization within 1 year.
• The first prospective randomized trial testing the hypothesis that CABG improves survival in patients with ischemic LV dysfunction [EF-26.7% ± 8.6%] compared to outcome with aggressive medical therapy

• Myocardial viability identifies patients with CAD and LV dysfunction who have the greatest survival benefit with CABG compared to aggressive medical therapy

1,212 patients enrolled in the STICH Revascularization Hypothesis Trial

601 patients included in the STICH Myocardial Viability Substudy

303 patients randomized to medical therapy alone
298 patients randomized to medical therapy plus CABG

243 patients with myocardial viability
60 patients without myocardial viability
244 patients with myocardial viability
54 patients without myocardial viability

95 deaths
33 deaths
83 deaths
25 deaths

P = 0.53 for the interaction between viability status and treatment assignment with regard to mortality

Figure 4. Flowchart of the STICH Myocardial Viability Substudy

STICH Trial- substudy
Conclusion

• Randomized trials of viability using PET and Cardiac MRI are lacking.

• Currently available evidence does not support the use of viability testing as the arbitrator in the decision making process regarding revascularization in ischemic cardiomyopathy

• In ischemic cardiomyopathy: Multiple factors play important prognostic role. Viability alone cannot provide an unequivocal answer

Thank you