Myocardial Viability Imaging With PET

Marcelo F. Di Carli, MD
Brigham and Women’s Hospital
Harvard Medical School
Boston, MA

Conflict of Interest: No Relations to disclose

Objectives

To review:
- Basic principles of cardiac cell metabolism and its changes during ischemia
- Radiotracers available to assess myocardial viability
- Recognition of viability patterns
- Strengths and limitations of protocols for preparation of patients for FDG imaging
- Interpretation of FDG images
- Clinical results

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Cardiac Substrate Metabolism

Glucose

Glycolisis

Pyruvate

Fatty Acids

β Oxidation

Acetyl CoA

Krebs cycle

ATP

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Effect of Changes in Plasma Substrates on Normal Myocardial Metabolism

- Fasting
  - Blood: ↓ plasma glucose, ↓ insulin, ↑ FFA
  - Myocardium: ↑ glucose uptake (FDG), ↑ FFA uptake

- Glucose-loaded
  - Blood: ↑ plasma glucose, ↑ insulin, ↓ FFA
  - Myocardium: ↑ glucose uptake (FDG), ↓ FFA uptake

Effect of Changes in Plasma Substrates on Myocardial Metabolism in Ischemia

- Ischemic
  - MBF: ↓
  - Blood: ↑ glucose uptake (FDG), ↑ glycogen breakdown, ↑ glucolysis, ↓ mitochondrial metabolism, ↓ FFA uptake
  - Myocardium: ↑ glucose uptake (FDG), ↓ FFA uptake

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Metabolic Imaging with PET

- F-18 FDG
- C-11 Glucose
- C-11 Palmitate
- F-18 Thia FAs
- C-11 Acetate
- O-15 Oxygen

FDG Uptake and Metabolism

Glycolysis

hexokinase

Glycogen

Glucose

Glucose-6-P

Phelps et al, JNM 1978

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Experimental Design

Repetitive Stunning

PET Imaging

2-DEcho

Hemodynamics

Radiolabeled microspheres


Time Course of Post-ischemic Dysfunction

Wall Motion Score


Cell Metabolism – Repetitive Stunning

Perfusion

FDG uptake

MVO2


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**Metabolic Viability Imaging with PET: Patient Preparation**

- Fasting 6-12 hr – fasting glucose measurement
- OPTIONS:
  1. Glucose Load 50 g (25-100 g) +/- Insulin Supplement
  2. Hyperinsulinemic/Euglycemic Clamp
  3. IV D-50-W (13-25g) +/- Insulin Supplement (Emory-Crawford Long H)
  4. Nicotinic Acid Derivatives (Niacin or Acipimox)
- Special Considerations
  1. Diabetes
  2. CHF with or without diabetes

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Standard Oral Glucose Load + IV Insulin

**General Principles**

- **Glucose load**: Always (even in diabetics), unless baseline BG >300 mg/dL
- **IV insulin**: Almost all patients, even if they are not diabetic
  - Use sliding scale depending on BG level (avoid large insulin doses)
  - K supplements rarely needed with the usual insulin doses (2-10 U, regular insulin)
  - Check BG levels every 10-15 mins
- **NEED TO OVERCOME INSULIN RESISTANCE!**
Imaging Protocols

**PET**
- N-13 ammonia
- Rubidium-82
- O-15 water
- FDG

**SPECT/PET**
- N-13 ammonia
- Rubidium-82
- O-15 water
- FDG

**ANIMA**
- Courtesy of Dr. Marcelo Di Carli, Brigham & Women’s Hosp

**Cardiac PET/CT Viability Protocol**
- Rb-82 50-60 mCi
- Dipy 0.55 mg/kg
- IV contrast

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Poor Quality FDG images

- Review:
  - QC
  - Patient motion
  - Doses of glucose, insulin and FDG

- Poor FDG uptake:
  - Review perfusion images for diagnosis
  - Repeat scan immediately; +/- delayed images
  - More insulin
  - Alternative test

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Segmental Visual Analysis

<table>
<thead>
<tr>
<th>Perfusion</th>
<th>FDG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Anterior</td>
</tr>
<tr>
<td>Septum</td>
<td>Inferior</td>
</tr>
<tr>
<td>Anterior</td>
<td>Inferior</td>
</tr>
<tr>
<td>Lateral</td>
<td>Inferior</td>
</tr>
</tbody>
</table>

Scores:
- 0 = normal
- 1 = minor defect
- 2 = moderate defect
- 3 = severe defect
- 4 = absent uptake

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Scores and EF changes for 3 Patient Examples

<table>
<thead>
<tr>
<th></th>
<th>JPD</th>
<th>FB</th>
<th>JS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAR (% of total LV)</td>
<td>42</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Mismatch (% of total LV)</td>
<td>5</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>MODEL: delta EF expected</td>
<td>0</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>OBSERVED delta EF</td>
<td>-1</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Pre-op EF</td>
<td>26</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Post-op EF</td>
<td>25</td>
<td>28</td>
<td>37</td>
</tr>
</tbody>
</table>

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Relative Predictive Accuracy of Myocardial Perfusion and FDG PET/SPECT

Myocardial Perfusion

FDG Imaging

8 studies - 233 patients
(≥17% of LV with PET mismatch)

FDG PET for Predicting Improvement in Global LV Function After Revascularization

Relation Between the Magnitude of Viability and Improvement in CHF After CABG

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Re-Hospitalization for CHF by PET Pattern of Viability and Mode of Treatment

Long-Term Prognosis of Patients With LV Dysfunction by PET Pattern of Viability and Mode of Treatment

Risk of Cardiac Events in Patients With PET Evidence of Viability Treated Medically and With CABG

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Conclusions

- Optimization of diagnostic quality requires careful patient preparation, particularly of those with CHF with or without diabetes.
- All FDG protocols have advantages and disadvantages and, thus, selection of the protocol should be based on the logistics of each laboratory.
- Quantitation (match/mismatch and scar, and LV function) is a very useful aid in clinical decision making.