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Positron Emission Tomography Assessment of Myocardial Viability

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OVERVIEW

Differentiation of left ventricular (LV) dysfunction due to myocardial hibernation or stunning versus myocardial scar is critical for appropriate treatment and prognosis assessment. ^{18}F-fluorodeoxyglucose (FDG) PET imaging is the only FDA-approved technique for the assessment of myocardial viability. Accurate detection of viable myocardium by PET is achieved by referencing regional ^{18}F-FDG metabolism to regional resting myocardial blood flow on perfusion images. The purpose of this document is to highlight the key elements of appropriately performed, high-quality myocardial positron emission tomography (PET) to detect viable myocardium. Topics covered include: indications, contraindications, optimal testing protocols, and reporting templates.

INDICATIONS FOR PET IMAGING

The 2016 American Society of Nuclear Cardiology (ASNC) imaging guidelines/Society of Nuclear Medicine and Molecular Imaging procedure standard for positron emission tomography (PET) nuclear cardiology procedures identifies appropriate indications for PET MPI. These include:

- Myocardial perfusion imaging
- Assessment of glucose metabolism
  - Myocardial viability
  - Detection of cardiovascular inflammation
  - Detection of cardiovascular infection

CONTRAINDICATIONS

Contraindications to PET imaging include:

- Inability to lie flat or still during image acquisition;
- Pregnancy;
- Weight exceeding the PET machine table limit or inability to fit inside the gantry;
- Claustrophobia (rarely).

TEST PREPARATION

- Assess patient's height, weight, chest circumference, ability to lie flat, pregnancy status, history of claustrophobia, and history of diabetes.
- The oral glucose loading protocol in **Table 1** typically produces a substrate and hormonal environment favoring myocardial metabolism of glucose over fatty acids.
- **NOTE**: Patient preparation protocols for the assessment of myocardial viability differ from those used to assess inflammation or infection. For assessment of myocardial viability the myocardium needs to shift toward glucose metabolism to maximize ^{18}F-FDG uptake to improve image quality, whereas with inflammation and infection, the myocardium is shifted to fatty acid metabolism so that tracer uptake is limited to active inflammatory cells.

Table 1. Oral glucose loading protocol for non-diabetic patients with fasting blood glucose < 250 mg/dL*

Fasting period	6-12 hrs
Glucose load	25-100 g
Maintain blood glucose 100-140 mg/dL at ^{18}F-FDG injection	Blood glucose 45-60 min after glucose load: 130-140 mg/dL → 1 unit regular insulin IV 140-160 mg/dL → 2 units regular insulin IV 160-180 mg/dL → 3 units regular insulin IV 180-200 mg/dL → 5 units regular insulin IV > 200 mg/dL → Notify MD
Imaging delay	45-60 min; if poor target-to-background ratio, consider giving 1-3 units regular insulin IV (based on repeat blood sugar level) and wait additional 45-60 min

**An alternate intravenous glucose loading protocol is available in the suggested reading. In patients with fasting blood glucose > 250 mg/dL and/or diabetes, no glucose load is needed, as regular insulin can be administered to bring down the blood glucose to 140 mg/dL.*

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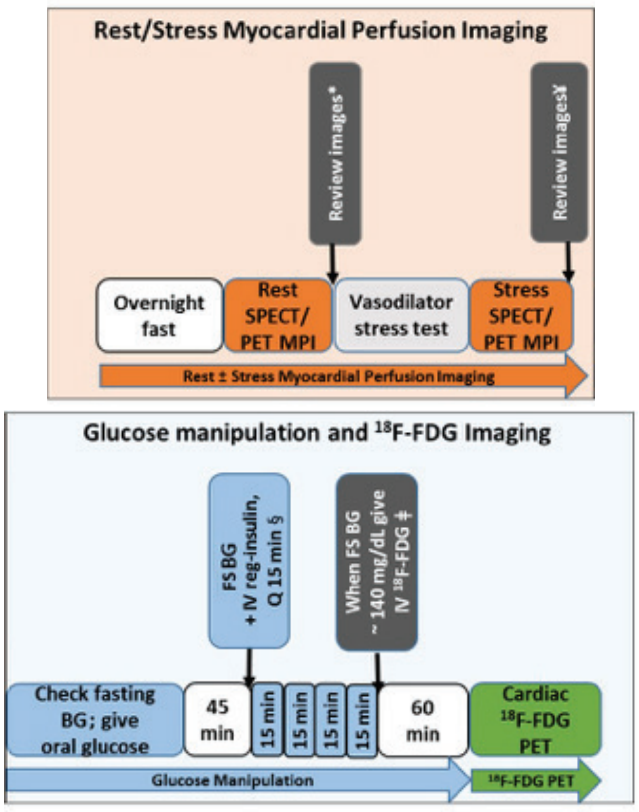
Table 2. Key characteristics of ^{18}F-FDG.

Physical half-life	110-min
Supply source	Cyclotron
Positron range	Short (excellent spatial resolution)
Critical organ	Bladder (frequent voiding 1-3 hrs post-administration)

^{18}F-FDG IMAGING PROCEDURE

Figure 1. Typical clinical flow of a ^{18}F-FDG PET myocardial viability study



- MPI = myocardial perfusion imaging
- *If indicated proceed to stress MPI, if not proceed to ^{18}F-FDG
- ¥ If no significant ischemia and viability is noted check FS glucose and proceed to ^{18}F-FDG PET/CT
- § administer regular insulin until FS glucose is in a rapid downward trend from its peak and below 200 mg/dL.
- When FSBG is ~140 mg/dL, inject 5-10 mCi of ^{18}F-FDG.
- ǂ Continue FS glucose monitoring at 15 minute intervals until BG is stable for at least two consecutive readings
- FS=finger stick; BG=blood glucose

The preferred protocol to assess myocardial viability is described in **Table 3.**

Table 3. Preferred ^{18}F-FDG PET myocardial viability protocol.

Assessment of resting and/or stress myocardial perfusion (PET or SPECT)*	
PET viability study	
Patient positioning	
Supine, arms raised above shoulders and supported	
CT topogram/scout scan for heart localization	
CT transmission scan for attenuation correction	
80-140 kVp, 10-20 mA, 4-5 mm slice thickness, no ECG gating, field of view from carina to 2 cm below inferior heart border, obtain at end-expiration or during shallow breathing	
^{18}F-FDG PET emission scan	
Acquisition mode	2D or 3D, static or list mode (simultaneous dynamic and ECG-gated)
^{18}F-FDG dose	5-15 mCi intravenously
Image duration	10-30 min
Reconstruction	Filtered backprojection or iterative reconstruction (e.g., ordered-subsets expectation maximization), reconstructed pixel size 2-3 mm, matched to perfusion images and between consecutive studies

**Should typically be performed in the same imaging session with identical parameters for patient positioning, attenuation correction, and image reconstruction; see PET Myocardial Perfusion Imaging Practice Points document.*

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INTERPRETATION AND REPORTING

- Viability assessment should start with segments that exhibit resting hyperfusion and contractile dysfunction on gated PET or SPECT myocardial perfusion imaging (MPI).
- Quantitative analysis with polar map displays that are compared with tracer- and gender-specific databases may be a useful aid to the visual interpretation of non-attenuation-corrected SPECT MPI.
- Interpretation of resting myocardial perfusion images and ^{18}F-FDG uptake patterns are summarized in **Table 4.**

Table 4. Interpretation of resting myocardial perfusion and ^{18}F-FDG uptake patterns.

Resting Myocardial Perfusion	^{18}F-FDG uptake	Interpretation
Normal	Preserved	Normal
Reduced	Preserved or enhanced	Viable myocardium (Perfusion-metabolism mismatch)
Normal or Near-normal	Reduced	Normal (if localized to septum in patients with left bundle branch block) or Viable but jeopardized myocardium Please note an exception in LBBB, where FDG uptake is reduced with normal resting perfusion, and that does NOT represent jeopardized myocardium. (Perfusion-metabolism reverse mismatch)
Proportionally reduced	Proportionally reduced	Non-viable myocardial scar (Perfusion-metabolism match)

- The extent of mismatch or match defect should be characterized as small (<10% of the LV), moderate (10-20% of the LV), or large (>20% of the LV). In addition, the severity of a match defect should be expressed as mild, moderate, or severe in order to differentiate between non-transmural and transmural myocardial infarction.
- If stress and rest MPI results are available, it is useful to add an estimate of the extent of stress-inducible ischemia in regions of normal resting perfusion and ^{18}F-FDG uptake, in regions with matched resting perfusion and ^{18}F-FDG defects, and/or in regions with resting perfusion and ^{18}F-FDG metabolic mismatch.