PET vs. SPECT: An MPI Case Review

“Cardiac PET MPI is a well-established and highly accurate technique for detecting hemodynamically significant CAD. The ability to reduce attenuation artifact is useful in all patients, but particularly the obese.”

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Purpose

- Present published data comparing the image quality and diagnostic accuracy of PET MPI to SPECT MPI in similarly matched patient types
- Report on Rb-82 PET MPI event-free survival and prognosis
- Demonstrate, through patient case studies, the effect of better image quality in the treatment of patients
  - Gender bias
  - BMI
  - Multi-vessel disease (MVD)
Figure 1. Image quality scores for PET and SPECT perfusion and ECG-gated scans

Why is the Image Quality with PET better than SPECT?

**Improved image quality for PET vs. SPECT due to:**

- Higher count rates (240% increase over SPECT)
- Improved spatial resolution; 3mm PET vs. 6mm SPECT
- Routine and robust attenuation correction on all scans
- Better detection of MVD

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Diagnostic Accuracy: PET vs. SPECT

BY GENDER

- **MEN**
  - SPECT: 69%
  - PET: 84%
  - *P = 0.55

- **WOMEN**
  - SPECT: 67%
  - PET: 88%
  - *P = 0.009

BY BMI

- **BMI<30**
  - SPECT: 70%
  - PET: 87%
  - *P = 0.05

- **BMI>30**
  - SPECT: 67%
  - PET: 85%
  - *P = 0.02

**MVD SENSITIVITY**

- **MEN**
  - SPECT: 48%
  - PET: 71%
  - *P = 0.03

- **WOMEN**
  - SPECT: 71%
  - PET: 84%
  - *P = 0.009

PET MPI: Improved Interpretive Certainty vs. SPECT MPI

Figure 2. Comparison of degrees of interpretive certainty of SPECT and PET studies

Rb-82 PET vs. Gated AC Tc-99m SPECT

SPECT:
Pooled Sensitivity = 85%
Pooled Specificity = 85%

AUC: 0.909
Q (★): 0.841

PET:
Pooled Sensitivity = 90%
Pooled Specificity = 88%

AUC: 0.95
Q (★): 0.8907

*P < 0.01 for Rb-82 PET vs. gated AC SPECT

Left Ventricular EF Reserve and Magnitude of Jeopardized Myocardium

Coronary angiogram results

Rb-82 PET MPI: Event-Free Survival

Summed Stress Score, Total Cardiac Events

Adjusted Event Free Survival

Follow up (years)

Log-rank p=0.001

Normal

Mild

Moderate - Severe

Rb-82 PET MPI: Prognosis

Prognostic Value of Stress Myocardial Perfusion Positron Emission Tomography: Results from a Multicenter Observational Registry

Cardiac death (N = 6,037)

- HR 12.9 (95% CI 7.8-21.4), P<0.0001
- HR 8.1 (95% CI 4.7-14.0), P<0.0001
- HR 2.8 (95% CI 1.7-4.7), P<0.0001
- Reference

All-cause death (N = 7,061)

- HR 3.8 (95% CI 3.0-4.8), P<0.0001
- HR 2.8 (95% CI 2.1-3.6), P<0.0001
- HR 1.4 (95% CI 1.1-1.7), P=0.001
- ≥20% myocardium
- 10 to 19.9% myocardium
- 0.1 to 9.9% myocardium
- 0% myocardium

CASE STUDIES
Case #1

Patient Profile

- **Demographics**: 77-year-old female
- **Body Habitus**: Wt: 160 lbs; Ht: 61 inches; BMI: 31
- **Risk Factor**: Hypertension
- **Reason for Test**: Atypical chest pain
- **ECG**: normal sinus rhythm and nonspecific T-wave abnormalities
- **Meds**: atenolol, famotidine, aspirin, anticoagulant

Following are images of a patient who underwent a SPECT MPI and a PET MPI study 2 weeks apart at Harvard/Brigham & Women’s Hospital in Boston, MA. The case and study all images courtesy of Marcelo DiCarli, MD (Harvard/Brigham & Women’s Hospital).
Case #1: SPECT Images
Case #1: Rb-82 PET Images
Case #1: SPECT and PET Images

Tc-99m

Rb-82
## Case #1: Summary

Cardiac catheterization was not performed because the PET MPI study was normal.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>SPECT</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of Stress</td>
<td>Adenosine (4 min)</td>
<td>Dipyridamole (4 min)</td>
</tr>
<tr>
<td>Clinical Response</td>
<td>Non-ischemic</td>
<td>Non-ischemic</td>
</tr>
<tr>
<td>BP Response</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>ECG Response</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Radiopharmaceutical</td>
<td>Tc-99m sestamibi</td>
<td>Rubidium-82</td>
</tr>
<tr>
<td>Rest / Stress Dose</td>
<td>11mCi / 33mCi</td>
<td>60mCi / 60mCi</td>
</tr>
<tr>
<td>Gated</td>
<td>Yes</td>
<td>Yes</td>
</tr>
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</table>
Case #2

Patient Profile

- **Demographics**: 59-year-old female
- **Body Habitus**: Wt: 140 lbs, H: 65 inches, BMI: 23.5
- **Reason for Test**: evaluation of atypical chest pain and dyspnea
- **Meds**: Metoprolol, amlodipine, captopril, furosemide, aspirin, simvastatin, bupropion

Following are images of a patient who underwent a SPECT MPI and a PET MPI study 12 days apart at Harvard/Brigham & Women’s Hospital in Boston, MA. The case and all study images courtesy of Marcelo DiCarli, MD and Sharmila Dorbala, MBBS (Harvard/Brigham & Women’s Hospital).
Case #2: SPECT Images
Case #2: Rb-82 PET Images
Case #2: SPECT and PET Images

Tc-99m

Rb-82
Case #2: Summary

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<td>BP Response</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>ECG Response</td>
<td>Negative*</td>
<td>Negative*</td>
</tr>
<tr>
<td>Radiopharmaceutical</td>
<td>Tc-99m sestamibi</td>
<td>Rubidium-82</td>
</tr>
<tr>
<td>Rest / Stress Dose</td>
<td>12mCi / 30mCi</td>
<td>36mCi / 36mCi</td>
</tr>
<tr>
<td>Gated</td>
<td>Yes</td>
<td>Yes</td>
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</table>

*Patient had normal sinus rhythm and non-specific ST-T wave abnormalities on the resting ECG prior to the MPI studies*
Case #2: Report Comparison

- **SPECT MPI Report**
  There was a small defect of moderate intensity in the mid to apical anterior wall that remained fixed on the rest images and most likely is due to breast attenuation artifact; however a non-transmural myocardial scar cannot be excluded.

- **PET MPI Report**
  There were no regional perfusion defects seen on the stress or rest images. The patient’s PET/CT test results are normal and suggest no evidence of flow-limiting CAD. The results suggest that the previously described fixed anterior wall defect (her prior SPECT study) is likely to represent an attenuation artifact.

  Cardiac catheterization was not performed because the PET MPI study was normal.
Case #3

Patient Profile

- **Demographics**: 82-year-old male
- **Body Habitus**: Wt: 210 lbs; Ht: 70 inches; BMI: 30.1
- **Risk Factor**: Hypertension
- **Reason for Test**: preoperative cardiac evaluation prior to hip replacement surgery
- **Meds**: aspirin, bisoprolol

Following are images of a patient who underwent a SPECT MPI and a PET MPI study 2 weeks apart at University Hospitals Case Medical Center in Cleveland, OH. The case and all images are courtesy of Jim O’Donnell, MD (University Hospitals Case Medical Center, Cleveland, OH).
Case #3: SPECT Images
Case #3: Rb-82 PET Images
Case #3: SPECT and PET Images

Tc-99m

Rb-82
Case #3: Summary

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<td>BP Response</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>ECG Response</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Radiopharmaceutical</td>
<td>Tc-99m sestamibi</td>
<td>Rubidium-82</td>
</tr>
<tr>
<td>Rest / Stress Dose</td>
<td>10mCi / 33mCi</td>
<td>47mCi / 47mCi</td>
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<tr>
<td>Gated</td>
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<td>Yes</td>
</tr>
<tr>
<td>Length of Time</td>
<td>2.5 hours</td>
<td>40 minutes</td>
</tr>
</tbody>
</table>
Case #3: Report Comparison

- **SPECT MPI Report**
  Fixed defect is noted at the apex, which does not move or thicken appropriately and likely represents a scar. There is no SPECT evidence of ischemia. LV ejection fraction of 40 percent (normal above 45 percent).

- **PET MPI Report**
  The PET images demonstrate the above-described apical scar pattern but also demonstrate a mild to moderate anterior ischemic pattern involving the distal half of the anterior segment. This is suggestive of mild peri-infarct ischemia. The LV ejection fraction in the PET study is 53% at rest rising to 57% with pharmacologic stress (normal left ventricular function). Statistically, the likelihood of a perioperative event is still fairly low.
Even though this patient received pre-operative clearance for hip surgery, the detection of ischemia on the PET study provided prognostically useful information to assist in the management of this patient’s progressive CAD.
Case #4

Patient Profile

- **Demographics:** 69-year-old female
- **Risk Factor:** Hyperlipidemia, Hypertension, Type II DM
- **Reason for Test:** admitted to hospital after a CVA; found to be in atrial fibrillation with small increase in troponin-I; abnormal ECG
- **Meds:** Coumadin, Lovenox, Toprol XL, Lipitor, Altace (over the last 24 hrs. prior to imaging per rest/stress dipyridamole cardiogen-82 PET report)

Following are images of a patient who underwent a rest/dipyridamole stress Rubidium-82 myocardial perfusion PET study. The case and all images are courtesy of Tim Bateman, MD (Cardiovascular Consultants, Kansas City, MO).
Case #4: Rb-82 PET Images

Transient Ischemic Dilation (TID) Ratio: 1.63 (normal = 1.0)

A larger cavity size on stress images can indicate a near-balanced flow reduction.
Case #4: Rb-82 PET Functional Images

PEAK STRESS
LVEF 50%

REST
LVEF 61%

A lower EF during exercise vs. rest is considered an abnormal compensatory response at a time of increased demand.
The combined test findings indicate the following:

- Virtually diagnostic for the presence of CAD.
- Apical ischemia probably in the distribution of the left anterior descending coronary artery.
- Severe transient ventricular dilation, suggesting possible near-balanced flow reduction in multiple coronary territories.
- Normal left ventricular function at rest (LVEF 61%).
- Significant drop in LVEF in response to pharmacologic stress.
- Prognostically concerning scan, with numerous markers of high-risk for major adverse coronary events.
Case #4: Catherization Correlation

The combined test findings indicate the following:

- Coronary angiography showed a 75% left main stenosis, a 90% stenosis of the mid LAD and a 70% right coronary artery stenosis
- CABG surgery was performed after recovery from the CVA


Slide References


Additional References

- Gary Heller and Robert Hendel, Editors: Handbook of Nuclear Cardiology: Cardiac SPECT and Cardiac PET. Springer-Verlag London ©2013
- Benjamin J. W. Chow et al, Prognostic Value of PET Myocardial Perfusion Imaging in Obese Patients, JACC Cardiovascular Imaging 2014; 7(3)
Additional References

- D’Egidio G, et al. Increasing Benefit From Revascularization is Associated With Increasing Amounts of Myocardial Hibernation; A Substudy of the PARR-2 Trial. JACC Cardiovascular Imaging 2009; 2(9)
Additional References

- Einstein AJ. Effects of Radiation Exposure From Cardiac Imaging: How Good Are the Data? J Am Coll Cardiol 2012; 59(6):553-565
Important Safety Information

- Image interpretation errors can occur with PET imaging. A negative image does not rule out recurrent prostate cancer and a positive image does not confirm its presence. Clinical correlation, which may include histopathological evaluation, is recommended.

- Hypersensitivity reactions, including anaphylaxis, may occur in patients who receive PET radiopharmaceuticals. Emergency resuscitation equipment and personnel should be immediately available.

- PET/CT imaging contributes to a patient’s overall long-term cumulative radiation exposure, which is associated with an increased risk of cancer. Safe handling practices should be used to minimize radiation exposure to the patient and healthcare providers.

- Adverse reactions, although uncommon, may occur when using PET radiopharmaceuticals. Always refer to the package insert prior to use.