Systematic Interpretation of Radionuclide MPI (R-MPI)-----: SPECT or PET

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ASNC IMAGING GUIDELINES FOR NUCLEAR CARDIOLOGY PROCEDURES

Standardized reporting of radionuclide myocardial perfusion and function

Peter L. Tillkemeier, MD, C. David Cooke, MSEE, Gabriel B. Grossman, MD, PhD, Benjamin D. McCallister Jr, MD, and R. Parker Ward, MD

JNC July 2009
Systematic Interpretation of SPECT or PET MPI

- Check for technical sources of error
- Assess Perfusion Defects
  - Semiquantitative visual assessment
  - Quantitative assessment
- Assess Regional Ventricular Function
- Check for Additional Abnormalities
- Incorporate all clinical information into final report

CHACHR  64 M #1111-1364
Teaching Points
Prone and Supine

With sestamibi or tetrofosmin, prone imaging can clarify questionable supine abnormalities
- Breast attenuation frequently shifts
- Less diaphragmatic attenuation
- Less patient motion, but
- Frequent anteroseptal artifact

Systematic Interpretation of SPECT or PET MPI

- Check for technical sources of error
  - Most common:
    - Patient motion
    - Breast/diaphragmatic attenuation
    - Adjacent extra-cardiac radioactivity
    - Poor count statistics
    - Misregistration (particularly with CT AC)
    - ECG-gating errors
Systematic Interpretation of SPECT or PET MPI

- Check for technical sources of error
- Assess perfusion defects
  - Location (presumed vessel)

17-Segment Scoring

- **0 = Normal**
- **1 = Slight reduction of uptake**
- **2 = Moderate reduction of uptake**
- **3 = Severe reduction of uptake**
- **4 = Absent of radioactive uptake**

AHA writing group on myocardial segmentation and registration for cardiac imaging. Circulation 2002;105:539-542
Systematic Interpretation of SPECT or PET MPI

- Check for technical sources of error
- Assess perfusion defects
  - Location (presumed vessel)
  - Magnitude (extent/severity)
Segmental Scoring of Perfusion Defects:
5 point scale

0= Normal
1= slight (equivocal) reduction of uptake
2= moderate reduction of uptake
3= severe reduction of update
4= absence of radioactive uptake

Berman/German in Clinical Gated Cardiac SPECT 2006;page 146

Magnitude of Perfusion Defects on SPECT/PET MPI

Extent → Proportion of myocardium hypoperfused:
related to location of stenosis

Severity → Degree of hypoperfusion:
A function of the degree of flow limitation by stenosis
Assessment of Risk by SPECT/PET MPI

- Prognosis/revascularization benefit: strongly related to magnitude of functional and perfusion impairment/ischemia
- Desirable to have a global variable expressing this magnitude
- LV function: LVEF
- Perfusion: Need to incorporate extent and severity of hypoperfusion:
  - Summed scores Berman, JACC 1995
  - % myocardium abnormal Hachamovitch, Circ 2003
  - Total perfusion deficit (TPD) Slomka, JNC 2005

Global Extent and Severity of Hypoperfusion

**Summed scores**
- Summed Stress Score (SSS) = sum of 17 stress scores
- Summed Rest Score (SRS) = sum of 17 rest scores
- Summed Difference Score (SDS) = SSS - SRS

**% Myocardium hypoperfused**
- % Myo Stress $= \frac{SSS}{68} \times 100$
- % Myo Fixed $= \frac{SRS}{68} \times 100$
- % Myo Ischemic $= \frac{SDS}{68} \times 100$

**Total Perfusion Deficit (TPD)**
- Stress TPD
- Rest TPD
- Ischemic TPD (Stress-Rest)
Advantages of expressing perfusion defect magnitude by “percent myocardium”

• “The summed difference score was 8”: ambiguous
  – How many segments were employed in the system?
  – What points could a segment have?
  – Was it better to have a small score or a large score?
• “10% of the myocardium was ischemic”: intuitive
DEFECT SIZE (EXTENT): Equivocal

# of segments: 1-2
SSS: 2-3
S-TPD: 3-4%

Cardiac Death Risk Is Increased Even with Equivocal SPECT-MPI

Nakazato, el al D-SPECT Submitted 2012
### DEFECT SIZE (EXTENT): Equivocal

<table>
<thead>
<tr>
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**Stress**

- # of segments: 1-2
- SSS: 2-3
- S-TPD: 3-4%

**Rest**

### DEFECT SIZE (EXTENT): SM - MED

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**Stress**

- # of segments: 2
- SSS: 4-5
- S-TPD: 5 - 7%

**Rest**
DEFECT SIZE (EXTENT): SM - MED

# of segments: 2
SSS: 4-5
S-TPD: 5 - 7%

DEFECT SIZE (EXTENT): MEDIUM

# of segments: 3
SSS: 6 - 7
S-TPD: 8 - 10%
**DEFECT SIZE (EXTENT): MEDIUM**

- **STRESS**
  - # of segments: 3
  - SSS: 6 - 7
  - S-TPD: 8 - 10%

- **REST**

**DEFECT SIZE (EXTENT): LARGE**

- **STRESS**
  - # of segments: ≥ 4
  - SSS: > 7
  - S-TPD: > 10%

- **REST**
DEFECT SIZE (EXTENT): LARGE

# of segments: ≥ 4
SSS:  > 7
S-TPD: > 10 %

DEFECT SEVERITY (Visual Score 0-4)

Mild/Equiv (Score 1)

Moderate (Score 2)

Severe (Score 3)

Absent (4)
DEFECT SEVERITY (QUANT)

Mild / Equivocal (1)

Moderate (2)

Severe (3)

Very Severe (Absent)(4)

() = scores

Visual Criteria for Abnormality of Perfusion on SPECT/PET MPI

Normal
All segments: 0

Probable normal
Few segments: 1

Equivocal
1 segment: 2

Probably abnormal
2 segments: 2

Definitely abnormal
≥ 3 segments: 2

Berman/German in Clinical Gated Cardiac SPECT 2006; page 157
Systematic Interpretation of
SPECT or PET MPI

• Check for technical sources of error
• Assess perfusion defects
  • Location (presumed vessel)
  • Magnitude (extent/severity)
  • Reversibility

Systematic Interpretation of
SPECT or PET MPI
Perfusion Defect Reversibility

• Reversible
• Partially reversible
• Nonreversible ("fixed")
  • Ischemia
  • Ischemia
  • *Possible* infarct
    – Attenuation
    – Severe ischemia
Systematic Interpretation of SPECT or PET MPI

• Check for technical sources of error
• Assess Perfusion Defects
  – Semiquantitative visual assessment
  – Quantitative assessment

Automatic Quantitative Analysis of SPECT/PET

4D M-SPECT

Emory Cardiac Tool Box

Cedars-Sinai QGS/QPS/QPET
Quantitative vs Visual Assessment of Serial SPECT MPI

Categories of Ischemic risk
Summary Perfusion Variables (17 segment model)

<table>
<thead>
<tr>
<th>Qualitative</th>
<th>TPD (% ischemic)</th>
<th>SDS</th>
<th># Rev segs*</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>&lt;2%</td>
<td>0-1</td>
<td>0</td>
</tr>
<tr>
<td>Equivocal</td>
<td>2-4%</td>
<td>2-3</td>
<td>1</td>
</tr>
<tr>
<td>Mild</td>
<td>5-9%</td>
<td>4-6</td>
<td>2</td>
</tr>
<tr>
<td>Moderate</td>
<td>10-14%</td>
<td>7-10</td>
<td>3-4</td>
</tr>
<tr>
<td>Severe</td>
<td>≥15%</td>
<td>≥11</td>
<td>≥5</td>
</tr>
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Systematic Interpretation of SPECT or PET MPI

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- Assess Regional Ventricular Function
INTERPRETATION OF Function on Myocardial Perfusion SPECT/PET

Quality Control

Rotating Summed Projections
  Counts
  Flashing Motion

Heart-rate Histogram

Time-volume Curve

Interpretation of LV Function on Myocardial Perfusion SPECT/PET

Regional Function
  • Gray Scale
  • Observe Endocardial Motion/myocardial thickening
  • 17 Segment Scoring
  • Contours On And Off

Ejection Fraction
  • Verify Contours (Cine)
  • Inspect Time-volume Curve
**Systematic Interpretation of SPECT or PET MPI**

- Check for technical sources of error
- Assess Perfusion Defects
  - Semiquantitative visual assessment
  - Quantitative assessment
- Assess Regional Ventricular Function
- Check for Additional Abnormalities

**SPECT or PET MPI**

**Ischemic risk**

**Non-perfusion High Risk Variables**

- TID
- Increased lung uptake
- Increased RV uptake
- Stress-induced wall motion abnormality
- Fall in LVEF >5%
- Reduced EF (<40%)
- Extensive coronary calcification
- Abnormal coronary flow reserve (PET)
Suggested Thresholds for TID

<table>
<thead>
<tr>
<th></th>
<th>Exercise</th>
<th>Pharm</th>
</tr>
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<tbody>
<tr>
<td>Dual isotope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest Tl-201/stress Tc-99m</td>
<td>1.22</td>
<td>1.36</td>
</tr>
<tr>
<td>Same day low dose/high dose Tc-99m</td>
<td>1.15</td>
<td>1.2</td>
</tr>
<tr>
<td>2 day Tc-99m or stress/redist Tl-201</td>
<td>1.1</td>
<td>1.15</td>
</tr>
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Systematic Interpretation of SPECT or PET MPI

Reporting

• Integrate Perfusion, Function, Additional Findings and Clinical Information
• Answer Question Being Asked

Likelihood of Angiography Significant CAD (≥50% Stenosis)

1. <2-9% Low
2. 10-29% Low Intermediate
3. 30-69% Intermediate
4. 70-89% High Intermediate
5. 90-94% High
6. 95-98% Very High
7. ≥99% Virtually Diagnostic
Systematic Interpretation of SPECT or PET MPI
Integration of Test Results: Nuclear Variables

- **Perfusion**
  - Extent & severity of perfusion defects
  - Stress
  - Rest
  - Reversible

- **Non-perfusion**
  - Lung uptake
  - RV uptake
  - TID
  - LV function
    - LVEF
    - LVEF fall
    - Stress WMA

Interpretation of SPECT/PET MPI
Integration of Test Results: Non-Nuclear Variables

**Exercise Stress**
- Exercise duration
- Rest and peak HR, BP
- % MPHR
- Rest/stress ECG
- ECG response to stress
- Clinical response to stress

**Adenosine Stress**
- Rest and peak/rest HR and Peak/rest ratio
- Rest/Peak SBP
- Rest/stress ECG
- Adjunctive walk?

- Symptoms/clinical presentation
- CAC/angiographic and other imaging findings
• Typical angina for 1 year, increased two months ago; always exertional
• FH: brother (52); father (47)
• Hypercholesterolemia
• Atorvastatin, ASA, metoprolol
**Final Report**

**Conclusion:** Clinical Response Ischemic Perfusion Abnormal (Reversible)

ECG Response Nonischemic Function Abnormal rest, worse after stress

These test results indicate a virtually diagnostic (100%) likelihood for the presence of angiographically significant coronary artery disease.

• LAD: a large severe reversible defect in the anterior, septal, distal inferior and apical walls.

The size of the defect indicates that the LAD stenosis is proximal. The presence of a stress induced apical wall motion abnormality, the severity of the perfusion defect, and the transient ischemic dilation of the left ventricle all indicate that the LAD stenosis is very high grade (likely >90%).

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**EXERCISE CAPACITY PREDICTS SURVIVAL**

Myers et al. NEJM, 346: 793, 2002
Underestimation of the Extent of CAD by SPECT MPI

Berman et al, J Nucl Cardiol 2007;14:521-8

101 consecutive stress MPS pts with LM CAD (≥50% stenosis)

CAC scanning helps identify high risk patient

Berman et al, J Nucl Cardiol 2007:14:521-8
**RJ 75 F ATA/SOB, DM, no walk adeno**

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**STRESS**

**REST**

**CAC 1463 (97th %)**
FO 60 M ATA/SOB, AF, HF, no walk adeno

FO 60 M ATA/SOB, AF, HF, no walk adeno
AC Scan (ultralow dose)          ECG-gated CAC scan

492 cases Scored within 1 category in 93% of cases

Agatston score is 367, and was visually estimated to be 100 to 399 by 1 reader and 400 to 999 by the other reader. (MAHI case)

Non-perfusion High Risk Variables on SPECT/PET MPI

• TID
• Increased lung uptake
• Increased RV uptake
• Stress-induced wall motion abnormality
• Fall in LVEF >5%
• Reduced EF (<40%)
• High CAC Score
Interpretation of SPECT/PET MPI
Components of Final Report

• Reason for test
• Technical quality
• Type stress/doses/protocol
• Magnitude and location of reversible defect (ischemia)
• Magnitude and location of non-reversible defect
• LVEF and changes from rest, ESV, and regional wall motion, TID, lung uptake, RV uptake
• Overall impression (comment re: high-risk markers, if present
• Comparison to previous studies
• Answer to specific question being asked

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JNC July 2009
The Nuclear Cardiology Report (ICANL)

### Required component

1. Succinct impression
2. Defect quantification
3. Wall motion findings
4. Indication
5. Timeliness
6. Nomenclature or standardization
7. Signature
8. Description of procedure
9. Date of report
10. Non-radioactive dose and route
11. Exact dose
12. Demographic items
13. Separate reports
14. Referring physician
15. Age/birth date
16. Gender
17. Route of administration of the RP
18. Typographical errors

ASNC Imaging Guidelines for Nuclear Cardiology Procedures
Standardized Reporting of Radionuclide Myocardial Perfusion and Function

- ASNC supports the **mandatory use** of structured reporting using **standardized data elements** in myocardial perfusion imaging reports.
- This should be implemented as part of the laboratory accreditation process

Tilkemeier et al. *JNC 2009*