The Use of Nuclear Cardiology in Clinical Decision Making

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"I understand he was in nuclear medicine."
Cardiovascular disease remains the leading cause of death in the United States. The mortality rate however, associated with cardiovascular disease, has decreased steadily over the past two decades.

This trend is largely attributable to improved detection and management of cardiovascular risk factors.
## Non-Invasive Testing

<table>
<thead>
<tr>
<th>Diagnostic</th>
<th>Prognostic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy</td>
<td>Outcome</td>
</tr>
<tr>
<td>Predicts who has CAD</td>
<td>Prediction of risk (death or MI)</td>
</tr>
</tbody>
</table>

Advantages of a Prognostic Endpoint:

- Defines who has disease and who is at risk for adverse events.
- Allows for more therapeutic options - risk factor modification.
Incremental Prognostic Value

<table>
<thead>
<tr>
<th>Pretest Likelihood</th>
<th>Incremental Value</th>
<th>No Incremental Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise Time</td>
<td>BP</td>
<td></td>
</tr>
<tr>
<td>ST-seg Δ</td>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Incremental Prognostic Value

\[ \chi^2 \]

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>5.1</td>
<td>P=ns</td>
</tr>
<tr>
<td>+Ex</td>
<td>7.4</td>
<td>P&lt;.01</td>
</tr>
<tr>
<td>Clin + Ex + Cath</td>
<td>25.0</td>
<td>P&lt;.01</td>
</tr>
<tr>
<td>Clin + Ex + SPECT</td>
<td>33.5</td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>33.7</td>
<td></td>
</tr>
</tbody>
</table>

NS=not significant

N = 316

Evaluation of CAD: A Diagnostic Approach

Patients with possible CAD

Normal

DIAGNOSTIC TEST

Abnormal

Low likelihood of CAD

Risk factor modification

Intermediate to high likelihood of CAD

Revascularization
Evaluation of CAD: A Prognostic Approach

Patients with suspected CAD referred to SPECT

Myocardial Perfusion Imaging with Gated SPECT

Normal Study
Mildly Abnormal Study
Mod-Severely Abnormal Study

RISK OF ADVERSE EVENT

LOW
Reassurance/Risk factor modification

INTERMEDIATE
Aggressive risk factor modification

HIGH
Revascularization
Prognostic Testing:
Classification into Risk Categories
(Cardiac Death Endpoint)

- **Low**
  Under 1% per year

- **Intermediate**
  1-3% per year

- **High**
  Greater than 3% per year

Based upon AHCPR Unstable Angina Guidelines (1995)
Risk Stratification: Basic Concepts

In patients with clinically stable CAD:

- Revascularization has not been shown to reduce MI rate
- Revascularization can reduce the cardiac death rate in selected high-risk subsets
- CABG or PTCA can reduce the risk of cardiac death
- The annual mortality rate of revascularization is at least 1%

Therefore, patients with a cardiac death rate <1%/year do not warrant revascularization for purposes of improving survival

Risk Stratification: Noninvasive Testing Markers

- Amount of infarcted myocardium
- Amount of jeopardized myocardium
- Degree of jeopardy
- Left ventricular systolic function

All can be assessed by measurements of perfusion or function
Semiquantitative-Visual Analysis

SSS = \sum \text{Segmental Stress Score}

SRS = \sum \text{Segmental Rest Score}

SDS = SSS - SRS

Segmental Scoring
0 = Normal
1 = Equivocal
2 = Moderate
3 = Severe
4 = Absent Uptake

Prognosis: Prediction of MI vs CD Using Myocardial Perfusion SPECT

Study Population

Initial Population 5807
Consecutive 1/1/91-12/31/93
Lost to follow-up 269
Incomplete data 4

Study Population 5534 (95%)
Early revascularization (<60 days after SPECT) 351

Final Population 5183

Follow-up Duration (>1 yr) 642 ± 226 Days

Cardiac Events
MI 158
Cardiac Death 119

Prognosis: Prediction of MI vs Cardiac Death by Myocardial Perfusion SPECT

Event Rate vs SSS Category (All Pts)

*Significant increase in rate as a function of SSS category.
**Significant difference in rate of MI vs death.

**Risk Stratification: Outcome by Management Strategy**

Cardiac Death Rate (%/yr)

<table>
<thead>
<tr>
<th>Scan Result</th>
<th>Med Rx</th>
<th>Early Revasc</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td>0.3</td>
<td>0</td>
</tr>
<tr>
<td>Mildly Abnl</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Moderately Abnl</td>
<td>2.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Severely Abnl</td>
<td>4.6</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*P<.01 vs patients undergoing revascularization early after MPI.

**P<.001 within patients treated with medical therapy after MPI.

Established Prognostic Role

Prognostic role of perfusion imaging has documented accuracy of risk assessment in the following populations and conditions:

- CAD – suspected or known
- Angina – stable or unstable
- Women
- Diabetics
- Post-MI
- Post-revascularization
- Preoperative screening for noncardiac surgery
END Study: Outcome by Screening Strategy

Revascularization

<table>
<thead>
<tr>
<th>Clinical Likelihood</th>
<th>Low</th>
<th>Int</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Events</td>
<td>16</td>
<td>27</td>
<td>30</td>
</tr>
</tbody>
</table>

Cardiac Death or MI

<table>
<thead>
<tr>
<th>Clinical Likelihood</th>
<th>Low</th>
<th>Int</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Events</td>
<td>2.5</td>
<td>5.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

END Study: Revascularization Rates by Screening Strategy

Revascularization Rate

Low: 16% (Revasc - Cath), 86% (Revasc - MPI + Cath)
Int: 27% (Revasc - Cath), 58% (Revasc - MPI + Cath)
High: 30% (Revasc - Cath), 51% (Revasc - MPI + Cath)

P < .00001 for Cath vs Cath + MPI

Functional Imaging: ECG-Gated Myocardial SPECT

Projection Data Sets (8-16 Intervals Each)

180° SPECT Acquisition

Tomographic short axis image sets (after reconstruction & reorientation)

Myocardial Perfusion
Gated SPECT Scan
Functional Imaging: ECG-Gated Myocardial SPECT

• Acquired during perfusion imaging
• 3-dimensional volumetric measure
  – LVEF
  – LVEDV/LVESV
  – Wall motion and thickening
• Completely objective
• Proven to be accurate and precise
**Functional Imaging: Prognostic Value of Gated SPECT**

<table>
<thead>
<tr>
<th>SSS</th>
<th>Normal</th>
<th>Mild/Mod ABNL</th>
<th>Severe ABNL</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF ≥ 45%</td>
<td>0.4%</td>
<td>0%</td>
<td>0.9%</td>
</tr>
<tr>
<td>EF &lt; 45%</td>
<td>0%</td>
<td>1.0%</td>
<td>5.7%</td>
</tr>
</tbody>
</table>

Cardiac Death Rate (%/yr)

- EF ≥ 45%: 0.4%, 0%, 0.9%
- EF < 45%: 0%, 1.0%, 5.7%

* *P < .0001*

Patients with normal perfusion had CD \( \leq 0.35\% / \text{yr} \), irrespective of EF group.

All patients with LVEF \( \geq 45\% \) had CD \(< 1\% / \text{yr} \), irrespective of SSS group.

Putting It Together: A Risk-based Approach to Suspected CAD

Patients with Suspected CAD

Tc-99 Sestamibi Myocardial Perfusion with Gated SPECT

- **Normal**
  - Very low risk for cardiac death, Low risk for MI
  - Reassurance Risk factor (RFM) modification

- **Mildly Abnormal**
  - Low risk for cardiac death, Intermediate risk for MI
  - Anti-anginal Therapy Aggressive RFM Cath if symptoms refractory to therapy

- **Mod-Severely Abnormal**
  - Intermediate to high risk for cardiac death or MI
  - Cardiac Cath RFM
"Is being kept waiting for two hours part of the stress test?"
Risk Factors

**Hypertension** - Normal = Systolic (under 120 mmHg); Diastolic (under 80 mmHg)

**Lipoproteins** - HDL > 60 mg/dl; LDL < 100 mg/dl;
Total Cholesterol < 200 mg/dl.

**Diabetes** - FBG (8 hours without food or drink - 70-130 mg/dl),
Postprandial BG (2 hrs. after the start of a meal < 180 mg/dl), HbA1c (glucose homeostasis ≤ 7.0%)

**Obesity** - Body Mass Index (indirect measurement of body fat calculated from a person’s body weight(kg) / [height (m)]^2.
Underweight, Normal, Overweight, Obese.
Waist size - Am. Heart Association: M < 40”; F < 35”
Am. Cancer Society: M < 35”; F < 30”.

**Smoking**

**Family History**

**Abnormal ECG**
Sx: Presents in ER with recurrent episodes of chest pain, anytime, felt by the patient to be indigestion.
Risk Factors: inc. lipids, HTN, smokes, + family Hx.
Resting ECG: Non specific ST-T waves
Lab: troponins minimally elevated.

Risk for CAD?
RS 78 yr. old male #012622

Lab: Repeat troponins normal
Adenosine MPI was performed:
  Large reversible lateral wall defect
  EF= 52%
  SSS= 23/0/23

Catheterization: high grade proximal Circumflex artery stenosis Tx. with angioplasty.
RS  Circumflex Stenosis
RS  During and after Balloon Angioplasty
Post-Percutaneous Transluminal Coronary Angioplasty Patients

- Frequent occurrence of restenosis with or without symptoms.
- Virtually all restenosis occur within the first 6 months.
- Nuclear Stress Testing is very accurate in detecting restenosis.
Guidelines for Post PTCA Nuclear Stress Testing

- Recurrent symptoms → Nuclear Stress Test
- Asymptomatic → Nuclear Stress Test (3-6 months and 1-2 years post PTCA).
- Moderate to severe ischemia → Repeat cath.
Sx: Chest pain while walking, same Sx. prior to a stent being inserted 6 months ago.
Risk Factors: Htn., Diabetes, had been a smoker, being treated for elevated cholesterol.
Resting EKG: Non specific ST-T wave changes.
Lab.: Total cholesterol 220; HDL (L); LDL (H); glucose (N).

Risk level of patient’s known CAD?
Sestamibi Lexiscan Stress Test

Findings:

1- Large partially reversible apical wall defect extending to the anterior and septal walls.

2- Slightly enlarged left ventricle with an ejection fraction of 50%.

3- SSS = 37/18/19.
BH

EF = 50%
Sx: Chest pain off/on, any time, minimal; Hx. of neurofibromatosis with intermittent migratory pain.

Risk Factors: Total Cholesterol - 105, HDL - 24 (L), LDL - 68, HTN (mild), smoker.

Resting EKG - non specific T wave changes in lead III.

Risk of CAD?
Sestamibi Treadmill Stress Test

Findings:

1- Bruce Protocol- 87% mhr; 7 min. 11 sec.; slight ST segment depression.
2- Moderate size reversible inferolateral wall defect.
3- Normal size left ventricle with an ejection fraction 59%.
4- SSS= 16/0/16.
Sudden arm and shoulder pain 2 wks. following CABG (LIMA to LAD)

Adenosine SPECT Imaging performed:
- Large reversible anterior wall defect
- Small fixed inferolateral wall defect at base.
- Left ventricle- slightly enlarged
  EF=37%  SSS=14/2/12

Re-catheterization: Clotted LIMA
KB  2 wks. post LIMA to LAD- arm pain  #102536
KB Occluded Proximal LAD #102536
Post-Bypass Surgery Patients

- 75% of vein grafts occlude or become severely stenosed in 10 years following CABG surgery.
- Nuclear Stress Testing is very accurate in detecting re-stenosis, predicting cardiac events, or a need for further intervention.
Guidelines for Post CABG Nuclear Stress Testing

- Patients who develop recurrent symptoms.
- Asymptomatic patients within 5-7 years of CABG surgery.
- Repeat Catheterization in patients showing moderate to severe ischemia.
JF 62 year old male

Chest tightness, non-exertional
Hypertension
Cholesterol- LDL increased
Normal resting EKG

Risk of CAD?
Sestamibi Treadmill Stress Test

Findings:
1- Bruce Protocol- 7 min. 45 sec.; no chest pain; nonspecific ST-T wave changes in V5 only.
2- Small reversible anterior wall defect.
3- Ejection Fraction
4- SSS= 5/0/5.

What next?
Medical treatment:

1- Aggressive risk factor therapy.
2- If chest pain continues consider cardiac cath.

<1% chance of significant cardiac event.
>1% chance of cardiac event with cath.
Conclusion

Patient mortality rate from CAD has been decreasing because of early detection and aggressive management of cardiovascular risk factors.

Order tests that are of prognostic value looking at potential patient outcomes and risk.

Do not ignore your own risk factors (be well).
GONE FISSION!