MYOCARDIAL PERFUSION SCINTIGRAPHY

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EVALUATION OF THE FUNCTION AND DISEASES OF THE HEART WITH NUCLEAR MEDICINE PROCEDURES (CARDIAC SCINTIGRAPHY)
The real function of the heart

The real trouble of the heart
"I like breakfast best, 'cause there's nothing green on my plate."
CARDIOVASCULAR SCINTIGRAPHY

• CORONARY ARTERY DISEASE:
• MYOCARDIAL PERFUSION SCINTIGRAPHY ($^{201}\text{Thallium}/^{99m}\text{Tc}-\text{Agents}/^{82}\text{Rhubidium}$)
• MYOCARDIAL VIABILITY ($^{201}\text{Thallium}/^{18}\text{FDG}$-PET)
• ACUTE MYOCARDIAL INFARCTION ($^{99m}\text{Tc}$-Agents)
• MYOCARDITIS, TRANSPLANT REJECTION
• $^{67}\text{Gallium}$ Imaging (Myosin Ab Imaging)
• GENERAL INDICATIONS (CHEMOTHERAPY etc)
• Evaluation of EF, Stroke Vol., Chamber Size, Wall Motion
  (MUGA/First Pass/Myocardial Perfusion)
CORONARY ARTERY DISEASE (CAD)

ATHEROMATOUS PLAQUES REDUCE MYOCARDIAL BLOOD FLOW
THE CLINICAL NEED FOR MPS

MANIFESTATIONS OF CAD IN DECLINING SEVERITY

(They depend on degree of stenosis, collaterals, demand and formation of acute thrombus)

• Sudden Death (AMI, Arrhythmias)
• Acute Myocardial Infarction
• Unstable Angina
• Typical Angina
• Atypical Chest Pain
• Asymptomatic
MYOCARDIAL PERFUSION SCINTIGRAPHY (MPS) FOR CORONARY ARTERY DISEASE (CAD)

(using $^{201}$TlCl$_2$, $^{99}$mTc-MP-Agents, PET-MP-Agents)

- **DIAGNOSIS** OF CLINICALLY SIGNIFICANT CAD (>60% lumen)
  **Indications** Chronic Stress Pain (Angina), Rest Pain (Unstable Angina), Acute Chest Pain (Acute Myocardial Infarction, Mi), Preoperative Evaluation Of Patients With Risk Factors

- **QUANTITATION** OF SEVERITY AND EXTENT OF CAD

- **ASSESS VIABILITY** OF ISCHEMIC MYOCARDIUM POST MI

- **OBTAIN PROGNOSIS** BEFORE OR AFTER INfarCTION  
  TO HELP THERAPY PLANNING

- **FOLLOW UP** EFFECT OF PTCA / CABG / MEDICAL Tx  
  OR JUST THE COURSE OF THE DISEASE
Coronary Artery Disease
Classic Symptoms in patients with angina pectoris:

Sudden onset of severe substernal chest pain radiating to the jaw or down the left arm.

Induced by:
- a) emotional stress
- b) exercise
- c) cold weather

Present in only 40-50% of Patients
OTHER DISORDERS MAY PRESENT WITH CHEST PAIN

Chest Pain in Patients with Normal Coronary Arteries

- Panic Disorder
- Esophageal Cause
- Microvascular Angina
- Other Causes
Ischemia may be the result of decreased supply or increased demand or both of them.

- occlusion or stenosis
- vasospasm
- vasodilator "steal"
- hypertension
- LVH
- exercise
- dobutamine
- adenosine
MANIFESTATIONS OF CAD: PATHOPHYSIOLOGY

RELATION OF CORONARY FLOW TO DEGREE OF STENOSIS

CORONARY FLOW

STRESS

REST

MANIFESTATIONS OF CAD: PATHOPHYSIOLOGY

DEGREE OF STENOSIS

![Graph showing the relationship between degree of stenosis and flow during stress and rest.](Gould KL, et al. Am J Cardiol. 1974;33:87-94.)
MANIFESTATIONS OF CAD: PATHOPHYSIOLOGY

RELATION OF CORONARY FLOW TO DEGREE OF STENOSIS and ISCHEMIA

STENOSIS > 60% becomes CLINICALLY SIGNIFICANT CAD

60-80% STENOSIS
↓
ISCHEMIA
At STRESS ONLY

STENOSIS > 80-90%
↓
At REST ISCHEMIA

THE MANIFESTATIONS OF CAD DEPEND UPON:

1. The Severity and Extend of Stenosis (Angina Pectoris)
2. The development of Collateral Vessels (Asymptomatic)

3. Formation of Thrombus (Myocardial Infarction)
CORONARY ARTERY DISEASE (CAD)
MYOCARDIAL INFARCTION

THROMBUS FORMATION STOPS MYOCARDIAL BLOOD FLOW AND CAUSES ACUTE INFARCTION
THE CLINICAL NEED FOR MPS

MANIFESTATIONS OF CAD IN DECLINING SEVERITY

(They depend on degree of stenosis, collaterals, demand and formation of acute thrombus)

• Sudden Death (AMI, Arrhythmias)
• Acute Myocardial Infarction
• Unstable Angina
• Typical Angina
• Atypical Chest Pain
• Asymptomatic
# Tests for Myocardial Ischemia

<table>
<thead>
<tr>
<th>Old Techniques</th>
<th>Assessment</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>Electrical Activity</td>
<td>Accuracy 65%</td>
</tr>
<tr>
<td>Angiography</td>
<td>Coronary Anatomy</td>
<td>Invasive/Anatomy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New Techniques</th>
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</thead>
<tbody>
<tr>
<td>Nuclear Medicine</td>
<td>Regional Blood Flow</td>
<td>Accuracy 80-90%</td>
</tr>
<tr>
<td>Echocardiography</td>
<td>Regional Wall Motion</td>
<td>Sensitivity low</td>
</tr>
<tr>
<td>CT /CTI</td>
<td>Lumen /Calcification</td>
<td>Specificity low</td>
</tr>
<tr>
<td>MRI Flow</td>
<td>Myocardial Perfusion</td>
<td>Being Evaluated</td>
</tr>
</tbody>
</table>
THE CLINICAL NEED FOR MPS

Clinical Examination and EKG at Rest and Special Tests are Suboptimal or Invasive
TREADMILL ECG TEST

• Informative, noninvasive, low risk

• Accuracy 65%

• Both FP and FN results
CARDIAC CATHETERIZATION

- Excellent anatomic definition of CAD
- Insufficient physiologic information
- Limited definition of viability
- Invasive, expensive, subjective
- Evaluation and Therapy (Angioplasty)
DIAGNOSTIC VISUALIZATION OF THE ISCHEMIC MYOCARDIUM WITH SCINTIGRAPHY
CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

DIAGNOSIS OF
CLINICALLY SIGNIFICANT CAD (>60% lumen)

Chronic Stress Pain (Angina), Rest Pain (Unstable Angina),
Acute Chest Pain (Acute Myocardial Infarction, Mi),
REST & STRESS MYOCARDIAL PERFUSION IMAGING
WITH LVEF & WALL MOTION STUDY:

- Normal: Very low probability for significant CAD or
good collateral vessels
- Abnormal: Cardiac Catheterization (and revascularization)
Thallium injected iv had the same distribution with the micro spheres \((^{131}\text{I}-\text{MAA})\), which were injected into the left atrium therefore

\(^{201}\text{Tl}\) shows \text{REGIONAL MYOCARDIAL PERFUSION} non invasively
Planar Imaging in volunteers showed the applicability of the method
### THALLIUM IMAGING: IMPACT ON PATIENT CARE

<table>
<thead>
<tr>
<th>Planar Rest and Stress</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thallium Imaging + ECG</td>
<td>90%</td>
</tr>
<tr>
<td>ECG alone</td>
<td>65%</td>
</tr>
<tr>
<td>Thallium alone</td>
<td>75%</td>
</tr>
</tbody>
</table>
WHY WE NEED MYOCARDIAL PERFUSION SCINTIGRAPHY (MPS)

The RESULTS of MPS are DIFFERENT from the ECG
The RESULTS of MPS are BETTER than the ECG
MPS is NON-INVASIVE as compared to Angiography
The RESULTS of MPS are DIFFERENT from the ECG

COMPARATIVE STUDY:
Exercise SPECT Imaging vs Exercise ECG in 2700 Patients with Suspected CAD

POSITIVE NUCLEAR SPECT STUDIES

NEGATIVE NUCLEAR SPECT STUDIES

Entire Population
The RESULTS of MPS are BETTER than the ECG

COMPARATIVE STUDY:
Exercise SPECT Imaging vs Exercise ECG in 2700 Patients with Suspected CAD

POSITIVE NUCLEAR SPECT STUDIES

NEGATIVE NUCLEAR SPECT STUDIES

Death or MCE
No Complications
Revascularization

Catheterized Population
ADVANCES IN PERFUSION IMAGING

• Introduction of Pharmacologic Tests

• Introduction of $^{99m}$Tc-Radiopharmaceuticals

• Tomography (SPECT) increased accuracy to 90%

• Artifact recognition - Attenuation Correction

• Functional data: EF, Volumes, Wall Motion

• Reduced Imaging Time (fast 90° dual detectors)
MYOCARDIAL PERFUSION SCINTIGRAPHY

• More than 3,000,000 procedures done annually

• Used to assess regional coronary blood flow

• Usually done with exercise or pharmacologic stress testing

• Its Safety and efficacy have been proven
MYOCARDIAL PERFUSION SCINTIGRAPHY (SPECT)

METHODS AND APPLICATIONS
MYOCARDIAL PERFUSION SCINTIGRAPHY

Radiopharmaceuticals

**Single Photon** Emission Comp. Tomo (SPECT)

- $^{201}$Thallium ($^{201}$Tl, 3-4 mCi)
- $^{99m}$Tc Sestamibi (Cardiolite, MIBI, 25 mCi),
- $^{99m}$Tc Tetrofosmin (Myoview, 25 mCi)

**Positron** Emission Tomography (PET) or PET/CT

- $^{82}$Rb (10-40 mCi) by Generator
- $^{11}$C-FFA (30 mCi) by Cyclotron
- $^{13}$NH$_3$ (15-25 mCi) by Cyclotron
Cellular Retention of Myocardial Perfusion Radiopharmaceuticals

Thallium, Sestamibi, Teboroxine, Tetrofosmin, Rubidium
MYOCARDIAL PERFUSION
NORMAL V/S ISCHEMIA

Blood supply by a stenotic artery at rest may suffice
We must apply stress to increase the need and elicit ischemia
MYOCARDIAL STRESS-TEST PROTOCOLS

Methods of Stress Testing

• **Physical Exercise**
  Treadmill
  Bicycle

• **Pharmacologic Stress**
  Vasodilators:  Adenosine, Lexiscan
                Dipyridamole
  Catecholamines:  Dobutamine
The radiopharmaceutical is injected at peak exercise, which must continue >1min after injection.
Coronary Artery Disease (CAD) may be treatable if diagnosed in time and before myocardial infarction or death occurs.

For the diagnosis of CAD Myocardial Perfusion Scintigraphy (MPS) is a Sensitive and Specific method.

MPS is proven effective for the early Diagnosis and Quantification of CAD, helps in Prognosis, in decision making about mode of Therapy, and can be used for follow up the course of the disease and results of treatment.
### MPS  DIAGNOSIS and PROGNOSIS

Myocardial Perfusion Scintigraphy Predicts Major Cardiac Events or The Need for Revascularization

348 patients (75 +/- 4 yo) with suspected CAD, followed for a mean of 2 years

<table>
<thead>
<tr>
<th>Event Rate</th>
<th>Revascularization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Tl:</td>
<td>149 pts</td>
</tr>
<tr>
<td>Abnormal Tl:</td>
<td>199 pts</td>
</tr>
</tbody>
</table>

*Shaw JACC 1985*
The diagram shows the MI or cardiac death rates in patients with normal and abnormal thallium scans.

- **Normal Thallium (n=149)**: MI, CV death = 2%, Revascularization = 5%
- **Abnormal Thallium (n=199)**: MI, CV death = 35%, Revascularization = 20%

The highest MI or cardiac death rate is observed in patients with abnormal thallium scans.
There is only a requirement:

**Adequate stress** is essential to uncover ischemia during MPS.
MPS  DIAGNOSIS and PROGNOSIS

Myocardial Perfusion Scintigraphy Predicts Cardiac Events more reliably when the Level of Stress is Adequate

189 patients with typical angina and negative EKG, had cardiac events (death, MI, late revascularization) per year after scintigraphy

<table>
<thead>
<tr>
<th>Event Rate</th>
<th>Event Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal TI with MPHR &gt; 85%: 108 pts</td>
<td>1.9% / year</td>
</tr>
<tr>
<td>Normal TI with MPHR &lt; 85%: 35 pts</td>
<td>8.6% / year</td>
</tr>
<tr>
<td>Abnormal TI: 46 pts</td>
<td>15% / year</td>
</tr>
</tbody>
</table>

Bairey AJC 1989
THE LEVEL OF STRESS MUST BE ADEQUATE

- Normal Thallium ≥ 85% MPH: 1.9% (n=108)
- Normal Thallium < 85% MPH: 8.6% (n=35)
- Abnormal Thallium: 15% (n=46)
LIMITATIONS OF THE PHYSICAL STRESS

• There is indeed a requirement for a successful MPS: **Adequate stress is essential** to uncover ischemia

• However, most of our patients, especially female, are unable to exercise to a level the test becomes diagnostic and fully useful. As a result many examinations are either useless or even misleading.

• Pharmacologic stress must be used when fitness for physical exercise is anticipated to be low.
CONTRAINDICATIONS TO PHYSICAL STRESS

• Aortic Stenosis
• Abdominal Aortic Aneurysm
• Left Bundle Branch Block
• Ventricular Paced Rhythm
• Inability to Exercise CNS or Orthopedic
• Limited Capacity for Exercise
• Peripheral Vascular Disease, COPD,
• Medications (eg. β blockers),
• Poor Motivation, Heart Failure,
• Previous Submaximal Exercise Test
MOST FREQUENT INDICATIONS FOR PHARMACOLOGIC STRESS

• Inability to Exercise
• Contraindication to Exercise
• Limited capacity to Exercise
• Left Bundle Branch Block: (use Adenosine, Dipyridamole)
• Asthma, Obstructive Lung Disease: (use Dobutamine)
PHARMACOLOGIC STRESS TESTING

MEDICATIONS

VASODILATORS

ADENOSINE or LEXISCAN:
  Direct receptor Effect, Rapid Onset/Offset

DIPYRIDAMOLE:
  Indirect Effect, Prolonged Action

SYMPATHETICOMIMETIC

DOBUTAMINE: Indirect Effect
  (Enhances Myocardial Contraction)
PHARMACOLOGIC STRESS TESTING WITH VASODILATORS

GENERAL COMMON PROPERTIES

Safe with Stable Patients

Proven Diagnostic and Prognostic Utility

May be Combined with Exercise

Avoided with Bronchospasm and AV Block

DIFFERENCES

DIPYRIDAMOLE: Indirect Effect, Prolonged Action

ADENOSINE/LEXISCAN: Direct receptor Effect, Rapid Onset/Offset
## PHARMACOLOGIC STRESS TESTING
### PROPERTIES OF VASODILATORS AND DOBUTAMINE

<table>
<thead>
<tr>
<th></th>
<th>LEXISCAN</th>
<th>ADENOSINE</th>
<th>DIPYRIDAMOLE</th>
<th>DOBUTAMINE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Life</strong></td>
<td>2 min</td>
<td>&lt;10 sec</td>
<td>33-62 min</td>
<td>2 min</td>
</tr>
<tr>
<td><strong>Mean time to peak</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Coronary flow velocity</strong></td>
<td>30 sec</td>
<td>56 sec</td>
<td>65 min</td>
<td>&lt; 10 min</td>
</tr>
<tr>
<td><strong>Onset of action</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanism of action</strong></td>
<td>Direct</td>
<td>Direct</td>
<td>Indirect</td>
<td>Indirect</td>
</tr>
<tr>
<td><strong>Patient with side effect requiring treatment</strong></td>
<td>3%</td>
<td>2%</td>
<td>16%</td>
<td>NA</td>
</tr>
</tbody>
</table>
INFUSION PROTOCOLS

LEXISCAN

- INJECT LEXISCAN (0.4-mg/5-ml IV injection for ~10 seconds)
- SALINE FLUSH (5 ml)
- INJECT RADIOTRACER² (10-20 seconds after flush)

ADENOSCAN

- INFUSE ADENOSCAN (140-mcg/kg/min IV infusion)
- INJECT THALLIUM-201

DIPYRIDAMOLE

- INFUSE DIPYRIDAMOLE (0.142-mg/kg/min IV infusion)
- INJECT THALLIUM-201 (within 5 minutes of infusion)

Continuous monitoring ECG, BP, HR, Respiration
Until baseline values have returned, usually 1-5min
PREPARATION FOR ADENOSINE STRESS

At least 24 hr no products containing Caffeine, theophylline and dipyridamole
ADENOSINE for Myocardial Stress test

MECHANISM OF ACTION

Adenosine is a potent vasodilator in most vascular beds.

(they exert their effect through activation of purine receptors)

Myocardial uptake of perfusion radiopharmaceuticals, like Thallium, Cardiolite, Myoview, and Ammonia, is directly proportional to coronary blood flow.

Adenosine increases blood flow in normal coronary arteries with little or no increase in stenotic arteries.

As a result, Adenosine causes relatively less uptake in vascular territories supplied by stenotic arteries, as compared to normal arteries.
CONTRA-INDICATIONS FOR ADENOSINE PHARMACOLOGIC STRESS

- 2\textsuperscript{nd} or 3\textsuperscript{rd} degree AV Block (except with pacemaker)
- Sinus node disease (except with pacemaker)
- Bronchoconstrictive / Bronchospastic Lung disease (asthma)
- Hypersensitivity to Adenosine
ADVERSE REACTIONS TO ADENOSINE

MILD REACTIONS

• Flushing 44%
• Chest Discomfort 40%
• Dyspnea or Urge to breathe deeply 28%
• Headache 18%
• Throat, Neck, or Jaw Discomfort 15%
• Gastrointestinal Discomfort 13%
• Light-headedness/Dizziness 12%

SERIOUS REACTIONS

• AV block
  1st-degree 2.9%, 2d-degree 2.6%, 3d-degree 0.8%
• Cardiac arrest, VT, MI have been reported
DISCONTINUE ADENOSINE INFUSION IN CASE OF

- Persistent or high-grade AV block
- Persistent or symptomatic hypotension
- Severe respiratory difficulties

TREATMENT OF ADENOSINE SIDE-EFFECTS

IV Theophylline 50-125 mg
(needed in less than 2% of patients)
LEXISCAN FOR MYOCARDIAL STRESS TEST

MECHANISM OF ACTION

A2A adenosine receptor agonist (with at least 10-fold lower affinity for the A1 adenosine receptor)

The effect of Lexiscan on coronary blood flow (a rapid increase to ≥2.5-fold baseline) is sustained for approximately 2.3 minutes, and decreases to less than twice the baseline level within 10 min.

The combination of low affinity for the A2A adenosine receptor and the presence of a coronary artery A2A adenosine receptor reserve allows rapid induction and sustain maximal coronary blood flow to conduct stress radionuclide MPI.
CONTRA-INDICATIONS FOR PHARMACOLOGIC STRESS

ADENOSINE or LEXISCAN

2nd or 3rd degree AV Block (except with pacemaker)

Sinus node disease (except with pacemaker)

Bronchoconstrictive/Bronchospastic Lung disease (asthma)

Hypersensitivity to Adenosine
## Adverse effect of Lexiscan v/s Adenosine

<table>
<thead>
<tr>
<th>Adverse Reaction</th>
<th>Lexiscan, % (N=1337)</th>
<th>Adenoscan, % (N=678)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Headache</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td>Flushing</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Chest discomfort</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Angina pectoris or ST-segment depression</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Dizziness</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Chest pain</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Nausea</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Abdominal discomfort</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Dysgeusia</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Feeling hot</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>
TREATMENT OF LEXISCAN SIDE-EFFECTS

IV Theophylline 50-100 mg
PHARMACOLOGIC STRESS TESTING
DIAGNOSTIC ACCURACY

COMPARISON OF

EXERCISE  ADENOSINE  DIPYRIDAMOLE  DOBUTAMINE

<table>
<thead>
<tr>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercise (n = 3266)</td>
<td>84</td>
<td>87</td>
</tr>
<tr>
<td>Adenosine (n = 763)</td>
<td>88</td>
<td>85</td>
</tr>
<tr>
<td>Dipyridamole (n = 1272)</td>
<td>87</td>
<td>81</td>
</tr>
<tr>
<td>Dobutamine (n = 161)</td>
<td>91</td>
<td>84</td>
</tr>
</tbody>
</table>

POTENTIAL ADVANTAGES OF COMBINING LIMITED EXERCISE WITH ADENOSINE

- No Change in Severity of Myocardial Perfusion Defect
- Improvement in Detection of Reversibility
- Reduced Non-cardiac Side Effects and Arrhythmias
- Improved Image quality from increased T/NT

MYOCARDIAL STRESS-TEST PROTOCOLS

A REST and a STRESS STUDY are usually performed.

METHODS OF STRESS TESTING

a) Physical Exercise
b) Pharmacologic Stress

METHODS OF RADIOPHARMACEUTICAL INJECTION

a) Thallium protocols (one or two injections)
b) Technetium labeled protocols (one day or two days)
c) Mixed protocols
d) PET protocols (\(^{82}\text{Rb}\) or \(^{13}\text{N}-\text{Ammonia}\))
PROTOCOLS FOR MPS

A. THALLIUM ONLY

a) **Single Injection at Stress** (3-4 mCi) → Redistribution
   Imaging immediately (Stress), and late (4 hr = Rest)

b) **Stress Injection** (3-4 mCi) and Imaging immediately
   Reinjection at rest (1.5 mCi) and imaging at 4 hr

c) **Rest Injection** (3-4 mCi) and Imaging at (30 min) 4 hr
   Re-imaging at 24 hr
PROTOCOLS FOR MPS

B. ⁹⁹ᵐTc MYOCARDIAL PERFUSION AGENTS

a) Two Day Protocols (rest / stress each 20-30mCi)

b) Same Day Protocol:
Rest injection (8 mCi) imaging after 60 min
Stress re-injection (24 mCi) and imaging after 30-60 min
PROTOCOLS FOR MPS

C. MIXED PROTOCOLS

**REST STUDY**

$^{201}$Tl (3-4 mCi) injection at rest; imaging at 30 min (4hr,24hr)

**STRESS STUDY**

$^{99m}$Tc-Agents (20-30 mCi) injection at peak stress; imaging at 30min-1hr
MIXED PROTOCOLS FOR MPS

ADVANTAGES

• IMPROVED QUALITY

$^{201}$Tl more sensitive for viability than $^{99m}$Tc-Agents
$^{99m}$Tc-Agents had better photons and short half life, the higher dose increases sensitivity for ischemia, allows functional evaluations (EF, Volumes, WM, )

• BETTER LOGISTICS

Facilitates imaging, utilizes resources better, shortens time the patient stays in the lab
CORONARY ARTERIES

- Right main coronary artery
- Posterior descending coronary artery
- Circumflex artery
- Left anterior descending artery
- Left main coronary artery
CORONARY ANATOMY: Angiography
AP Caudal View of Left CA
CORONARY ANATOMY: Angiography
AP Cranial View of Left CA
SPECT STUDIES: THE THREE AXES
A 55 yo man with typical angina pectoris has a stress and rest MPS
SPECT STUDIES: THE THREE AXES

Diagnosis
Anterior Wall Ischemia

*a severe reversible defect*
ASSESSMENT OF VENTRICULAR FUNCTION IN CONJUNCTION WITH PERFUSION IMAGING

GATED SPECT AT REST

- Global and regional thickening and wall motion
- LV Ejection Fraction, global and regional
- LV Volumes: Stroke Volume, ESV, EDV
EDGE DETECTION, LVEF, VOLUME MEASUREMENTS EDV, ESV

LVEF=58%

Germano et al 1995
EDGE DETECTION, LVEF, VOLUME MEASUREMENTS EDV, ESV

IN CASES WITH PERFUSION DEFECTS

LVEF = 28%

Germano et al 1995
WALL MOTION EVALUATION
EF BY MYOCARDIAL PERFUSION SCINTIGRAPHY COMPARISON WITH FPRA

EF: Gated SPECT vs. first pass

\[ y = -1.15 + 0.98x \quad r = 0.910 \]
\[ n = 55 \]

Germano et al., 1994
EF BY MYOCARDIAL PERFUSION SCINTIGRAMPHY INCREMENTAL PROGNOSTIC VALUE

CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

QUANTITATION OF EXTENT AND SEVERITY OF CAD
(Before or after cardiac catheterization)

REST & STRESS MYOCARDIAL PERFUSION IMAGING
WITH LVEF & WALL MOTION STUDY IS PERFORMED

a) Severity of ischemia: mild, moderate, severe
b) Extend of ischemia: percent of total wall found ischemic
c) Vessel(s) involved: Single, Two, Multiple, LAD/LCx/RCA
d) Function: Wall motion, Volumes, EF (global and regional)
CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

QUANTITATION OF EXTENT OF CAD
(Before or after cardiac catheterization)
EXTEND OF ISCHEMIA AFFECTS PROGNOSIS

CARDIAC EVENT FREQUENCY DURING SURGERY

- No Ischemia (n=225): 1%
- One Territory Ischemia (n=30): 8%
- Two Territory Ischemia (n=71): 20%
- Severe or Extensive Ischemia (n=29): 52%
A 61 yo lady is evaluated for chest pain (not typical)
SEVERITY OF ISCHEMIA AFFECTS PROGNOSIS

a mild reversible defect

Diagnosis: Inferolateral Wall Ischemia

Stress

Rest

Short Axis

Vertical Long

Horizontal Long Axis
A 55 yo man with typical angina pectoris has a stress and rest MPS
SEVERITY OF ISCHEMIA AFFECTS PROGNOSIS

Diagnosis: Severe Anterior Wall Ischemia

*a severe reversible defect*
MPS PROGNOSIS

THE SEVERITY OF HYPOPERFUSION ON REST / STRESS MYOCARDIAL SCINTIGRAPHY IS A PREDICTOR OF CARDIAC EVENTS

5000 pts with SPECT studies followed 642 +/- 226 days

Event rate (% per year)

- Normal scan (N = 2946): Cardiac Death 0.3, Myocardial Infarction 0.5
- Mildly abnormal scan (N = 884): Cardiac Death 0.8, Myocardial Infarction 2.7
- Moderately abnormal scan (N = 455): Cardiac Death 2.3, Myocardial Infarction 2.8
- Severely abnormal scan (N = 898): Cardiac Death 2.8, Myocardial Infarction 4.2

POLAR MAP OR BULL’S EYE

Base

Counts

Angle

Circumferential
Profile Analysis
For each Slice

Anterior

Septum

Inferior

Lateral

Bullseye

Short axis slices
POLAR MAP OF TERRITORIES SUPPLIED BY EACH CORONARY ARTERY

- Anterior
- LAD
- Septum
- Apex
- LCX
- Lateral
- RCA
- Inferior
<table>
<thead>
<tr>
<th>REST STUDY</th>
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<th>CONCLUSION</th>
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<tr>
<td>No defect</td>
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MPS: NO DEFECT = NO ISCHEMIA
A 45 yo patient presents with typical angina pectoris
Has an exercise and rest MPS
MPS: INFEROLATERAL WALL
REVERSIBLE DEFECT = ISCHEMIA RCA
A 79 yo man with history of CAD and MI has an Adenosine MPS
MPS: ANTERIOR WALL MOSTLY FIXED DEFECT = INFARCT WITH PERI-INFARCTION ISCHEMIA

Anterior Wall  Partially Reversible Defect
A 45 yo lady with atypical chest pain has an exercise and rest MPS
MPS: ANTERIOR WALL FIXED DEFECT = INFARCT OR HIBERNATION

Anterior Wall Unchanged (Fixed) Defect
THREE DECADES OF EXPERIENCE IN MYOCARDIAL PERFUSION SCINTIGRAPHY

Based on tens of thousands of publications

The Tests is Considered
Safe
Accurate
Cost Effective
ONE DAY REST-STRESS Tc-SESTAMIBI (8mCi-24mCi)
COMPARISON WITH ANGIOGRAPHY

<table>
<thead>
<tr>
<th>NUMBER OF PATIENTS</th>
<th>108</th>
</tr>
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<tr>
<td>SENSITIVITY</td>
<td>94%</td>
</tr>
<tr>
<td>SPECIFICITY</td>
<td>96%</td>
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TN = 72, TP = 31, FN = 2, FP = 3

<table>
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<tr>
<th>POSITIVE PREDICTIVE VALUE</th>
<th>91%</th>
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<td>NEGATIVE PREDICTIVE VALUE</td>
<td>97%</td>
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<tr>
<td>ACCURACY</td>
<td>95%</td>
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First evaluation of our studies
REST THALLIUM AND STRESS Tc-SESTAMIBI
(3mCi and 30mCi)
COMPARISON WITH ANGIOGRAPHY

NUMBER OF PATIENTS 72
SENSITIVITY 90%
SPECIFICITY 97%

TN = 32, TP = 32, FN = 04, FP = 01

POSITIVE PREDICTIVE VALUE 97%
NEGATIVE PREDICTIVE VALUE 88%
ACCURACY 93%

Second evaluation of our studies
Before non-cardiac surgery, in patients presented with history or symptoms and signs or EKG findings suspicious for CAD:

REST & STRESS MYOCARDIAL PERFUSION IMAGING WITH LVEF & WALL MOTION STUDY:

- **Normal:** Very low risk for peri-operative major cardiac events (MI and death)
- **Abnormal:** Cardiac Catheterization (and revascularization)
MPS PROGNOSIS/PREOPERATIVE SCREENING

Myocardial Perfusion Scintigraphy (Thallium Dipyridamole) Predicts Perioperative MI / Death

(Despite the exclusion of patients who underwent revascularization because of an abnormal Tl study)

Among 335 patients with major non-coronary surgery 130 patients with abnormal Tl had such complications

And the Extend of Reversibility is Proportional to Perioperative Events

Lette AJC 1992
CARDIAC EVENT

- **NO ISCHEMIA (n=225)**: 1%
- **ONE TERRITORY ISCHEMIA (n=30)**: 8%
- **TWO TERRITORY ISCHEMIA (n=71)**: 20%
- **SEVERE OR EXTENSIVE ISCHEMIA (n=29)**: 52%

Lette AJC 1992
Acute Chest Pain

when there is clinical suspicion of acute MI

with inconclusive EKG and enzymes:

REST MYOCARDIAL PERFUSION IMAGING

• NORMAL study: Consider other cause of chest pain
  May schedule stress scintigraphy

• ABNORMAL: Patient Admission-Therapy for MI-CAD
CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

PROGNOSIS BEFORE OR AFTER MI

REST & STRESS MYOCARDIAL PERFUSION IMAGING

WITH LVEF & WALL MOTION STUDY:

Normal: Less than 0.5% per year major cardiac events

Abnormal: PTCA or CABG to prevent (a high rate of)

major cardiac events (MI or death)
MPS  PROGNOSIS (RISK STRATIFICATION)

MYOCARDIAL PERFUSION SCINTIGRAPHY
(THALLIUM EXERCISE)
PREDICTS MAJOR CARDIAC EVENTS

In 404 patients with a mean age of 65 years who were followed for a mean of 2 years, incidence of MI or cardiac death was 0.5% in normal, 5% in one vessel, 13% in =>2 vessel disease.

Iskandrian AJC 1988
MPS: PROGNOSIS (RISK STRATIFICATION)

- Normal TI scintigraphy (n=183): 0.5%
- 1 vessel TL abnormality (n=145): 5%
- >2 vessel TL abnormality (n=76): 13%
MPS PROGNOSIS

MYOCARDIAL PERFUSION SCINTIGRAPHY (TI), WHEN ABNORMAL AND CONCORDANT WITH EKG-TEST, IS ASSOCIATED WITH SHORTER EVENT-FREE SURVIVAL

It predicted a 3.6-fold risk for a coronary event (independent of conventional risk factors) for 23 patients with abnormal / concordant TI / EKG as compared to 384 patients of all the other groups.

(Along x-axis: numbers of patients at risk / year for 8 years concordant / positive TI and EKG at bottom and all other group patients at top)

Fleg Circulation 1990
PROGNOSTIC VALUE OF VASODILATOR MYOCARDIAL PERFUSION SCINTIGRAPHY IN PATIENTS WITH LBBB

Event-free survival (%)

0 20 40 60 80 100

Low risk
High risk

Year

0 1 2 3

(119) (35) (63) (16)

*P < 0.0001

CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

FOLLOW UP DISEASE OR THERAPY

REST & STRESS MYOCARDIAL PERFUSION IMAGING WITH LVEF & WALL MOTION STUDY:

• Normal or Stable: Medical Therapy

• Recurrence or Deterioration: PTCA or CABG or change in Medical Tx
A 57 yo man underwent angioplasty because of LAD disease
He had MPS before and after Angioplasty
Anteroseptal Wall Defect Resolved (Effect of Angioplasty)
### INTERPRETATION OF MYOCARDIAL PERFUSION SCINTIGRAPHY

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A 45 yo lady with atypical chest pain has an exercise and rest MPS
MPS: ANTERIOR WALL FIXED DEFECT
= INFARCT OR HIBERNATION

Anterior Wall  Severe Unchanged (Fixed) Defect
A 55 yo man with typical chest pain has an exercise and rest MPS
MPS: NO ISCHEMIA ; FIXED SEVERE DEFECT: SCAR v/s HIBERNATING MYOCARDIUM

STRESS MIBI

REST THALLIUM

Anterior Wall  Severe Unchanged (Fixed) Defect
CLINICAL USE OF MYOCARDIAL SCINTIGRAPHY

MYOCARDIAL VIABILITY POST (OR PRE) MI:

1) MPS: a) normal perfusion at rest = viable myocardium

   b) a fixed rest defect = scar or hibernation to differentiate:

2) $^{18}$F-DEOXY-GLUCOSE (FDG)-PET STUDY:

   MYOCARDIUM VISIBLE = VIVABLE MYOCARDIUM

Visible myocardium on FDG with a rest Tl perfusion Defect=
MISMATCH WITH Tl= HIBERNATING myocardium

FDG+MPS Matching DEFECT = SCAR
A 63 yo patient with a history of heart attack and an inconclusive EKG had MPS and FDG/PET study
FDG PET FOR MYOCARDIAL VIABILITY

MYOCARDIAL SCAR

Inferolateral Wall  Severe Matching Defect on MPS and FDG
Compare Perfusion with Viability
FDG-PET FOR MYOCARDIAL VIABILITY

PERFUSION/METABOLISM **MISMATCH** =
= VIABLE HIBERNATING MYOCARDIUM

Anteroseptal Wall  Severe Defect on MPS
but viable (**Mismatching**) on FDG

REST THALLIUM

FDG PET

Short axis slices from the apex (left) to the base of the heart

REVASCULARIZATION INDICATED
PERFUSION / $^{18}$FDG MISMATCH ES UNDERLINE THE NEED FOR REVASCULARIZATION

- Among 43 patients with Mismatch in Perfusion/FDG, 26 who were revascularized showed increased survival as compared to those (17/43) with medical therapy.
- Among 70 patients with No-Mismatch in Perfusion/FDG, there was no difference in survival between 17 patients who were revascularized and 53 treated medically.

DiCarli AJC 1994
Please explain to us what we see in the next picture and what lessons we learn from it.
PERFUSION / \(^{18}\)FDG MISMATCHES underline the need for Revascularization

A. Mismatch

B. No Mismatch

In Mismatch, Revascularization Increases Survival

DiCarli AJC 1994
MYOCARDIAL PERFUSION SCINTIGRAPHY (MPS) FOR CORONARY ARTERY DISEASE (CAD)

(using $^{201}\text{TlCl}_2$, $^{99m}\text{Tc-}$MP-Agents, PET-MP-Agents)

- **DIAGNOSIS** OF CLINICALLY SIGNIFICANT CAD (>60% lumen)
  CHRONIC STRESS PAIN (ANGINA), REST PAIN (UNSTABLE ANGINA), ACUTE CHEST PAIN (ACUTE MYOCARDIAL INFARCTION, MI), PREOPERATIVE EVALUATION OF PATIENTS WITH RISK FACTORS

- **QUANTITATION** OF SEVERITY AND EXTENT OF CAD

- **ASSESS VIABILITY** OF ISCHEMIC MYOCARDIUM POST MI

- **OBTAIN PROGNOSIS** BEFORE OR AFTER INFARCTION

  TO HELP THERAPY PLANNING

- **FOLLOW UP** EFFECT OF PTCA / CABG / MEDICAL Tx

  OR JUST THE COURSE OF THE DISEASE
COMPARISON OF ECHO WITH SCINTIGRAPHY

Advantages of Scintigraphy
- Ischemia not required for regional abnormality
- Quantification of perfusion abnormality - extent and severity
- Greater reproducibility through quantification
- Detection of peri-infarction ischemia
- High success rate
- Not as dependent on physician’s technical expertise
- Extensive literature on clinical value
COMPARISON OF ECHO WITH SCINTIGRAPHY

Equal Value
Detection of disease in patients with normal function at rest
Left ventricular function

Advantages of Echocardiography
Ease and rapidity of study
“On-line” visualization of the heart
Evaluation of pericardium, valves, myocardium
MYOCARDIAL PERFUSION SCINTIGRAPHY

George N. Sfakianakis MD
Professor of Radiology and Pediatrics
Director, Division of Nuclear Medicine

University of Miami
School of Medicine
Division of Nuclear Medicine