Nuclear Perfusion Imaging of Angina

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Goals of Presentation

• Understand what a perfusion scan is
• Understand what it can tell us when a patient has chest pain
Introduction—Mr. O

• Pt. is a 66 y.o. male
• IDDM x 28 yrs.
• HTN
• Hypercholesterolemia
• 80 pack-year smoker
• No previous cardiac hx
HPI

• Band-like chest pain, 10/10
• Increasing in severity over last 2 months
• Brought on with exertion
• In ED, relieved with sublingual NTG
• Perfusion scan was ordered.
What is a Nuclear Perfusion Scan?

- Injection of radioactive isotopes that accumulate in heart tissue and are detected by a gamma ray sensor.
- The distribution of the isotope corresponds to the amount of blood reaching a given area.
- The test can be done under exercise stress, or at rest (90% occlusion detected at rest; 50% occlusion detected stressed)
Who should get a Scan?

• Step 1: Take history/perform exam
• Step 2: Assess CRFs
• Step 3: Obtain resting EKG
• Step 4: If nl. EKG and low risk, STOP
• Step 5: If med/high risk, get exercise EKG
• Step 6: If exercise EKG nl, STOP
• Step 7: If exercise EKG abnl, go to scan
Mr. O’s Stressed Perfusion Scan

- Modified Bruce protocol—treadmill
- 4 min. duration
- 87% of max HR obtained
- Sx: 10/10 chest pain
- Pain resolved after 6 min.
- EKG: 3 mm. horizontal ST depressions in V4-V6 (lateral territory)
EKG Changes

Pre-stress

Post-stress
Modified Bruce Protocol

• Bruce protocol: Begin walking at 1.7 mph and 10% grade (5 METS), gradually increase q3min. up to 5.5 mph, 20% grade.

• Modified = 2 x 3 min. warm up periods at 1.7 mph and 0% grade, and 1.7 mph and 5% grade respectively.

• Modified for pts. with exercise limitations due to cardiac disease.
METS?

- 3-5 METS = easy walking
- 5-7 METS = raking leaves, singles tennis
- 7-9 METS = running 6-7 mph
- 13 METS = ?
METS?

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Gamma Ray Tracing

- Step 1: Thallium injection at the door
- Step 2: Imaging @ 15 min.
- Step 3: Exercise stress test @ 60 min.
- Step 4: MIBI injection @ 1 min. prior to quitting
- Step 5: Imaging @ 90 min.

- Three agents:
  - Thallium
  - Sestamibi
  - Tetrofosmin
Thallium

• Potassium analogue
• High extraction fraction
• Thallium uptake dependent on cell viability, intact Na/K ATPase pump
Thallium Disadvantages

- Low energy emission (70-80 keV)
- Low energy rays scatter and attenuate easily
- Long half-life (74 hrs), which limits dose, count rate and efficiency
- Redistribution of tracer to ischemic areas
Sestamibi/Tetrofosmin

- **Tc99m 2-methoxyisobutylisonitrile**
- **Uptake not related to Na/K ATPase activity.**
- **Passive diffusion across and binding to intact sarcolemmal & mitochondrial membranes.**
- **No redistribution—mibi stays in cells, gives snapshot of perfusion at time of ischemia.**
Sestamibi/Tetrofosmin

- Less total radiation than Thallium
- Shorter half-life (6 hrs)
Head to Head

- **Thallium**
  - 70 keV
  - $t_{1/2} = 74$ hrs
  - Rad dose = 0.21 mCi

- **Sestamibi**
  - 140 keV
  - $t_{1/2} = 6$ hrs
  - Rad dose = 0.02 mCi
Best of Both Worlds

- Current protocol: dual-tracer
- Give thallium for rest imaging
- Give sestamibi for exercise imaging
- Brings test time under 3 hours
- Single-tracer takes 6-24 hours
Epidemiology

• Sensitivity ~ 90% for CAD
• Specificity ~ 90% for CAD
• False positives
  – Breast tissue ~ anterior wall defect
  – Diaphragm ~ inferior wall defect
  – LBBB ~ perfusion defect
  – Upward creep: apparent reversible defect in the inferior and basal inferoseptal walls as heart returns to nl. position following exercise.
Mr. O’s Scintigraphy Results

• Severe defects in:
  - inferior portion of lateral wall
  - lateral portion of inferior wall

• Lateral—reversible

• Inferior—partially reversible
Mr. O’s Perfusion Scan Images

stress

resting
Mr. O’s Perfusion Scan Images

stress

resting
Imaging Views

(From the Cardiovascular Imaging Committee, American College of Cardiology; the Committee on Advanced Cardiac Imaging and Technology, Council of Clinical Cardiology, American Heart Association; and the Board of Directors, Cardiovascular Council Society of Nuclear Medicine: ACC/AHA/SNM Policy Statement: Standardization of cardiac tomographic imaging. J Nucl Cardiol 1:117, 1994.)
Perfusion Territories

Mr. O’s Vertical Long Section

LV

Base

Apex

Filling defect
Mr. O’s Horizontal Long Section
Mr. O’s Polar Map of LV

Filling defect
Perfusion

Why Bother with Nukes?

• Non-invasive
• Digital images are quantifiable
• Highly reproducible
• Findings on perfusion scan correlate well with disease outcomes, better than cath alone.
• Able to risk-stratify pts into low/med/high risk groups for future cardiac events, and be aggressive/conservative on this basis
Why not go straight to cath?

• >10,000 subjects w/ chest pain
• 5000 had a scan before cath
• 5000 had cath only
• Result: no difference in outcome, but total cost and follow-up cost were 30-40% lower for scan group. (Shaw LJ, Miller DD, Romeis JC, et al: Gender differences in the noninvasive evaluation and management of patients with suspected coronary artery disease. Ann Intern Med 120:559, 1994.)
• Supported by the EMPIRE study
Mr. O’s Cardiac Catheterization

- EF 45%
- LMCA: 60% occluded, mod. calcification
- LAD: 70%, mod. calc.
- pCx: 90%, ostial calcific lesion
- RCA: 90%
- mRCA: 70%, with thrombus
Coronary Anatomy

http://www.methodisthealth.com-health-heart-artcoro.htm.gif
Mr. O’s Cardiac Catheterization Images
Cardiac Catheterization Images

LM

LAD

C

70%

90%
Mr. O’s Cardiac Catheterization Images
Mr. O’s Cardiac Catheterization Images

40%

LM

LAD

D
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LM

LAD
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60%

LM

LAD
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LAD

LM

C
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Mr. O’s Cardiac Catheterization Images

RCA

PDA
Mr. O’s Cardiac Catheterization Images

Filling defects = thrombi
Distal occlusion 90%

RCA

PDA
Hospital Course

- Dx: severe 4-vessel CAD
- Admitted to Farr 3, seen by CT Surgery
- Tx: 4V-CABG asap
Summary

• Nuclear perfusion scans are highly diagnostic and prognostic tests that are minimally invasive.
• They demonstrate physiologically significant perfusion deficits, often above what anatomical studies can show.
• Cost-effective for med/high risk patients.
The End
References


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