Fundamentals of Nuclear Cardiology

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Objectives

☐ To understand the **Principles of Nuclear Cardiac Imaging**
  - Radiotracers
  - Image acquisition and processing
  - Stress protocols

☐ To appreciate **Image Artifacts**
  - Attenuation
  - Patient motion
Basic Concepts

- Intravenous injection of radiotracer
  - Myocardial uptake (perfusion and function, necrosis)
  - Blood pool (function)
- Acquisition of image with gamma camera
- Computer processing and review
Thallium-201

- Cyclotron produced (expensive)
- Long half-life of 73 hours
  - limits patient dose (low counts and poor gated images)
- Low energy of 68 to 80 kev
  - tissue attenuation
- Redistribution
  - must image 15 minutes after stress injection
TI-201 Uptake During Adenosine Hyperemia

+ = TI-201
TI-201 Uptake During Adenosine Hyperemia

Flow (% normal)

Activity (% normal)

+ = TI-201
Tc–99m Sestamibi or Tetrofosmin

- Tc-99m is generator produced
- Short half-life of 6 hours
  - Larger dose
- Ideal energy of 140 kev
  - Less tissue attenuation
- No redistribution
  - 2 injections and ‘leisurely’ imaging
TI-201 vs Tc-99m-MIBI
Uptake during Hyperemia

+ = TI-201
○ = Tc 99m-MIBI
Perfusion Radiotracers

Ex

Rest

Thallium-201  Sestamibi  Tetrofosmin
Perfusion Radiotracers

Thallium-201

Sestamibi

Tetrofosmin
Which is True?

A. TI-201 has a shorter half-life than Tc-99m
B. TI-201 is cheaper than Tc-99m
C. Gated TI-201 images are better than gated Tc-99m tetrofosmin
D. Diagnostic accuracy of stress TI-201 is better than stress Tc-99m tetrofosmin
E. TI-201 radiodosimetry is higher than Tc-99m
Components of a Gamma Camera

- Collimator
  - ‘Screens’ gamma rays (reduces scatter)
- Scintillation detector (NaI)
  - Converts gamma rays into light
- Photocathode tubes
  - Converts photons into electrons
  - Electric current proportional to energy of gamma ray
Tomographic Imaging (SPECT)

- Superior to planar 2D images
  - Better separation of structures
  - No overlap
  - Less background and better contrast
- Series of rotating planar projection images reconstructed into a 3D volume
- Filtered backprojection
Image Reorientation

- Short Axis
- Horizontal Long Axis
- Vertical Long Axis
Coronary Artery Territories

- RCA
- LCX
- LAD
Coronary Arteries Related to the Polar Map

Anterior

Septal

Inferior

Anterior

LAD

Inferior

Lateral

LCX

RCA
Normal Case

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ECG-gated Perfusion SPECT

SPECT acquisition

Projection Images

Reconstruction & Reorientation

Tomographic Short Axis Images

8-16 frames/step, ECG-gated

SPECT acquisition
Normal Thickening

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**Short Axis Beating Slices**

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**Horizontal Axis Beating Slices**

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**Vertical Axis Beating Slices**

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**Lateral**
Normal Wall Motion
Normal LV Function

EF 58%
EDV 82 cc
ESV 34 cc
Stress Testing Protocols

- **Thallium-201**
  - Stress-redistribution using a single injection at stress

- **Tc-99m sestamibi or tetrofosmin**
  - Two injections required for stress and rest imaging
1 Day Rest/Stress Tc-99m Radiotracer Protocol

Rest Injection (7-8 mCi)

Rest SPECT (0 min 45-60 min)

Stress Injection (22-25 mCi)

TM (2 hrs)

Stress SPECT (45-60 min)
Ischemic Cascade

- Angina
- Ischemic ST depression
- Global LV dysfunction
- Significant perfusion defect
- Regional myocardial dysfunction
- Flow heterogeneity

Exercise Stress

- Increases metabolic demand (HR X SBP)
- Results
  - Positive if ST depression
  - Negative if no ST depression at 85% target HR
  - Inconclusive test if no ST depression and 85% target HR not achieved
  - Non-interpretable with LBBB
Dipyridamole (Persantine) Stress

- Coronary and peripheral vasodilator

- Indications
  - Inability to exercise
  - Poor exercise tolerance
  - LBBB or pacemaker
  - Early post-infarction/unstable angina
Image Artifacts

- Tissue Attenuation
- Patient Motion
Case 1 Wall Motion
Case 1 LV Function

EF 71%
EDV 87 cc
ESV 25 cc
What is your interpretation?

A. Inferior scar
B. Inferior ischemia
C. Inferior scar and ischemia
D. Diaphragmatic attenuation
Case 2

Short Axis (Apex→Base)

Horiz Long Axis (Post→Ant)

Vert Long Axis (Sep→Lat)
Case 2

LV Volume Curve

Interval: 1 of 8  ○ Ungated

ED VLA Slice (frame = 7)

ES VLA Slice (frame = 3)

LV Vol (ml)
Study #1
Study #2

Gating Interval

ED VLA Slice (frame = 7)

ES VLA Slice (frame = 3)
Case 2
What is your interpretation?

A. Anterior scar
B. Anterior ischemia
C. Anterior scar and ischemia
D. Breast attenuation
What is your interpretation?

A. Apical scar
B. Inferior scar
C. Apical and inferior scar
D. Breast attenuation
Case 4

SHORT AXIS

Stress

Rest

VLA

Stress

Rest

HLA

Stress

Rest
Case 4 Projection Images

Stress

Rest
What is your interpretation?

A. Anteroseptal ischemia
B. Inferolateral ischemia
C. Anteroseptal and inferolateral ischemia
D. Cardiac trauma
E. Vertical Patient Motion
Case 5

Short Axis (Apex→Base)

Horiz Long Axis (Post→Ant)

Vert Long Axis (Sep→Lat)
What is your interpretation?

A. Apical scar
B. Anterolateral ischemia
C. Anterolateral ischemia and apical scar
D. Cardiac trauma
E. Vertical Patient Motion
Summary

- **Principles of Nuclear Cardiac Imaging**
  - Radiotracers
  - Image acquisition and processing
  - Stress protocols

- **Common Image Artifacts**
  - Attenuation
  - Patient motion