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Cardiac Imaging with Nuclear Medicine

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Outline

- Patient presentation
- Why use nuclear medicine?
- The physics, equipment, and radiotracers
- Stress testing
- Patient outcome

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Patient H.S.

- 38 YOM presenting to ED with chest pain
- Substernal chest pain, radiating to back and left arm, with SOB
- PMHx: HIV, Hyperlipidemia
- Meds: Anti-retrovirals
- SocHx: 1 pack/d
- PE: BP 120/70. HR 76. Otherwise wnl.

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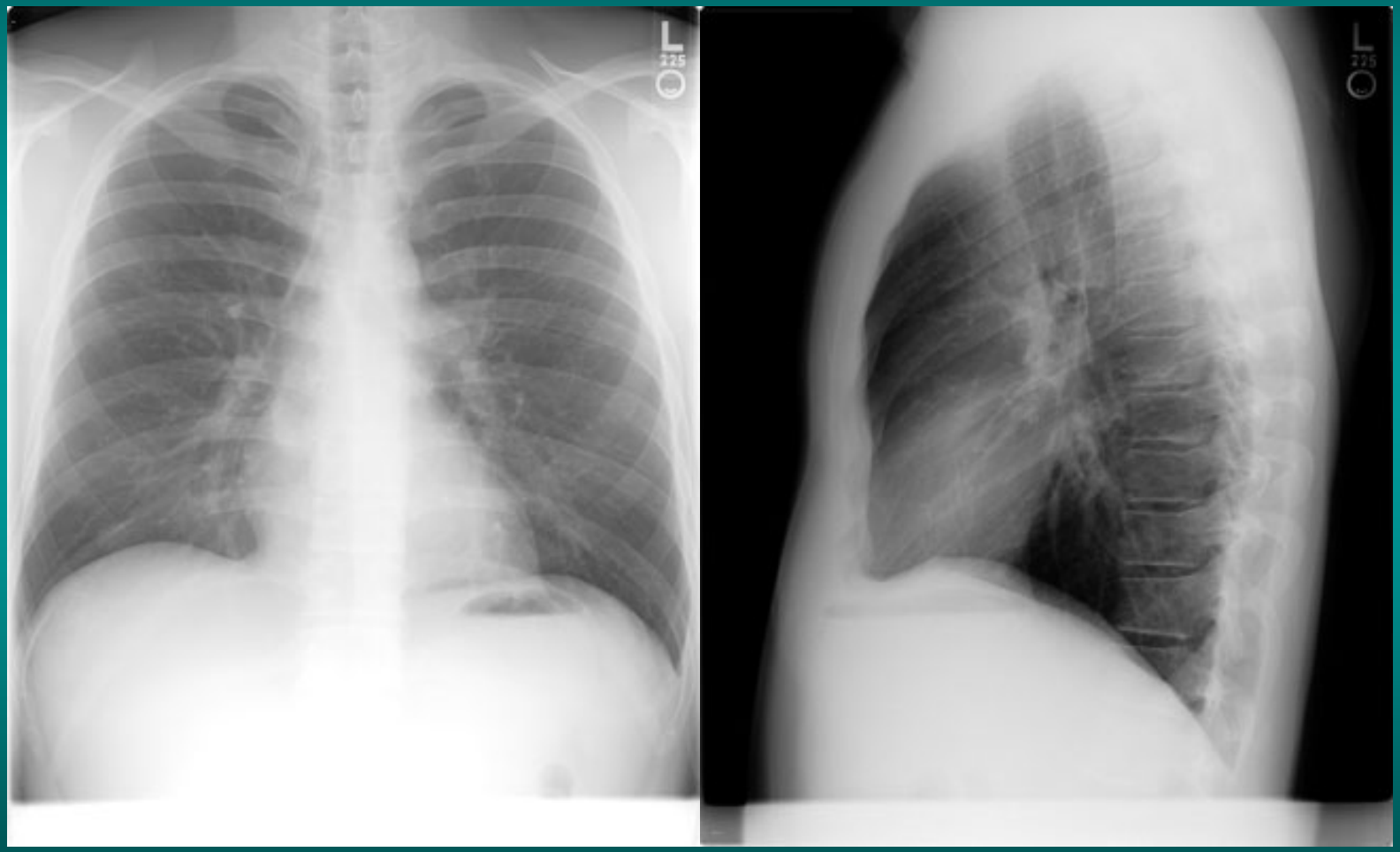
Patient HS - Presenting CXR



- Read as normal.

BIDMC PACS

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Patient H.S.

- What to do next?

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Why Use Nuclear Medicine?

- Indicates areas of myocardium with
  - Hypoperfusion
  - Ischemia
  - Viability
  - Dysfunction

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Cardiac Parameters Measured

- Perfusion
- Myocardial viability
  - Time course
- Ejection fraction (EF)

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Use of Nuclear Medical Imaging

- Indication varies with clinical situation

Situation	Indication
Acute myocardial infarction	Diagnose “culprit” artery, area at risk, final extent of infarction, ejection fraction (EF)
Unstable angina	Diagnose “culprit” artery
Chronic ischemic heart disease	EF
Improvement with PTCA	Perfusion, EF

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Testing Modalities

- Planar
  - Oldest modality
  - No 3-D reconstruction
- SPECT
  - Standard of care
  - Rest and stress imaging
- PET
  - Less widely used, more experimental
  - Higher cost

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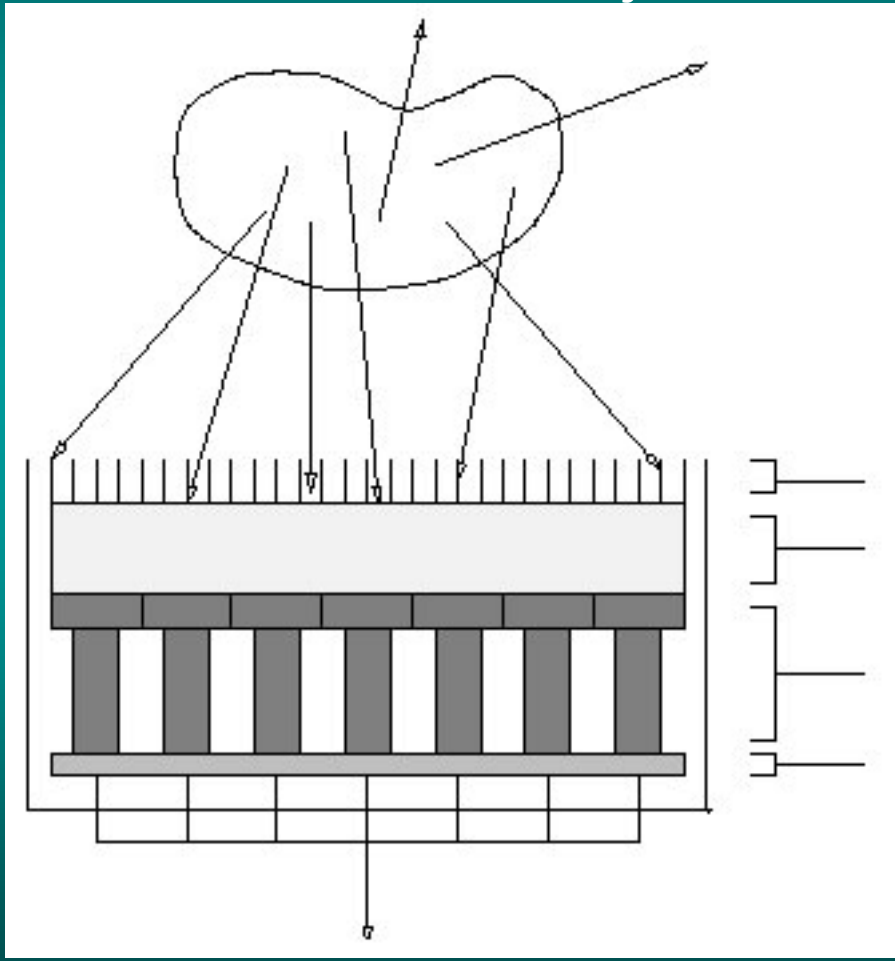
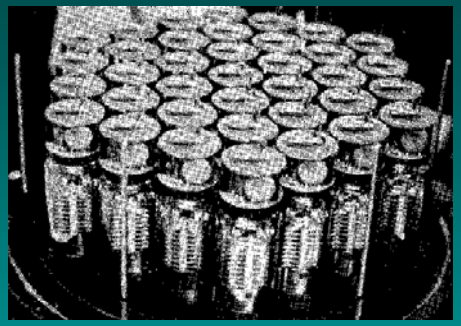
The Physics

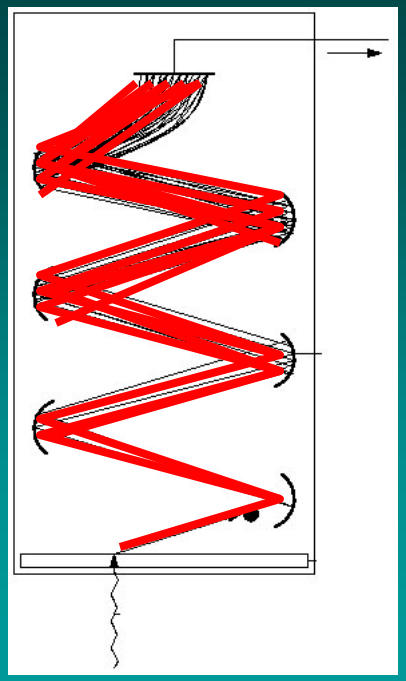
Radioactive Body



Computer and Display



PMT array



A PMT

Collimator (Pb)

Detector Crystal (NaI)

Photomultiplier Tubes (PMTs)

Localization Circuit

http://www.physics.ubc.ca/~mirg/home/tutorial/hardware.html

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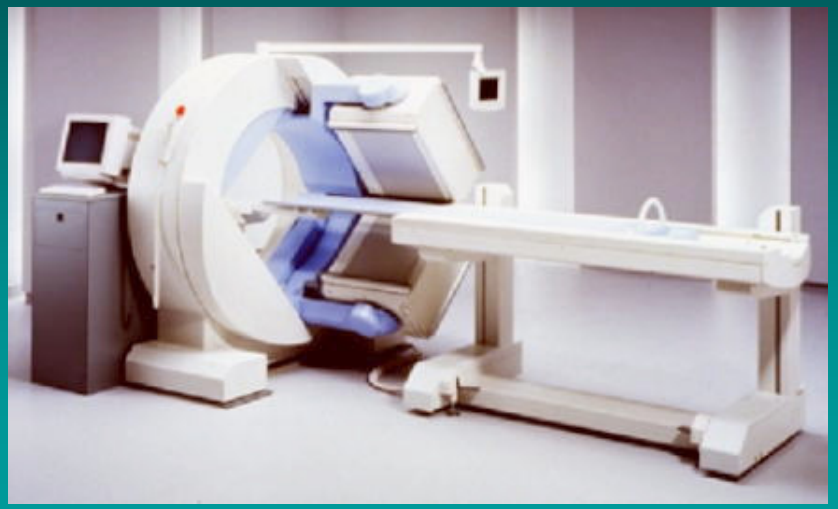
The Equipment

Planar

GE 300

http://www.kfshrc.edu.sa/radiology/assets/images/nuc4.jpg

SPECT



Siemens ECAM

http://www.siemensmedical.com

PET

GE Advance

www.nationalpetscan.com/images/scanner.jpg

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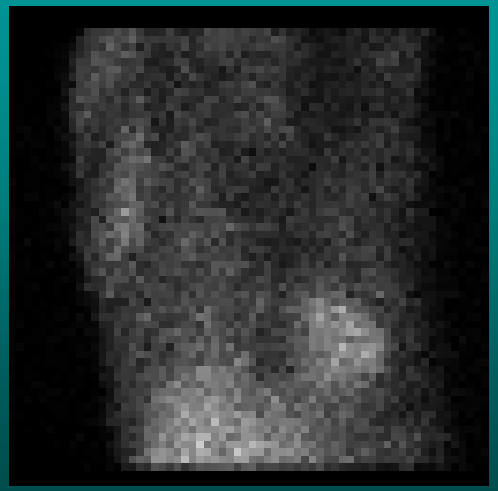
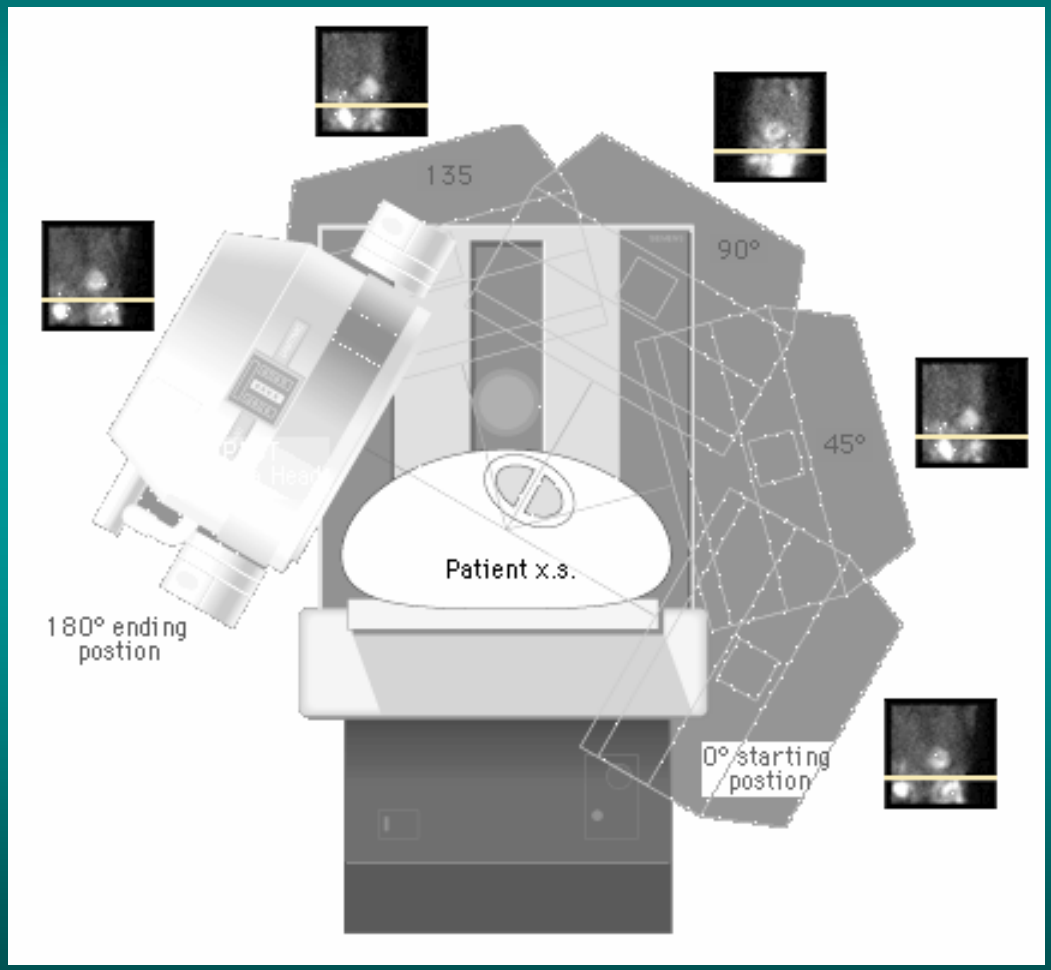
SPECT Reconstruction

- Planar images from multiple axes
- Reconstruct 3-D
- Similar to CT reconstruction



Cine courtesy of Dr. Donohoe



http://info.med.yale.edu/intmed/cardio/imaging/techniques/spect_camera/graphics/spect_camera.gif

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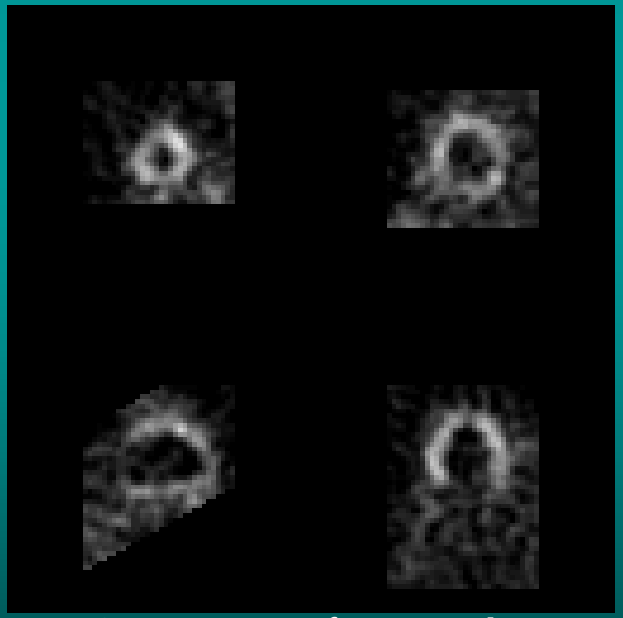
Gating for Ejection Fraction

- Gate the acquisition using the ECG
- Calculate the EF by the end systolic and end diastolic volumes

$$EF = \frac{LVEDV - LVESV}{LVEDV}$$

Patient with dilated CM



Cine courtesy of Dr. Donohoe

EF = 13%

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Cardiac Imaging Radiotracers

- Gamma Camera (Planar / SPECT)
  - Thallium-201
  - Technetium-99m labeled Sestamibi
  - Technetium-99m labeled Tetrofosmin
- PET
  - Fluorine-18 labeled Fluorodeoxyglucose
  - Rubidium-82
  - Nitrogen-13 labeled ammonia

Will discuss here

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Thallium-201

- Tl-201
  - Photon emitter (70-80 keV)
  - Half-life: 64 hours
- Na-K ATPase actively pulls Tl into cells
- Distribution immediately after injection vs. delayed uptake (redistribution)
- Wash out + active transport in = redistribution
- Good for imaging perfusion, viability

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Technetium-99m Sestamibi

- Tc-99m
  - Photon emitter (140 keV)
  - Half-life: 6 hours
- Lipophilic cationic complex
- Uptake proportional to blood flow
- Much slower clearance than Tl-201: need 2 injections for stress and rest images
- Better resolution than Tl-201
- Better uptake but more expensive than Tetrofosmin

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Stress Test

- Exercise preferred
  - Bruce Protocol
  - Target: 85% max HR
- Otherwise pharmacologic
- Inject radionuclide at peak stress
- Do rest imaging before or after

Bruce Protocol

Stage	Time (mins)	Speed (mph)	Gradient
	3	1.7	10%
		2.5	12%
		3.4	14%
	3		
	3		
	Etc...		

Okay, I'll inject the radiotracer.

I'm starting to get tired.

http://www.cardiocontrol-us.com/images/products/stress2.jpg

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Pharmacologic Stress Test

Agent	Dipyridamole	Adenosine	Dobutamine
Mechanism	Blocks adenoside reuptake, causing coronary vasodilation	Adenosine receptor A2a causes coronary vasodilation	Stimulates A1, B1, B2 receptors, increasing O2 demand and secondary vasodilation
Hemodynamics	Incr. HR, Incr. BP	Incr. HR, Decr. BP	Incr. HR
Side Effects	Minor	Flushing, nausea, heart block	Chest pain, NSVT, MI
Contraindicataions	Bronchospasm, AV block, sick sinus syndrome	Bronchospasm, AV block, sick sinus syndrome	Recent coronary syndrome, hemodynamic / electrophysiologic instability

From Up to Date: www.utdol.com/application/image.asp?file=card_pix/compar6.gif

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Stress Test - Patient Perspective

- No caffeine or theophylline-containing medications (adenosine antagonists)
- No beta-blockers or nitrates unless assessing improvement with medication
  - less effect with dipyridamole or adenosine
- Avoid sildenafil (Viagra) in case nitroglycerine (NTG) is needed

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Back to our patient...

http://www.contusalud.com/website/images/270400/chest_pain.jpg

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Patient H.S. - MIBI Stress Test

- Performed to identify “culprit” lesion
- Resting images obtained first with Tl-201
- 9.5 minutes on Bruce Protocol
- Attained 82% target HR
- Experienced angina and stopped due to pain
- Tc-99m Sestamibi injected at peak stress

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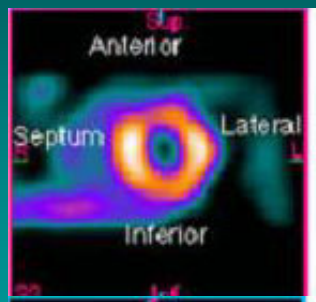
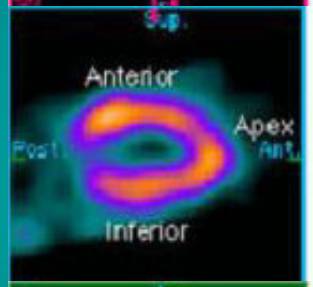
Patient H.S. - Initial Scan



Stress

Short axis

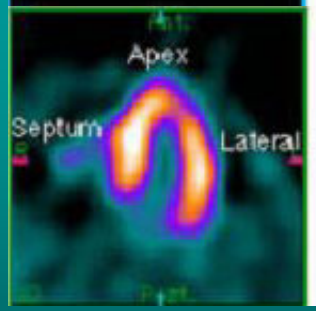
Rest



Stress

Horizontal long axis

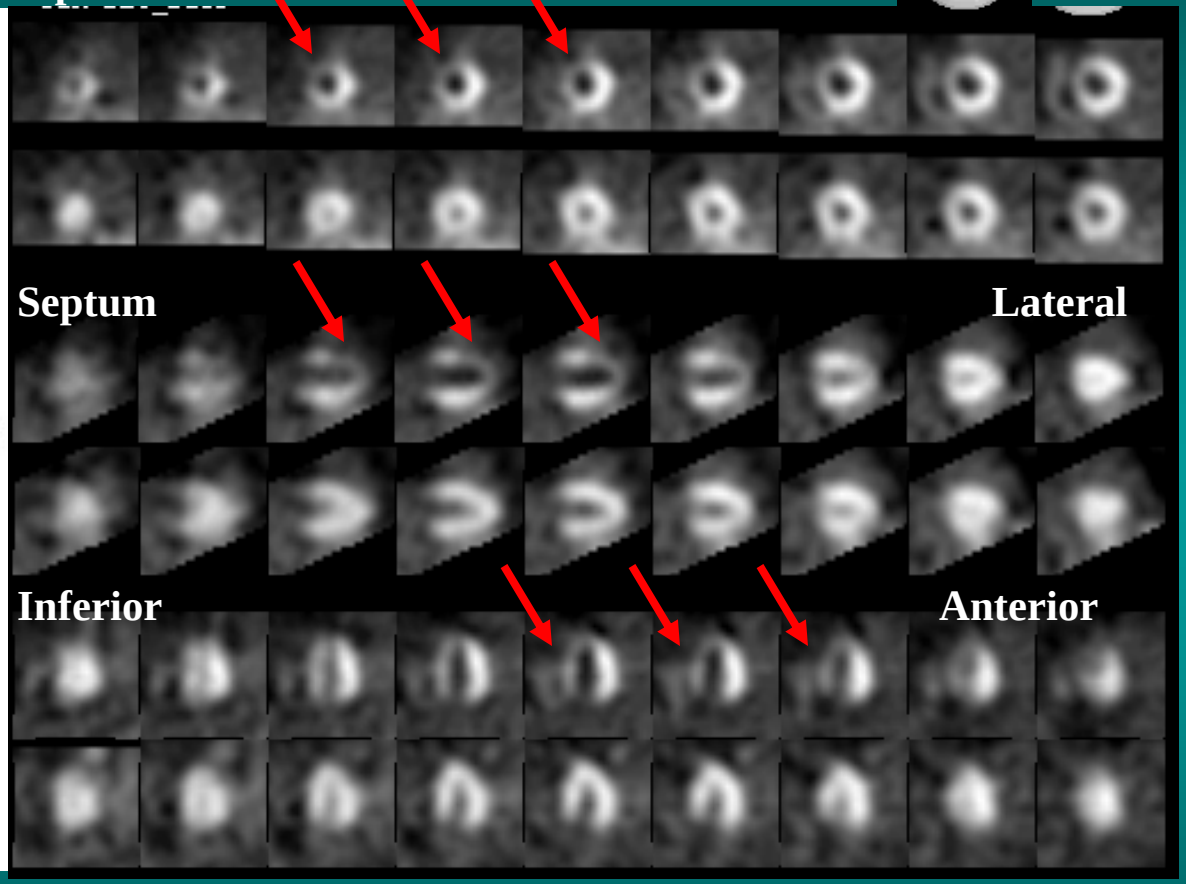
Rest

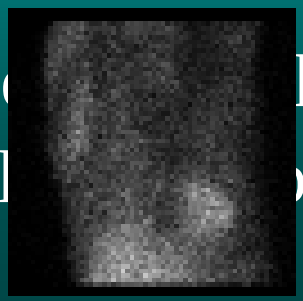


Stress

Vertical long axis

Rest





- Large[illegible]le anterior, apical, septal perfusion defect
- Singl[illegible]roximal LAD disease
- EF = 53%

Cine and patient images courtesy of Dr. Donohoe

Diagram: http://www.physics.ubc.ca/~mirg/home/tutorial/pics/heart.jpg

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Patient H.S. - Treatment

- Interventional cardiology
  - Proximal LAD
    - Atherectomy
    - PTCA
    - Stenting
  - First diagonal branch
    - PTCA
- Resolution of symptoms, discharged.

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Patient H.S. - Recurrence

- 3 months s/p intervention: recurrence of chest pain
  - Refused admission; left AMA.
  - Discharged on Plavix and Diltiazem.
- Agreed to repeat MIBI stress test one month later.
  - 15 minutes on a Bruce Protocol
  - Attained 92% target HR

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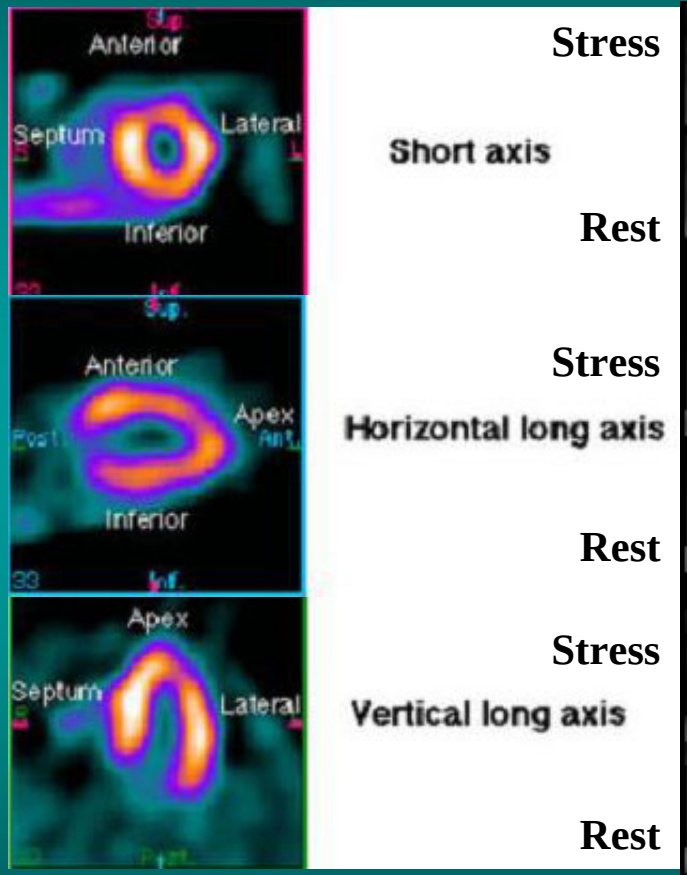
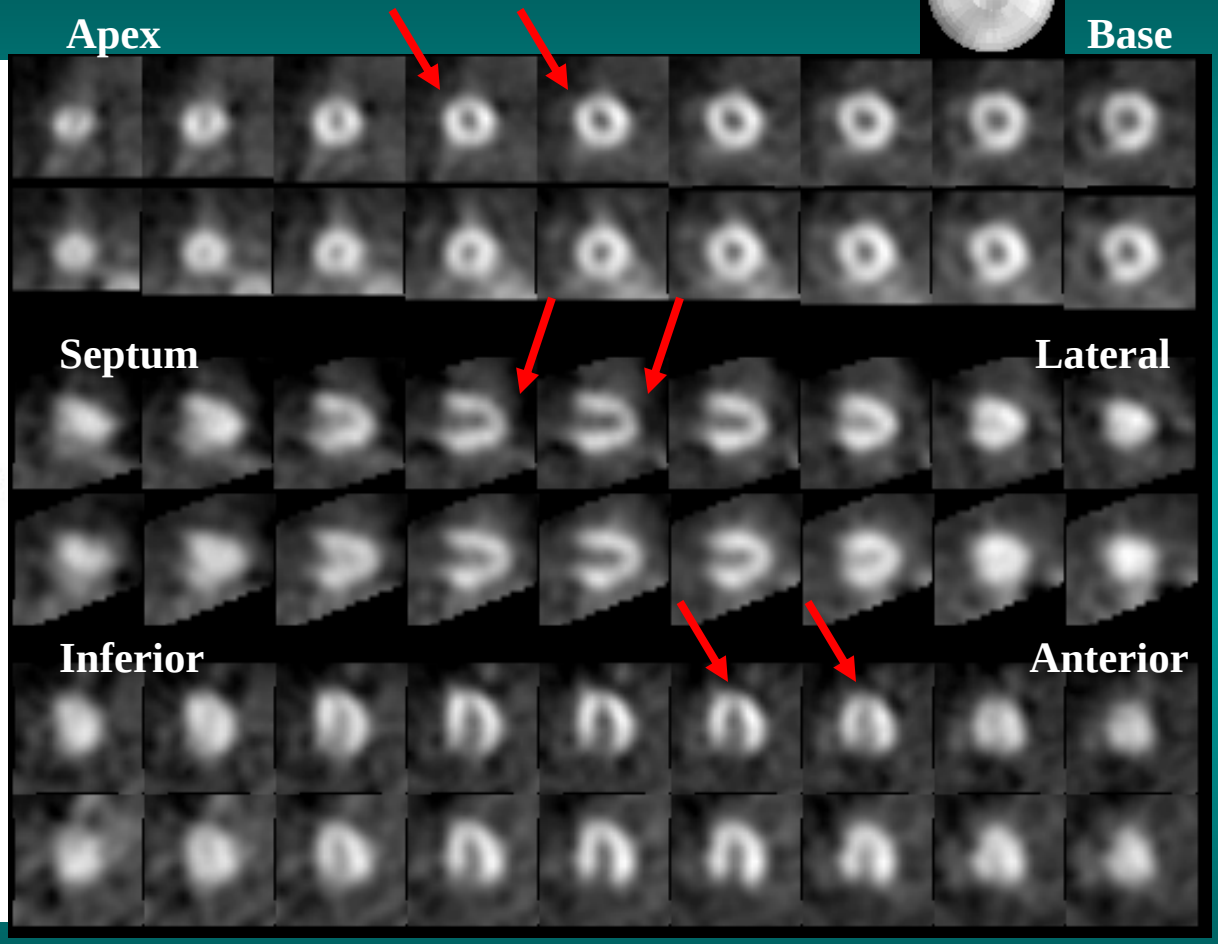
Patient H.S. - s/p Stenting





- Mild reversible defect distal anterior wall and apex
- Possible partial in-stent restenosis

Cine and patient images courtesy of Dr. Donohoe

http://www.physics.ubc.ca/~mirg/home/tutorial/pics/heart.jpg

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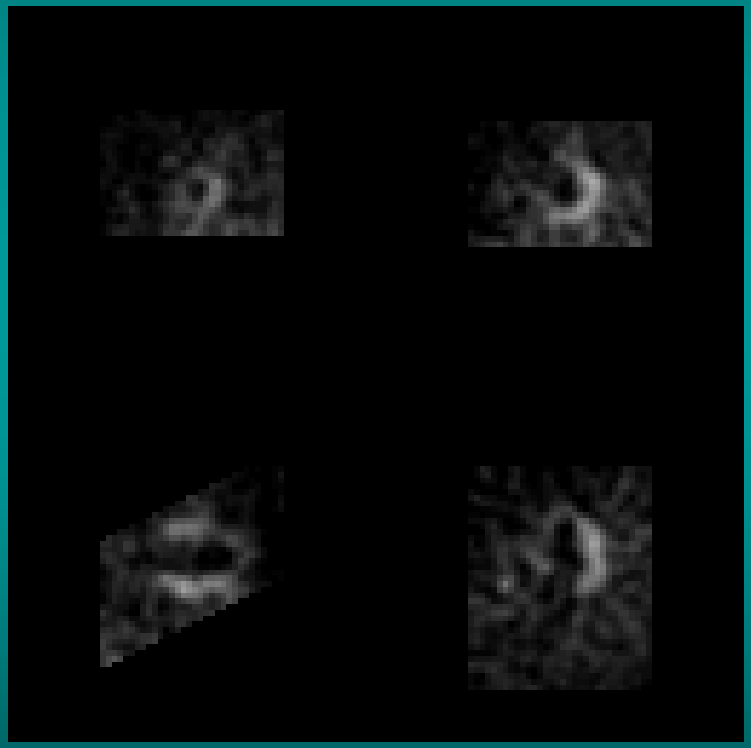
Patient H.S. - Cardiac Function

- Ejection Fraction?

EF = 70%

Thus, good cardiac function



Cine courtesy of Dr. Donohoe

Conclusions

- Nuclear medicine images physiology
- SPECT imaging with Tl-201 and Tc-99m Sestamibi can
  - Localize pathology
  - Indicate severity of disease

References

- Principles of Nuclear Medicine. Eds: Wagner HN, Zsolt S, Buchanan JW. WB Saunders; 2nd ed (1995)
- www.physics.ubc.ca/~mirg/home/tutorial/hardware.html (SLIDE 10)
- www.kfshrc.edu.sa/radiology/assets/images/nuc4.jpg (SLIDE 11)
- www.siemensmedical.com (SLIDE 11)
- www.nationalpetscan.com/images/scanner.jpg (SLIDE 11)
- info.med.yale.edu/intmed/cardio/imaging/techniques/spect_camera/graphics/spect_camera.gif (SLIDE 12)
- www.cardiocontrol-us.com/ images/products/stress2.jpg (SLIDE 17)
- Up to Date: www.utdol.com/application/image.asp?file=card_pix/compar6.gif (SLIDE 18)
- http://www.contusalud.com/website/images/270400/chest_pain.jpg (SLIDE 20)
- www.physics.ubc.ca/~mirg/home/tutorial/pics/heart.jpg (SLIDES 22 and 25)

Acknowledgements

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