Pearls & Pitfalls in nuclear cardiology

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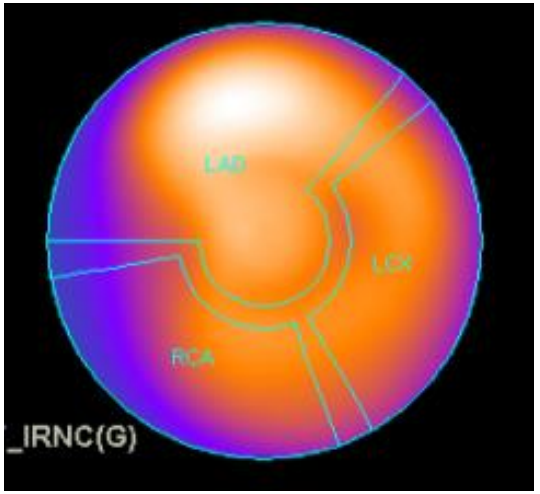
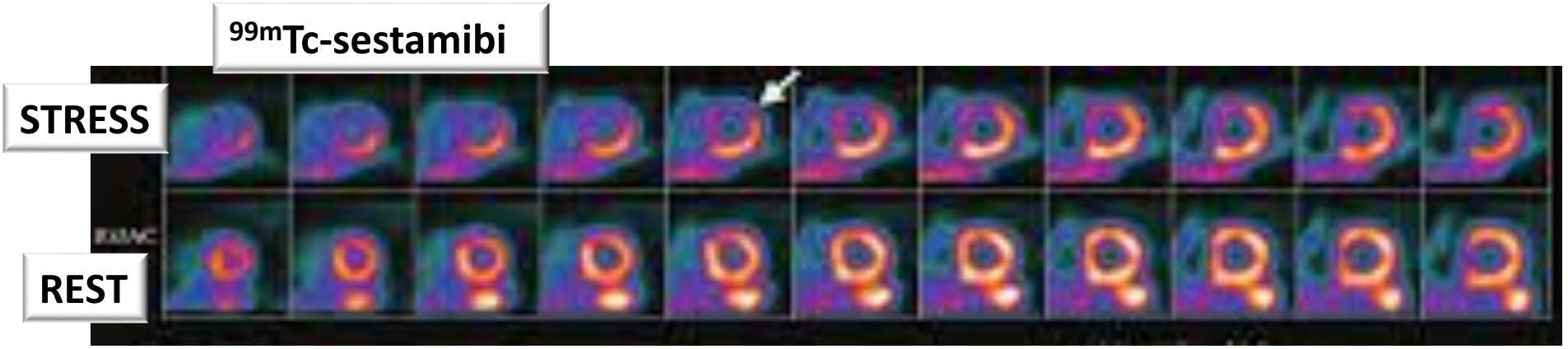
Principle of **myocardial perfusion** imaging (MPI)

- Radiotracer <u>uptake</u> in the myocardium reflects regional <u>MBF</u>





Myocardial perfusion tracer

SPECT-based myocardial perfusion tracer

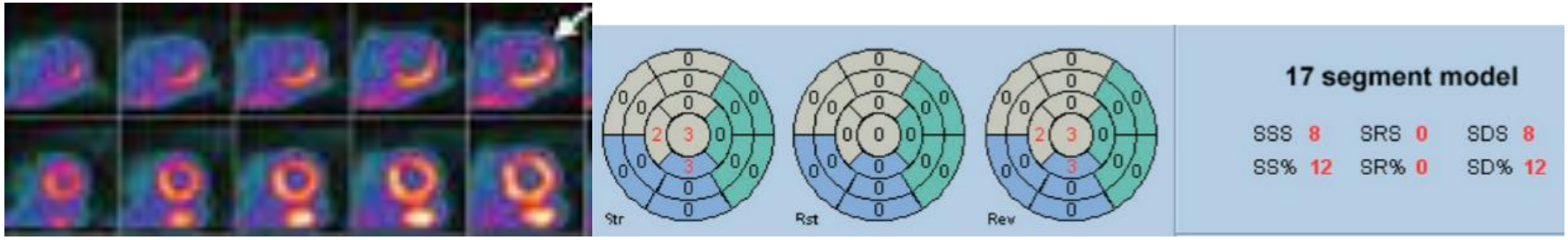
- Thallium-201 (^{201}Tl)
- ^{99m}Tc-based agent
  - **^{99m}Tc-sestamibi**
  - ^{99m}Tc-tetrofosmin
  - ^{99m}Tc-teboroxime

PET-based myocardial perfusion tracer

- N-13 ammonia ($^{13}NH_3$)
- O-15 water ($H_2{}^{15}O$)
- ^{82}Rb

Interpretation: Stress & Rest studies

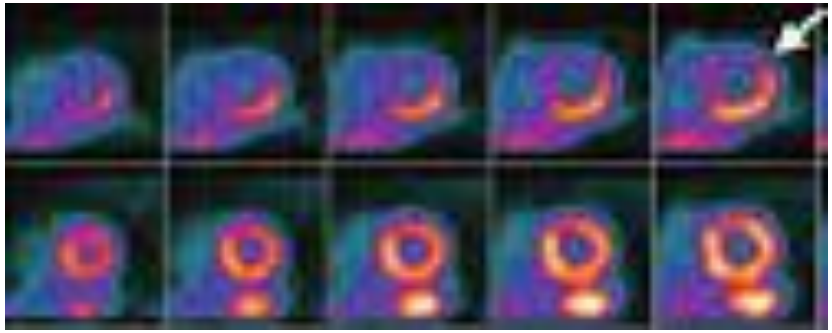
- Visual/ semi-quantitative assessment



- ➢ <u>Relative</u> uptake/flow to regional myocardium
- ➢ Identify physiologic significant flow-limiting coronary lesion

Pitfalls

- May underestimate balanced ischemia
- May underestimate an occlusive lesion in the region with the highest uptake

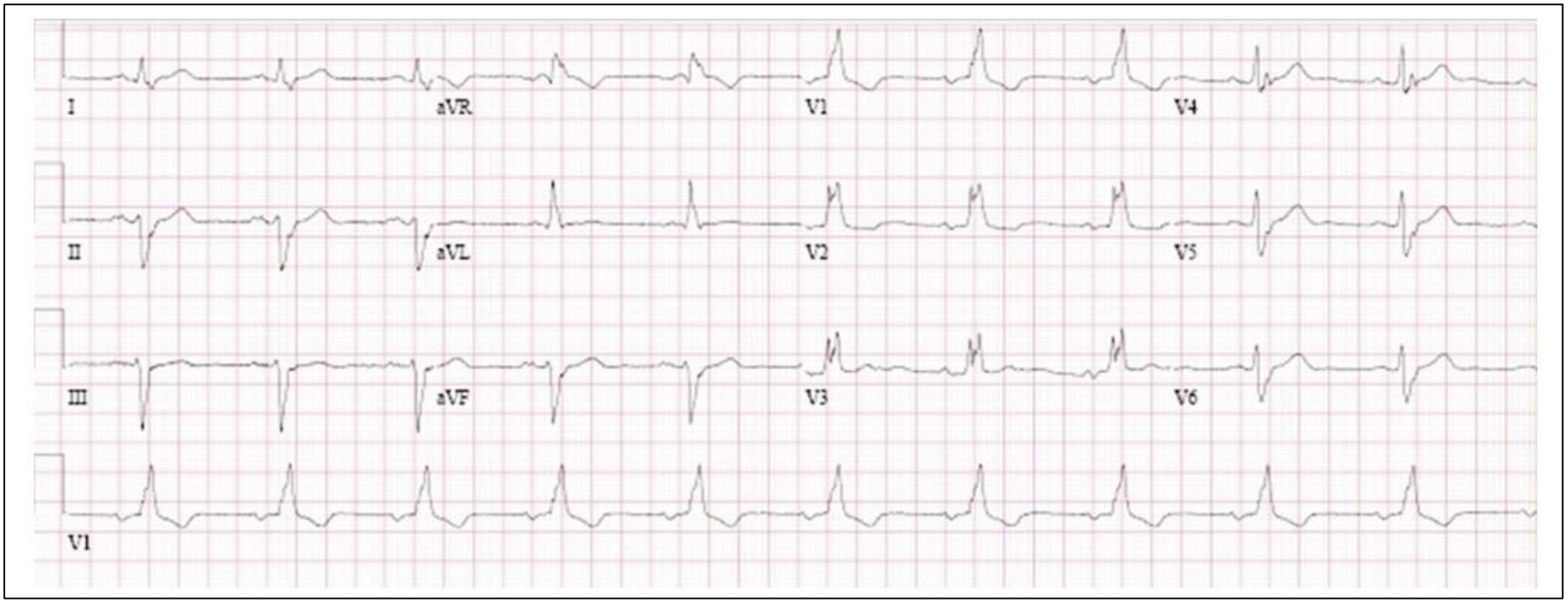


Case study

Case study

- A 74-year-old man with hypertension & diabetes was referred for preoperative assessment prior to bladder surgery.
- He reports a “normal” stress test 14 years ago
- He denies chest pain
- Dipyridamole PET MPI was requested for preoperative risk assessment.

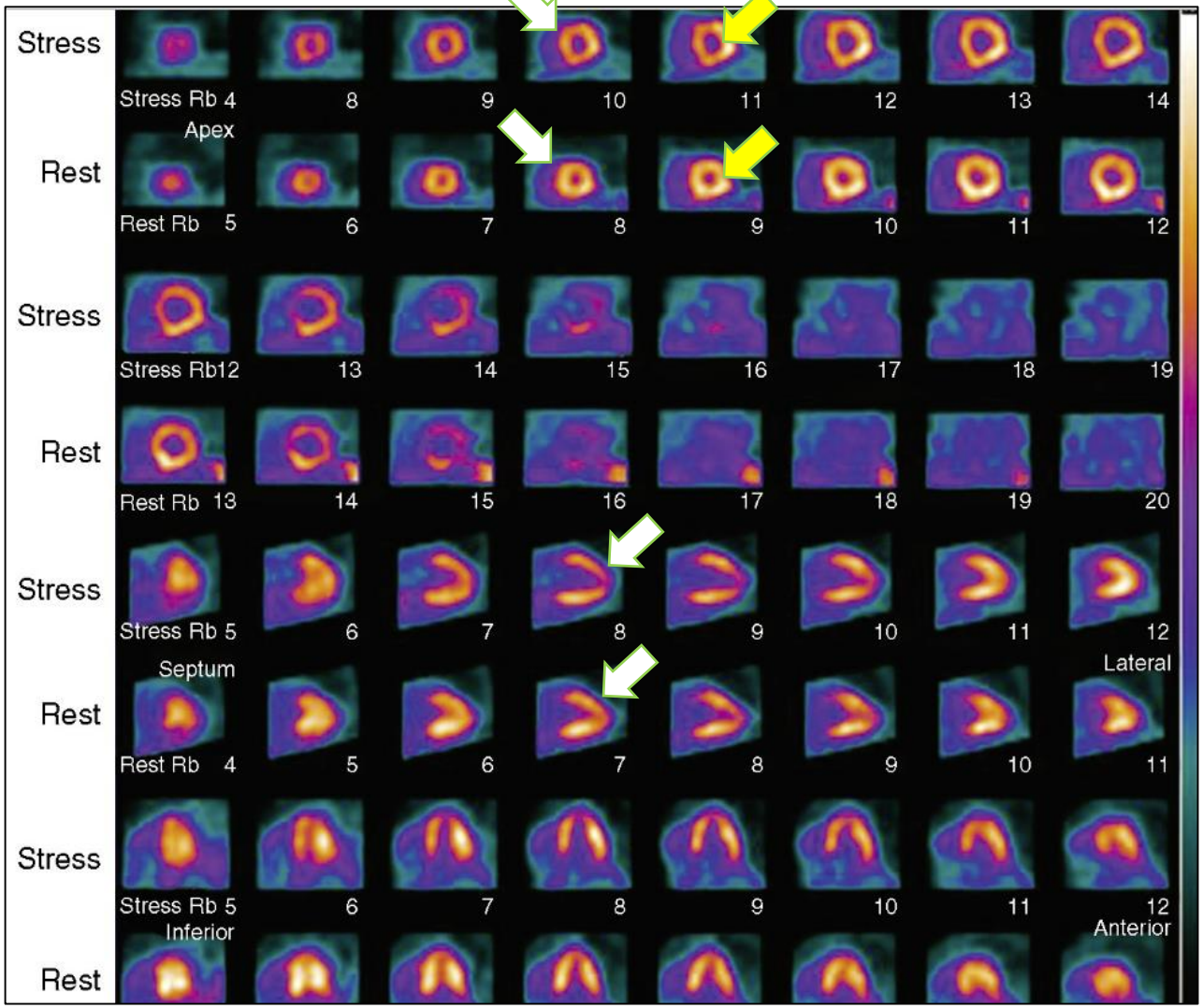
12-Lead ECG



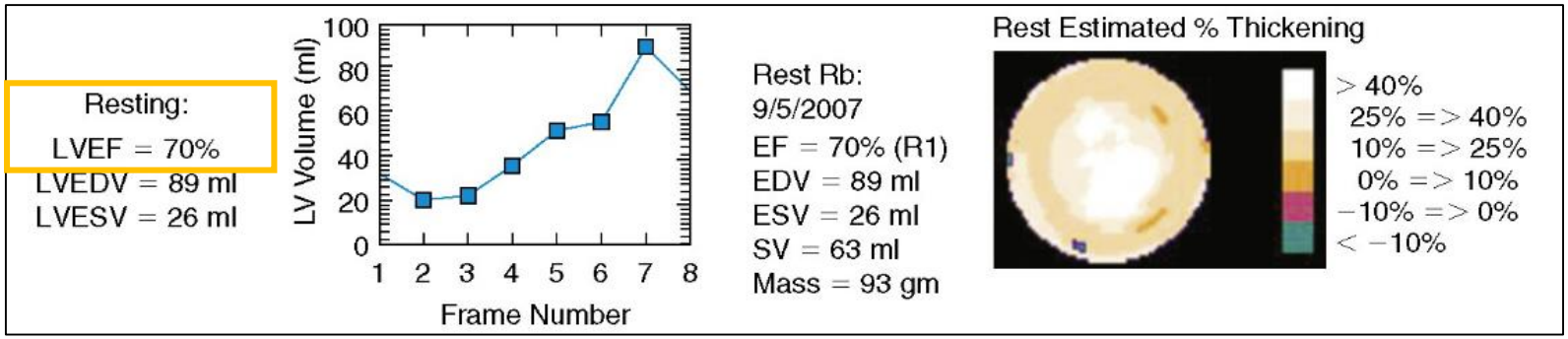
The baseline ECG demonstrates normal sinus rhythm, right bundle branch block, and left anterior fascicular block.

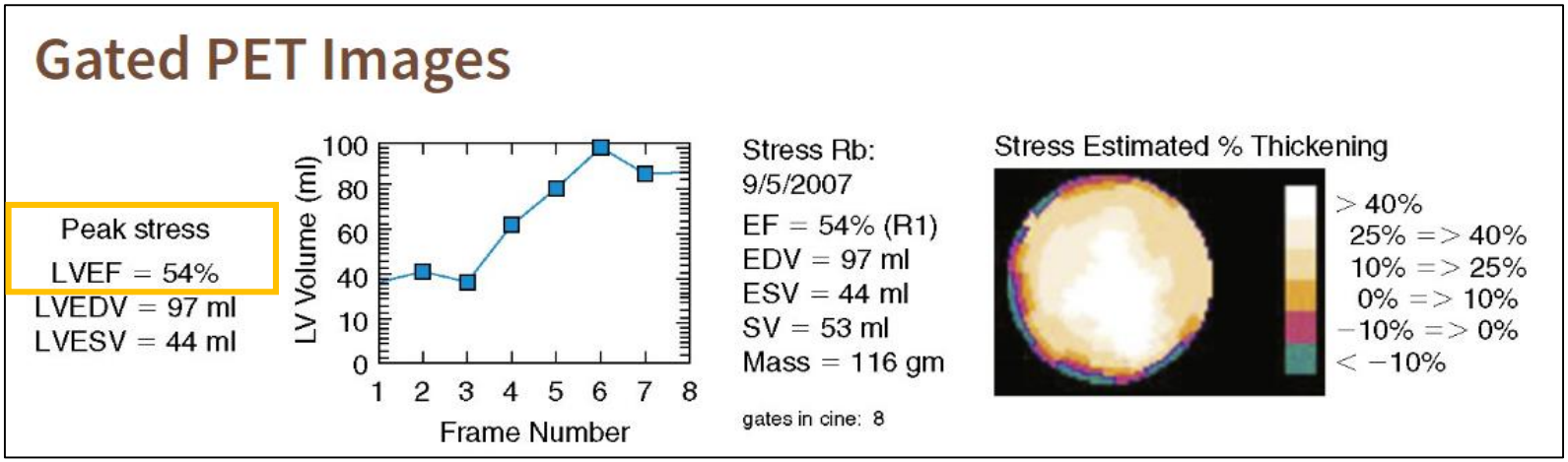
PET images

^{82}Rb



- Reversible perfusion defect at apical anteroseptal wall
- Transient dilatation of LV cavity (TID = 1.39)





- Decrease in LVEF at peak dipyridamole stress is an abnormal finding on gated PET
- Common in patients with extensive CAD, multivessel disease, or left main disease

Case study

- Coronary angiography
  - Mild diffuse left main disease
  - Moderate diffuse LAD stenosis
  - 80% proximal circumflex stenosis
  - 50% ostial RCA stenosis, and 30% mid-RCA stenosis

Pitfalls

- **Detection of Balanced Ischemia**

1) The presence of multivessel CAD can be underestimated by techniques that measure only "relative" myocardial perfusion.
2) Elevated stress/rest LV cavity ratio (transient dilatation of LV cavity) is a marker of extensive ischemia →"high-risk" marker on MPI
3) A decline in LVEF from rest to peak stress on gated PET → marker of extensive ischemia, predicts the presence of severe/ or multivessel CAD

Quantitative myocardial perfusion PET

SPECT-based myocardial perfusion tracer

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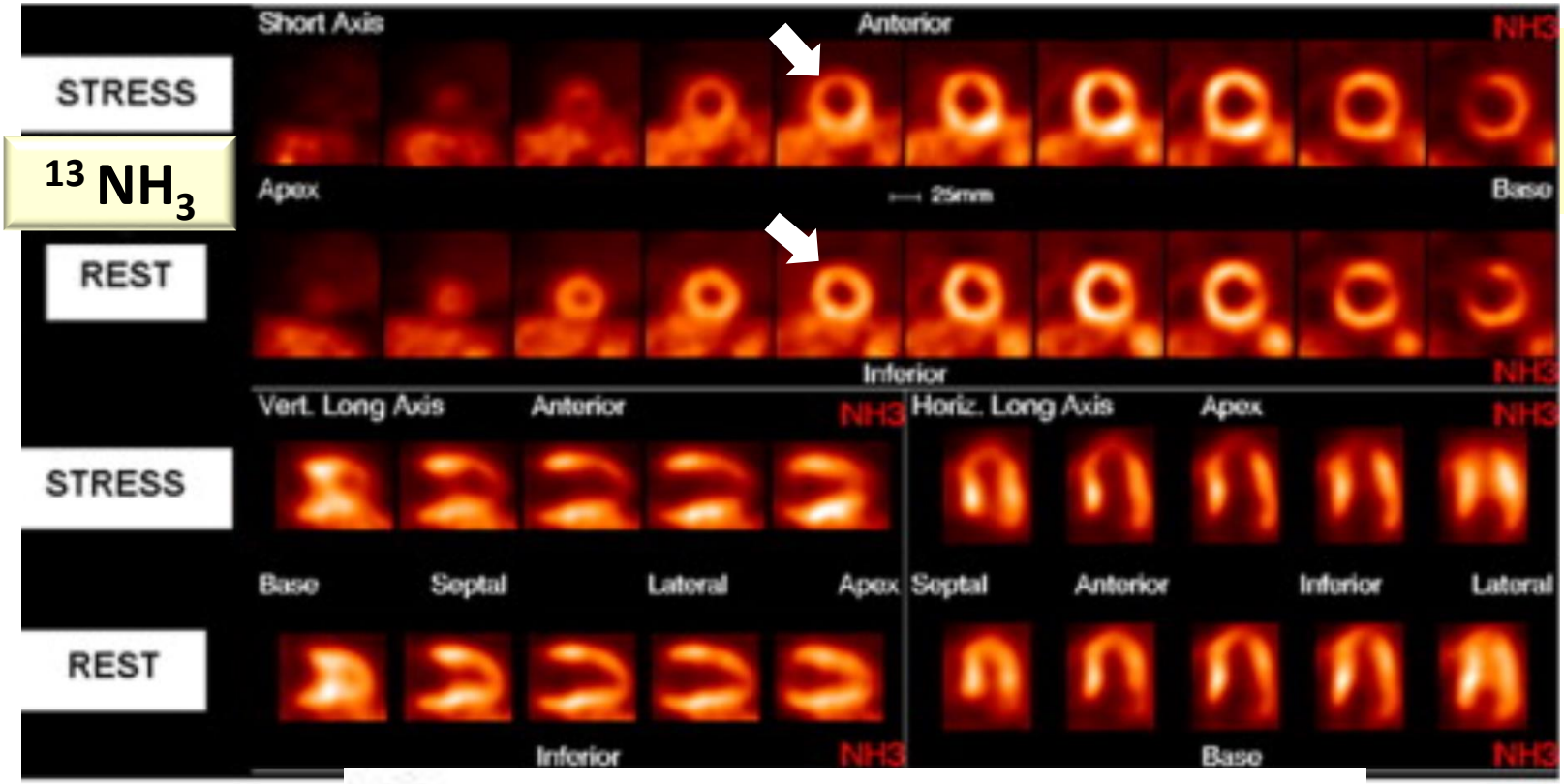
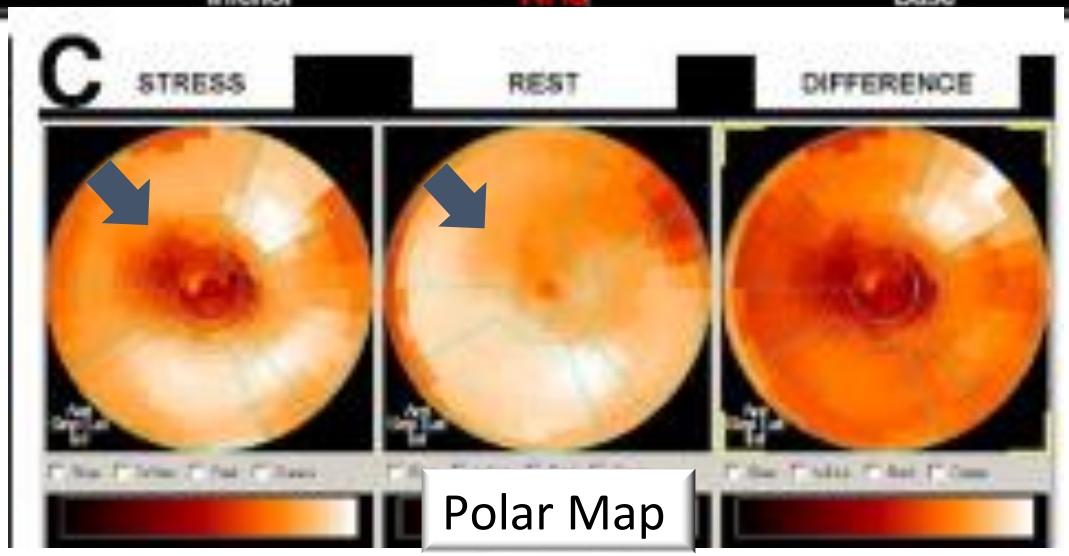


A 61-year-old patient with DM, HT



Cardiac PET Imaging for the Detection and Monitoring of Coronary Artery Disease and Microvascular Health . J Am Coll Cardiol Img. 2010;3(6):623-640.

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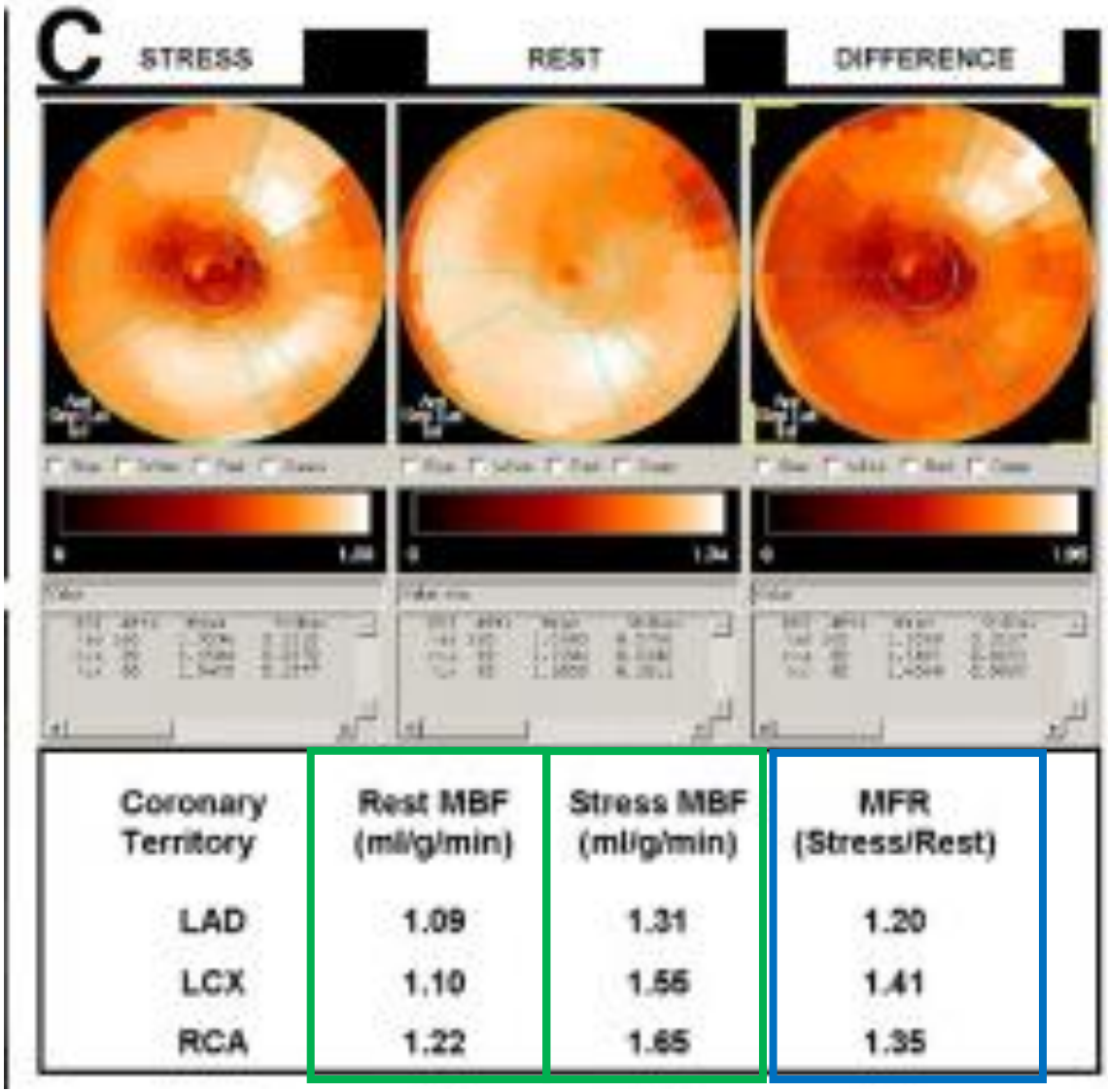

Coronary Territory	Rest MBF (ml/g/min)	Stress MBF (ml/g/min)	MFR (Stress/Rest)
LAD	1.09	1.31	1.20
LCX	1.10	1.56	1.41
RCA	1.22	1.65	1.35

Quantitative Myocardial Blood Flow

Myocardial Flow Reserve (MFR) < 2

Cardiac PET Imaging for the Detection and Monitoring of Coronary Artery Disease and Microvascular Health . J Am Coll Cardiol Img. 2010;3(6):623-640

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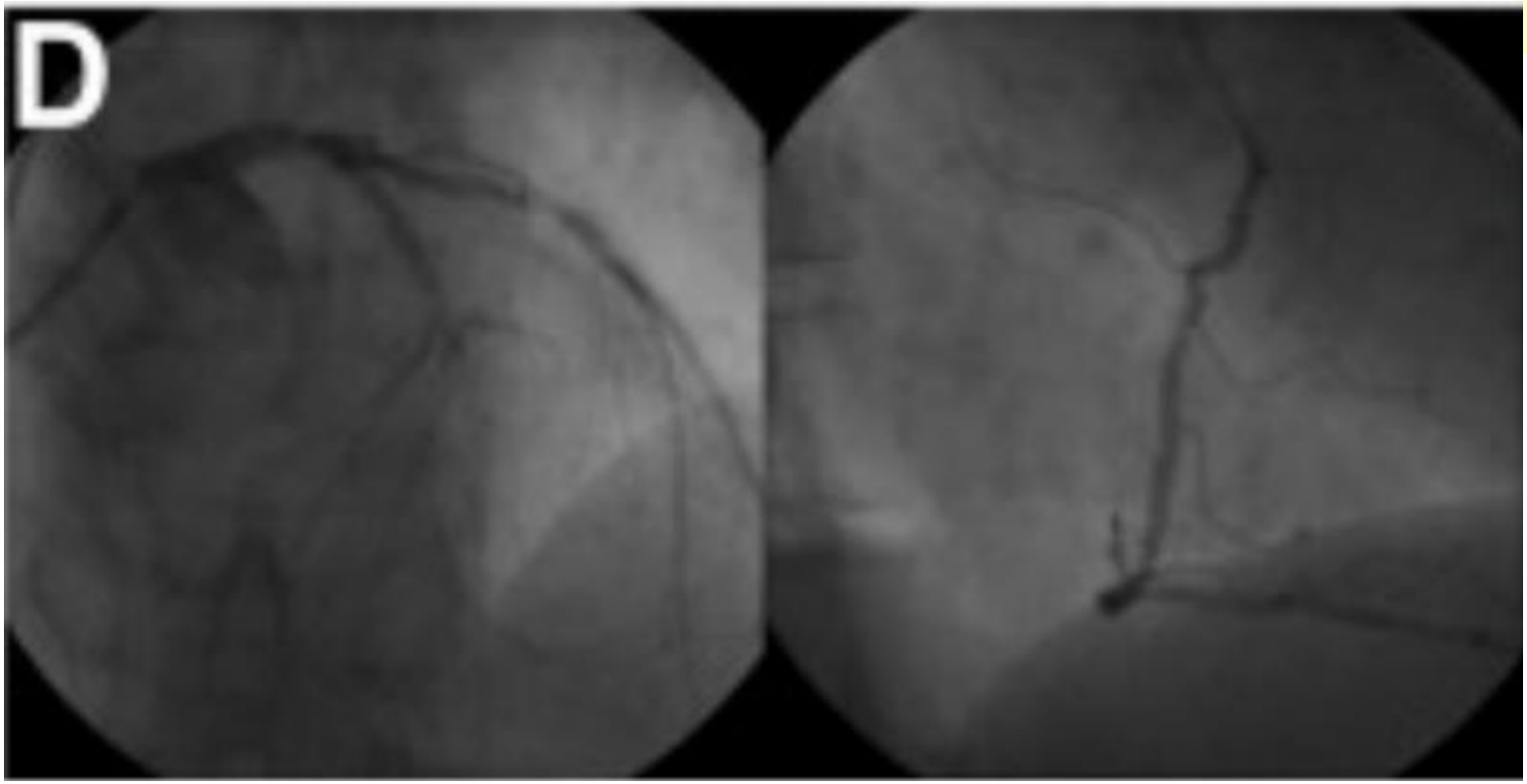


- Severe occlusion of the LAD
- 80% stenosis in the proximal LCX
- Sequential 50% to 60% lesions in RCA

Cardiac PET Imaging for the Detection and Monitoring of Coronary Artery Disease and Microvascular Health . J Am Coll Cardiol Img. 2010;3(6):623-640.

Clinical Utility of Quantitative Myocardial Blood Flow

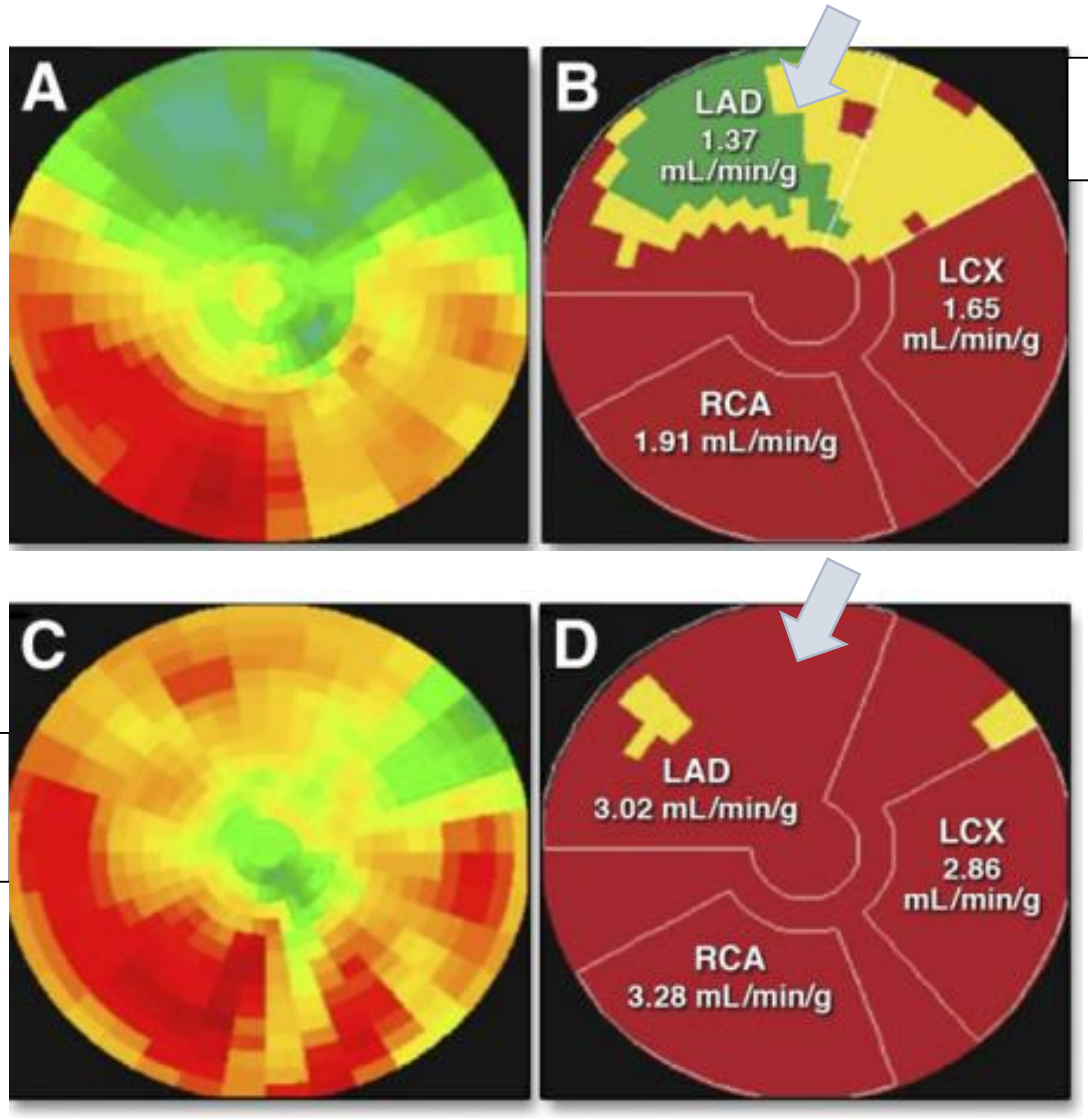
PET-based tracer

- Identification of subclinical CAD
- Improved characterization of CAD burden
- Identification of “balanced” reduction of MBF in all vascular territories
- Allows for reliable comparison between baseline & follow-up studies

Cardiac PET Imaging for the Detection and Monitoring of Coronary Artery Disease and Microvascular Health . J Am Coll Cardiol Img. 2010;3(6):623-640.

Polar Map of Myocardial Tracer Uptake During Adenosine stress

$^{13}NH_3$



Decrease MFR in 3 territories

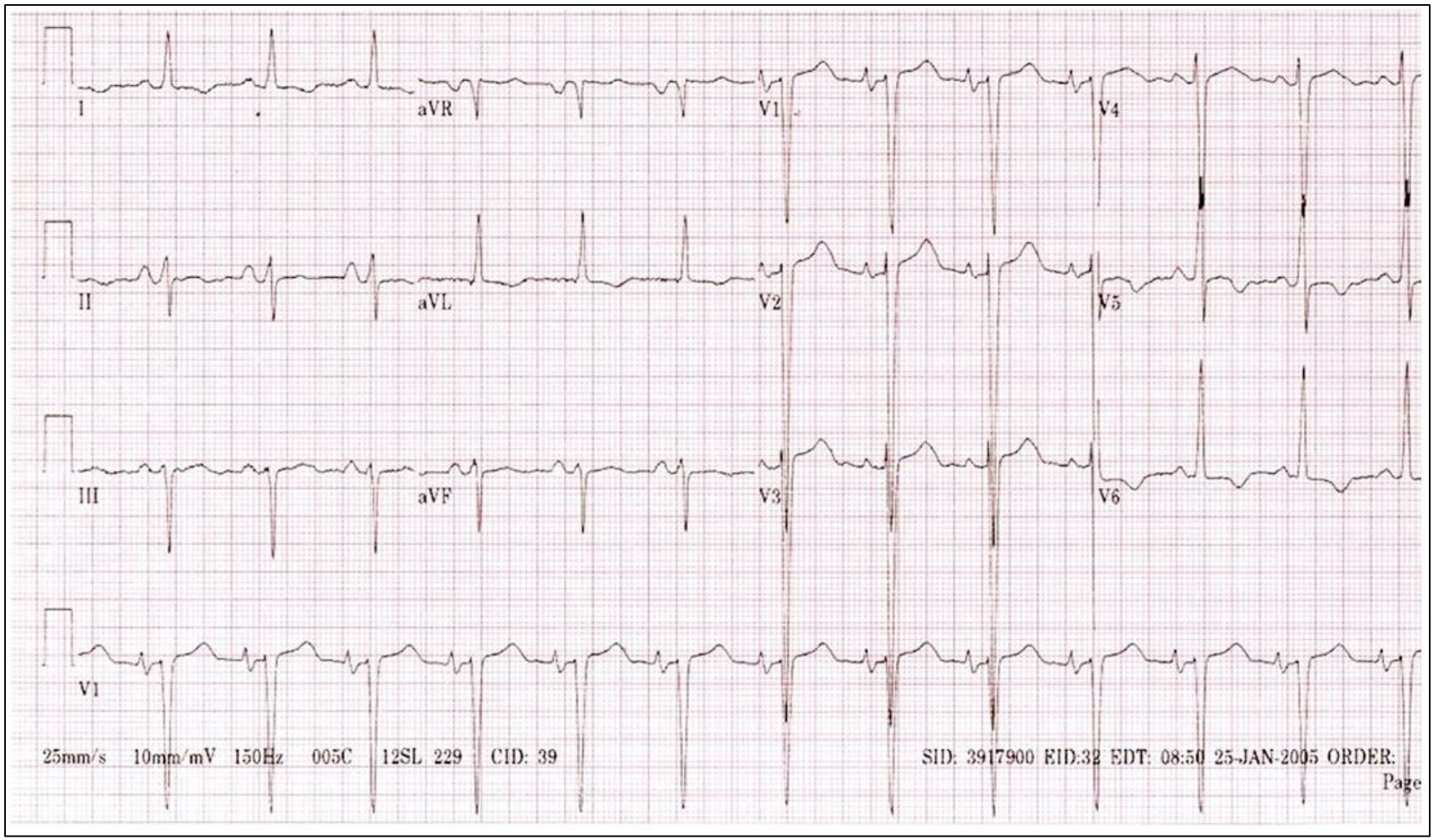
Follow-up at 1 yr after medical therapy

Dilsizian V et al. Journey in evolution of nuclear cardiology: Will there be another quantum leap with the F-18 labeled myocardial perfusion tracers? J Am Coll Cardiol Img. 2012;5:1269-84

Artifacts on MPI

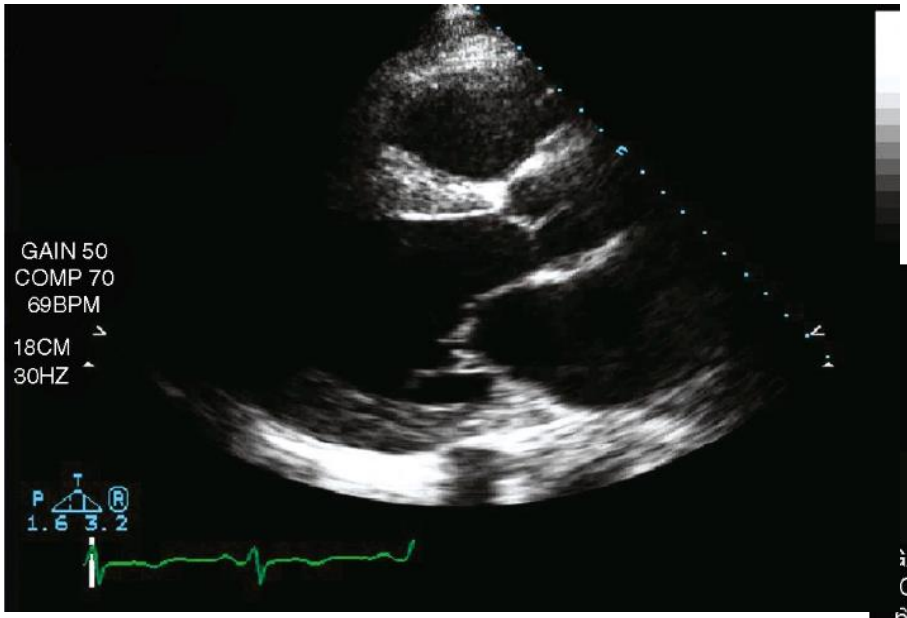
Case study

- A 36-year-old man with HT described a 6-month history of exertional dyspnea and leg edema
- He had stopped taking his antihypertensive medications several months ago
- He admitted to consuming a “moderate” amount of alcohol on a daily basis

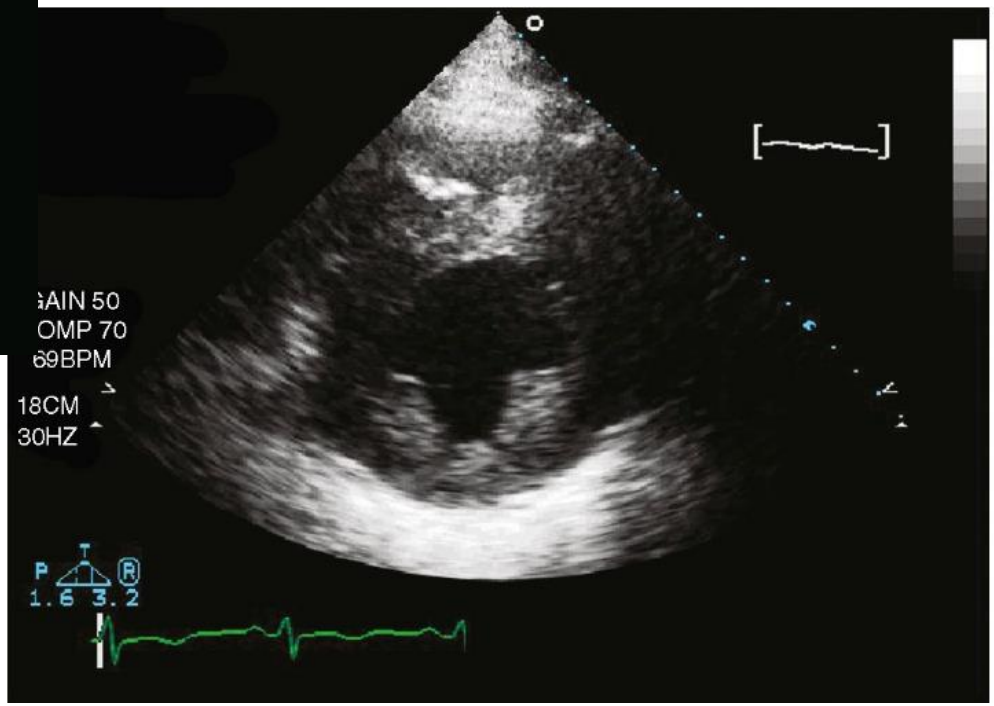


- The baseline ECG demonstrates sinus rhythm, increased QRS voltage consistent with left ventricular hypertrophy (LVH)
- Non-specific ST-T abnormalities possibly related to LVH
- There is also evidence of left atrial enlargement

Echocardiography



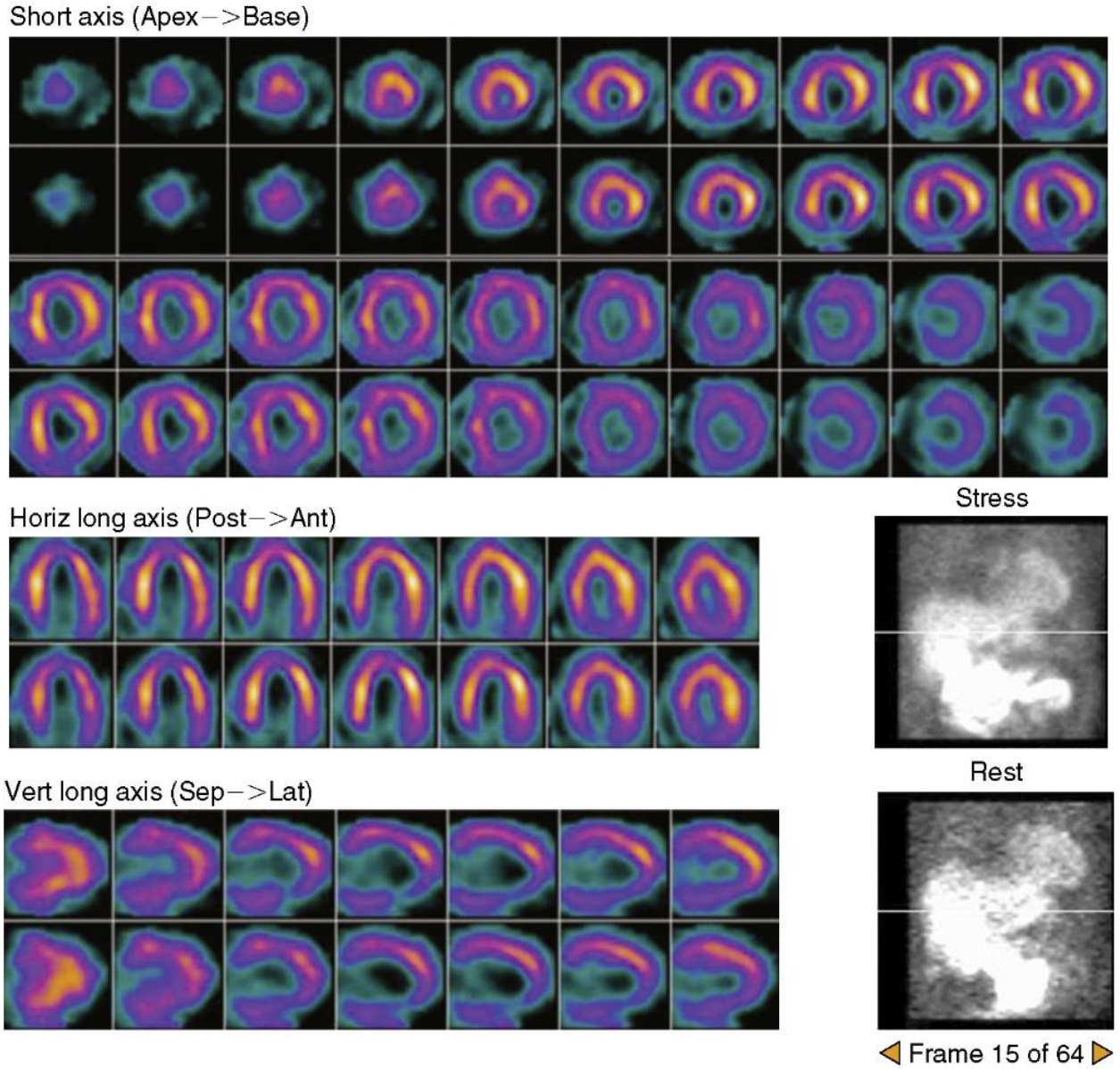
Parasternal long-axis



Short-axis

- LV dilation: increase LV end diastolic diameter
- Increased LV wall thickness
- Severe global LV systolic dysfunction, estimated LVEF of 25%
- These findings are consistent with ischemic or non-ischemic cardiomyopathy

- He was referred for adenosine stress ^{99m}Tc-sestamibi SPECT MPI to evaluate for ischemic cause for LV dysfunction
- During 4-minute adenosine infusion, no adenosine-induced symptoms were reported.
- Baseline BP was elevated, but the blood pressure response to adenosine was normal.
- No significant ECG change during stress & recovery periods.

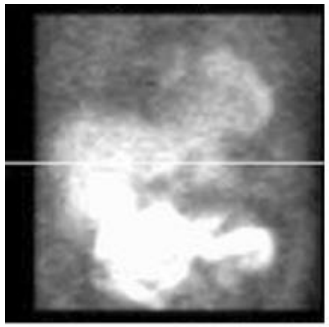


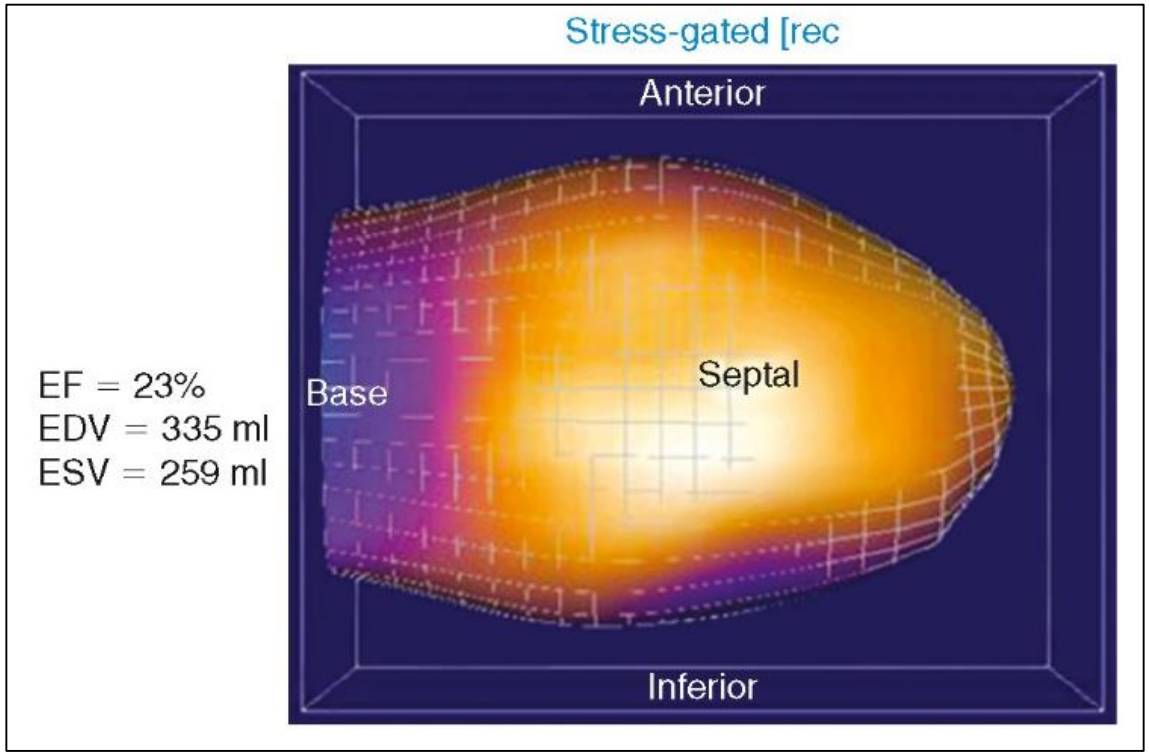
- The SPECT images demonstrate moderate to severe fixed perfusion defect at inferior wall extending from base to apex
- Fix LV cavity dilatation

- DDx:

  - inferior wall infarction

  - non-ischemic cardiomyopathy with **inferior wall attenuation artifact** (diaphragmatic attenuation), esp male, or pt with cardiomegaly





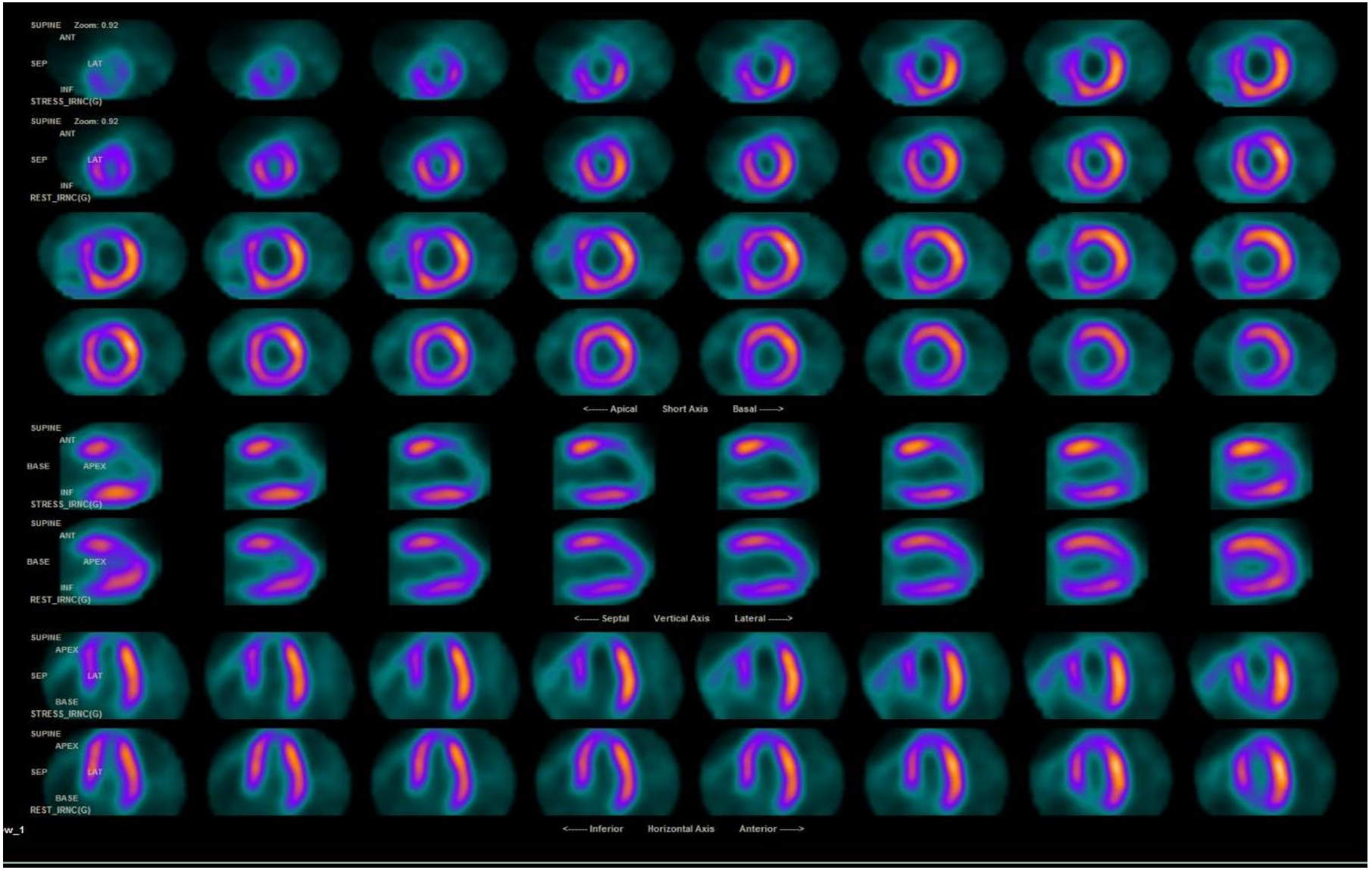
- Post-stress gated SPECT: global LV hypokinesis, LVEF = 23%
- LV EDV = 335 ml, and LV ESV = 259 ml; markedly increased

SPECT MPI

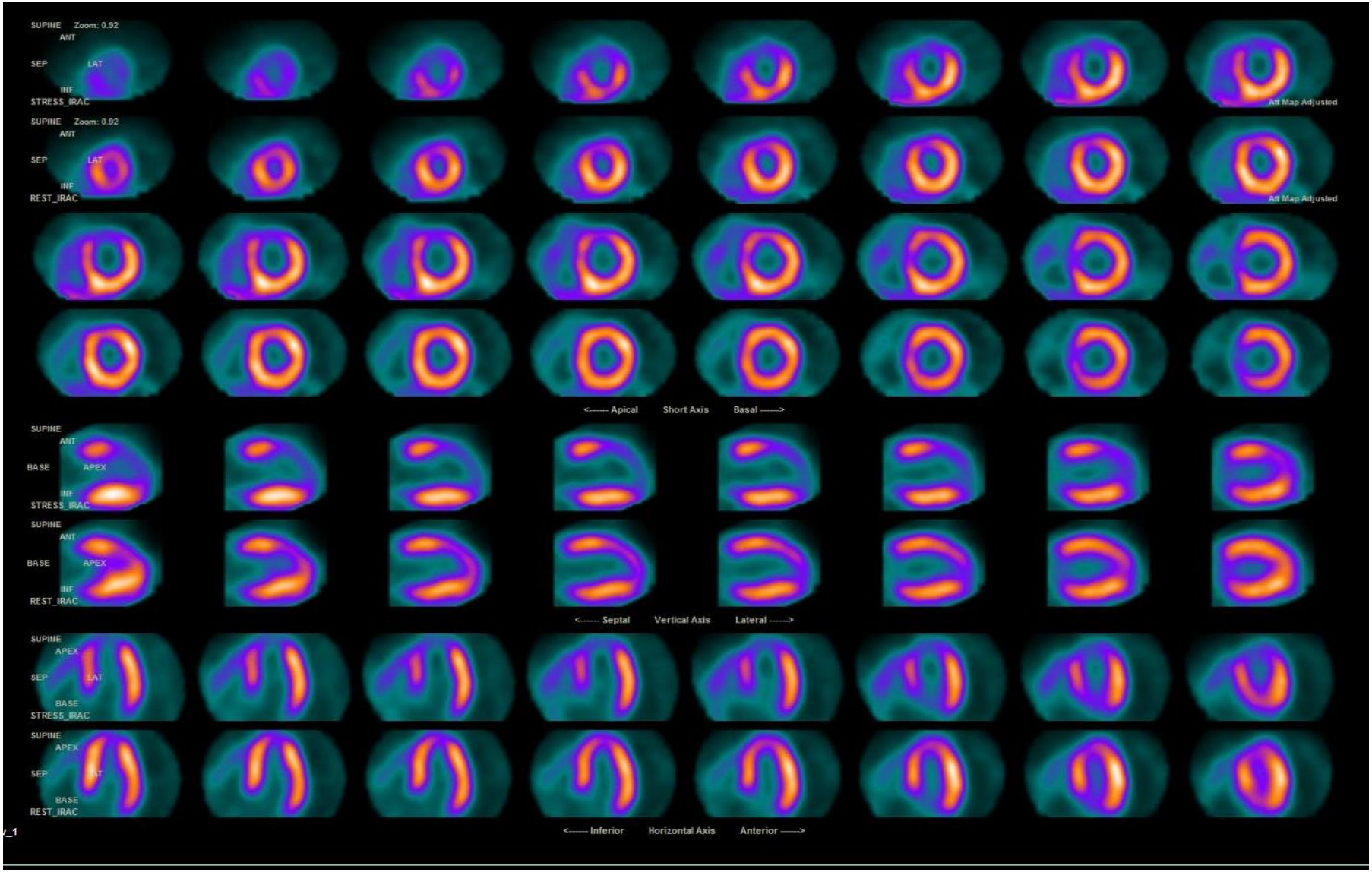
- Fixed inferior wall perfusion defects can be seen in patient with non-ischemic cardiomyopathy, due to attenuation by the enlarged heart

- This can be improved by CT attenuation correction image, or by using PET MPI

Non-attenuation correction (NAC)



Attenuation correction (AC)

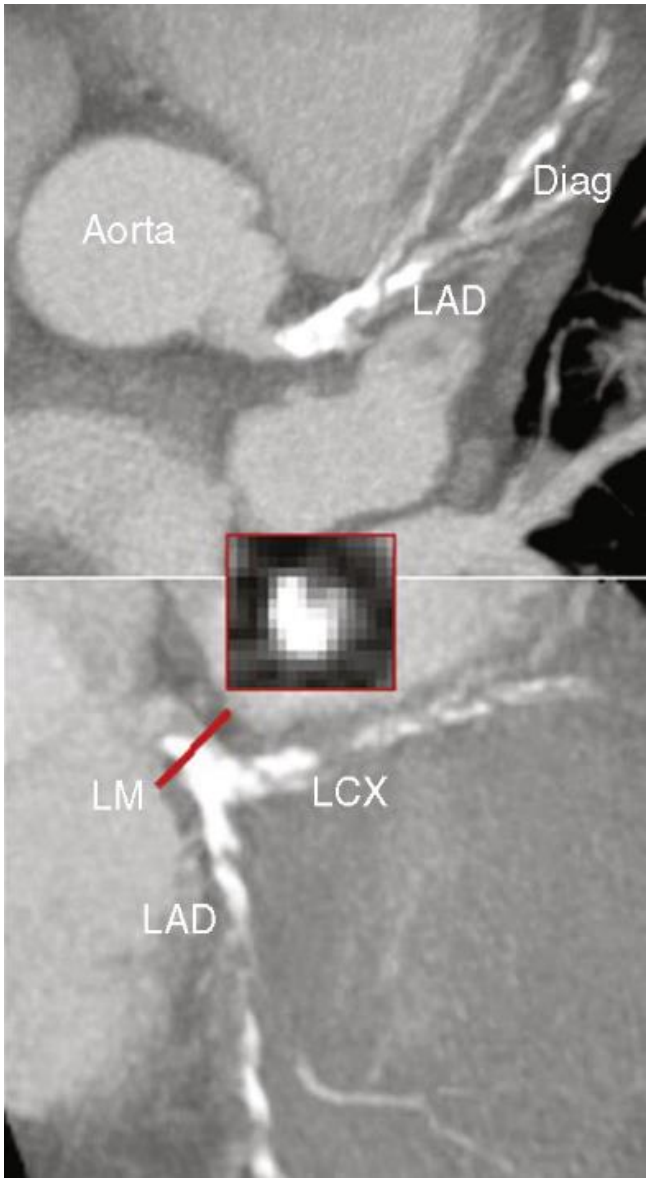


Artifacts

- Breast attenuation artifact
  - anterior or lateral wall, fix or reversible defect
- Diaphragmatic creep artifact
  - usually occur after exercise → inferior wall defect
- Motion artifact
- Interfering adjacent splanchnic activity

  - mask area of defect, or produce inferior wall defect (reconstruction/filter artifact)

Pearls of MPI



- A 68-year-old male was referred for preoperative risk evaluation for atypical chest pain.
- The selected multiplanar reformats of his CT coronary angiogram demonstrating extensive calcified coronary plaque in left main, LAD, and LCX arteries.

CTA has some limitation for accurately assess degree of luminal narrowing in vessels with heavy calcification

- CTA has some limitation for accurately assess the degree of luminal narrowing in vessels with heavy calcifications

- CTA ability used as a surrogate for physiologic significance is only modest

- SPECT or PET MPI may play a significant role in the selection of patients for catheterization because it gave physiologic information.

- The non-randomized Coronary Artery Surgery Study (CASS) registry

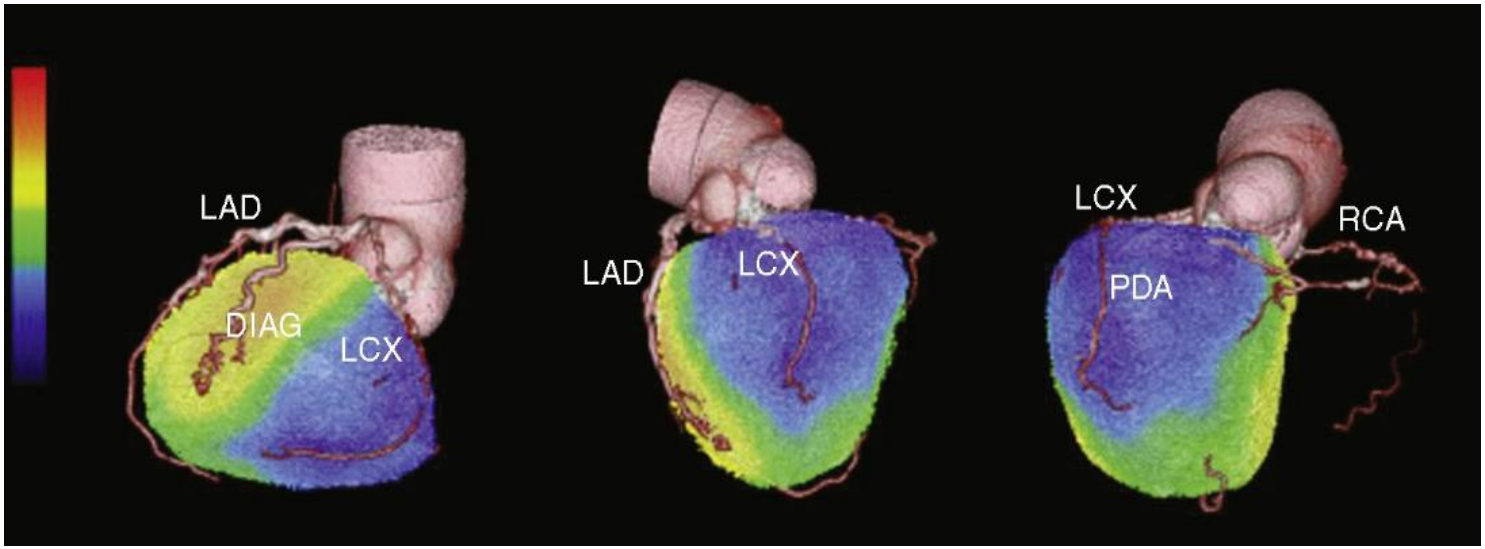
: surgical revascularization in pt with CAD improved survival only among those with three-vessel disease with severe ischemia on exercise stress testing

: medical therapy was a superior initial therapy in pt without this finding

- MPI would have clinical impact for revascularization decision making.

Dual-modality imaging

- In patients with multivessel CAD
  - Dual-modality imaging would allow better localization of the culprit stenosis and offer a more targeted approach to revascularization



- CTA demonstrated three-vessel CAD.
- Fused 3D reconstructions of CTA-stress MPI demonstrated large area of stress-induced perfusion abnormality (deep blue color) in LCX territory.

Assessment of Microvascular dysfunction

Assessment of Microvascular dysfunction

Prognostic information

- Cardiac Syndrome X:
  - typical angina pectoris with normal/near normal (stenosis <40%) coronary angiogram with/without ECG change
  - atypical angina pectoris with normal/near normal coronary angiogram plus a positive none-invasive test (exercise tolerance test or myocardial perfusion scan) with/without ECG change

- Diabetes
- Hypertrophic cardiomyopathy
- Cardiac Allograft Vasculopathy (CAV)
  - endothelial injuries induced by immune response process

Cardiac Allograft Vasculopathy. Circulation 2008, Vol 117;16

Cardiac Allograft Vasculopathy

Invasive test:

- Intravascular Ultrasound: during 1st year
- Coronary Angiography: may underestimates extent & severity of disease

Non-invasive test:

- Myocardial perfusion SPECT, PET

  - Annual myocardial perfusion SPECT has a high negative predictive value & well suited to screening for significant CAV (1)

- Dobutamine Stress Echocardiography
- Contrast-enhanced transthoracic echocardiography

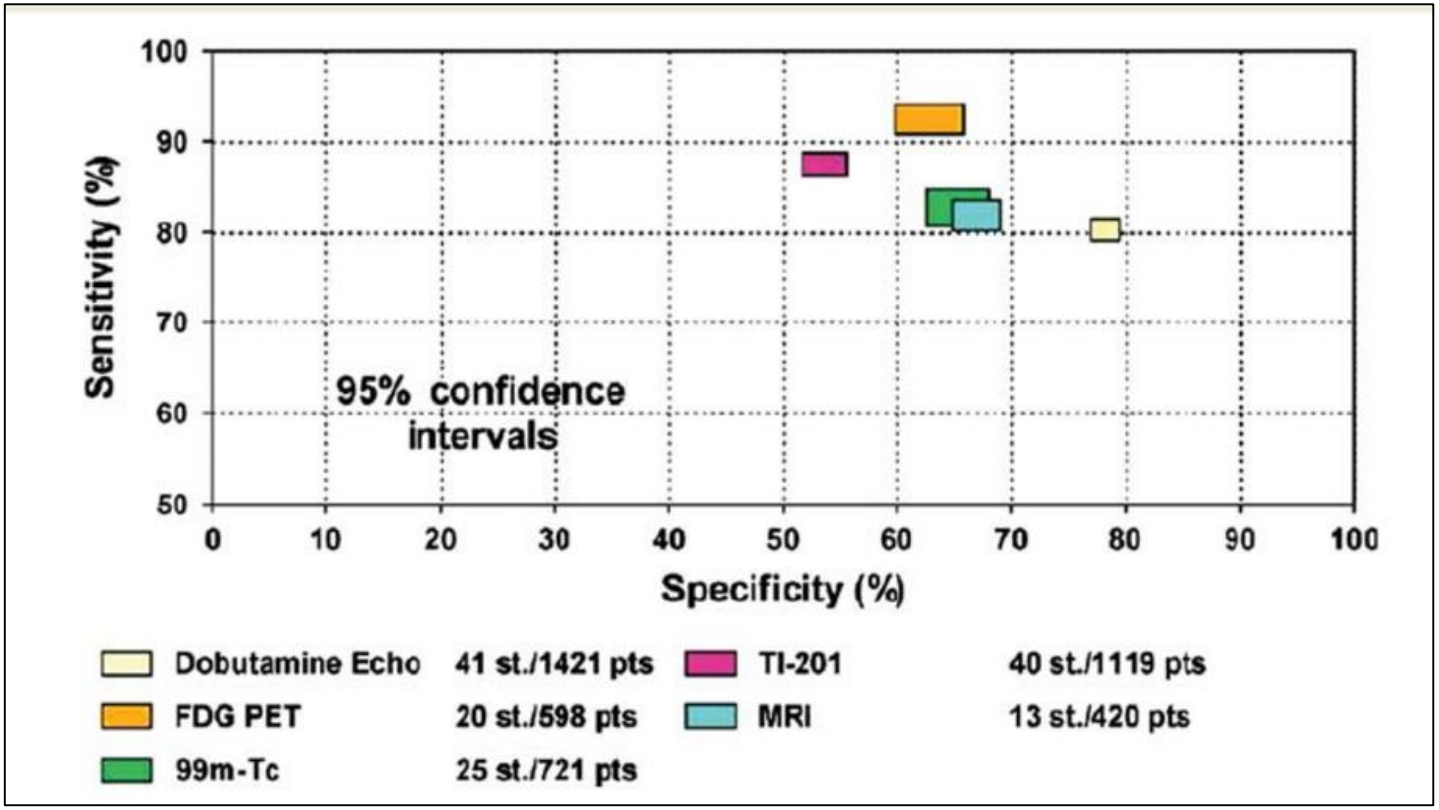
MPR as assessed by PET agrees well with Plaque volume index as determined by IVUS in recipients with normal coronary angiography results (2)

1.Myocardial perfusion scintigraphy as a screening method for significant coronary artery stenosis in cardiac transplant recipients. J Heart Lung Transplant. 2000; 19
2.PET Assessment of Myocardial Perfusion Reserve Inversely Correlates with Intravascular Ultrasound Findings in Angiographically Normal Cardiac Transplant Recipients. J Nucl Med 2010,;51

Viability assessment

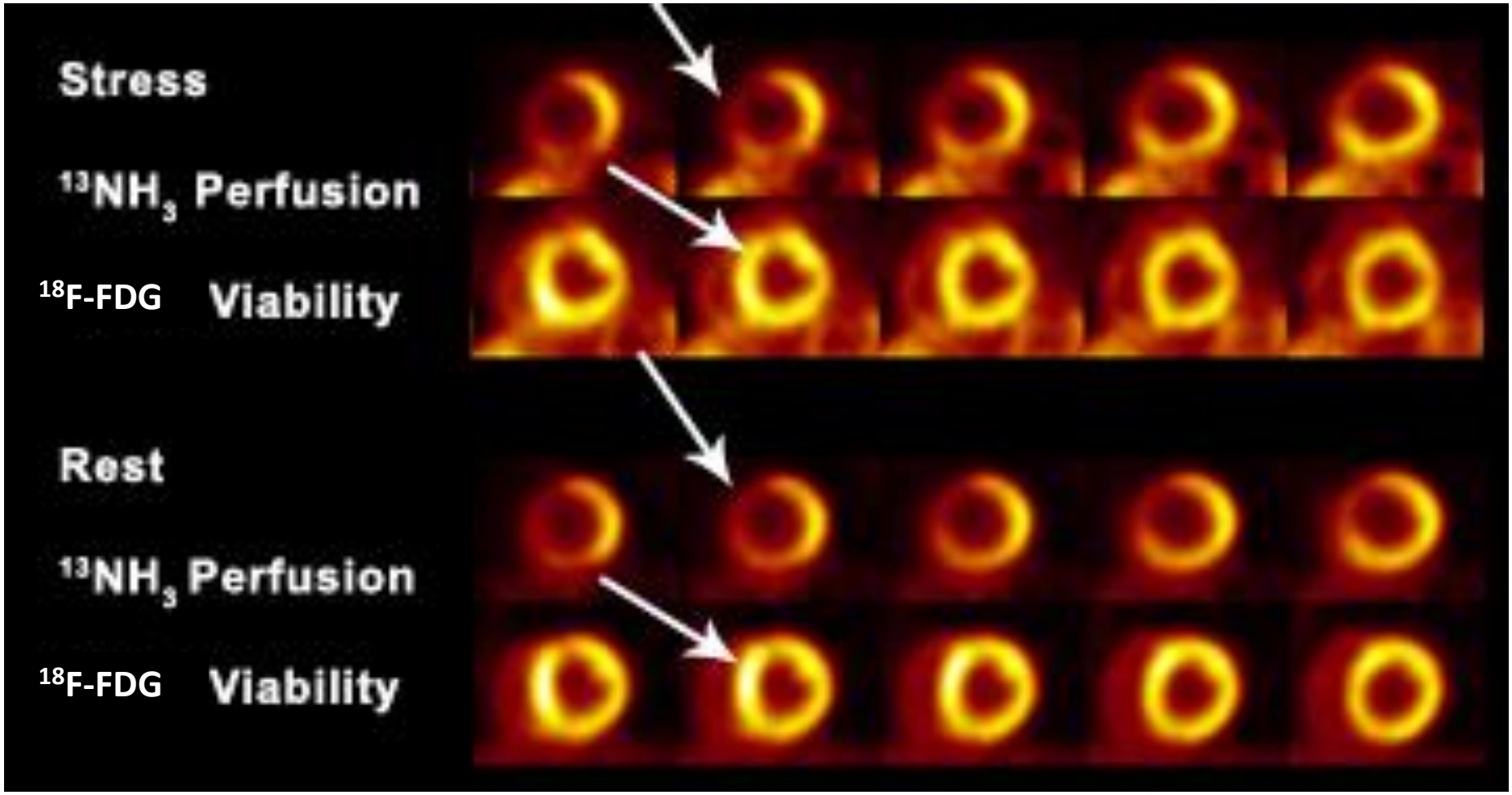
Assessment of myocardial viability

- ^{201}Tl
- ^{99m}Tc-sestamibi + nitroglycerin/ dobutamine gated
- **^{18}F-FDG:** Gold standard



- Sensitivities & specificities with 95% confidence intervals of the various techniques for the prediction of recovery of regional function after revascularization.
- **^{18}F-FDG PET** was shown to have the **greatest sensitivity**
- Dobutamine echocardiography was shown to have greatest specificity

Schinkel AF, et al. Hibernating myocardium: diagnosis and patient outcomes. Curr Probl Cardiol 2007;32:375–410



- Perfusion-metabolism (^{18}F-FDG) mismatch
- Indicative of ischemic but viable myocardium

http://www.petscaninfo.com/zportal/portals/phys/clinical/petct_case_studies/heart_disease/heart_case1

Conclusion:

Pitfalls:

- SPECT MPI may underestimate “balanced ischemia” & occlusive lesion in region with highest uptake
- Beware of attenuation artefacts on SPECT MPI

Pearls:

- Quantitative myocardial perfusion PET
- Define flow-limiting physiologic significance in multivessels disease
- Assessment of Microvascular dysfunction
- Viability assessment using ^{18}F-FDG PET

Thank you for your attention

KCMH