Nuclear Cardiology

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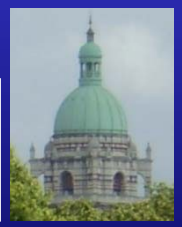
Imperial College London



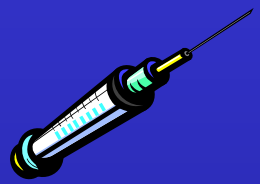
Royal Brompton & Harefield

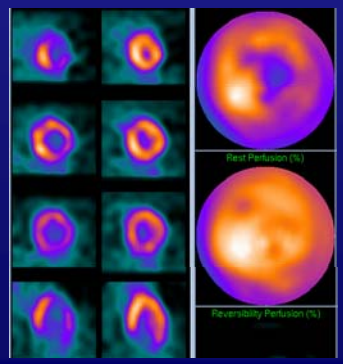
Radionuclide Imaging Techniques

Perfusion	→	Radionuclide SPECT imaging Positron emission tomography (PET)
Function	→	Radionuclide ventriculography Gated-ECG SPECT
Sympathetic innervation	→	MIBG (Meta Iodo Benzyl Guanidine)
Myocardial metabolism	→	F-18 fluorodeoxyglucose (^{18}FDG) I-123-labelled modified fatty acids

Radionuclide MPS - Principles

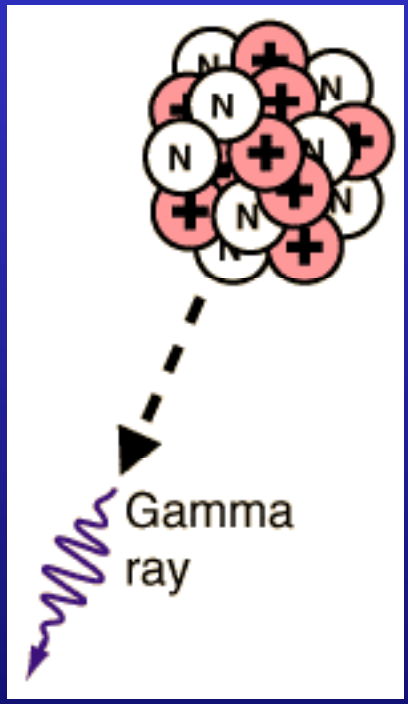
- Perfusion tracers
- Cardiac stress
- Gamma camera
- Image reconstruction and interpretation





Radionuclides

- Unstable isotopes or nuclides are called radioisotopes or radionuclides
- Nuclear transitions lead to emission of a gamma ray
- Electron transitions lead to emission of an X-ray

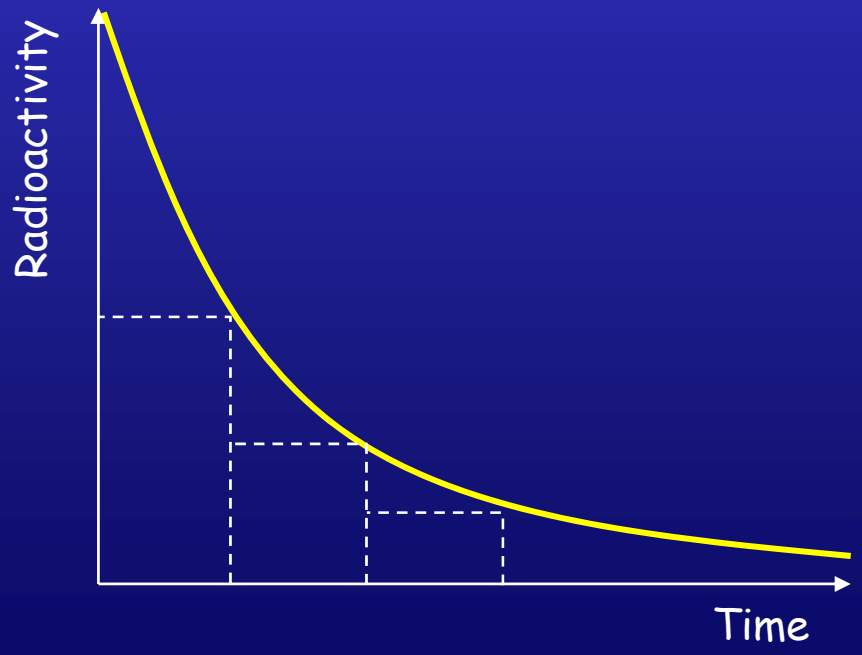


Radioactive decay

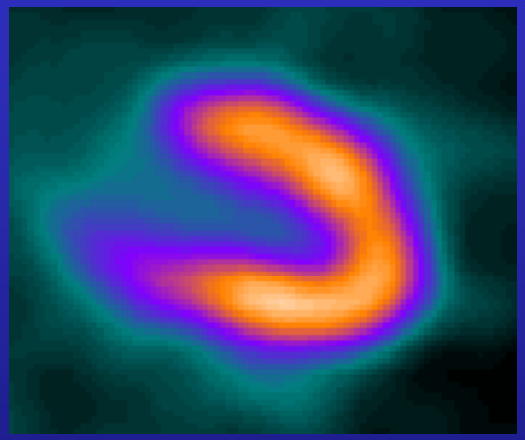
Exponential decay is characterised by half-life

(the time for half of the radioactive nuclei in a sample to decay)

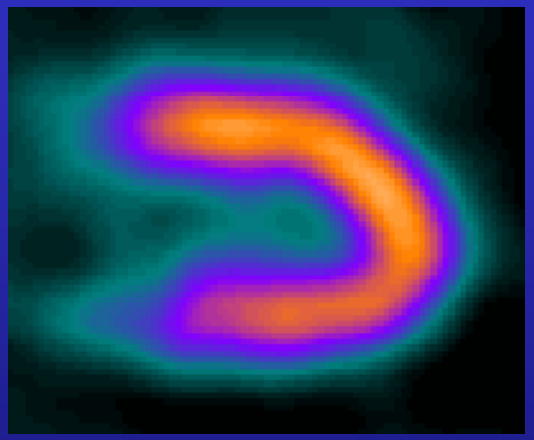
^{238}U	4.5×10^9 years
^{14}C	5730 years
^{226}Ra	1600 years
^{131}I	8 days
^{201}Tl	72 hours
^{99m}Tc	6 hours
^{18}F	2 hours
^{15}O	2 minutes



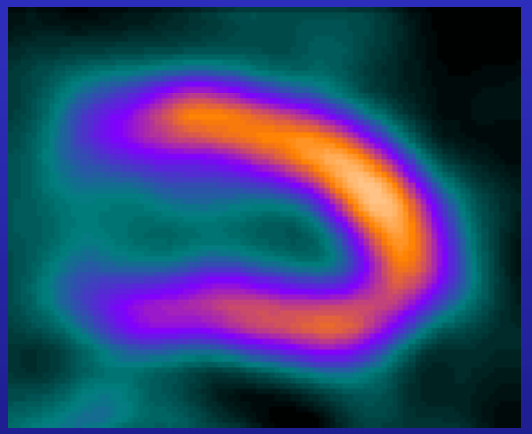
Myocardial perfusion tracers



Thallium-201

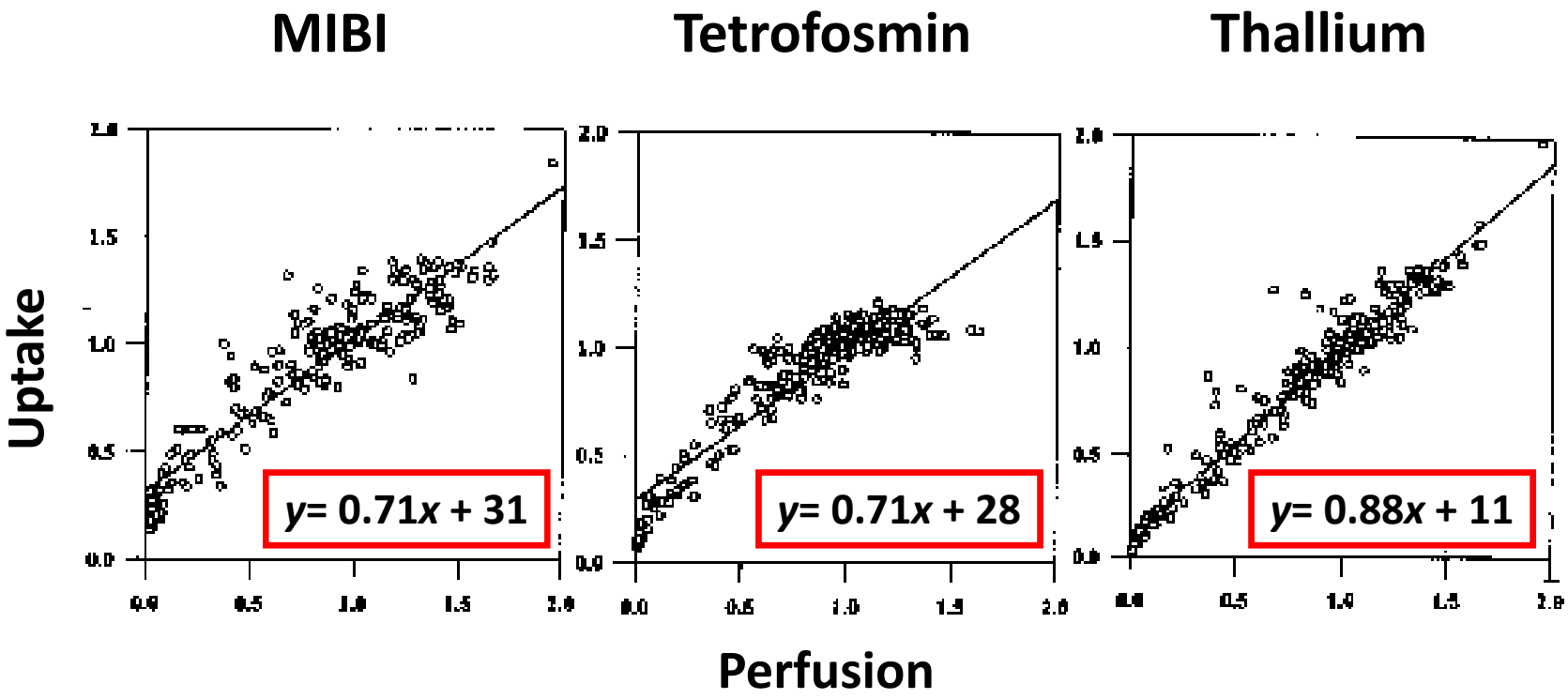


Tc-99m MIBI



Tc-99m Tetrofosmin

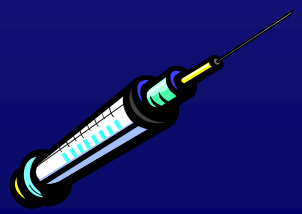
Tracer Uptake versus Perfusion



Meleca JNM 1997 38:1847-1856

Imaging protocols

Thallium	Stress – redistribution Stress – redistribution – reinjection Stress – reinjection Stress – reinjection – 24 hour imaging Rest Rest – redistribution
Technetium	Two day One day, stress – rest One day, rest – stress
Dual isotope	Rest thallium – stress technetium Others
Adjuncts	Nitrate Fatty meal



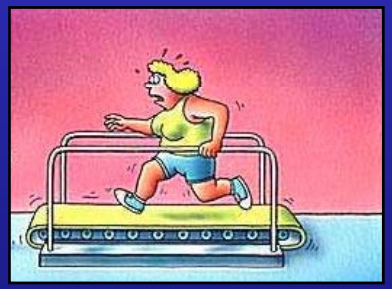
Dosimetry and Radiation Exposure According to ARSAC * Recommendations 2006

Radionuclide	Imaging	Diagnostic Reference Level MBq	Effective Dose mSv
Thallium-201	Stress/Redistribution	80	14
Tc-99m	Stress (one-day)	250	2 - 2.5
	Rest (one-day)	750	5.6 - 7.5
	Two-day protocol	400	3 - 4

* Administration of Radioactive Substances Advisory Committee

Cardiac stress

- Exercise
  - Dynamic
  - Isometric

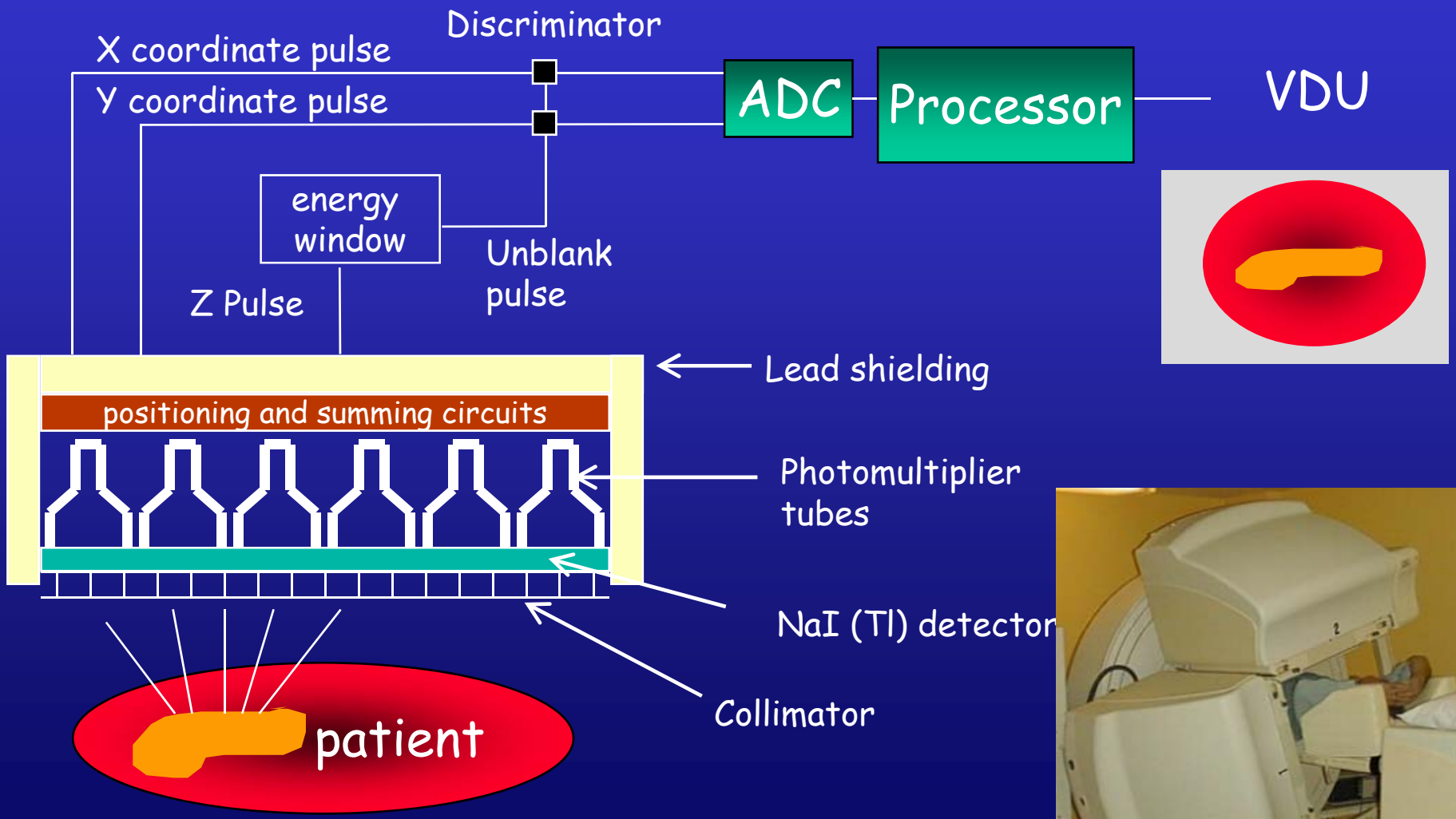


- Other
  - Pacing
  - Cold pressor test

- Vasodilators
  - Adenosine
  - Dipyridamole
  - Regadenoson (Rapiscan)

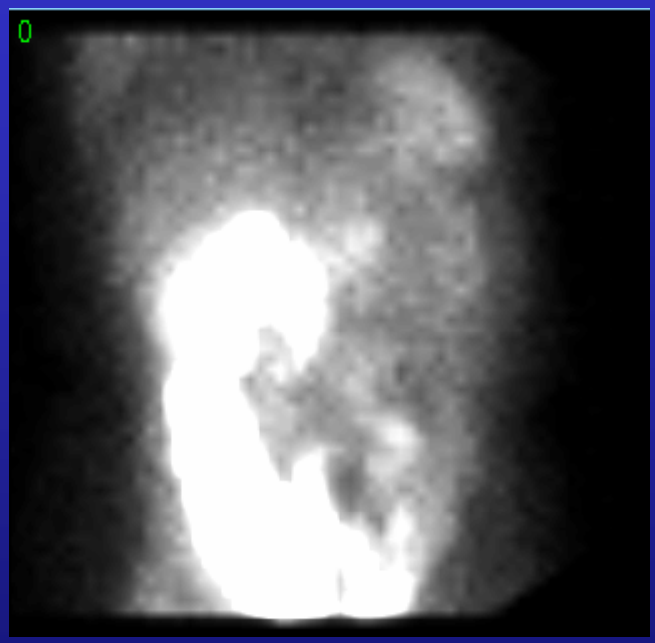
- Inotropic agents
  - Dobutamine

Gamma Camera



Raw Cardiac SPECT Data

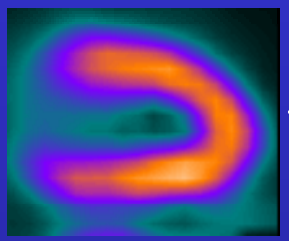
- Heart within FOV
- Sources of artefact
  - motion & upward creep
  - attenuation by soft tissue or objects
  - hot activity next to heart
  - low counts
- Pathology
  - LV dilation/TID
  - RV dilation/hypertrophy
  - lung uptake
  - other significant tracer uptake outside heart
  - pattern of myocardial uptake



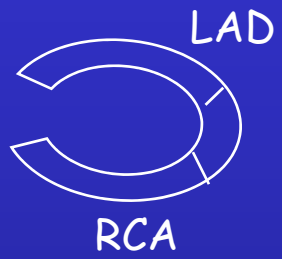
Cine raw data

Tomograms

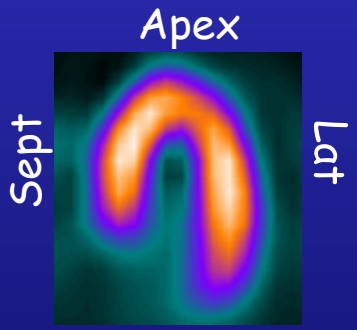
VLA

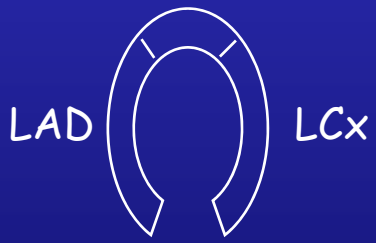


Vascular territories

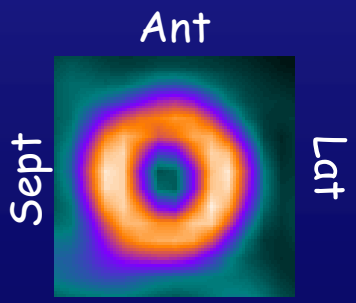


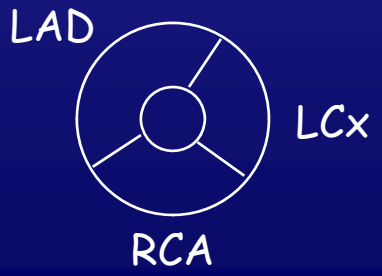
HLA





SA

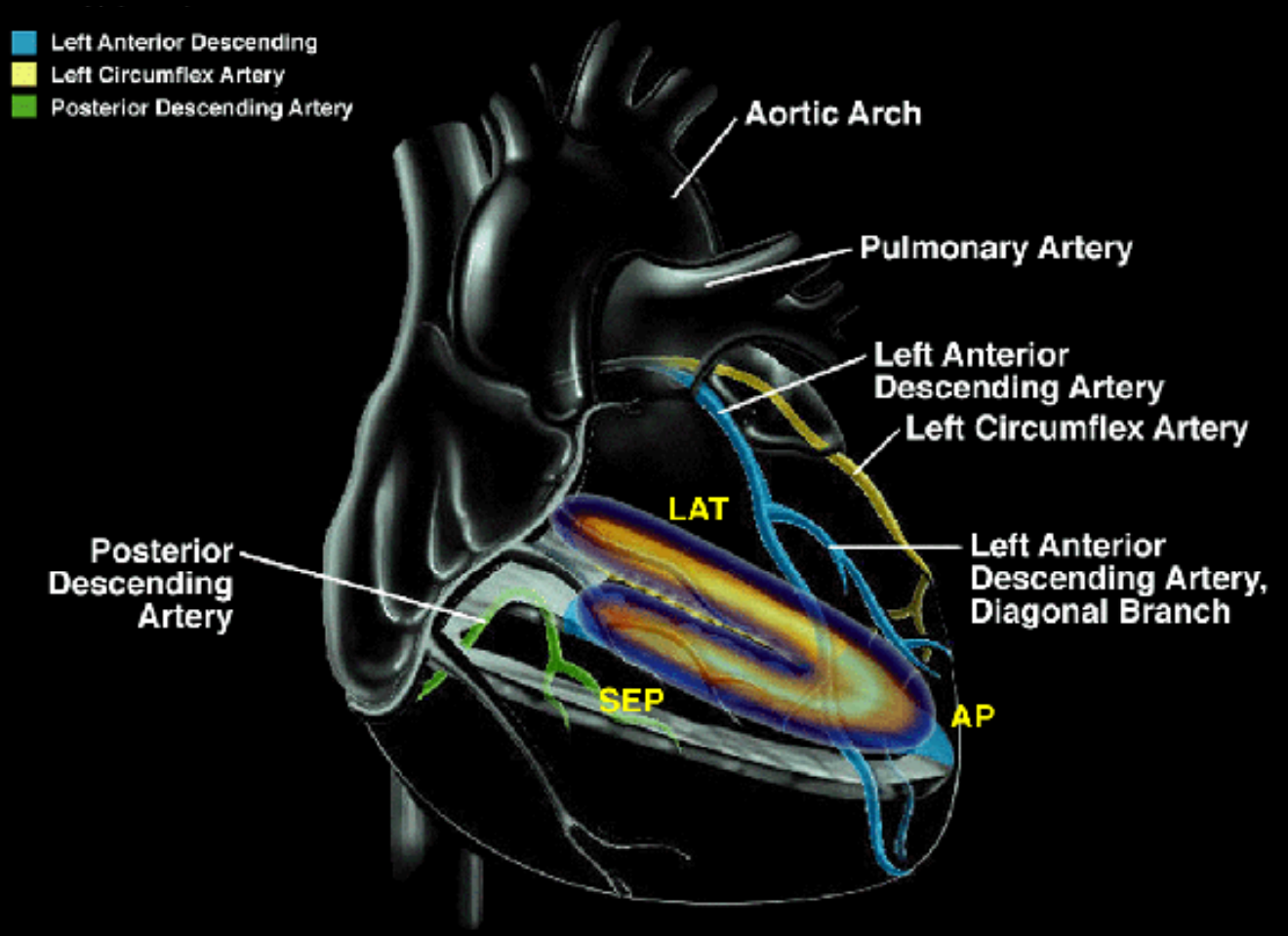




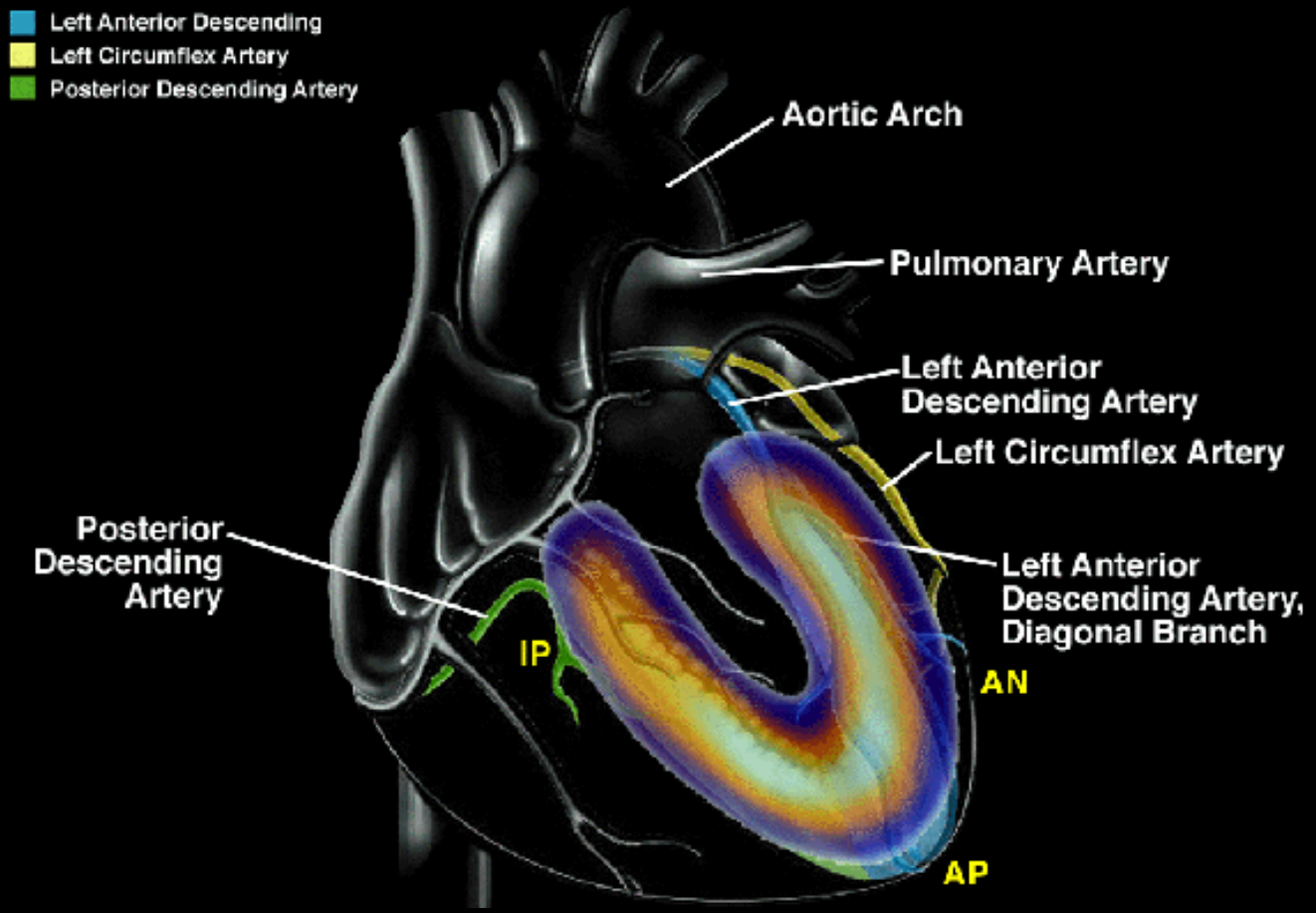
TOMOGRAPHIC VIEWS

Horizontal Long Axis

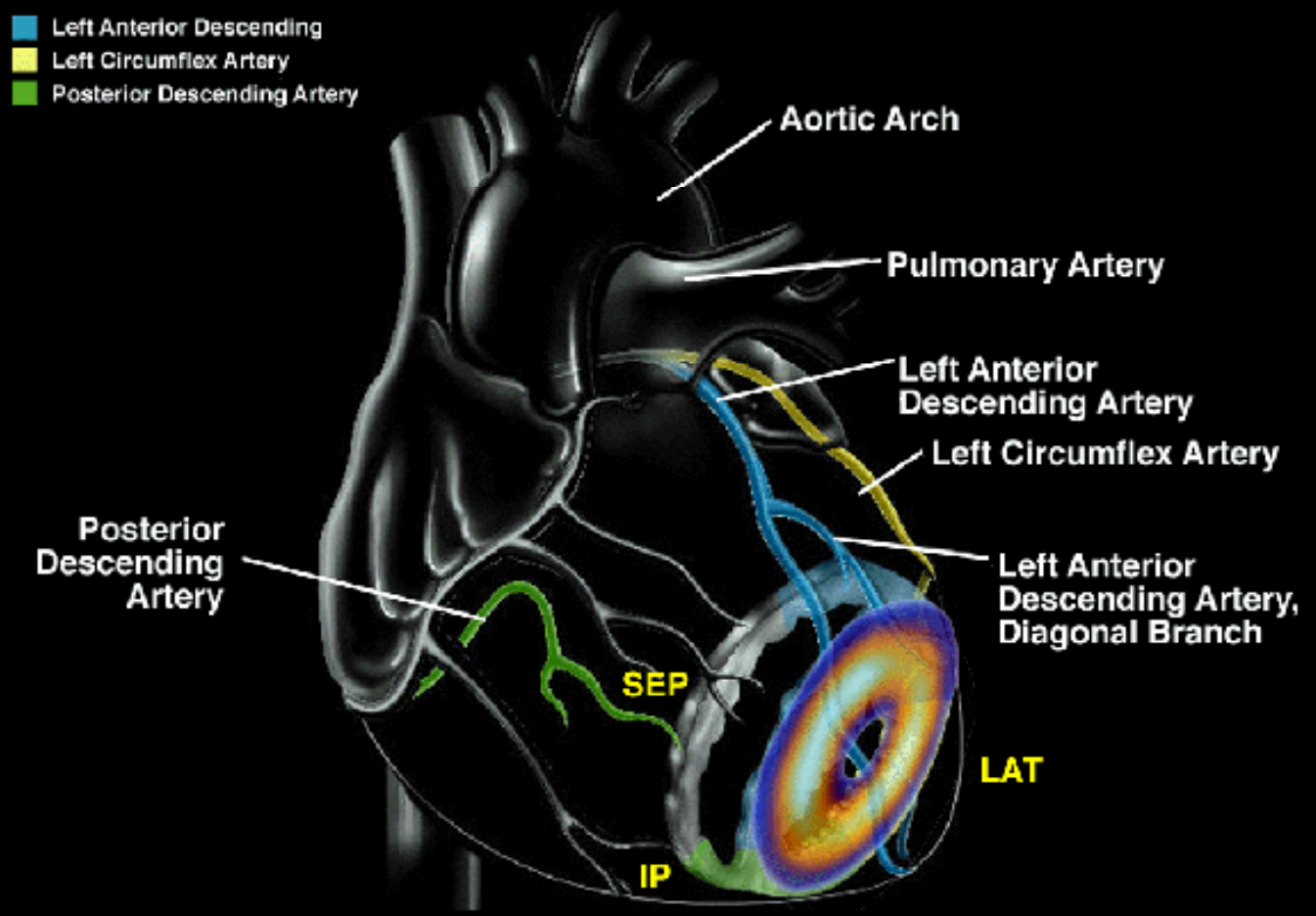
(HLA)



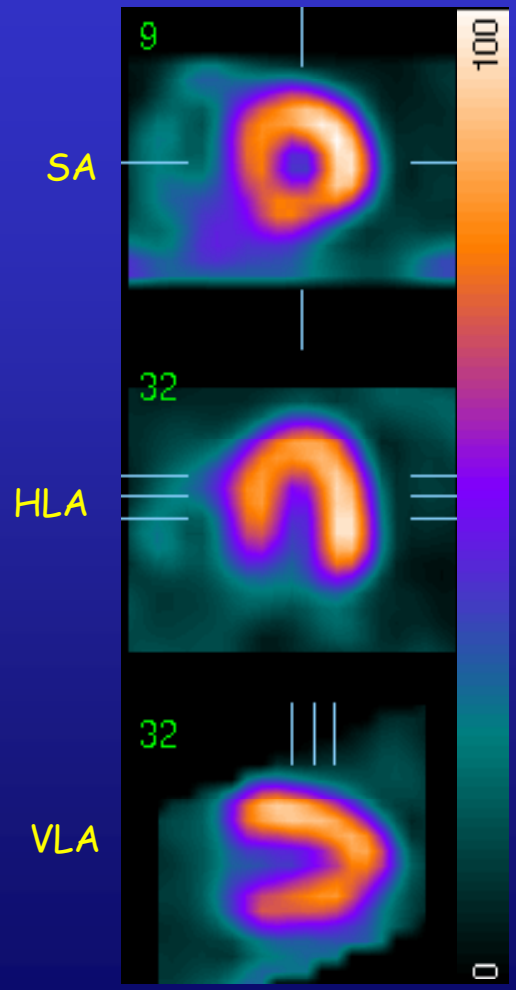
Vertical Long Axis (VLA)



Short Axis (SA)

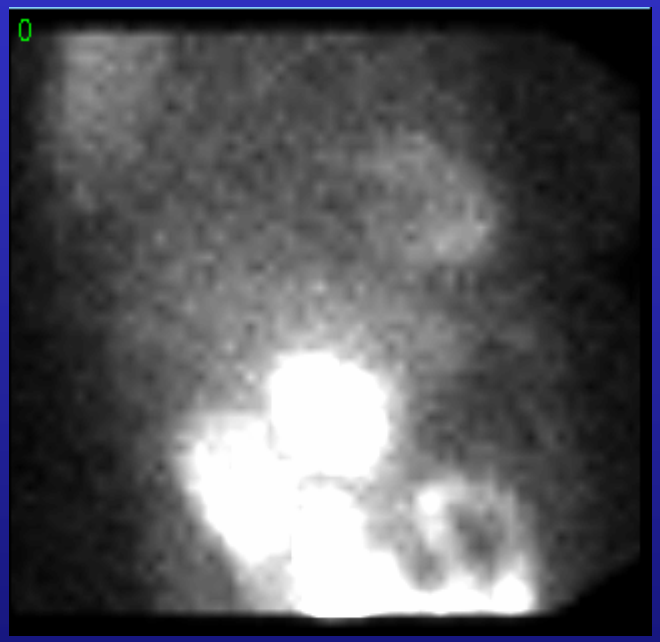


Normal



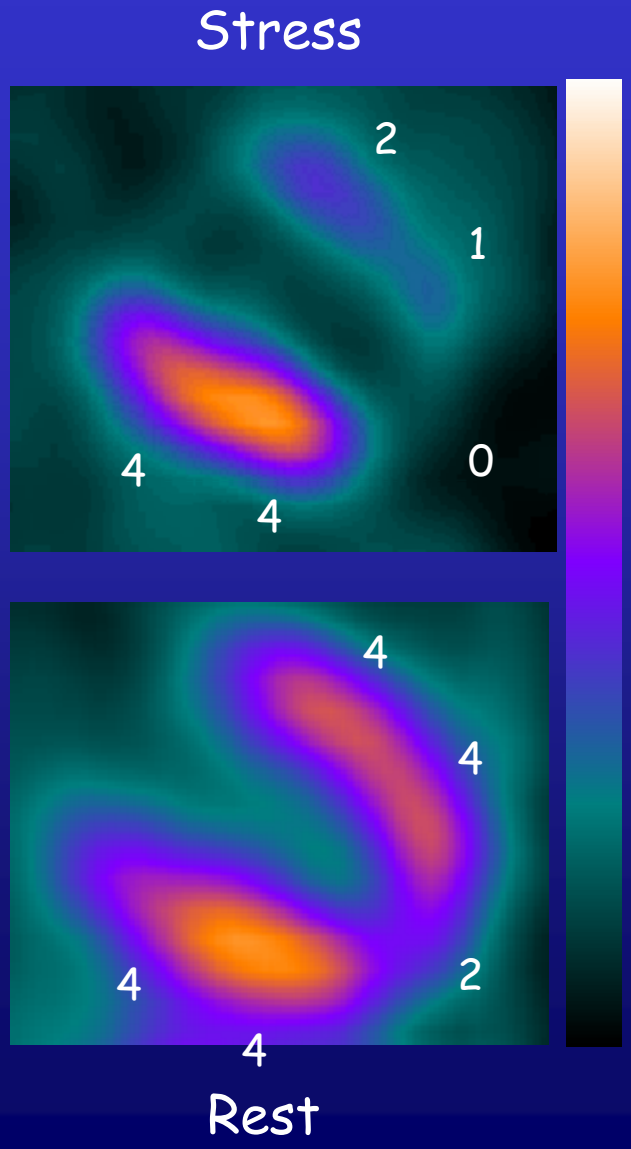
Stress

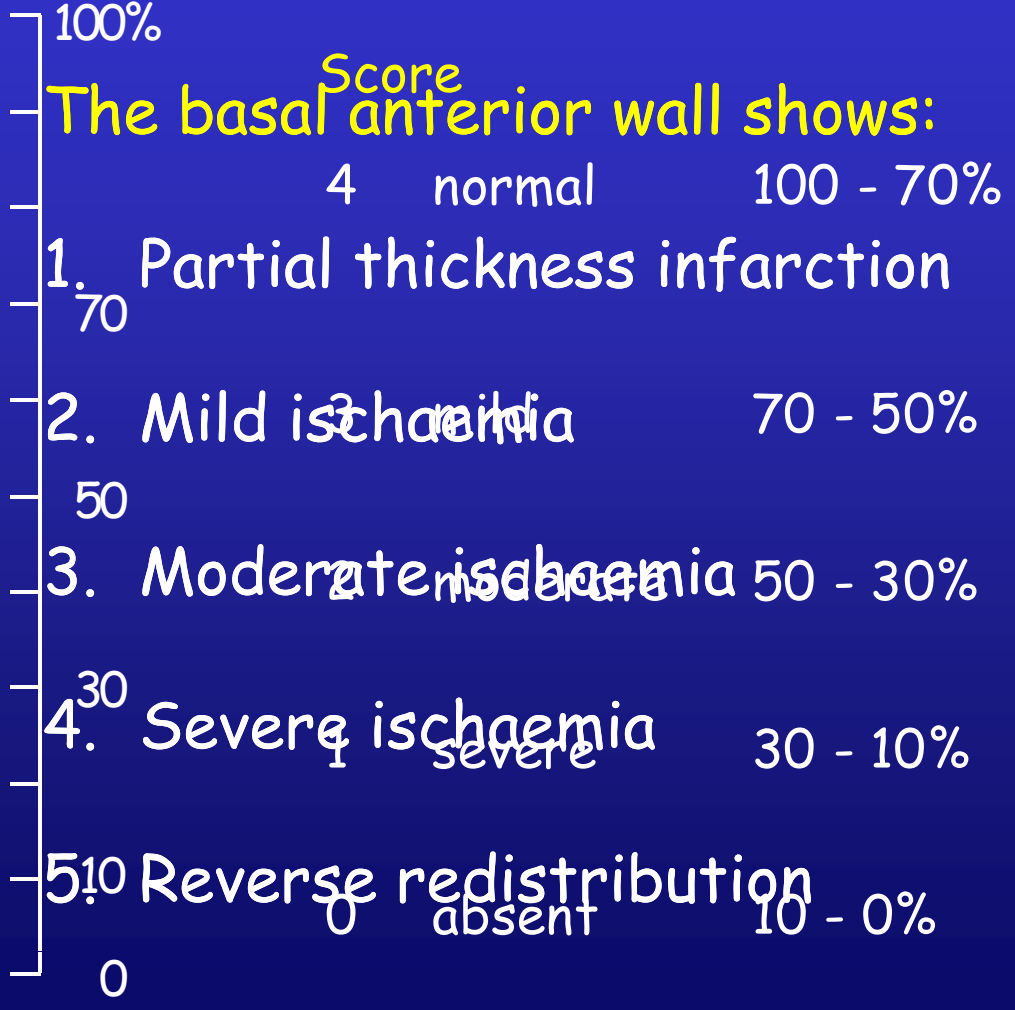
67-year old female ex-smoker with atypical chest pain.



- homogeneous
- septum-to-lateral wall ratio <1
- septum slightly shorter than lateral wall

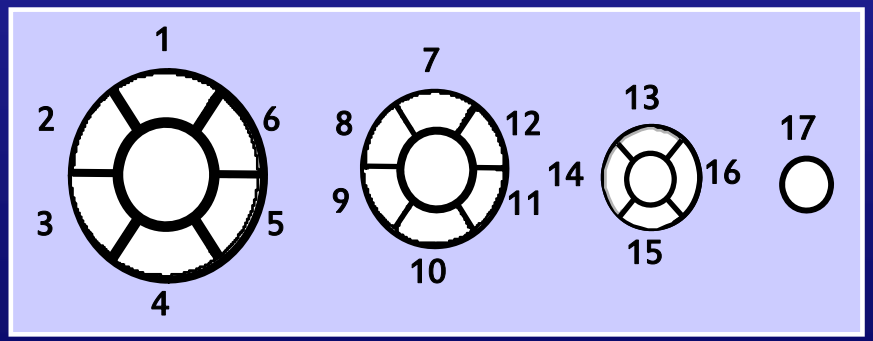
Image interpretation



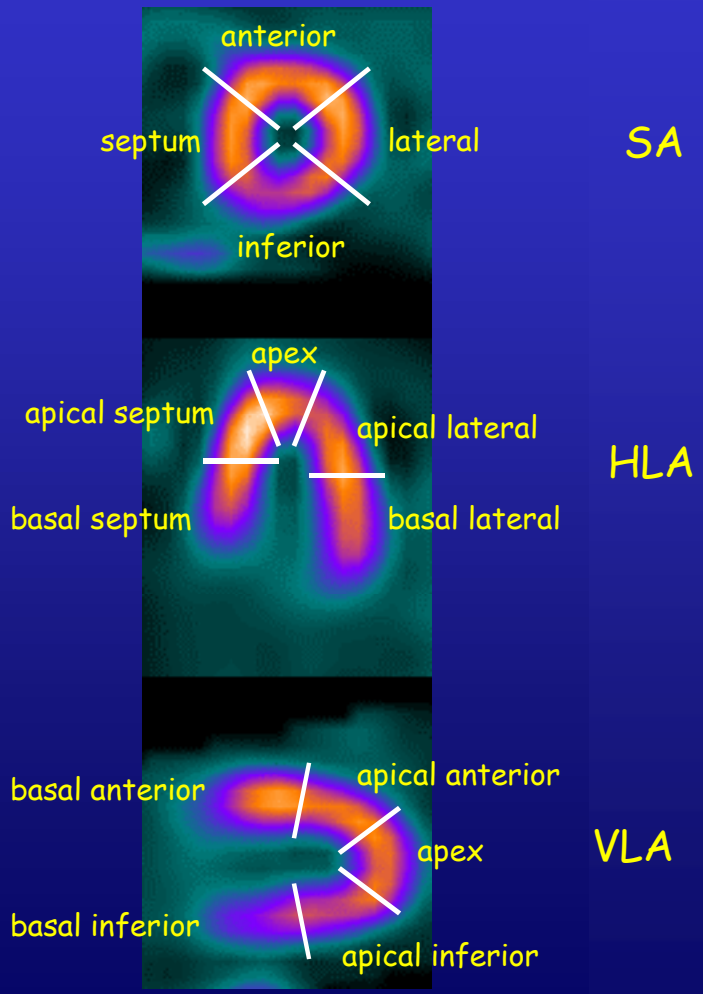


Interpretation: Extent of Defect

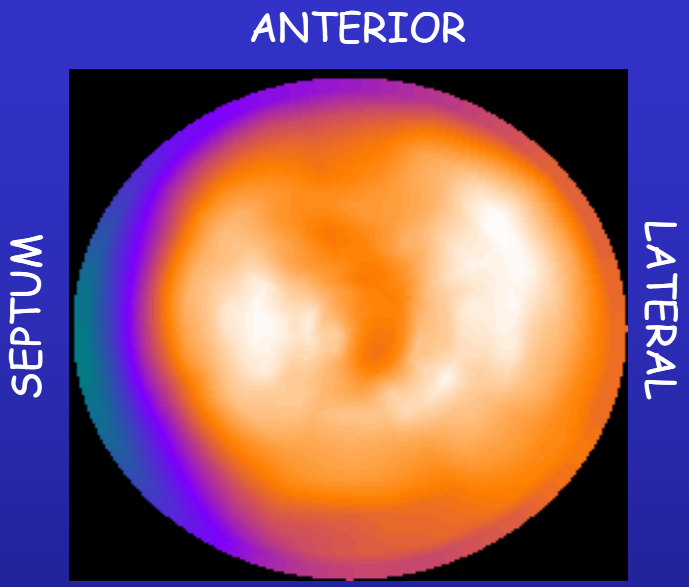
- 9, 17- or 20-segment models
- 9-segment model most useful clinically

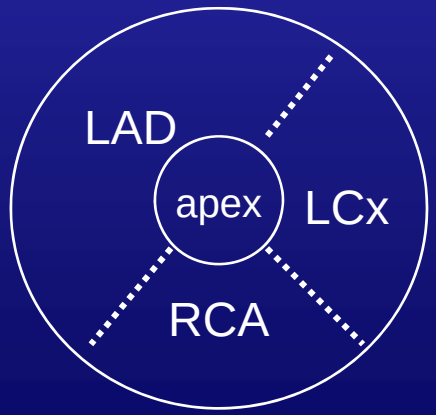


17 segments

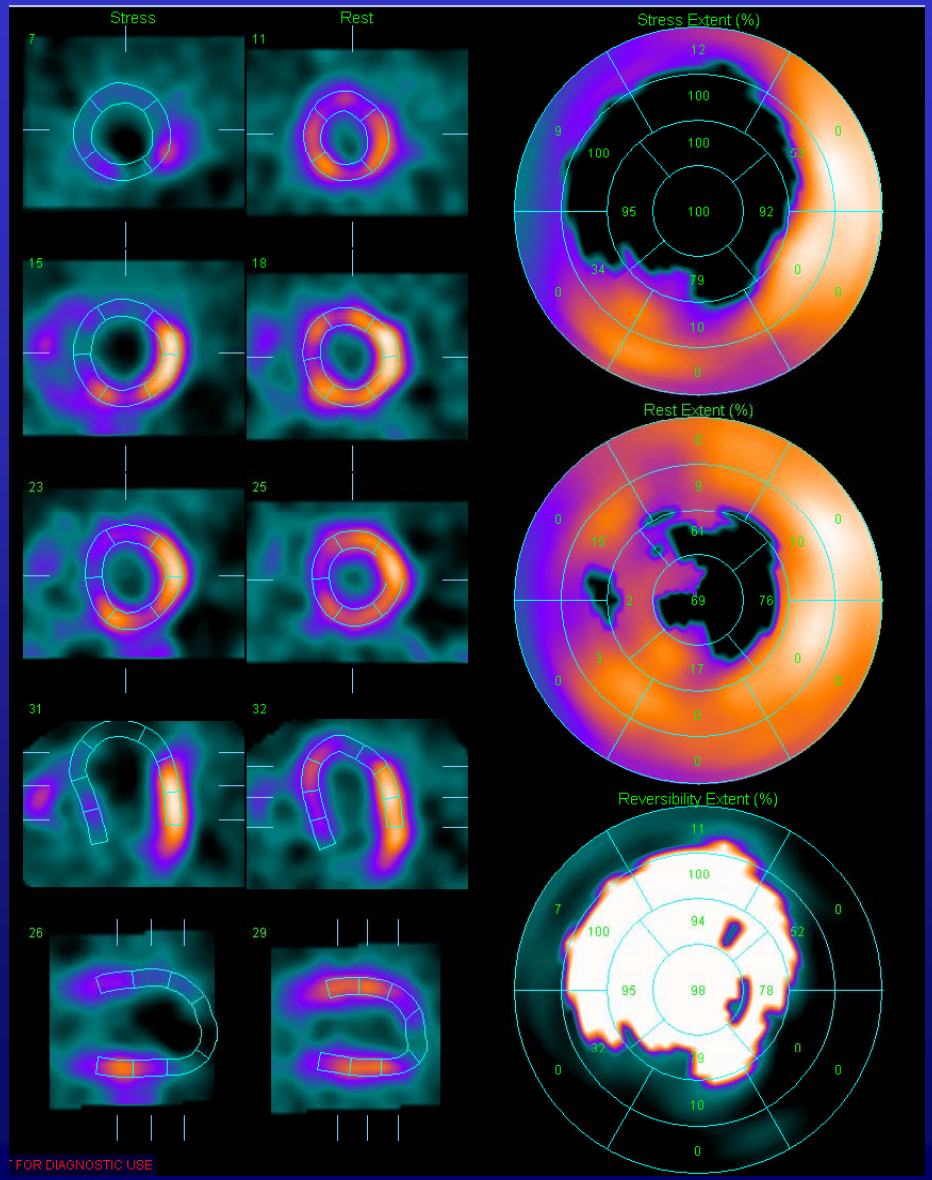


Quantification: Bull's Eye Plot

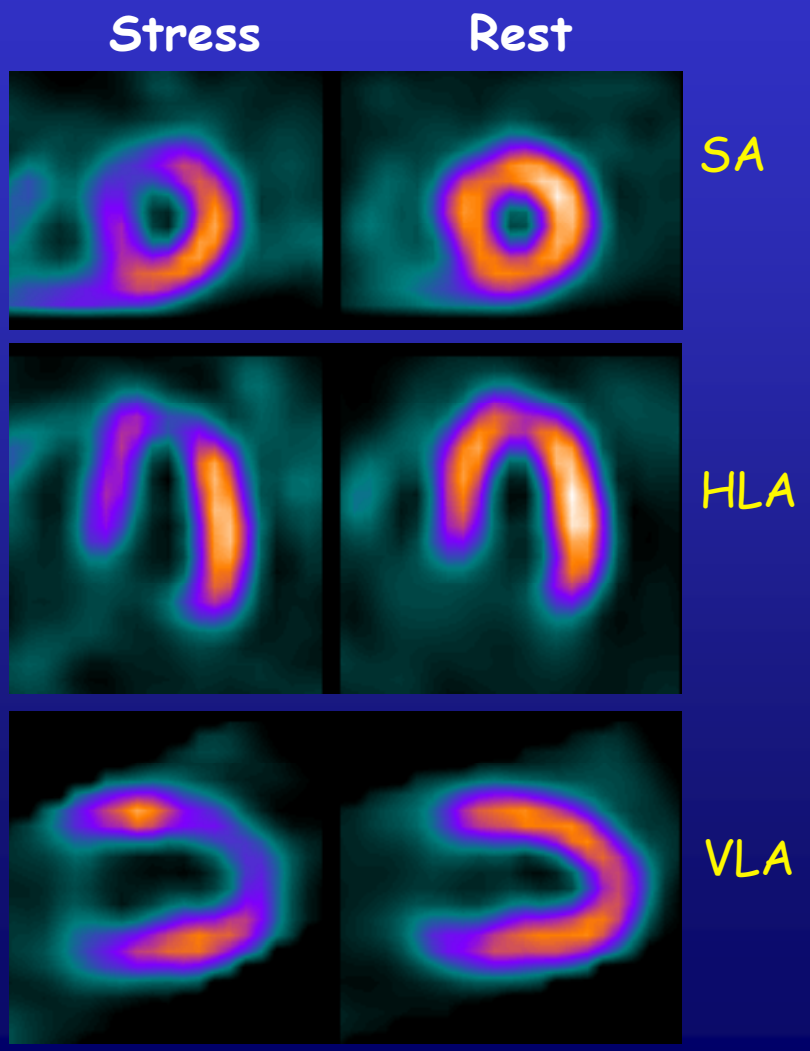


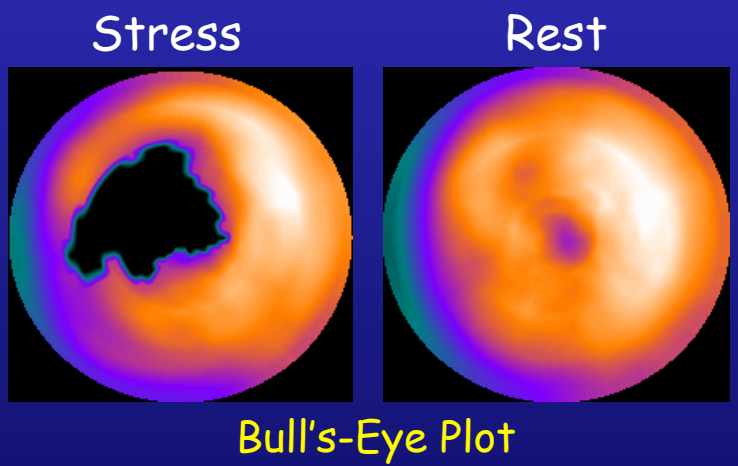


Vascular territories



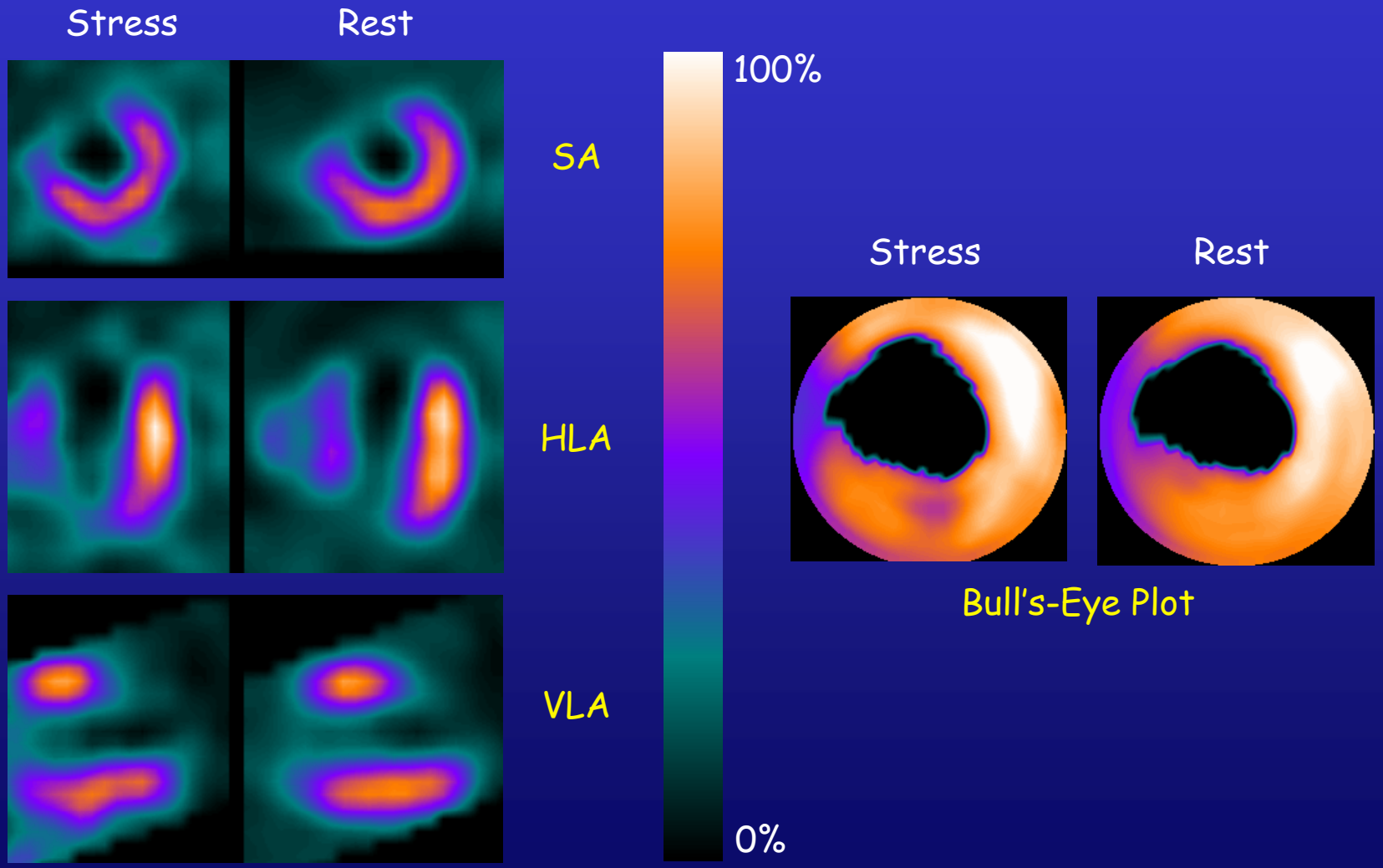
Myocardial Perfusion Patterns





Bull's-Eye Plot

Myocardial Perfusion Patterns



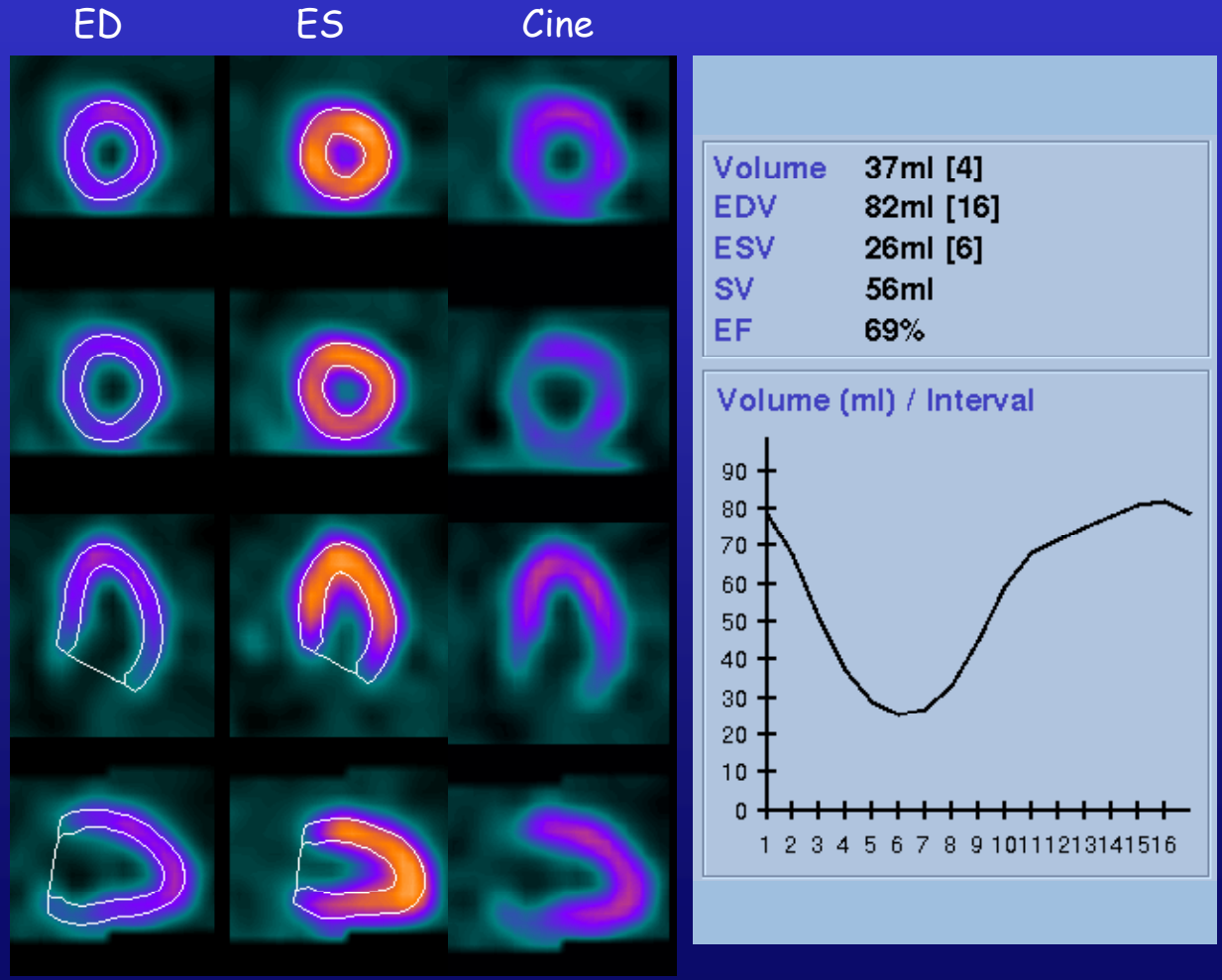
Quantification

- **Volumes**
  Identifies endocardial and epicardial borders
  → Ellipsoid fitted to endocardial borders

- **Left ventricular volume/ interval curve**
  Volume calculated and plotted for each interval
  → change in volume relative to time

- **LVEF (16-frame gating)**
  EF =
  EDV – ESV / EDV x 100

QGS Cedar Sinai Software



Heart ONLINE

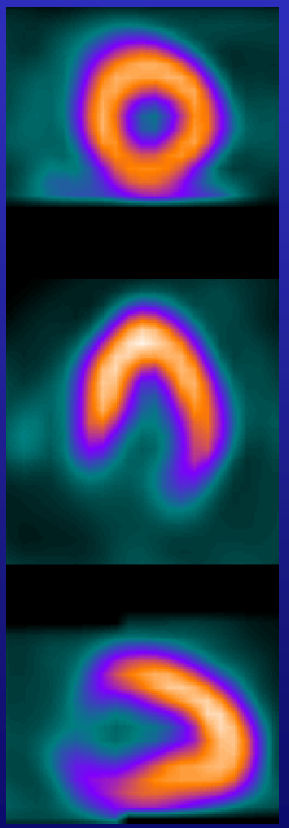
Procedure guidelines for radionuclide myocardial perfusion imaging

C Anagnostopoulos, M Harbinson, A Kelion, K Kundley, C Y Loong, A Notghi, E Reyes, W Tindale and S R Underwood

- To assess the presence and severity of coronary obstruction

- To aid the management of patients with CAD:
  - Risk stratification and prognosis (e.g. after MI or before non-cardiac surgery)
  - To guide strategies of revascularisation
  - To assess adequacy of revascularisation

- To assess viability and hibernation



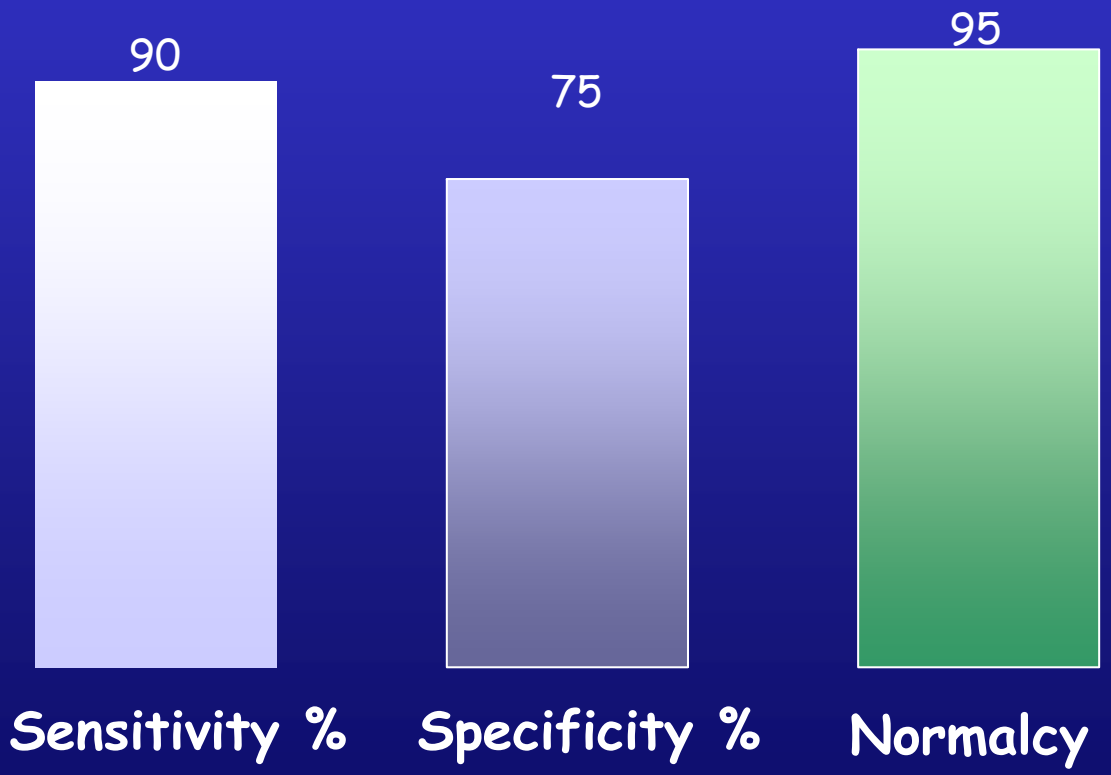
Normal Perfusion
Tetrofosmin MPI

Indications for MPS

- Special indications:
  - Anomalous coronary arteries
  - Muscle bridging
  - Kawasaki's disease

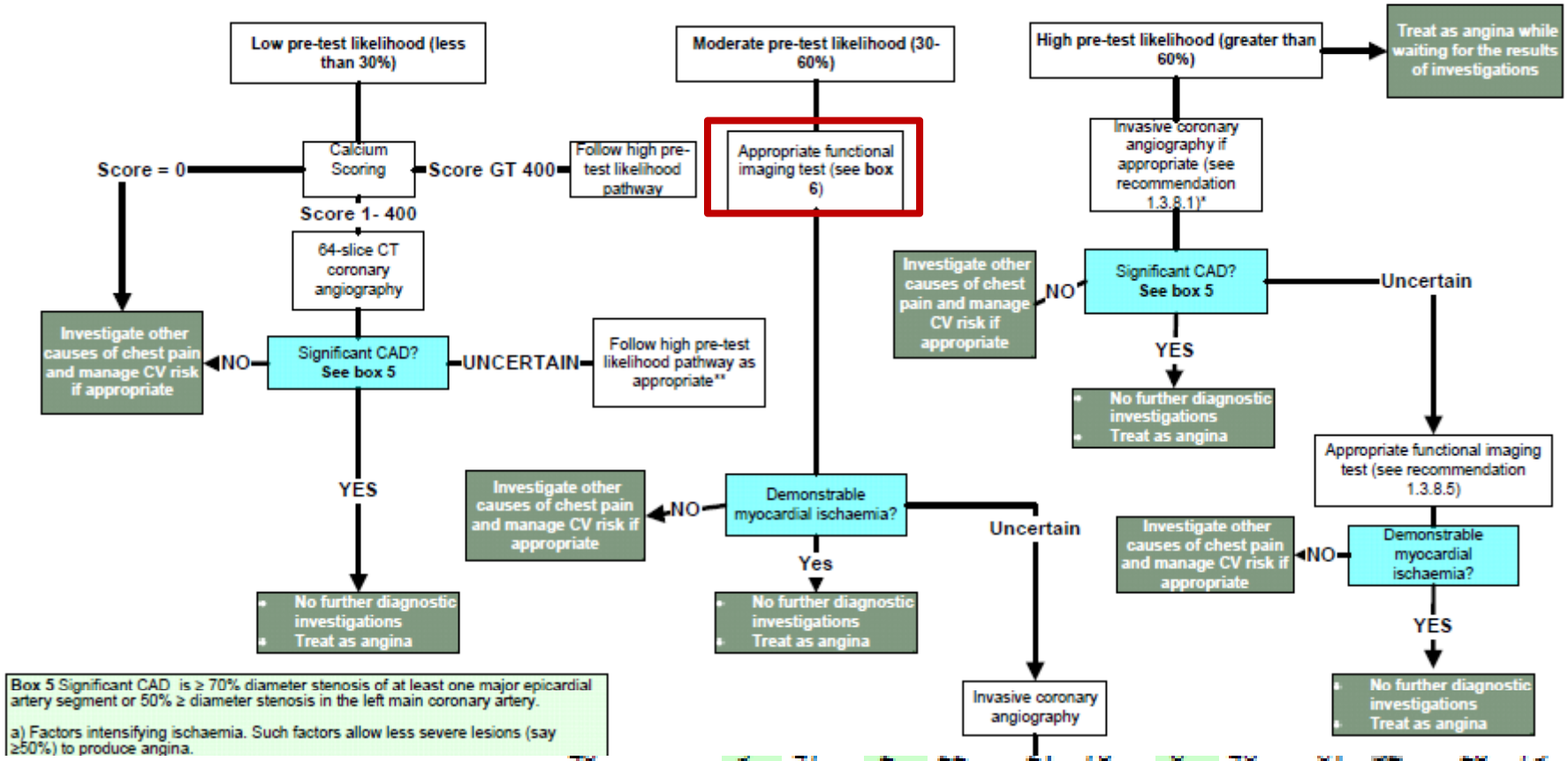
Procedure Guidelines for Radionuclide Myocardial Perfusion Imaging. Anagnostopoulos C et al
Heart 2004;90:Suppl 1

Diagnostic accuracy of MPS



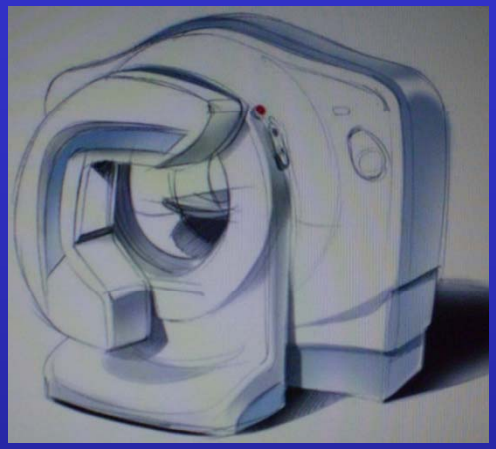
Loong CY, Heart 2004 (Suppl V) 90:v2

New NICE Guidelines for Stable Chest Pain



NICE guidelines 2010.In print

Intermediate likelihood of CAD



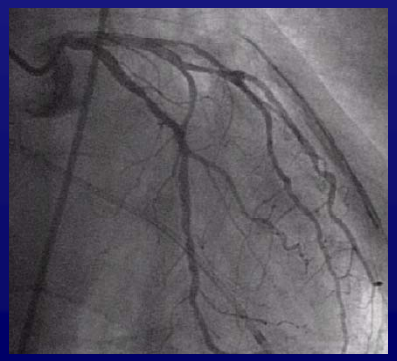
Functional Imaging

Reversible myocardial ischaemia

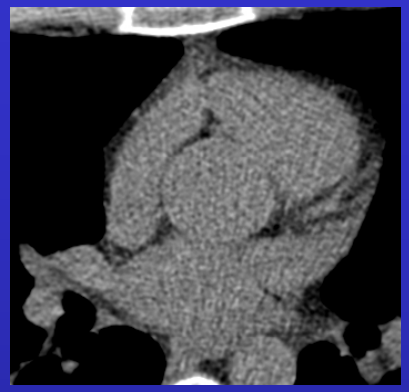
No → Investigate other causes of chest pain

Yes → Treat as stable angina

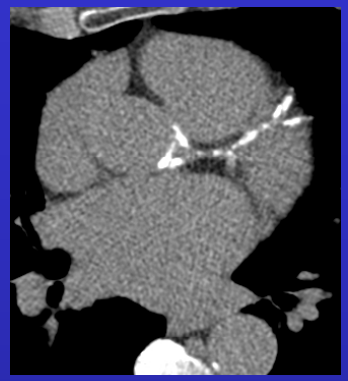
Uncertain



Low likelihood of CAD

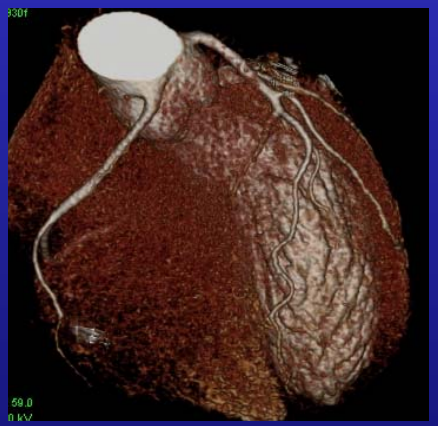


CT calcium scoring



1 - 400

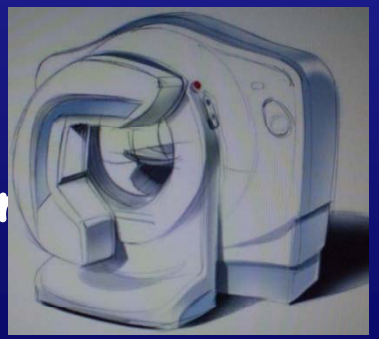
If zero



>400

Investigate other causes of chest pain

64-slice or above CTA

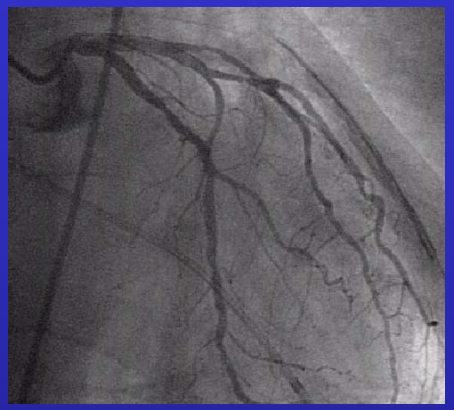


No ← Significant CAD → Uncertain

Yes

Treat as stable angina

High likelihood of CAD



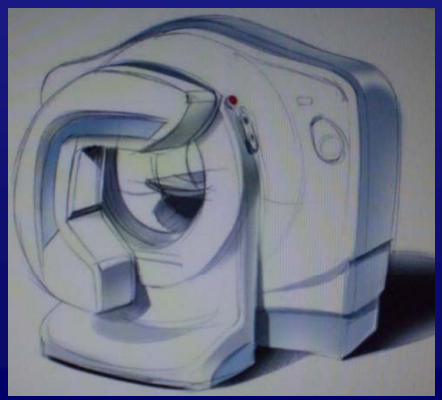
Significant CAD

No

Yes

Investigate other causes of chest pain

Uncertain



Treat as stable angina

MPS as gatekeeper to angiography

European Heart Journal (2006) 27, 29–34
doi:10.1093/eurheartj/ehi503

Clinical research

Potential impact of myocardial perfusion scintigraphy as gatekeeper for invasive examination and treatment in patients with stable angina pectoris: observational study without post-test referral bias

Poul F. Høilund-Carlsen[1]*, Allan Johansen[1], Henrik Wulff Christensen[1], Werner Vach[2], Mette Møldrup[1], Peter Bartram[1], Annegrete Veje[1], and Torben Haghfelt[3] for the Myocardial Ischemia Logistics Evaluation Study (MILES) Group

[1]Department of Nuclear Medicine, Odense University Hospital, Odense, Denmark; [2]Department of Statistics, University of Southern Denmark, Odense, Denmark; and [3]Department of Cardiology, Odense University Hospital, Odense, Denmark

European Heart Journal (2006) 27, 3–4
doi:10.1093/eurheartj/ehi627

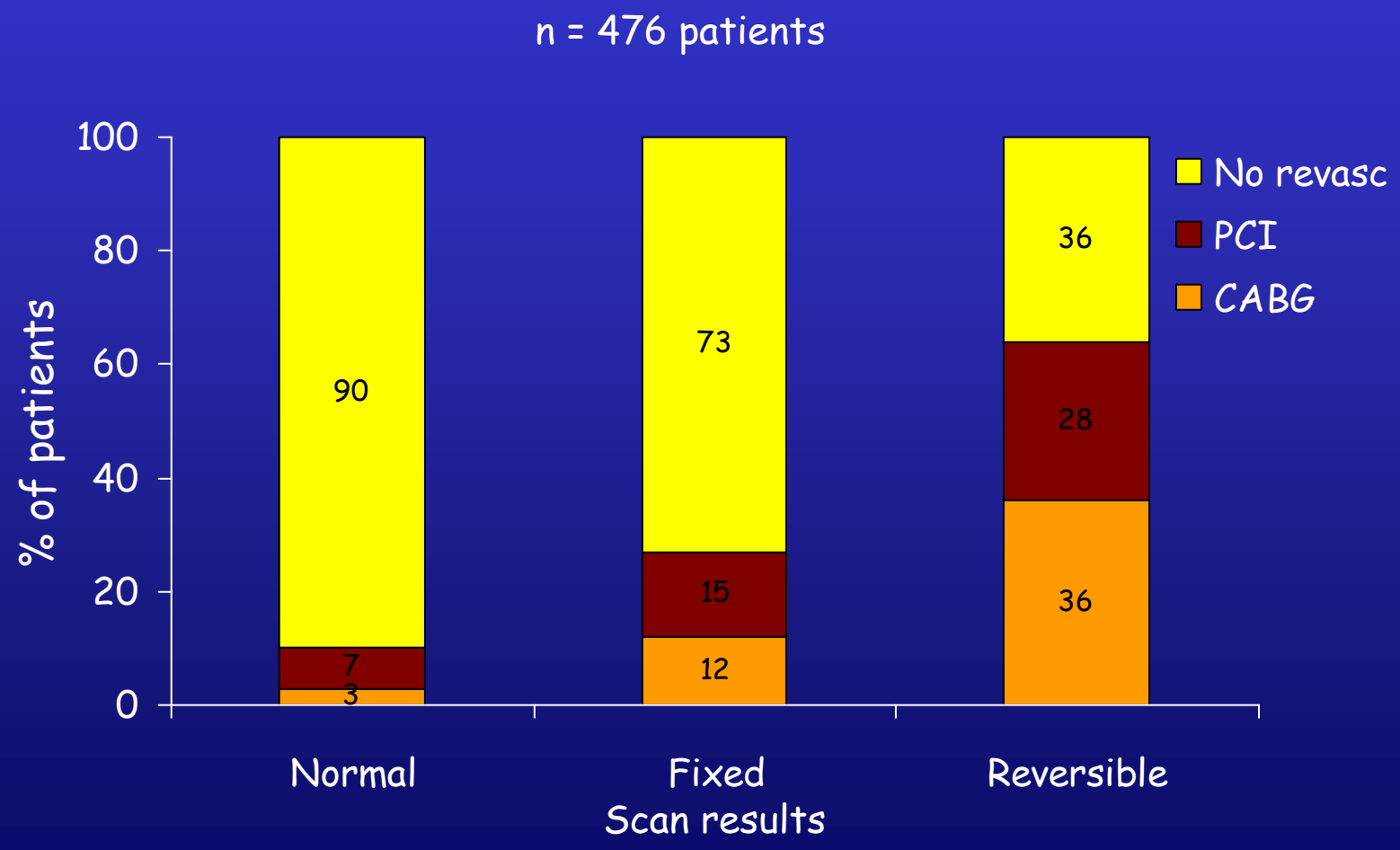
Editorial

Myocardial perfusion scintigraphy: an important step between clinical assessment and coronary angiography in patients with stable chest pain

Eliana Reyes and Stephen Richard Underwood*

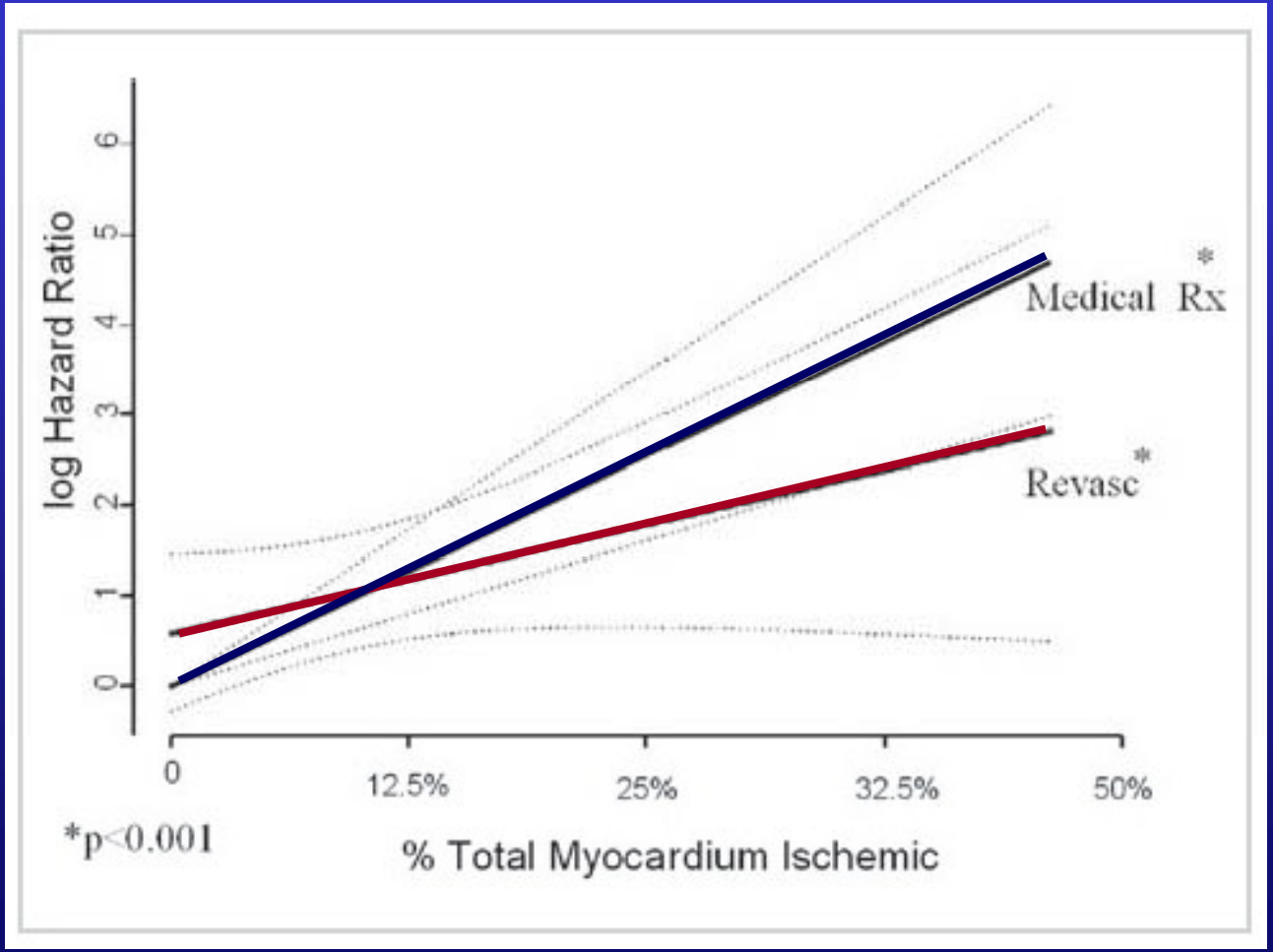
Imperial College, National Heart and Lung Institute, London, UK and Royal Brompton Hospital, Sydney Street, London SW3 6NP, UK

MPS as gatekeeper to angiography



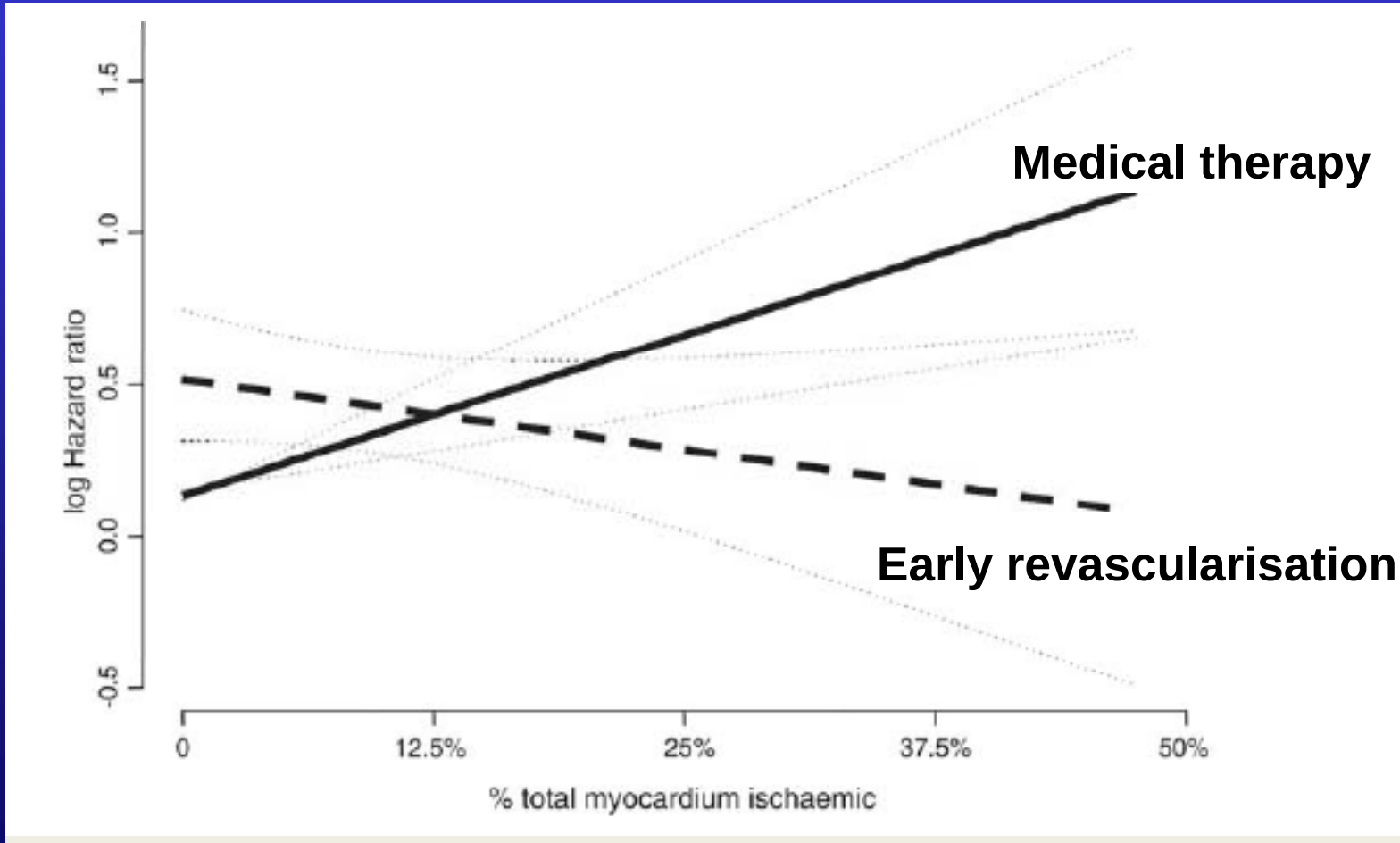
Hoilund-Carlsen et al. Eur Heart J 2006; 27:29

MPS-guided therapy and prognosis



Hachamovitch. Circulation 2003;107:2900

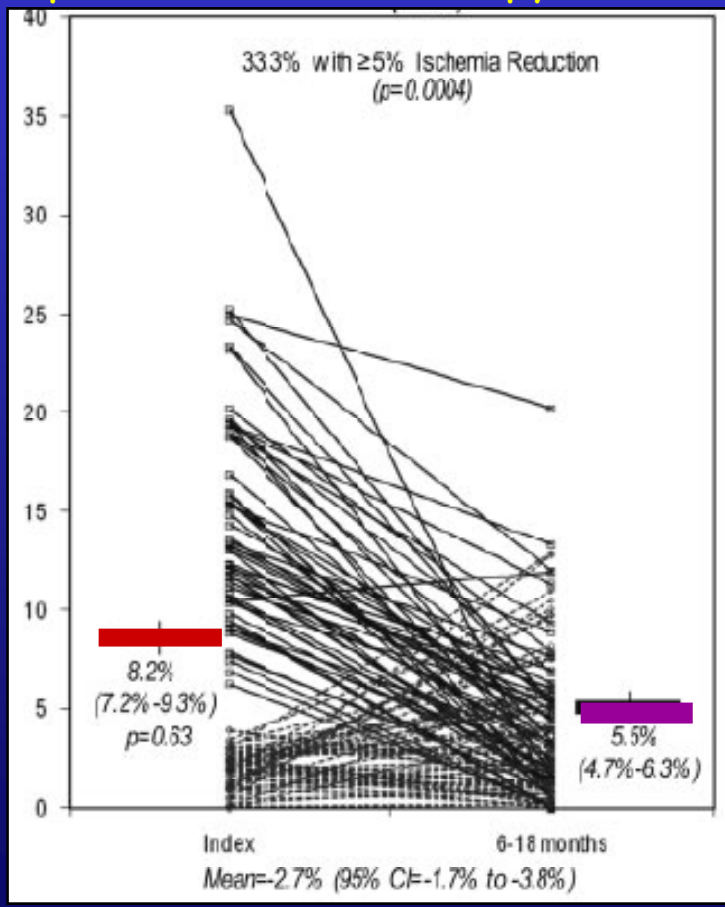
MPS-guided therapy and prognosis



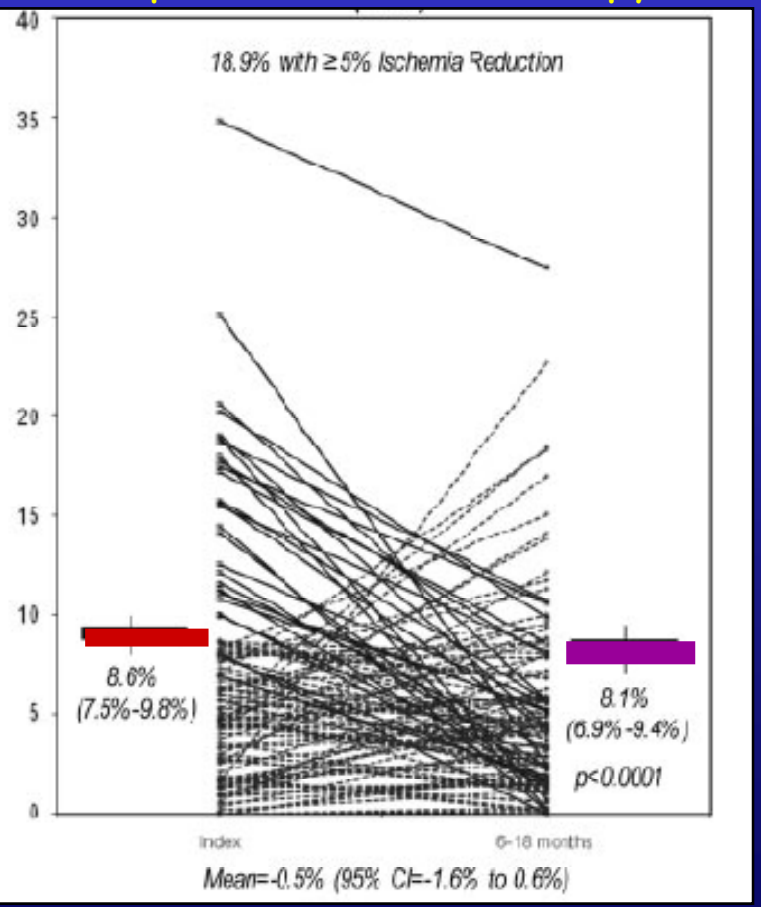
Hachamovitch. European Heart Journal 2011

COURAGE trial, nuclear sub-study

Optimal medical therapy and PCI

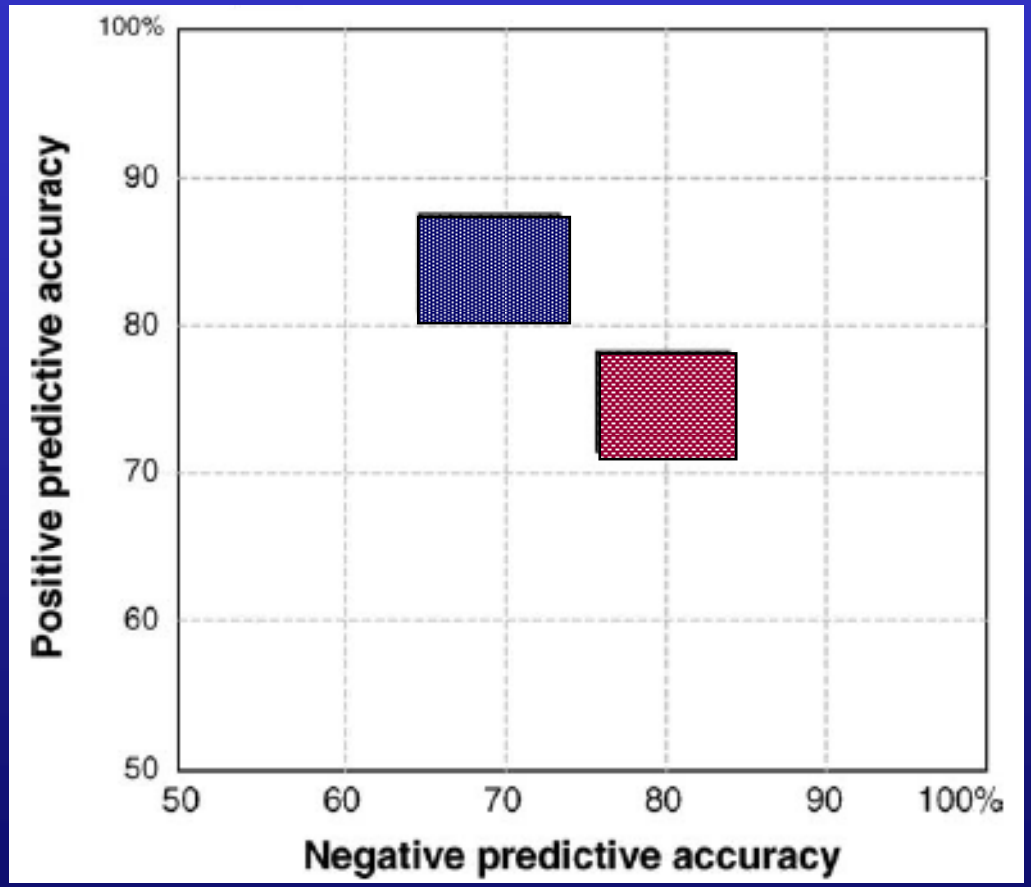


Optimal medical therapy



Shaw. Circulation 2008;117:1283

Viability assessment



Echo

Nuclear

SR Underwood et al. Eur Heart J 2004;25:815

Indication	Test	Class	Evidence	Society
Viability assessment in CAD patients with HF without angina	Non-invasive imaging	IIa	B	
Prediction of improvement in regional and global LV function	MPS PET	I	B	

I = strong; II = conflicting evidence; III = not in favor
A= high; B= intermediate; C= consensus

ESC and ACC/AHA Guidelines for Diagnosis and Management of Heart Failure 2008 & 2009

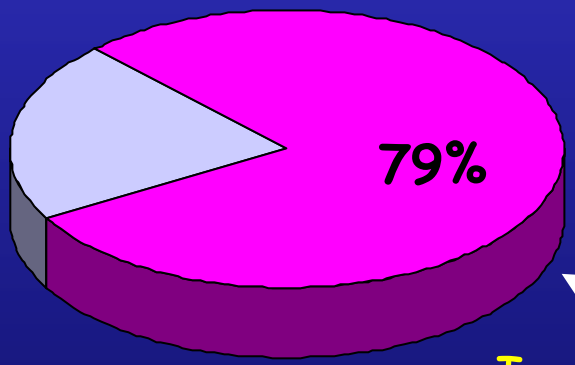
ACC/AHA/ASNC Guidelines for Clinical Use of Cardiac Radionuclide Imaging 2009

Hibernation – the need for ischaemia

N=100 regions with abnormal thickening pre-op

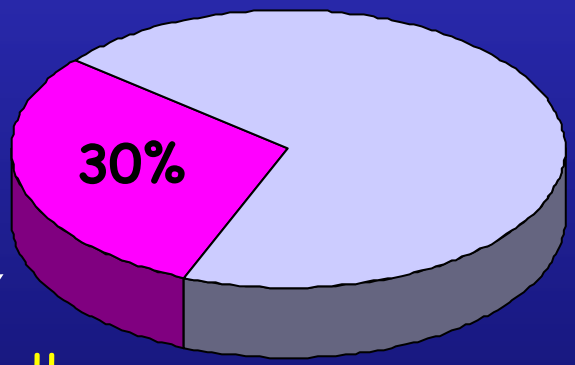
Reversible/ischaemic regions

n=56



Mild to moderate fixed defect/partial-thickness infarction

n=20



Improved regional wall thickening post revascularisation p<0.001

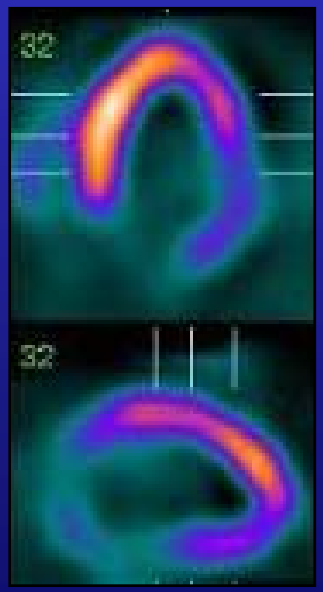
Kitsiou AN. Circulation 1998; 98: 501

Defining Hibernation

- Dysfunctional at rest

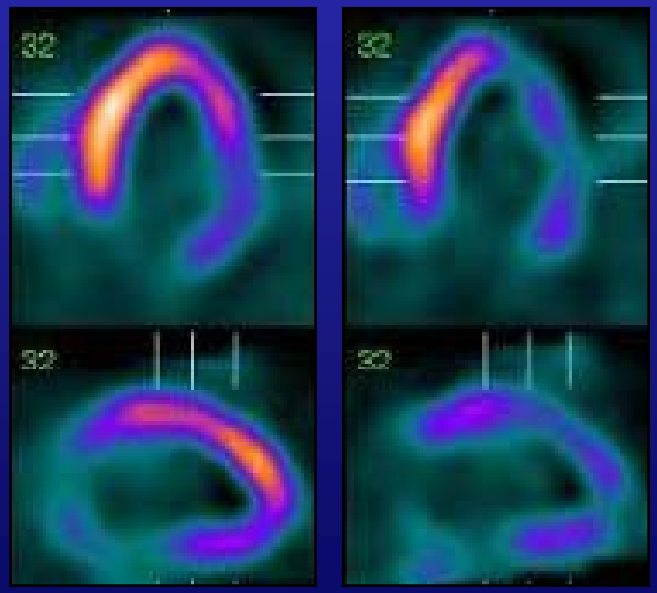
LVEDV 215ml
LVEF 30%

- Viable



Rest

- Ischaemic with stress



Rest Stress

Prediction of Recovery of LV Function

	Patients, n	Sensitivity, Mean (95% CI)	Specificity, Mean (95% CI)	PPV, Mean (95% CI)	NPV, Mean (95% CI)
Conventional nuclear					
^{99m}Tc-sestamibi [60]	19	71 (51–91)	40 (18–62)	. . .	. . .
SPECT FDG[63,70]	94	86 (79–93)	93 (88–98)	. . .	. . .
^{201}Tl rest, reinjection[22,62,63,65]	211	84 (79–89)	70 (64–76)	97 (92–100)	93 (86–100)
^{201}Tl rest redistribution+FDG[64]	47	86 (76–96)	92 (84–100)	90 (81–99)	89 (80–98)
Total	371	84 (80–88)	77 (73–81)	94 (89–98)	91 (85–97)
Echocardiography					
DSE[22,60,62,63,65,66,72]	408	76 (71–80)	81 (77–85)	84 (77–91)	91 (85–96)
DSE+strain rate[66]	55	67 (55–79)	89 (81–97)	. . .	. . .
End-diastolic wall thickness[22]	43	63 (49–77)	68 (54–82)	. . .	. . .
Total	506	74 (70–77)	81 (77–84)	84 (77–91)	91 (85–96)
PET					
FDG[49,70]	205	81 (75–86)	65 (59–72)	. . .	. . .
Total	205	81 (75–86)	65 (59–72)	. . .	. . .

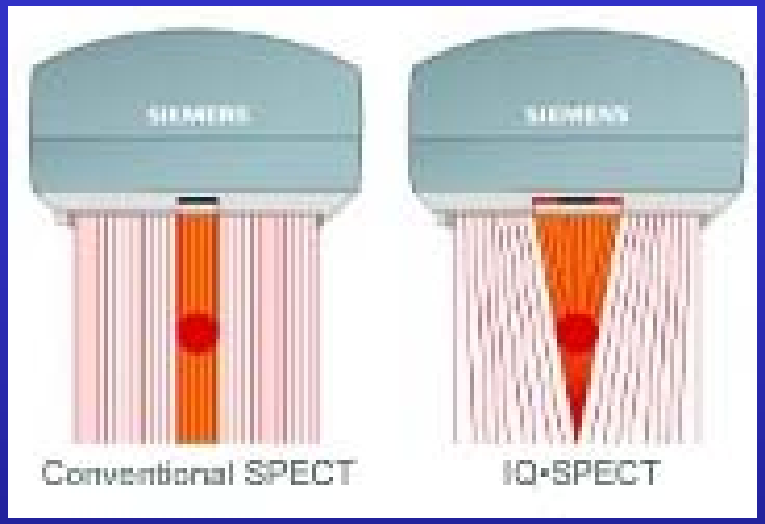
PPV indicates positive predictive value; NPV, negative predictive accuracy.

Camici. Circulation 2008;117:103

What is new?


cingular
12:34 PM
SMS
Text
Tuesday
9
Calendar
Photos
Camera
Calculator
Stocks
Maps
Weather
Notes
Clock
Settings
Phone
Mail
Web
iPod

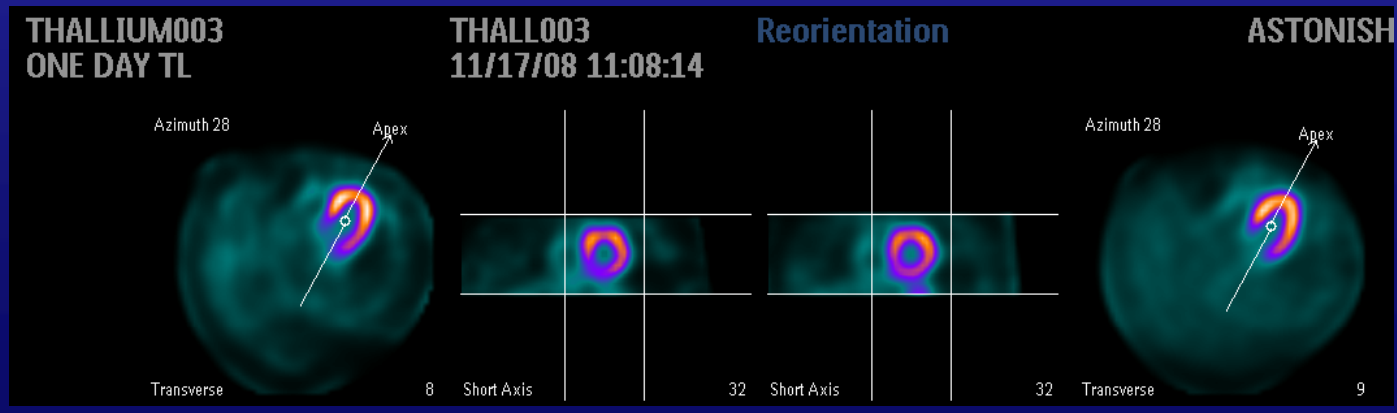
Innovations 2011



Conventional SPECT IQ SPECT

Novel collimator technology

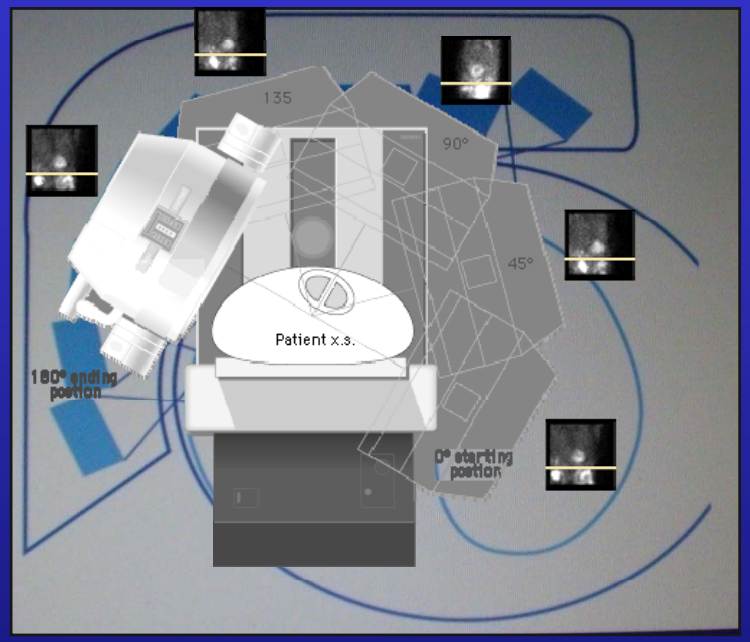
Iterative reconstruction with Resolution Recovery



Next Generation Scanners

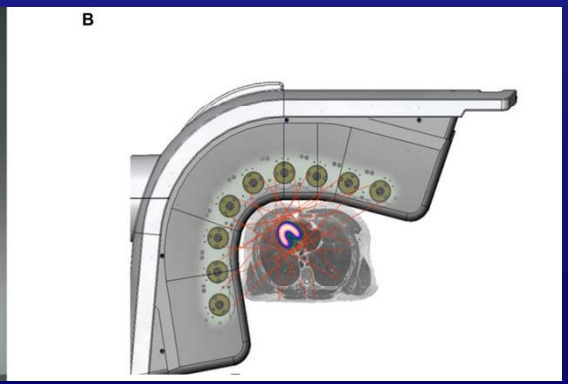
Cadmium Zinc Telluride (CZT) Detectors

- Focus pin-hole collimation
- 3D reconstruction
- Stationary data acquisition



- Acquisition time 3-5 minutes

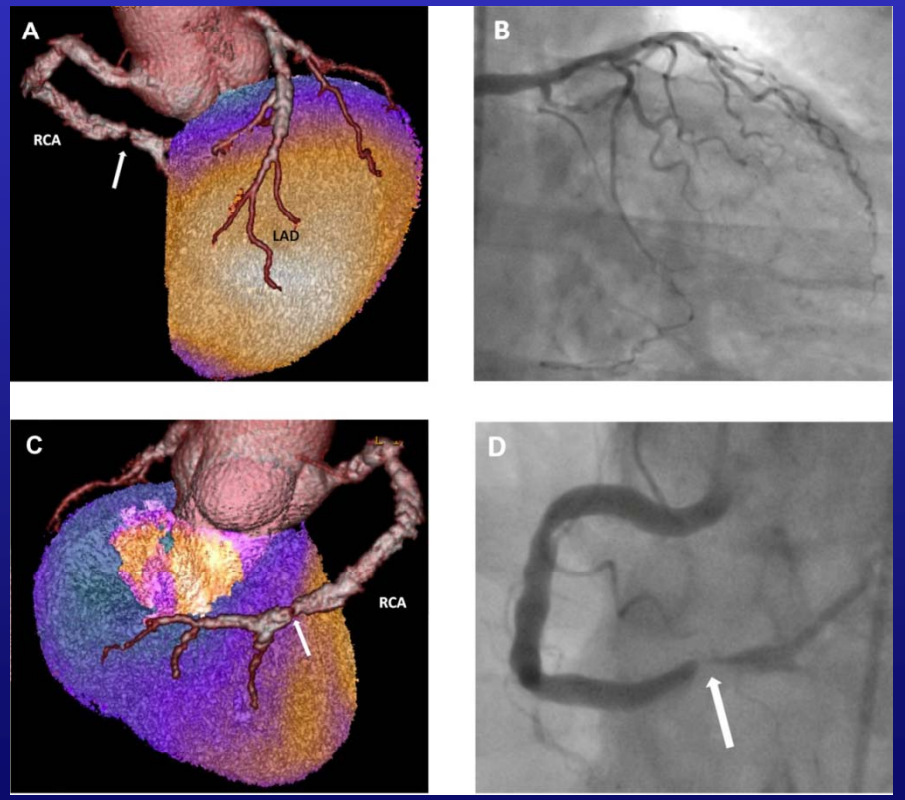
- Global and regional MBF in ml/min/g of tissue



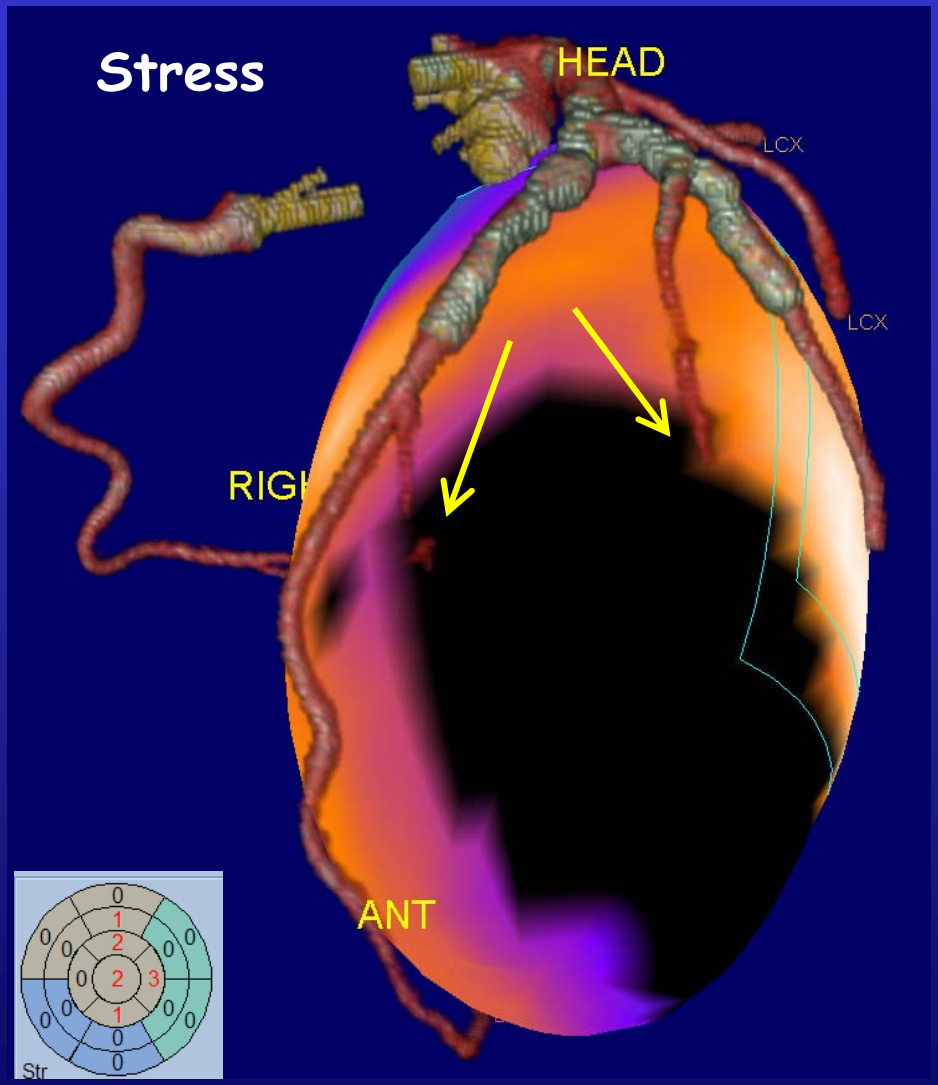
Combined imaging: MPS/CTA

- Separate systems:
  - Side by side interpretation
  - Software-based fusion
- Hybrid systems

European Society of Nuclear Medicine
Position statement:
"Fusion has incremental value over stand-alone imaging"



Courtesy of Dr Liz Prvulovich, UCL London


Stress
HEAD
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LCX
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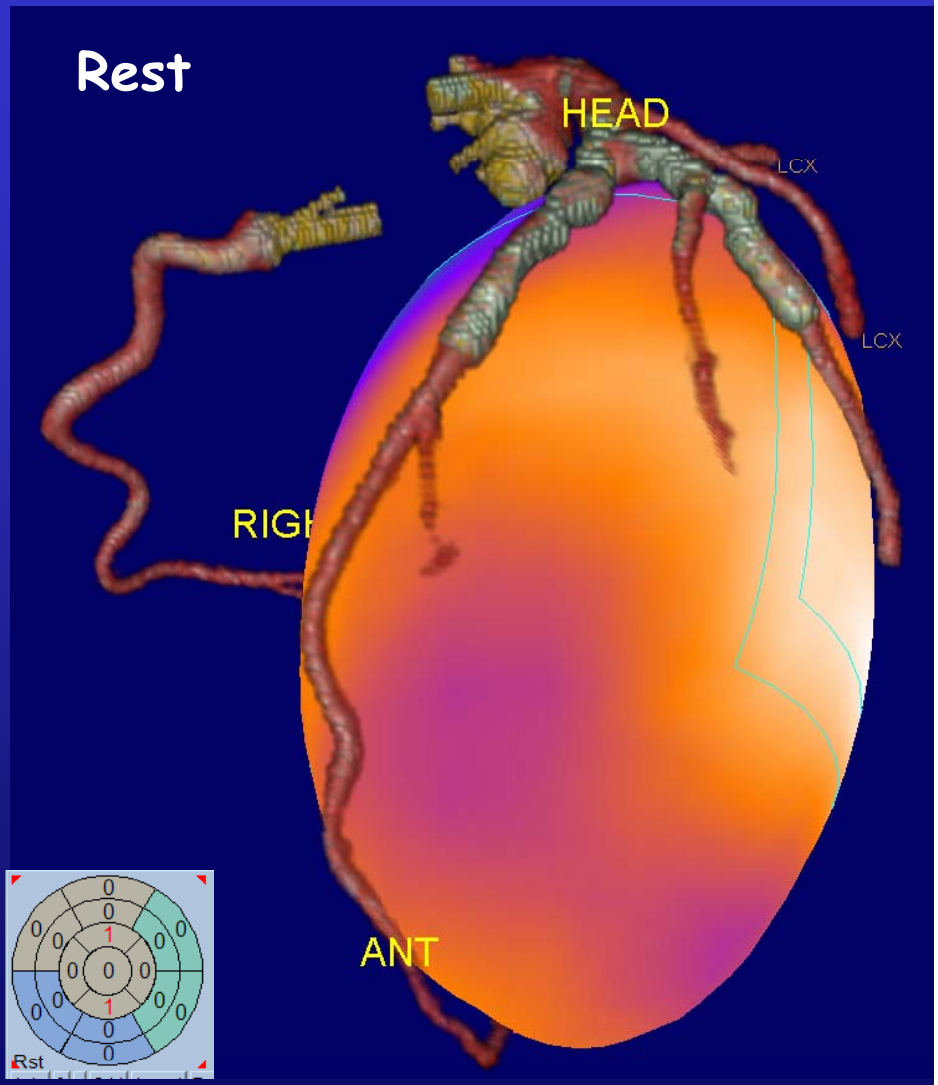
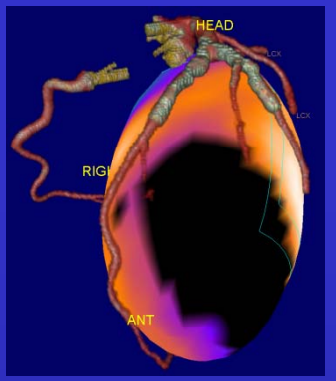

Rest
HEAD
LCX
LCX
RIGH
ANT
Rst

MPS+CTA or Fusion?

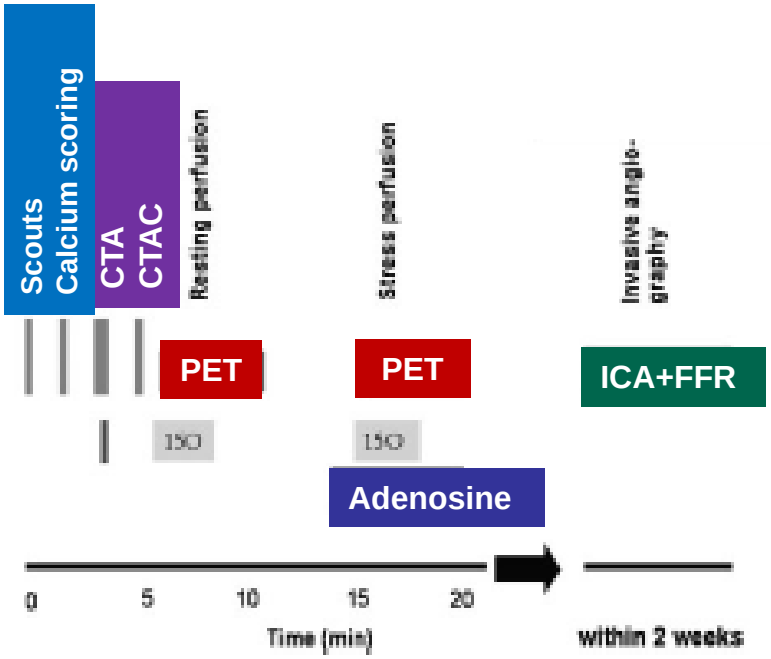


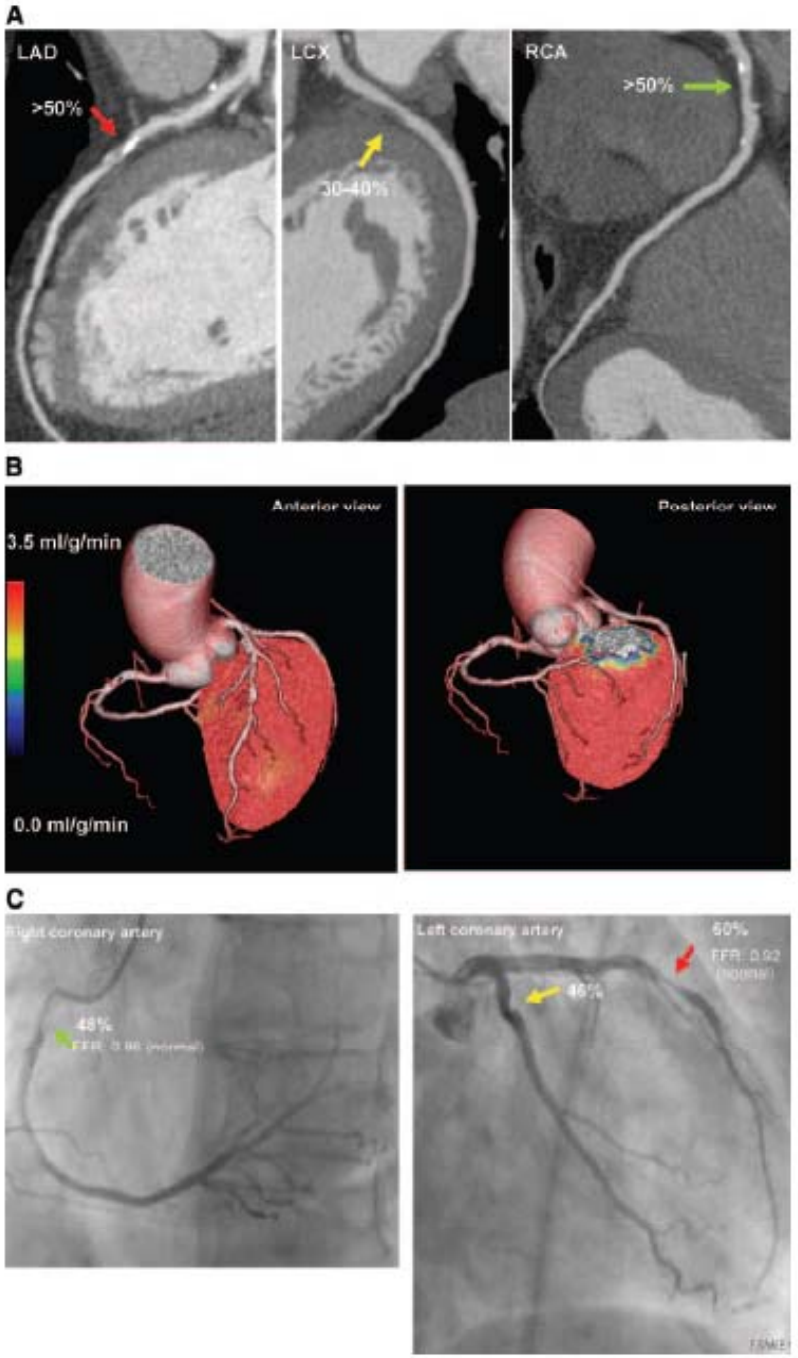
Anatomic target	MPI	*P*	MPI+CTA	*P*	MPI-CTA fusion
CAD, global assessment	0.75	NS	0.81	0.02	0.88*
LAD coronary artery	0.59	0.03	0.70	0.006	0.81†

* 0.005 vs MPI
† < 0.0001 vs MPI

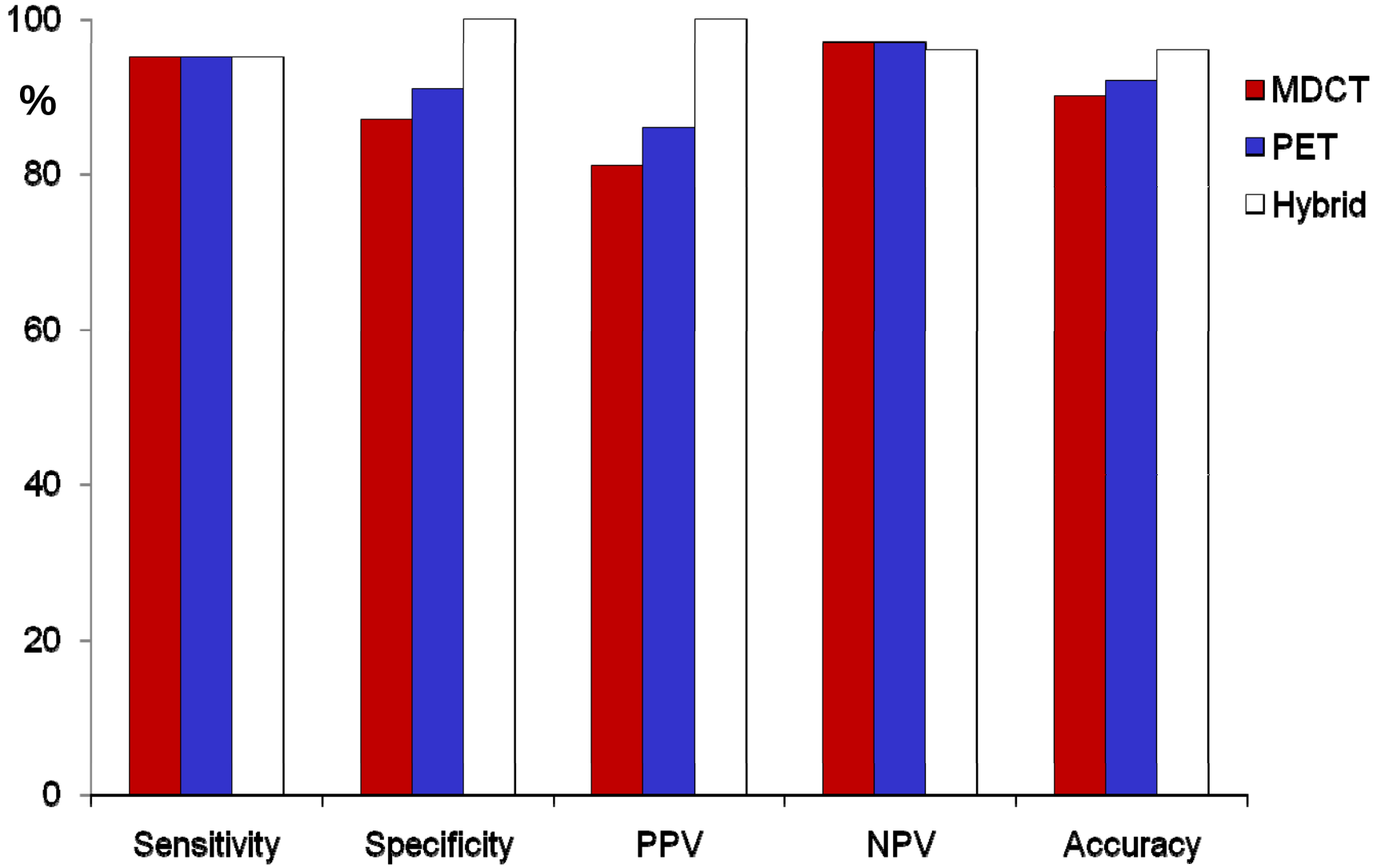
Santana CA et al. Society of Nuclear Medicine 2007 annual meeting; June 2007; Washington, DC

Study Protocol





Kajander and Knuuti. Circulation 2010;122:603



Kajander and Knuuti. Circulation 2010;122:603