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Choosing SPECT or PET for stable chest pain

Dr Parthiban Arumugam
Consultant Nuclear Medicine Physician
Manchester University NHS Foundation Trust

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Outline

- Perfusion imaging – PET tracers and Rb imaging protocol
- Case examples –
  - SPECT versus PET (relative perfusion images)
  - Clinical value of blood flow measurement
- Literature and Guidelines

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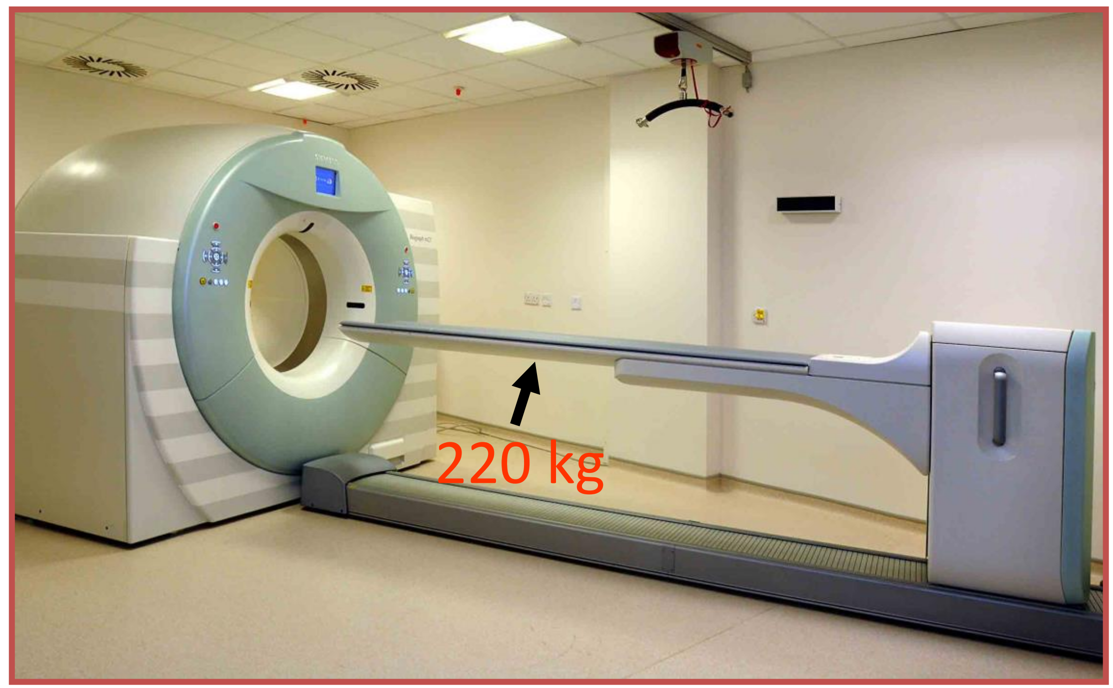
Cardiac perfusion PET radionuclides

	^{13}N ammonia	^{82}Rb
Half life (minutes)	9.96 minutes	76 seconds
Imaging duration	10 – 20 min	6 – 10 min
Administered Activity (3D Scanner)	740 MBq (20 mCi)	740 – 1480 MBq (20 – 40 mCi)
Production	Cyclotron	Generator
Typical distances to annihilation event in tissue (FWHM)	0.26 - 0.62 mm	0.56 – 1.43 mm
Image resolution	**Excellent**	**Good**
First pass extraction fraction	**80%**	**65%**
Perfusion defect contrast	**Excellent**	**Good**
Pharmacological stress	**Routine**	**Routine**
Treadmill exercise	Possible (Static/Gated Only)	Technically challenging

Equipment

CardioGen-82 generator – Rubidium
(half life 75 seconds)



PET CT Scanner

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Acquisition Protocol – 20 minutes

topogram
↓
CTAC Rest

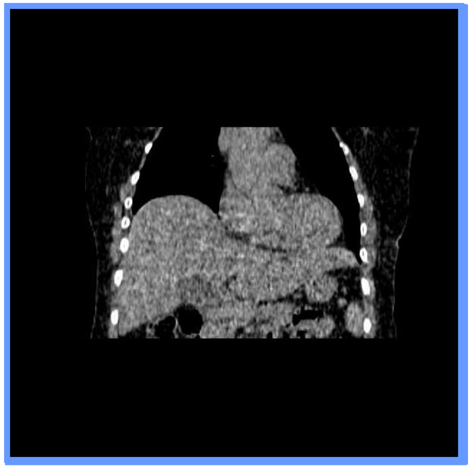
^{82}Rb infusion 1110MBq (~15-30 sec) →

↓
PET Rest
(5min scan)

Adenosine infusion (4.5mins) or Regadenoson (20 seconds) →

^{82}Rb infusion 1110 MBq (2.0 mins after adenosine or 50 seconds post regadenoson) (~15-30 sec) →

↓
PET Stress
(5min scan)
↓
[CTAC Stress]
↓
Image reconstruction **only** takes 10 minutes



22cm

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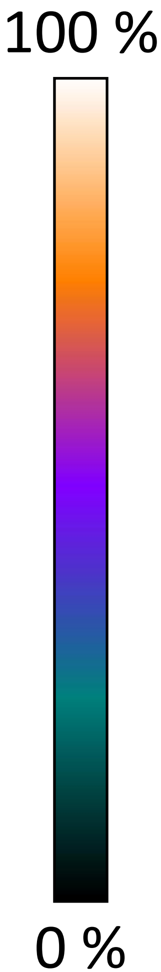
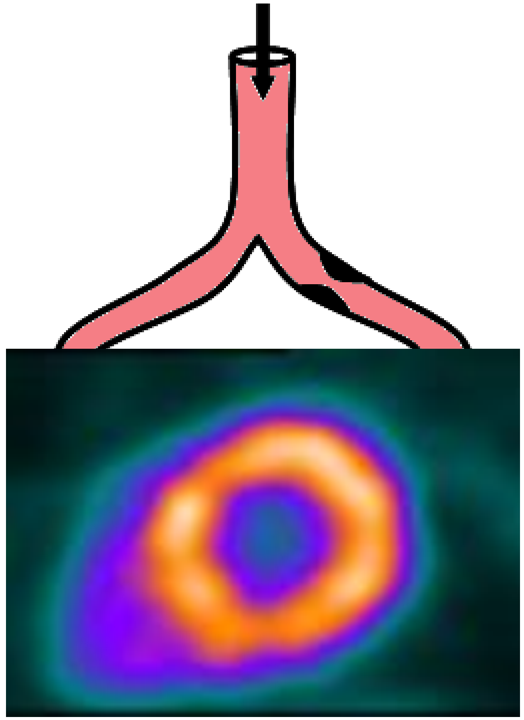
Relative perfusion assessment

(Regional Ischaemia)

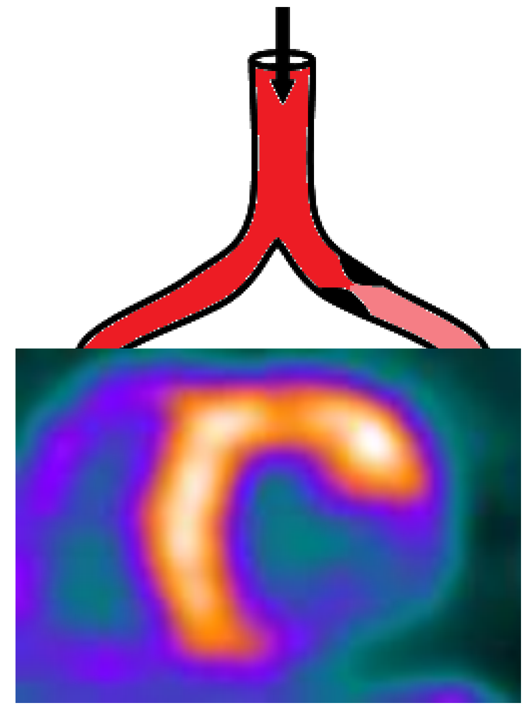


REST



Adequate flow despite narrowing

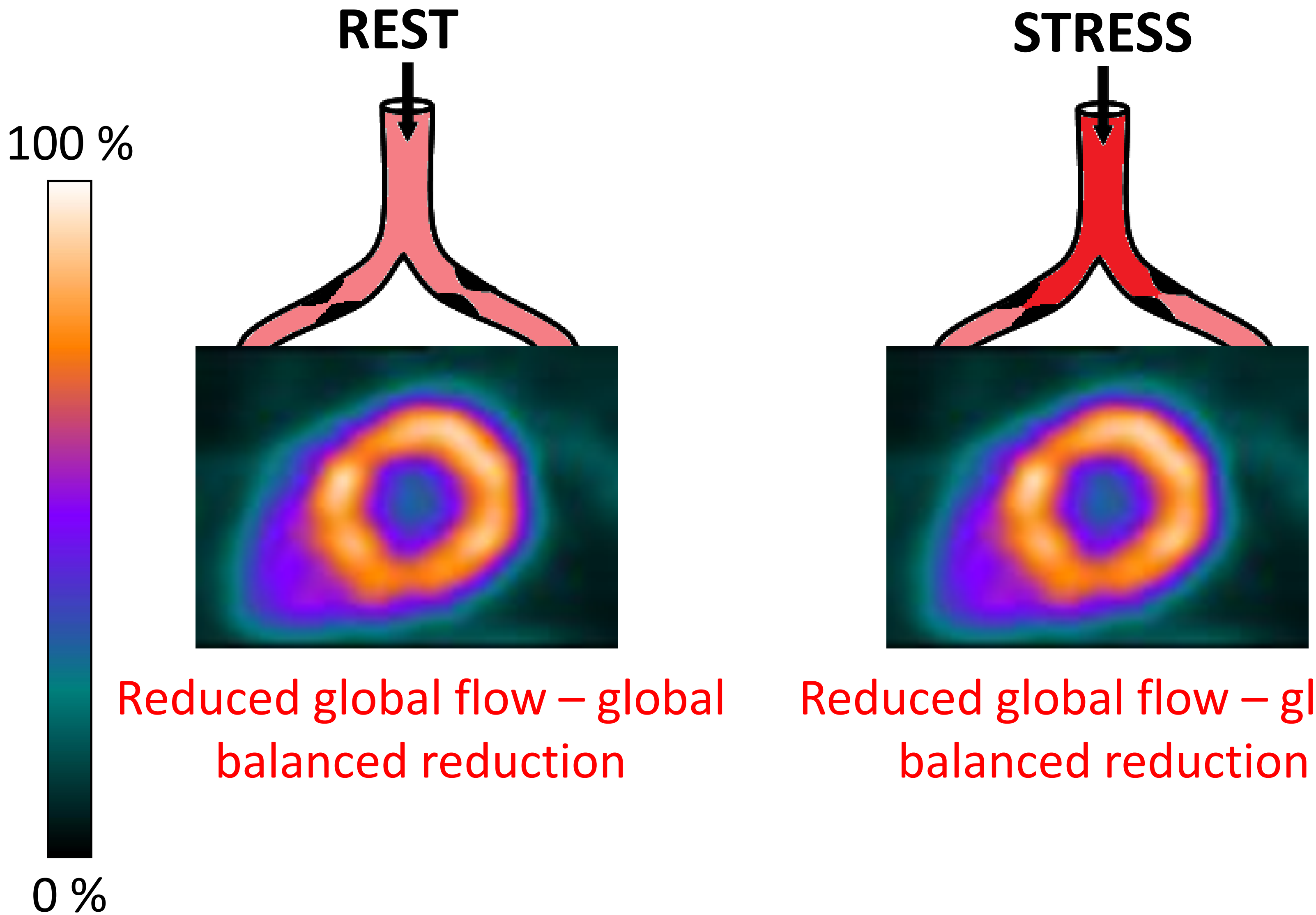
STRESS



Demand outstrips supply – regional reduction

Relative perfusion assessment

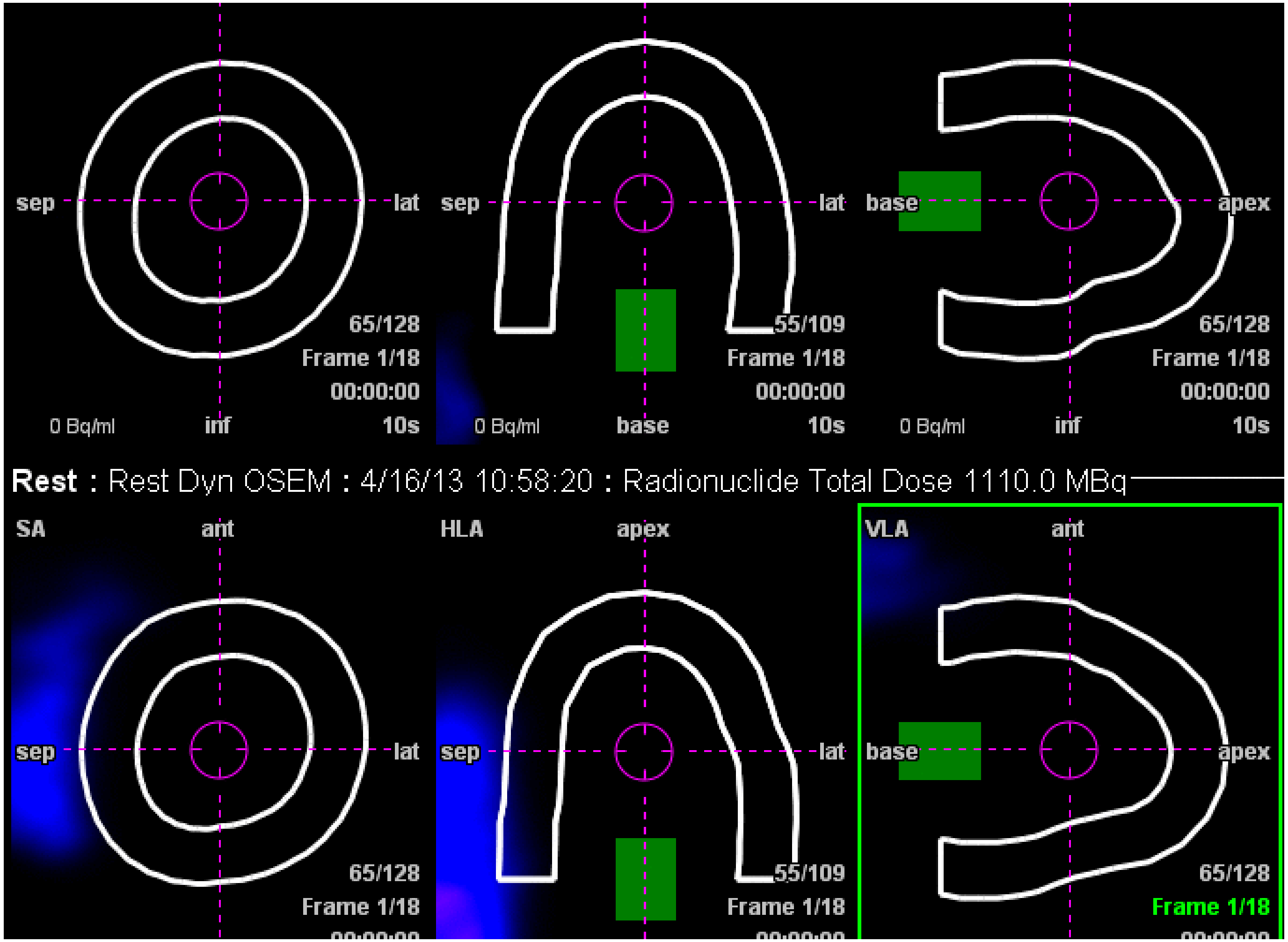
(Multivessel disease)



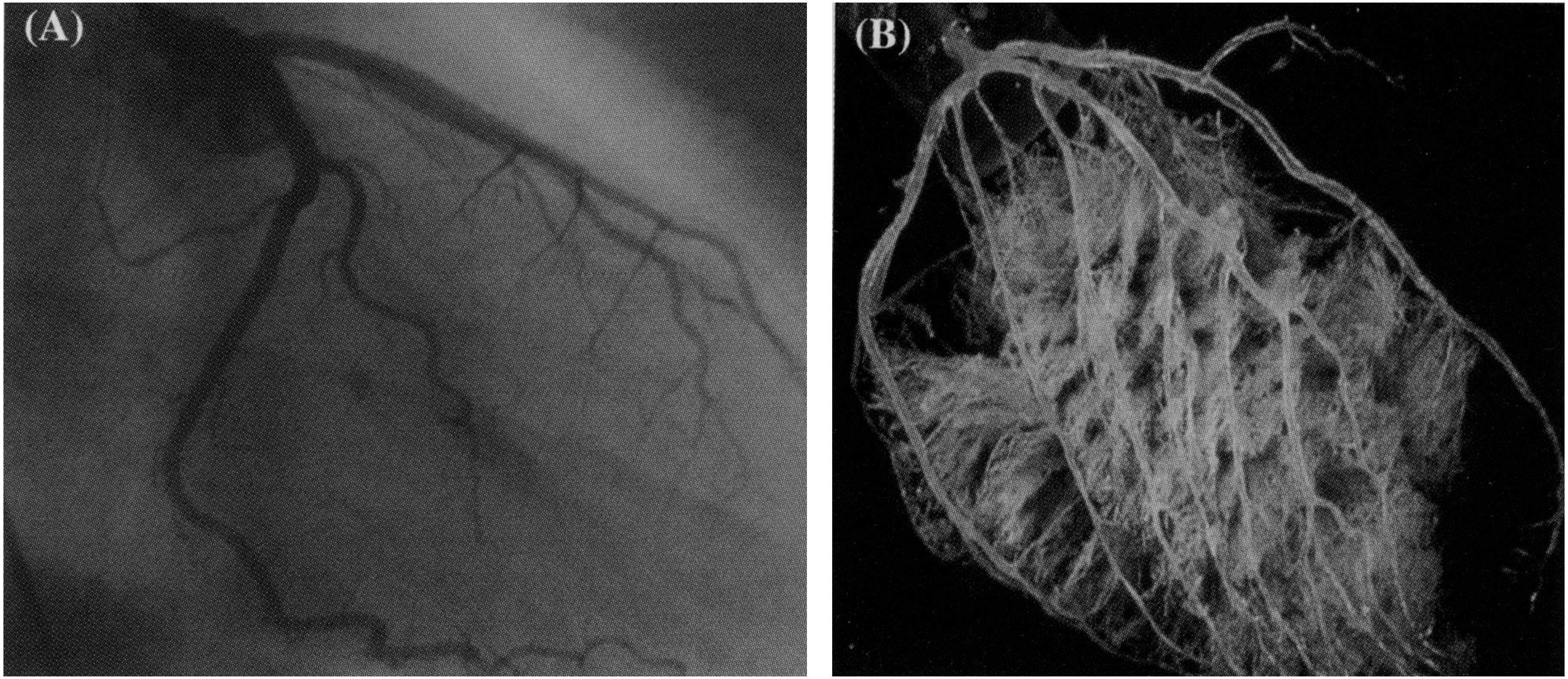
Reduced global flow – global balanced reduction

Reduced global flow – global balanced reduction

Dynamic Images



Coronary Blood Flow



PET Quantitative assessment Rubidium

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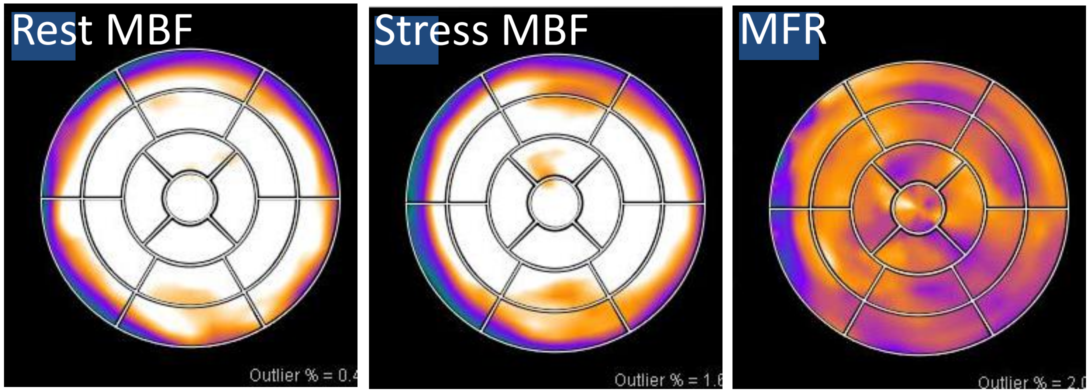
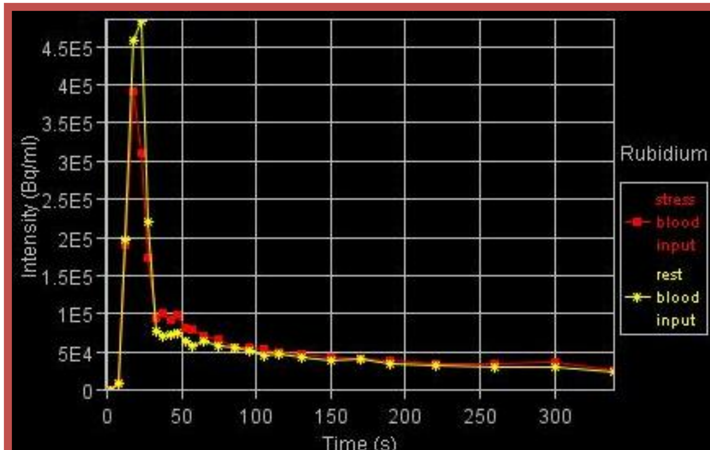


Myocardial Flow Reserve
=
Stress MBF / Rest MBF

Normal Ranges
Rest MBF: 0.6 – 1.3 ml/gm/min
Stress MBF: 1.2 – 3.3 ml/gm/min

	QMP (ml/g/min)				Reserve	
	Stress		Rest			
	mean	std dev.	mean	std dev.	mean	std dev.
LAD	2.47	0.61	0.93	0.17	2.67	0.63
LCX	2.42	0.58	0.90	0.23	2.72	0.33
RCA	2.81	0.70	0.93	0.26	3.10	0.54
Global	2.53	0.64	0.92	0.21	2.79	0.57



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TP

- 62 female
- Typical angina.
- Normal BMI
- No reversible risk factors for CAD

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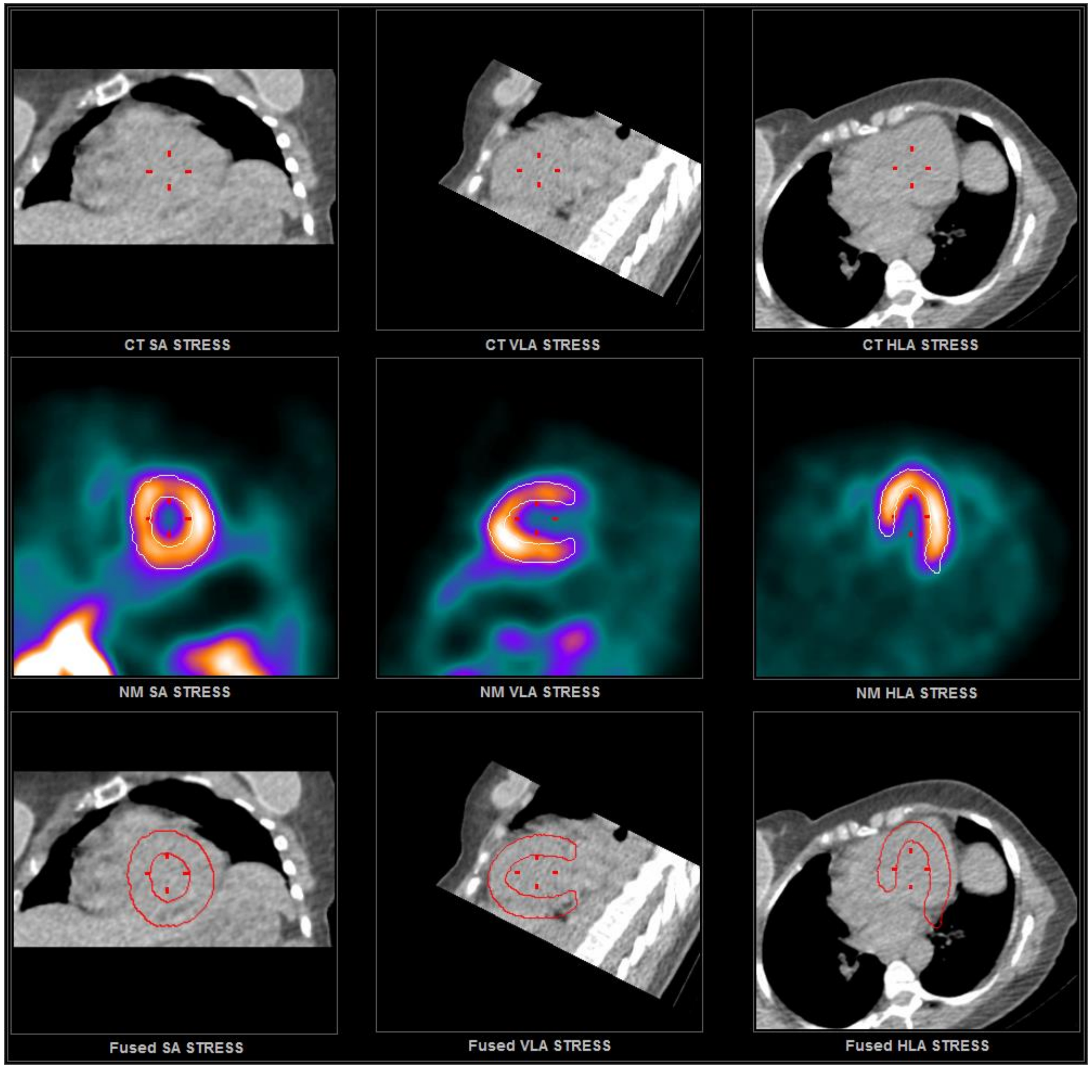

Perfusion Images

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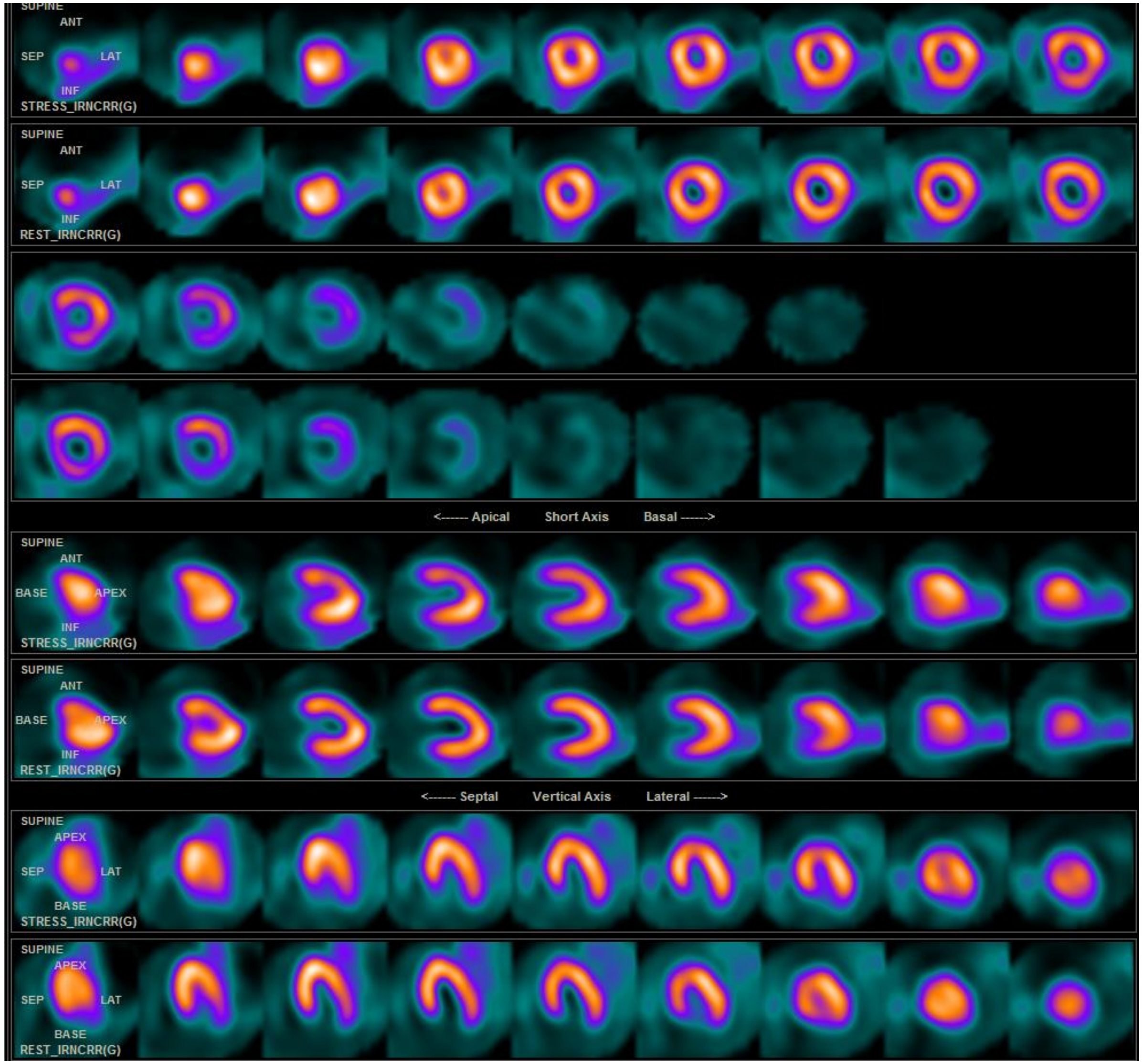
Stress
Rest
Stress
Rest
Stress
Rest
Stress
Rest



Tc-99m
SPECT
NAC

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Perfusion Images

Stress

Rest

Stress

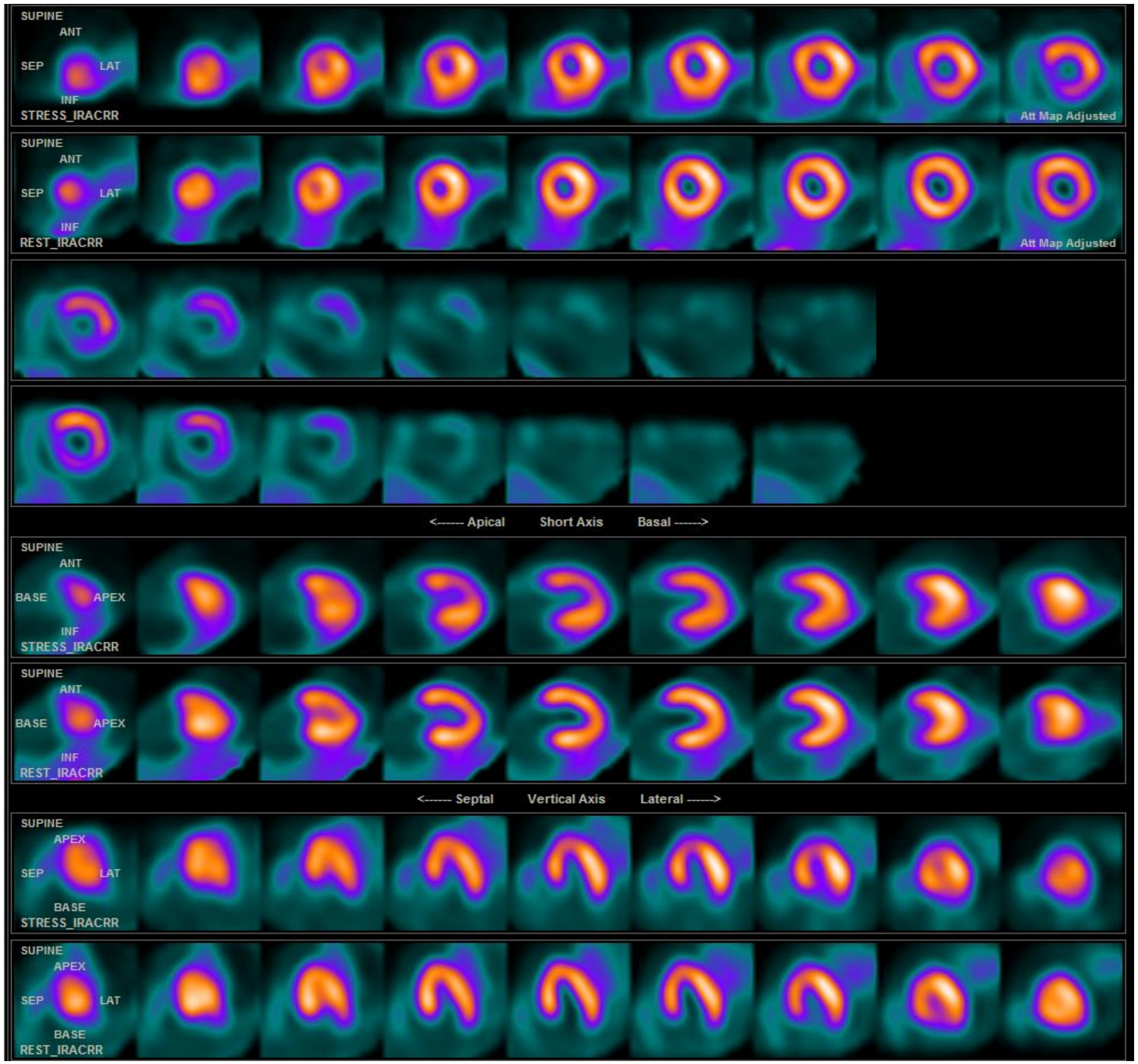
Rest

Stress

Rest

Stress

Rest



Tc-99m

SPECT

AC

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Perfusion Images

Stress

Rest

Stress

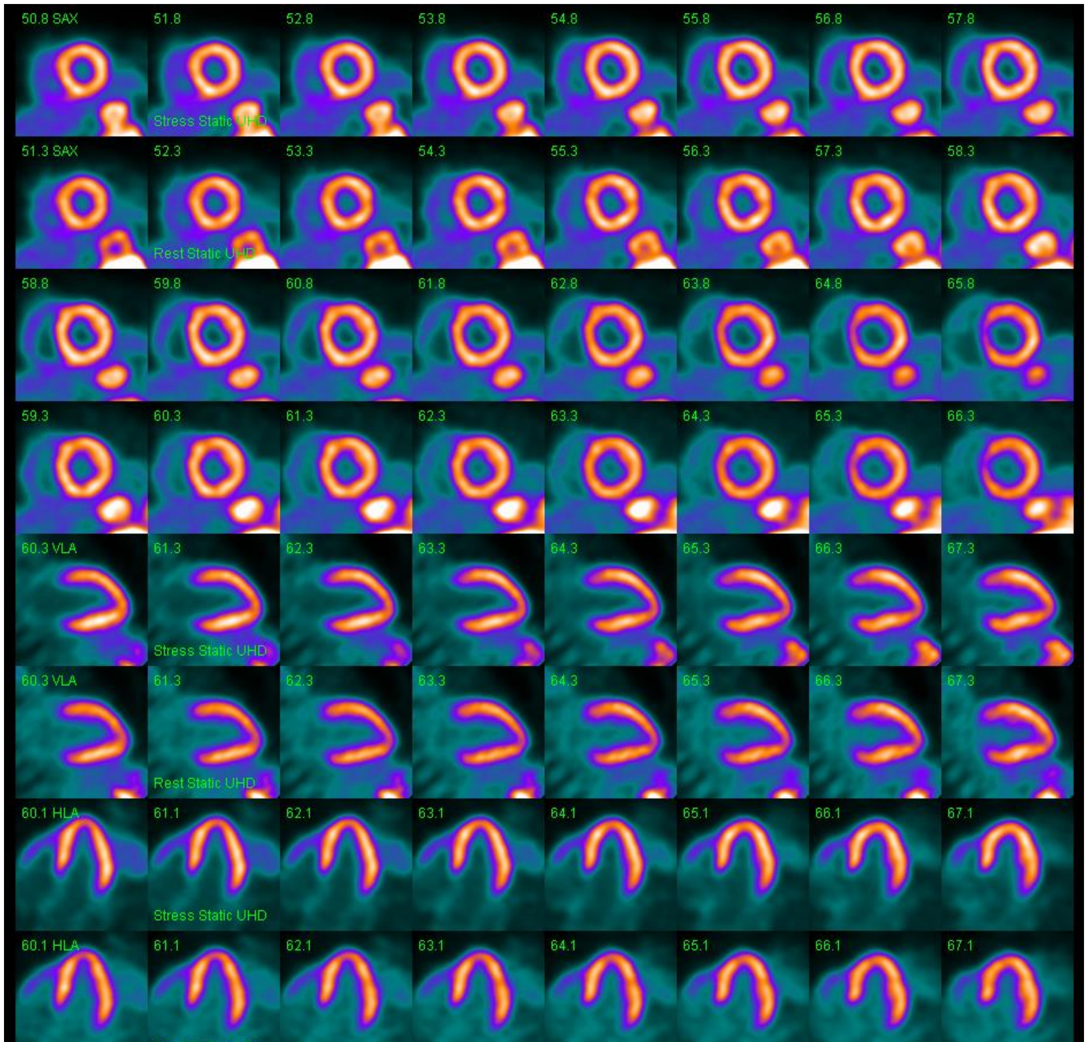
Rest

Stress

Rest

Stress

Rest



Rb-82
PET

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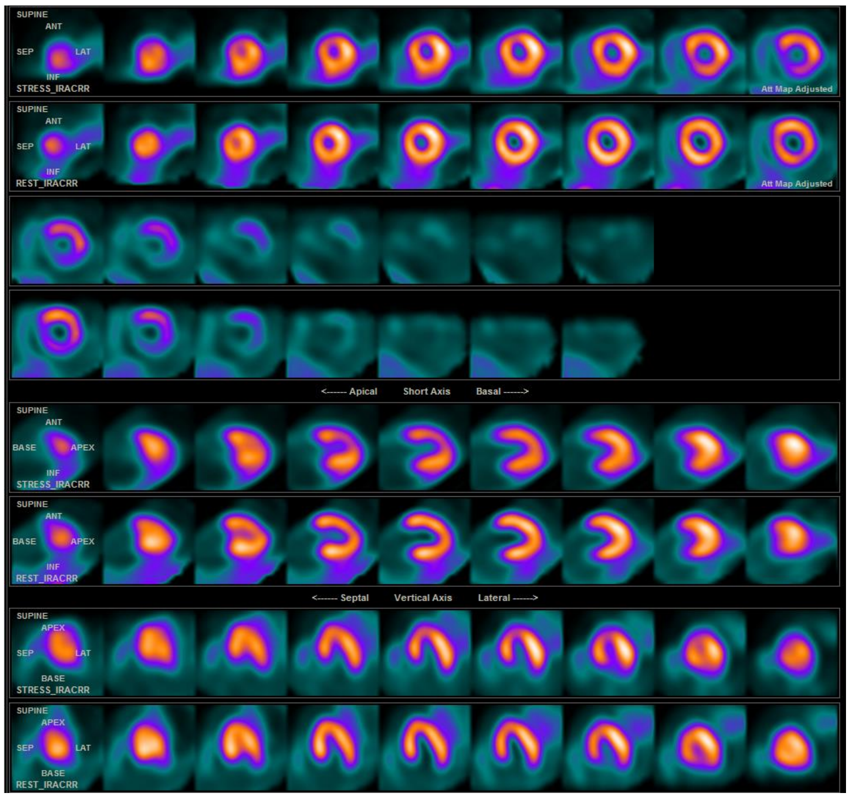
Perfusion Images

Tc-99m SPECT



Rb-82 PET

Stress

Rest

Stress

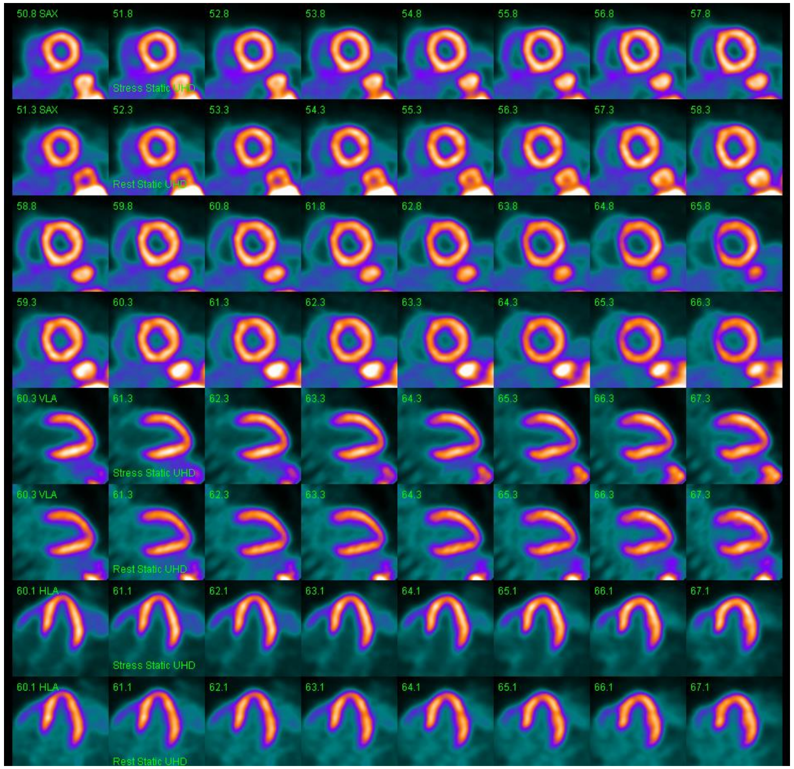
Rest

Stress

Rest

Stress

Rest



Slices NAC

Stress

Rest

Stress

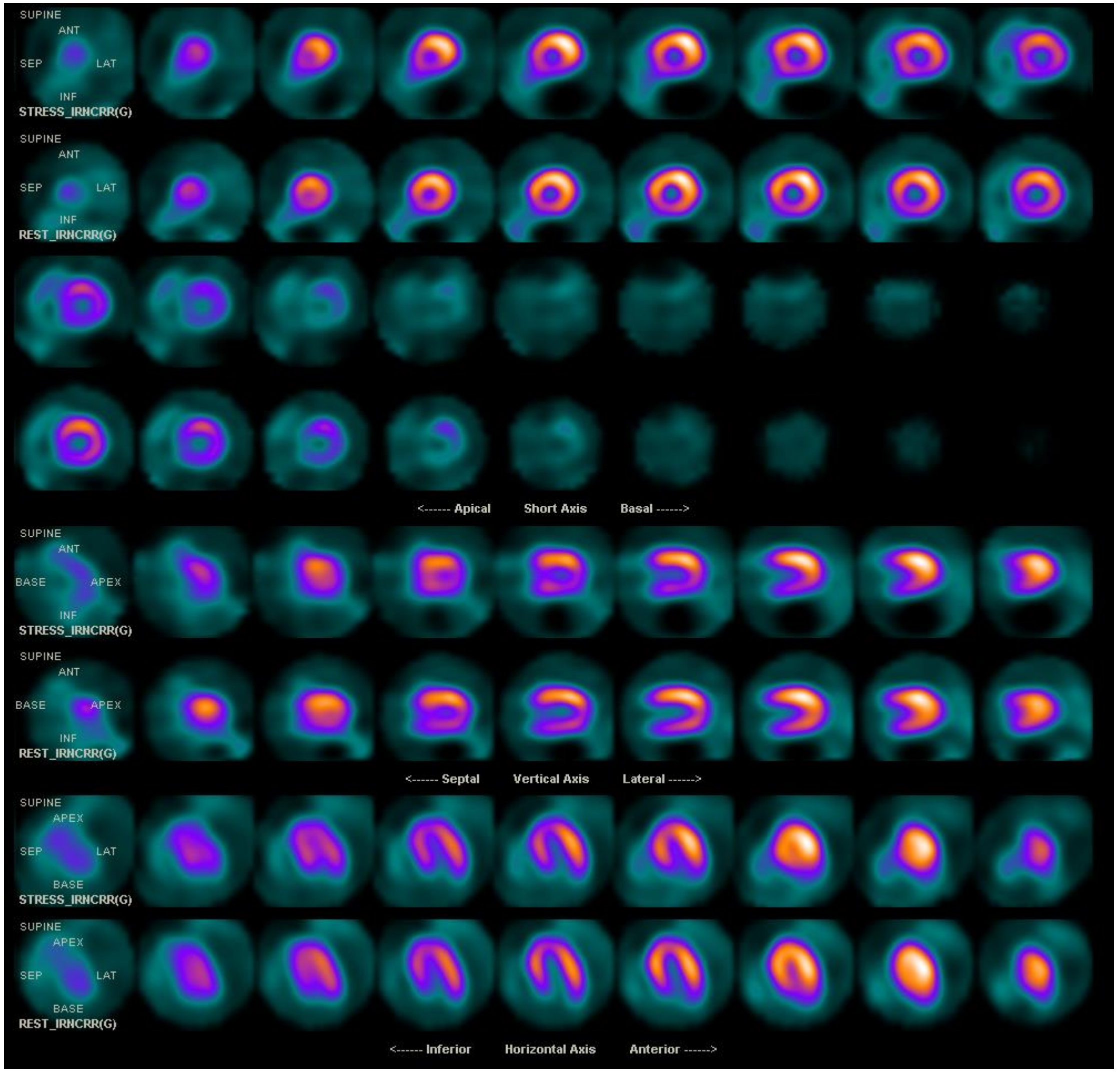
Rest

Stress

Rest

Stress

Rest



Tc-99m
SPECT
NAC

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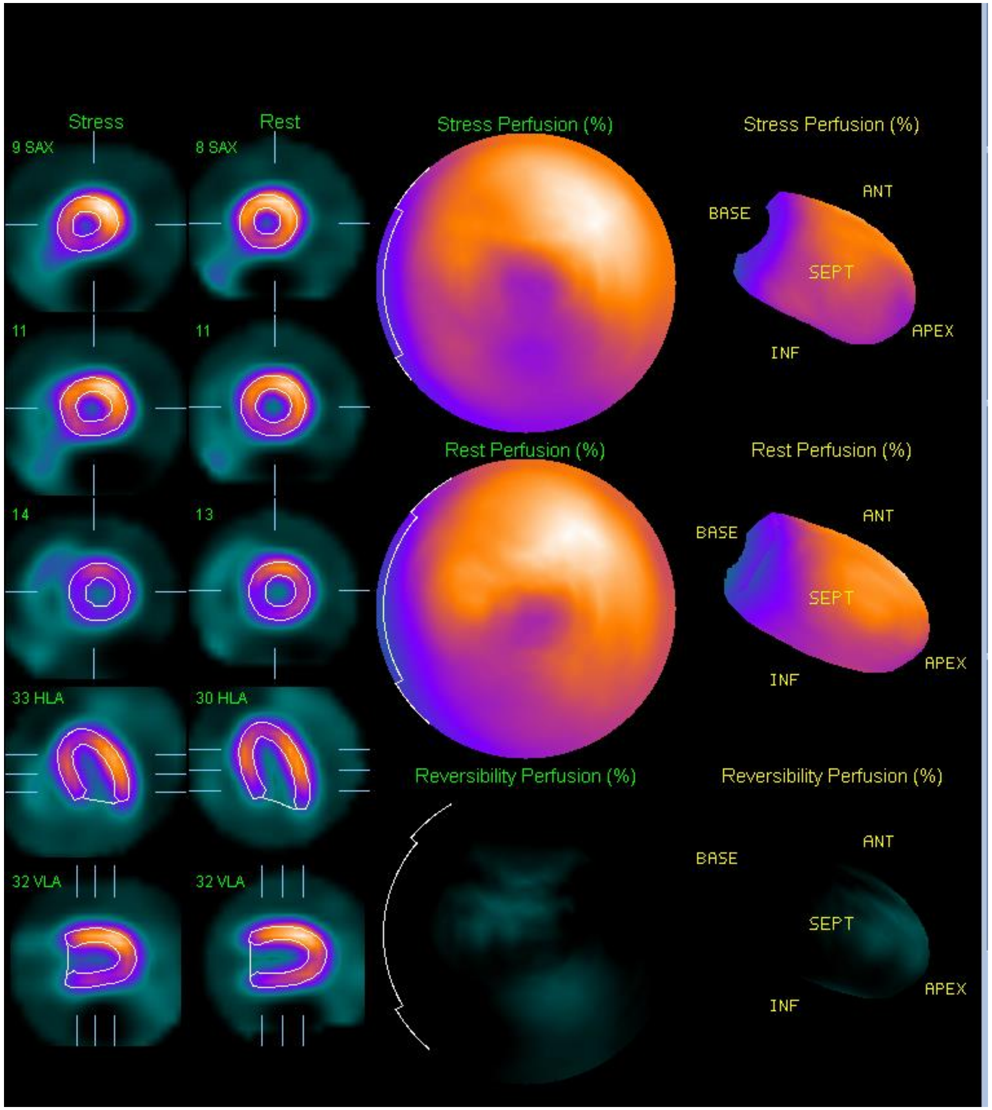
Polar Plot



Slices AC

Stress

Rest

Stress

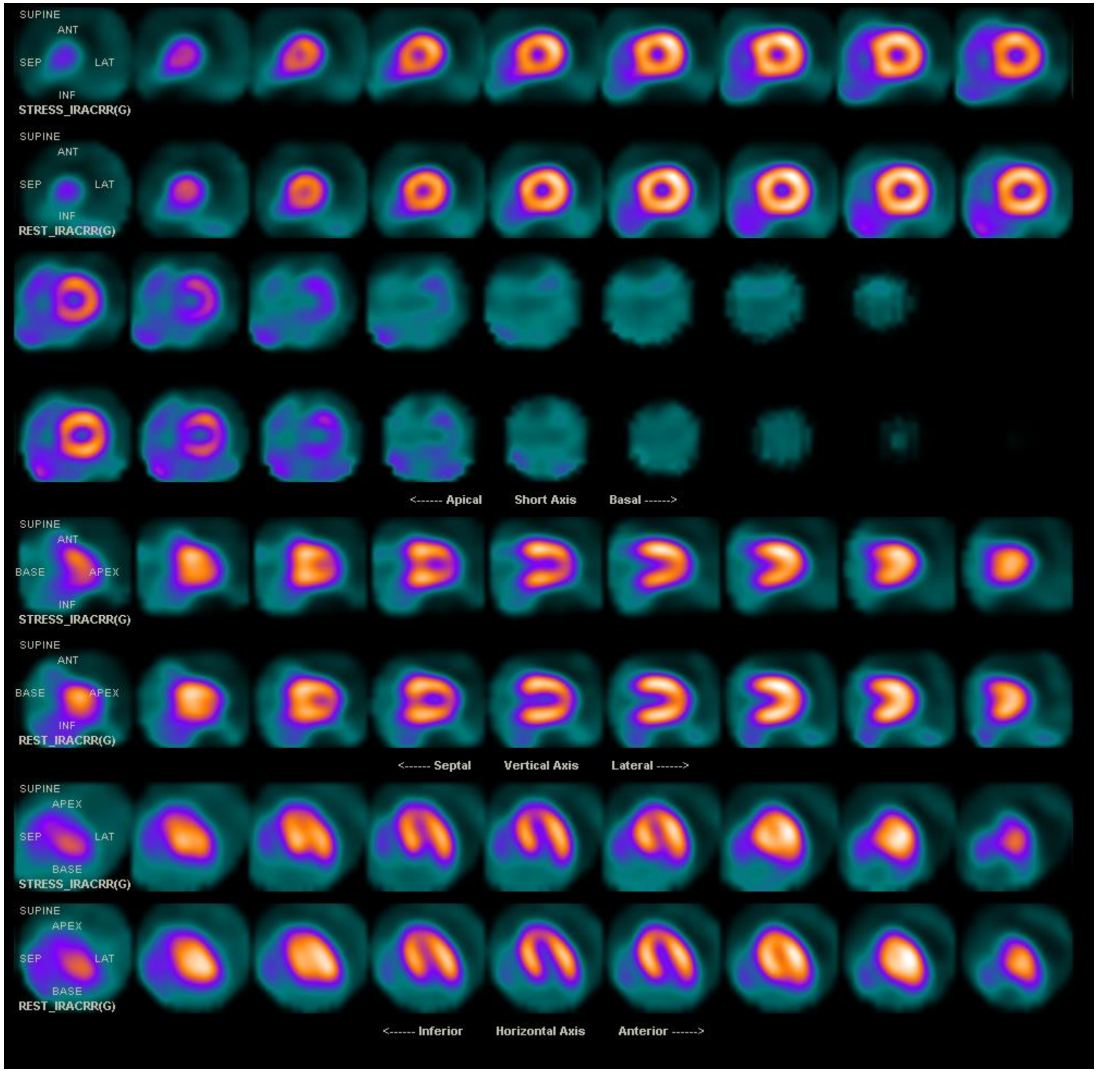
Rest

Stress

Rest

Stress

Rest



Tc-99m SPECT

AC

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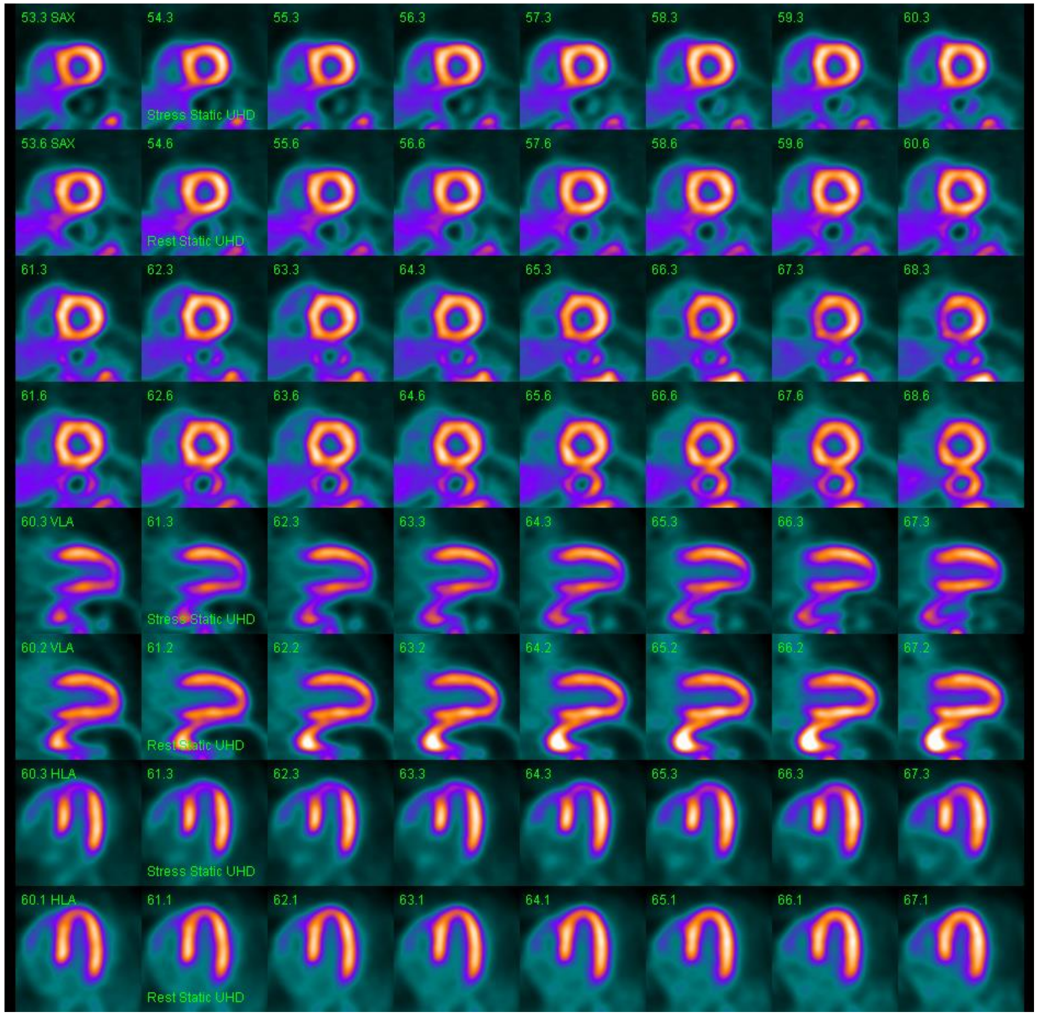
Rb PET



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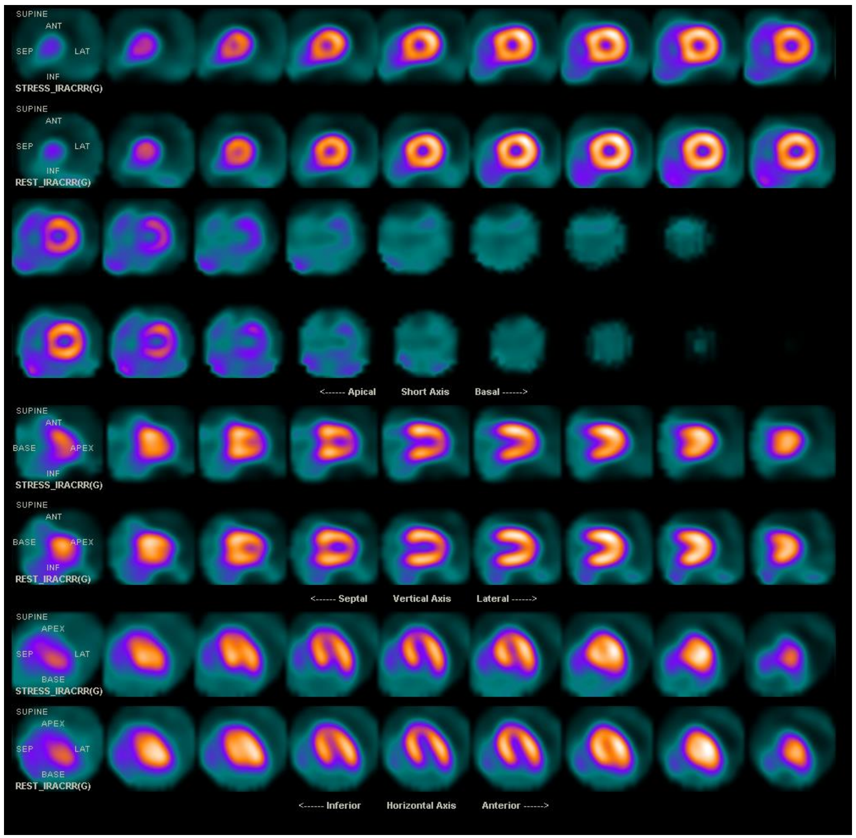
Perfusion Images

Tc-99m SPECT



Stress

Rest

Stress

Rest

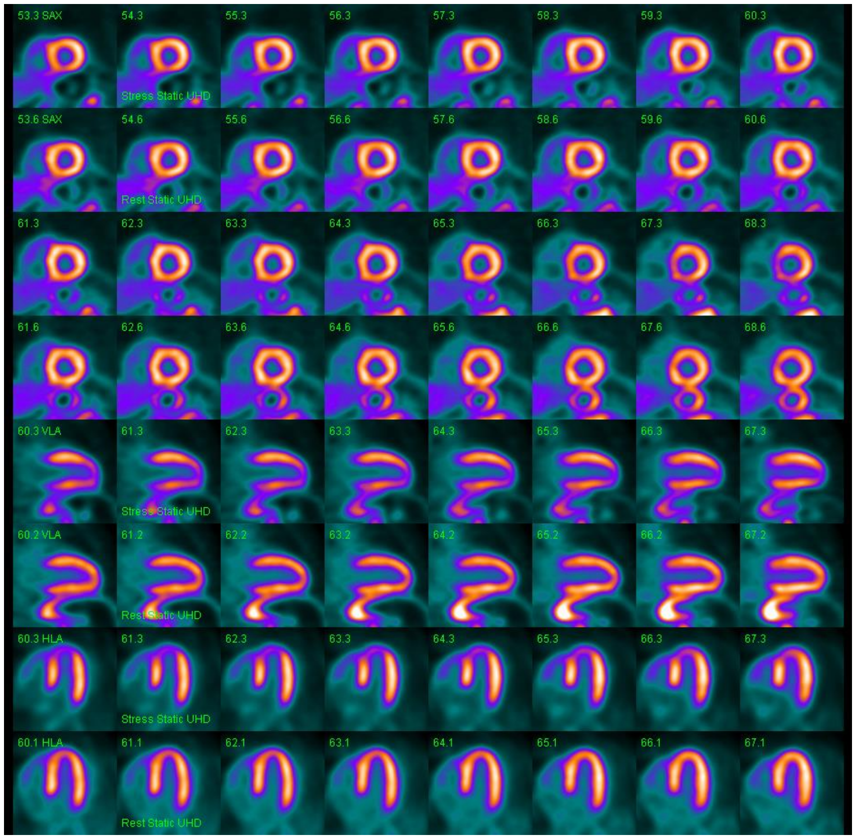
Stress

Rest

Stress

Rest

Rb-82 PET



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RF

- 68 year old male
- Exertional angina
- Risk factors for CAD
  - Hyperlipidaemia
  - Age
- Uneventful SPECT Adenosine stress protocol

Perfusion Images

Stress

Rest

Stress

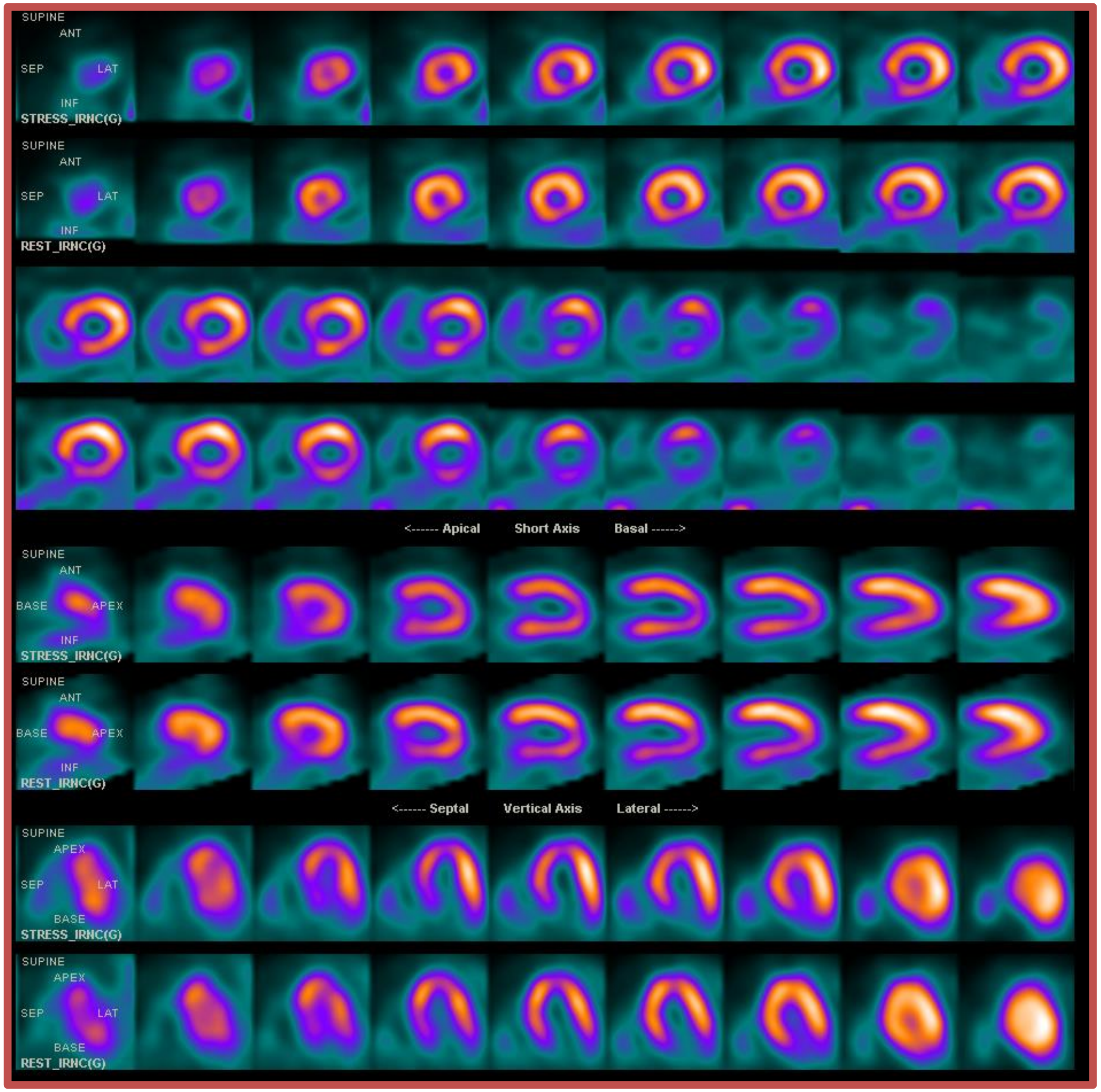
Rest

Stress

Rest

Stress

Rest



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SPECT

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Perfusion Images

Stress

Rest

Stress

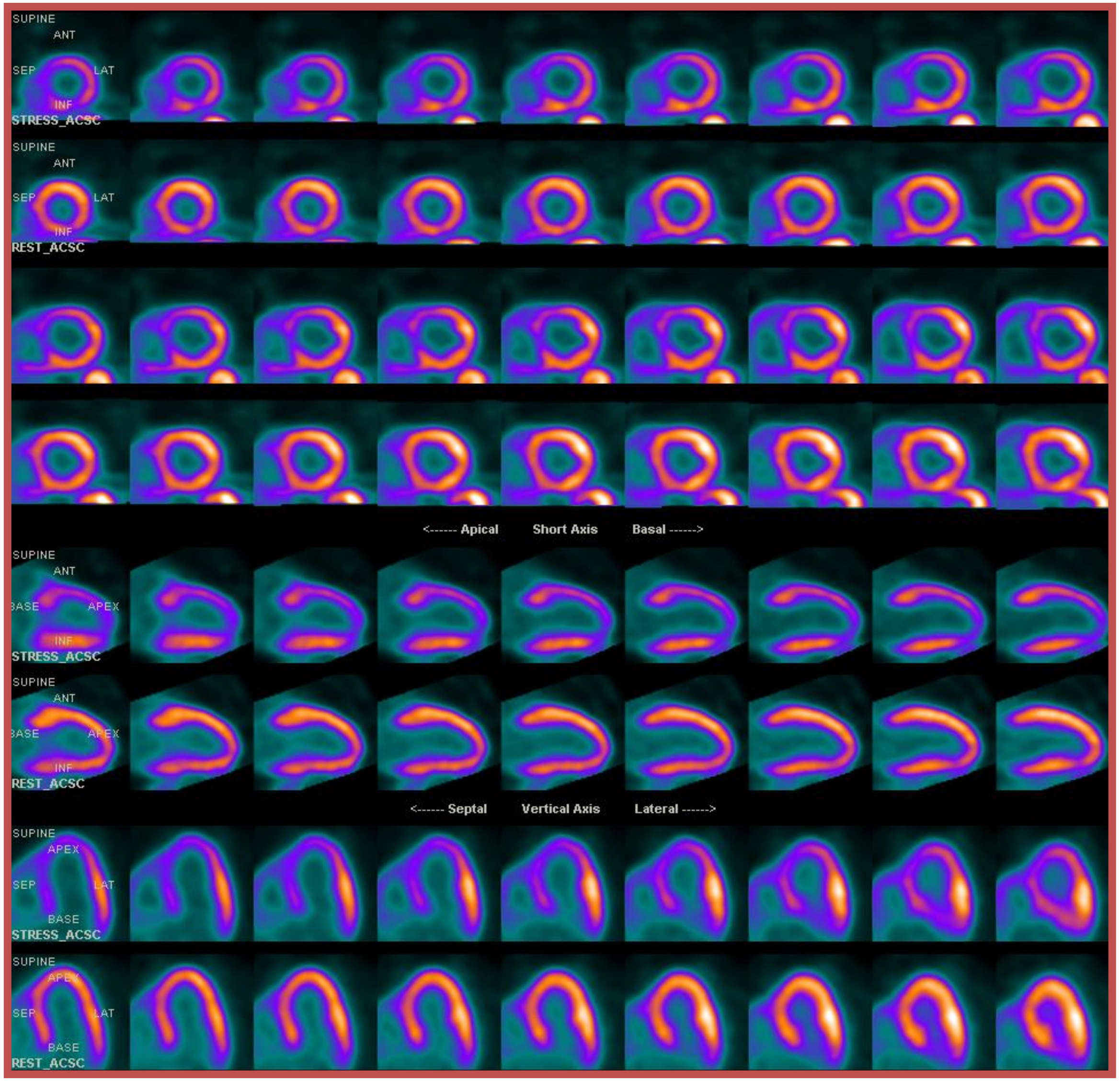
Rest

Stress

Rest

Stress

Rest



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PET

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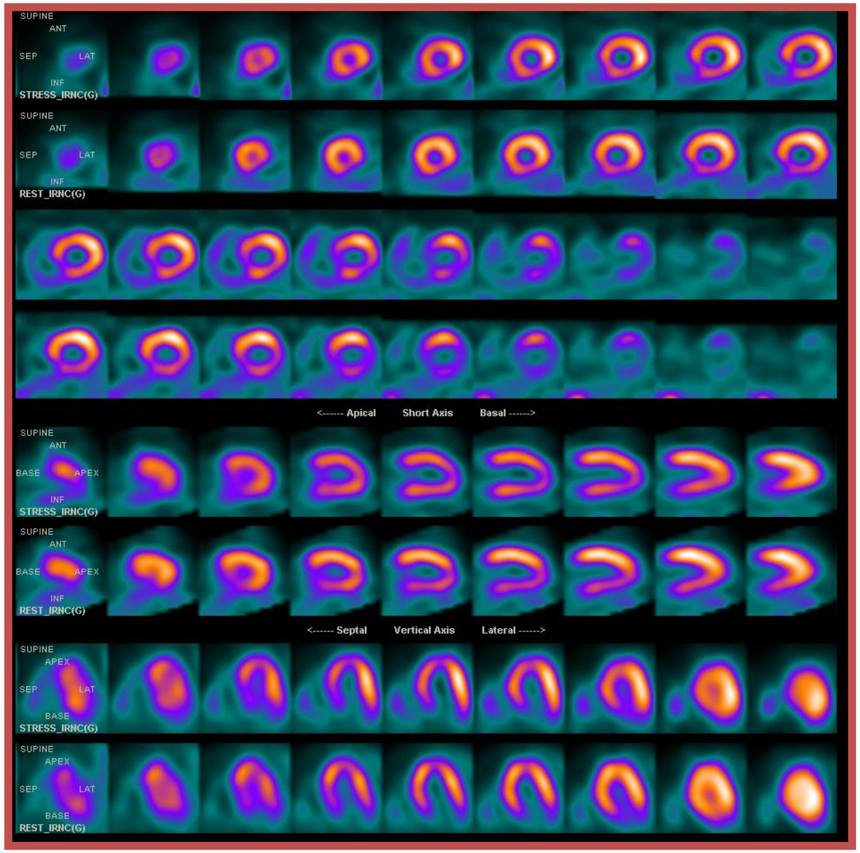
Perfusion Images

Tc-99m SPECT



Stress

Rest

Stress

Rest

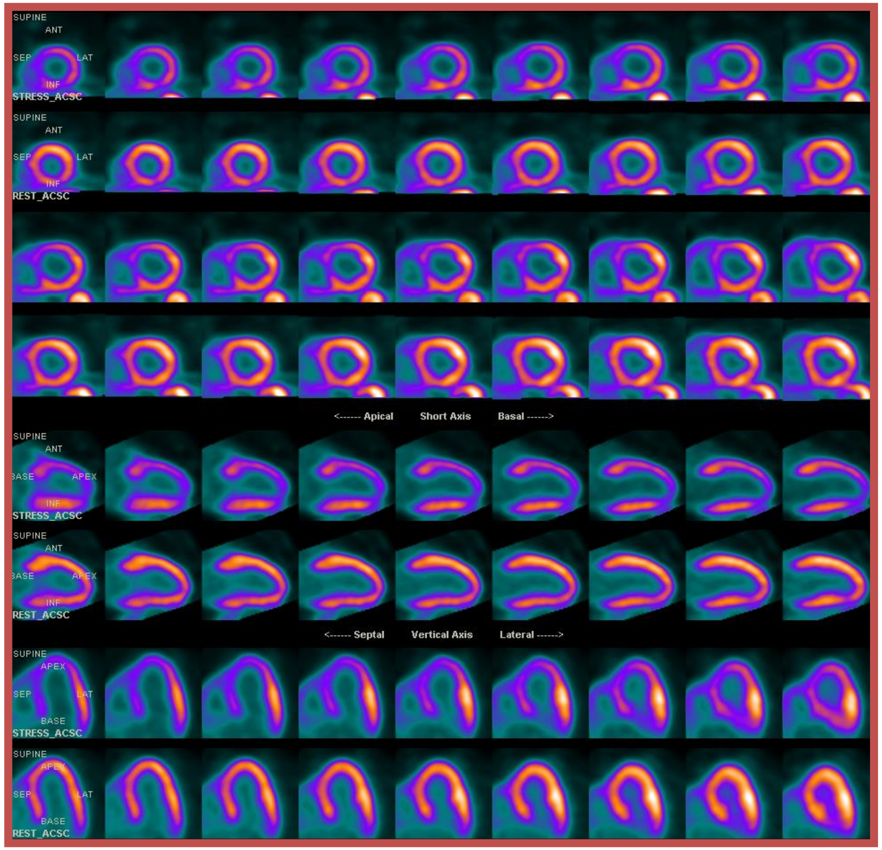
Stress

Rest

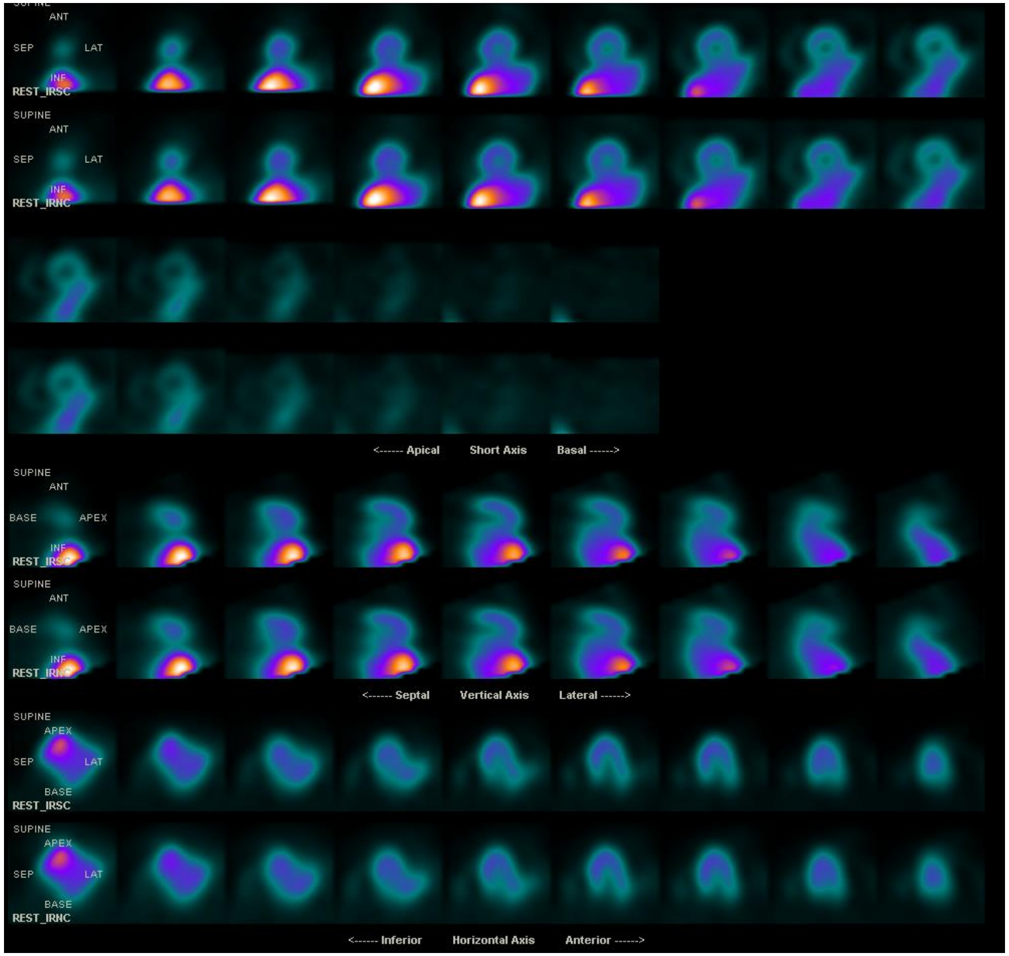
Stress

Rest

Rb-82 PET



Rest SPECT images



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Rb

Stress

Rest

Stress

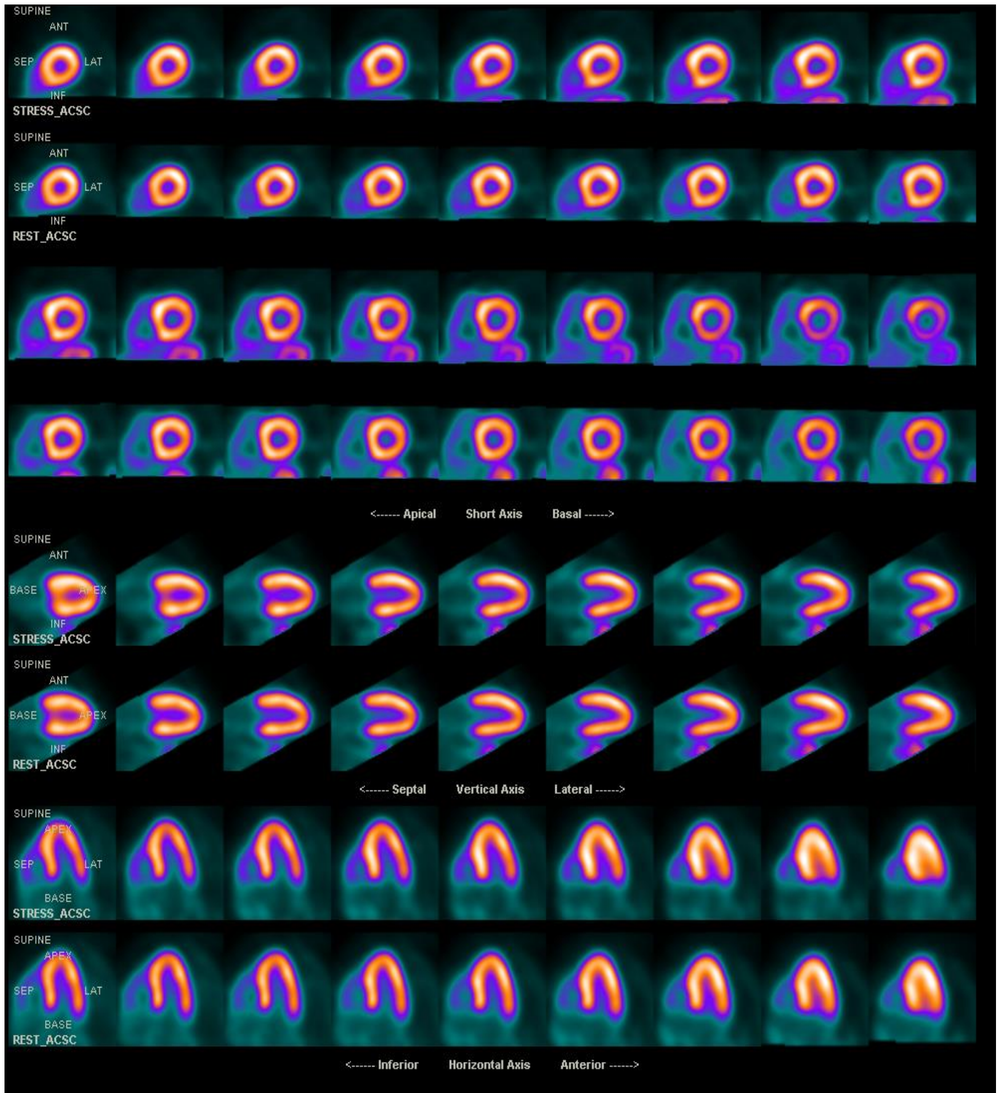
Rest

Stress

Rest

Stress

Rest



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Case example – Suspected CAD

- 79 year old female
- Atypical angina
- No reversible risk factors for CAD
- High coronary calcium (UK NICE guidelines)
- Cannot exercise

Calcium score CT

Calcium score

Artery	Number of Lesions (1)	Volume [mm³] (3)	Equiv. Mass [mg CaHA] (4)	Calcium Score (2)
LM	0	0.0	0.00	0.0
LAD	2	253.4	60.47	391.2
CX	1	104.3	25.20	156.9
RCA	7	353.3	89.17	418.9
Total	10	711.0	174.84	966.9

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Rb-82 PET Perfusion Images

Stress

Rest

Stress

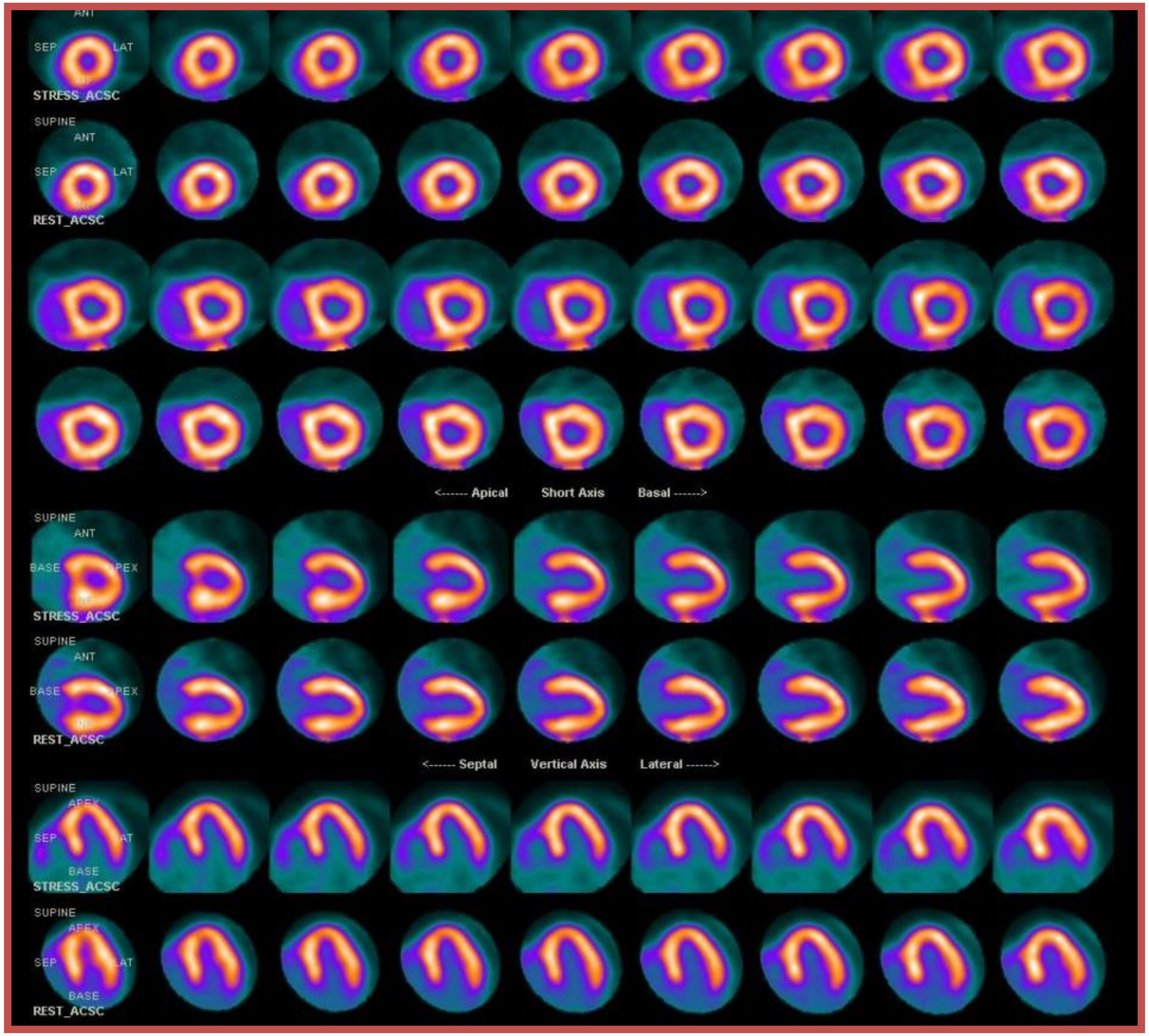
Rest

Stress

Rest

Stress

Rest



Absolute Blood Flow Measurement

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	QMP (ml/g/min)				Reserve	
	Stress		Rest			
	mean	std dev.	mean	std dev.	mean	std dev.
LAD	2.47	0.61	0.93	0.17	2.67	0.63
LCX	2.42	0.58	0.90	0.23	2.72	0.33
RCA	2.81	0.70	0.93	0.26	3.10	0.54
Global	2.53	0.64	0.92	0.21	2.79	0.57

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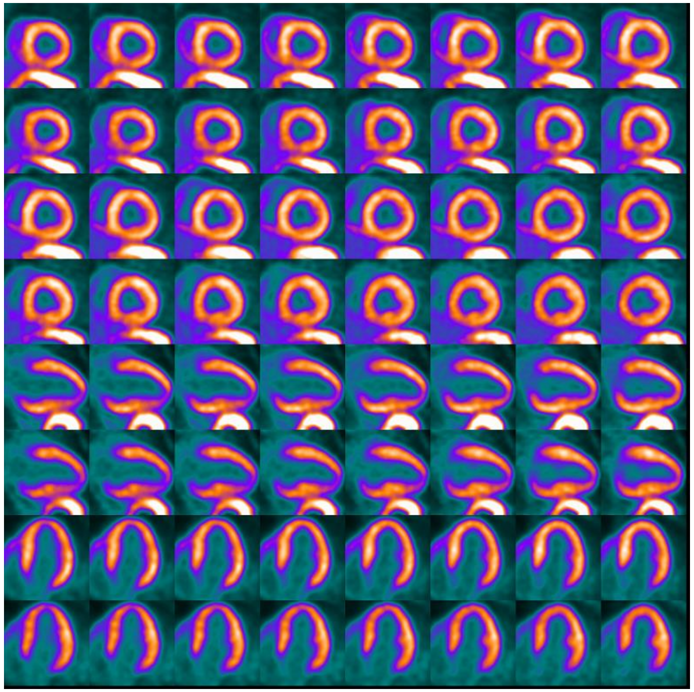
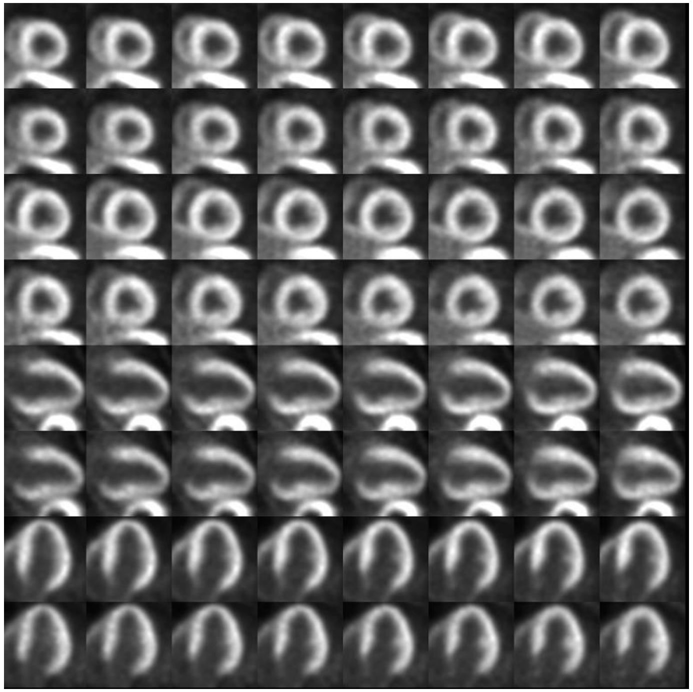
Case example – suspected CAD

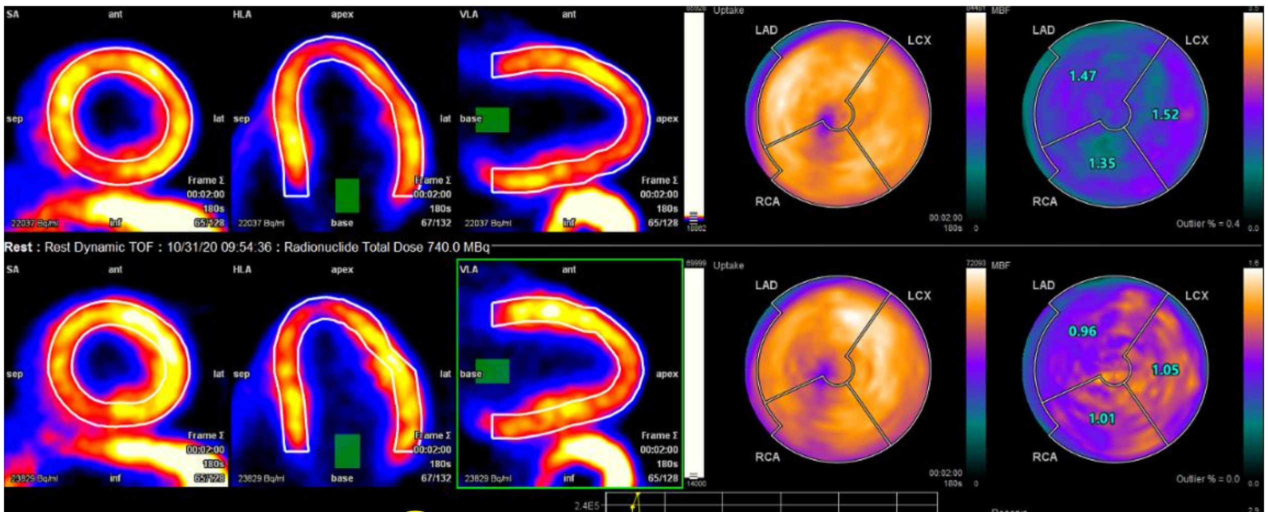
- Age and gender: 63 year old male
- Reason for study: Atypical Chest Pain and LBBB
- Risk factors: current smoker, family history of premature CAD and high BMI (33)
- Meds: Aspirin, Bisiprolol and S/L GTN

Relative perfusion Images





Myocardial Blood Flow (MBF) – Siemens MBF



	Flow (ml/g/min)				Reserve	
	Stress		Rest			
	mean	std dev.	mean	std dev.	mean	std dev.
LAD	1.47	0.17	0.96	[illegible]	1.56	[illegible]
LCX	1.52	0.24	1.05	[illegible]	1.48	[illegible]
RCA	1.35	0.24	1.01	0.11	1.36	[illegible]
Global	1.46	0.22	0.99	0.13	1.49	0.29

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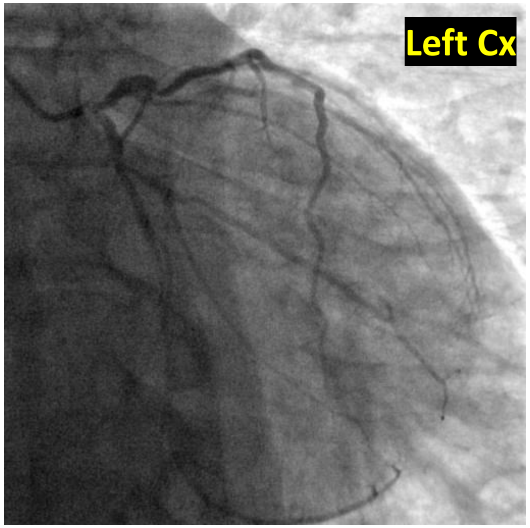
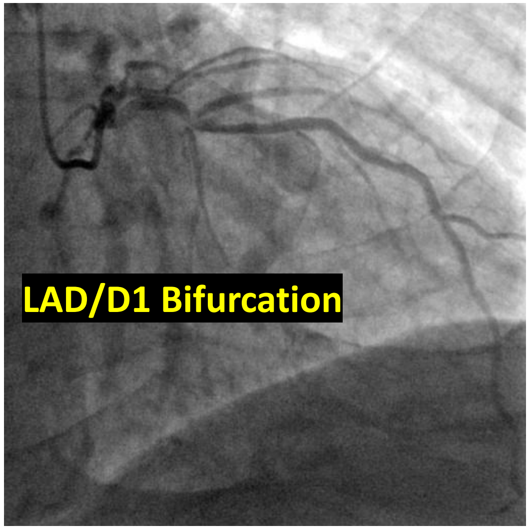
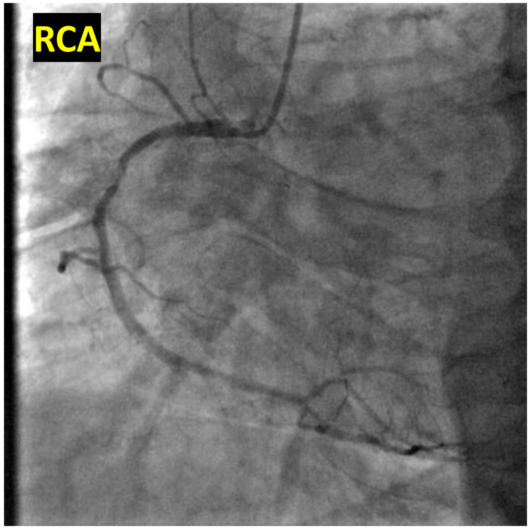
Coronary Angiography





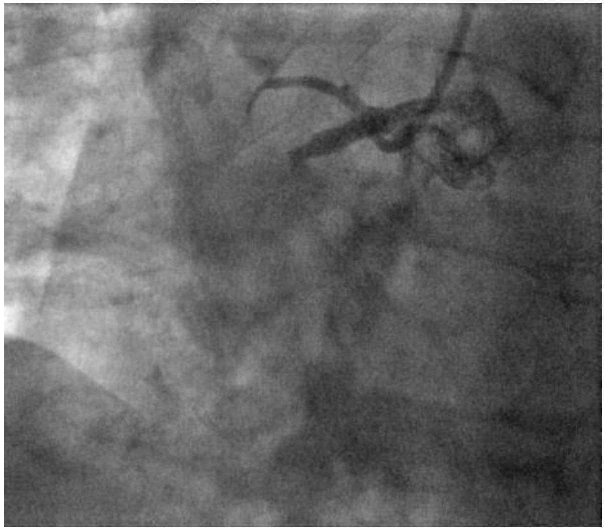


In view of multivessel disease, patient was referred for CABG

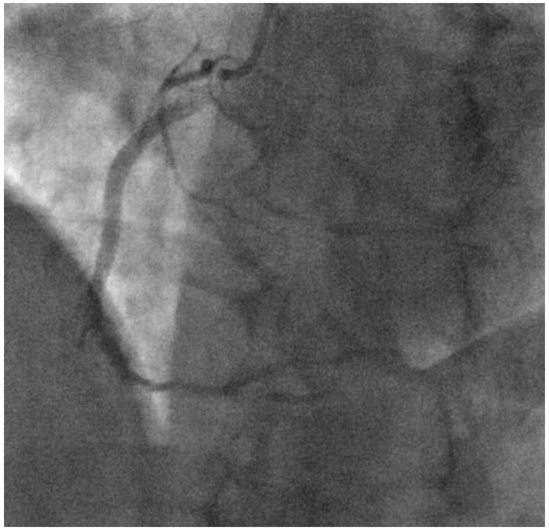
Case example - High BMI

- 61-year old female
- Atypical chest pain status post primary PCI to RCA following presentation with inferior MI one year prior
- High BMI (**height 1.58 m and weight 154 kg, BMI 62 kg/m^2**)

Invasive Coronary Angiography
NSTEMI Primary PCI

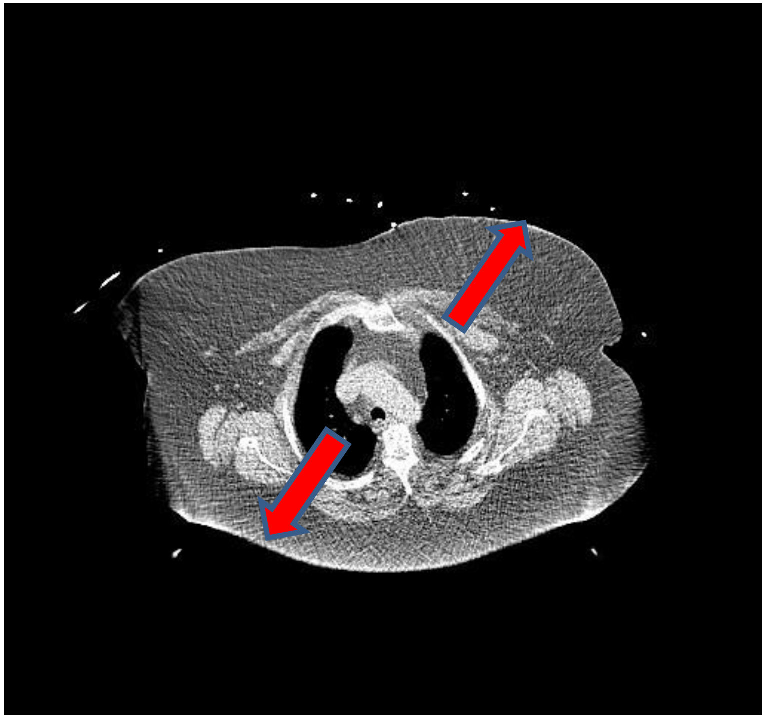


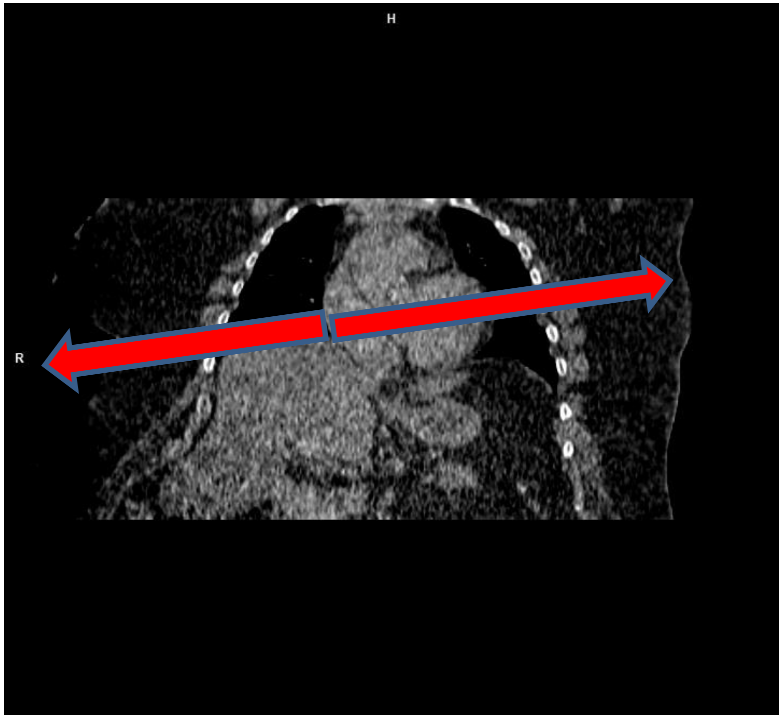
Pre PCI



Post PCI

CT Chest Showing Significant Tissue Interposition Between Mediastinum and Chest Wall





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Relative Perfusion Images

Stress

Rest

Stress

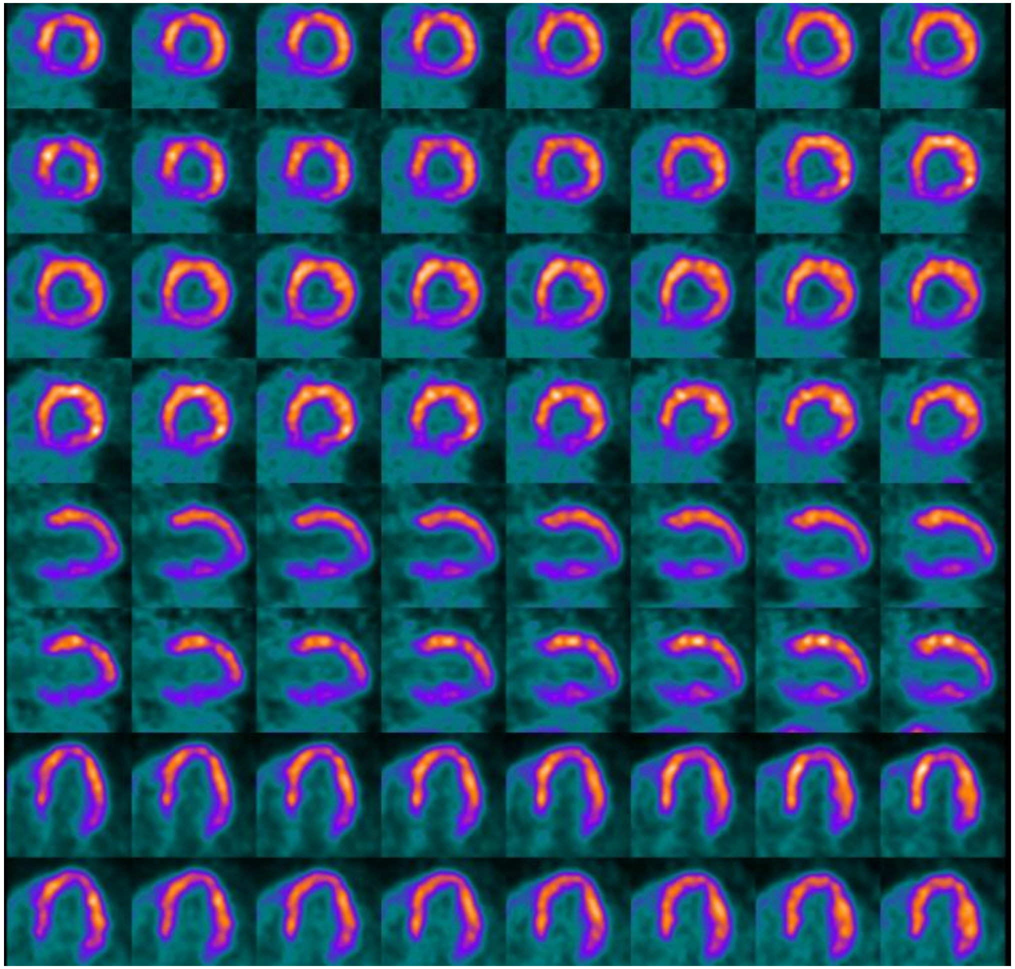
Rest

Stress

Rest

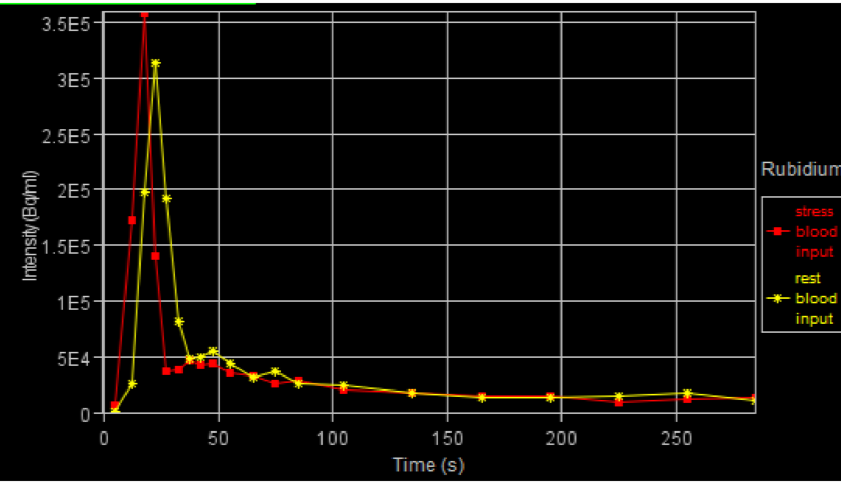
Stress

Rest



Myocardial Blood Flow

	Flow (ml/g/min)				Reserve	
	Stress		Rest			
	mean	std dev.	mean	std dev.	mean	std dev.
LAD	1.90	0.42	0.89	0.17	2.15	0.40
LCX	1.79	0.31	0.98	0.17	1.84	0.23
RCA	1.08	0.16	0.53	0.10	2.07	0.31
Global	1.67	0.48	0.83	0.23	2.05	0.36



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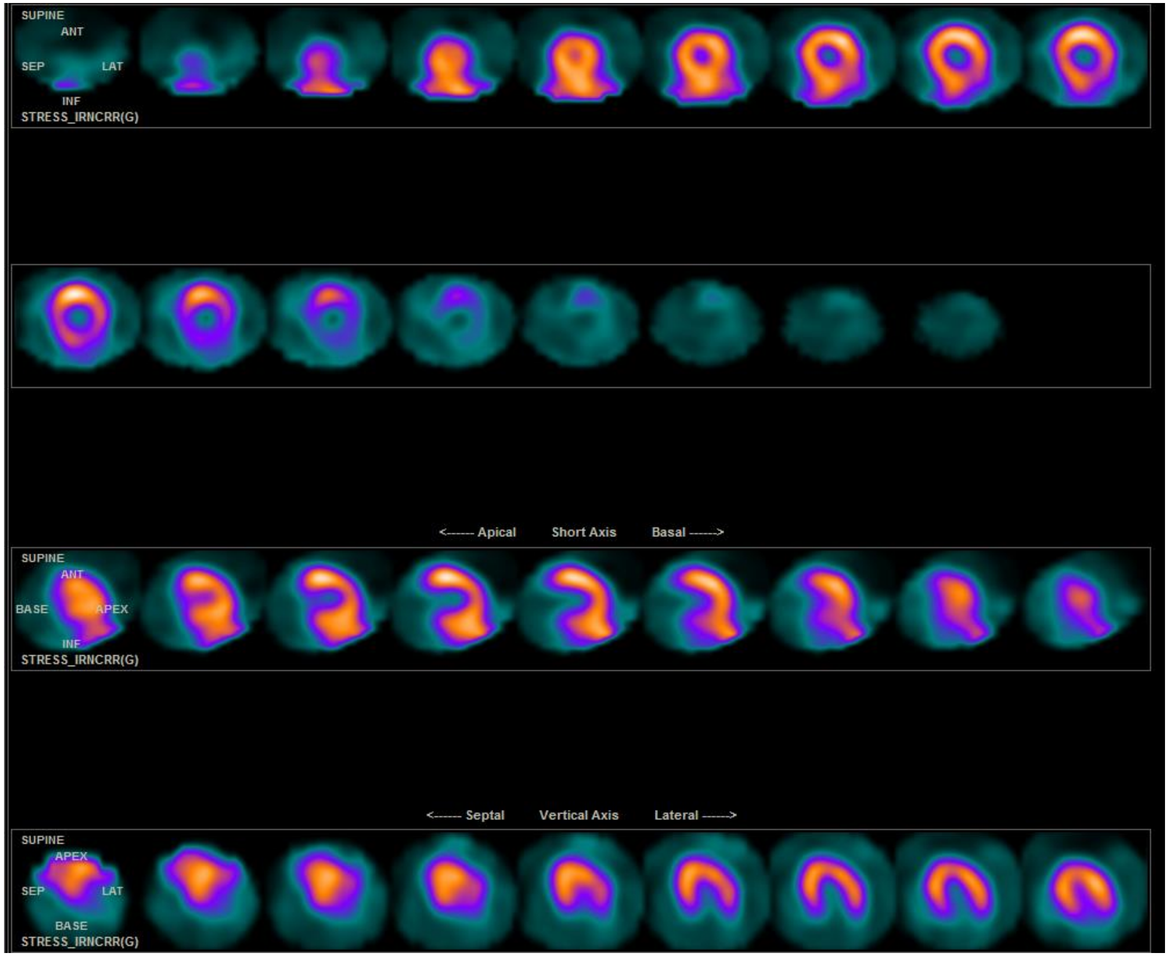
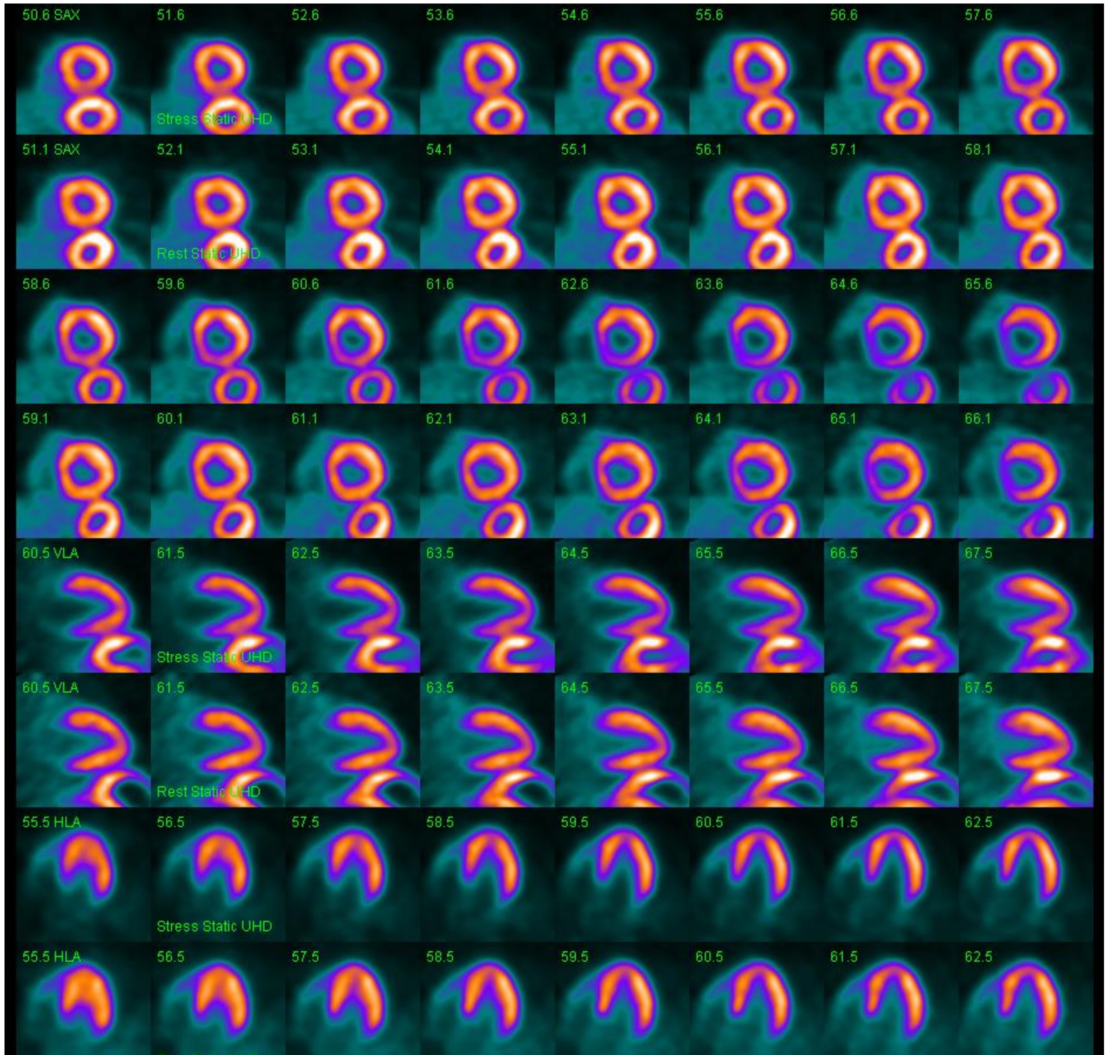
MB

- 63 Female
- Recurrent chest pain
- Troponin negative
- Hypertension, hyperlipidaemia and ex smoker

Stress SPECT



Rubidium relative perfusion images



Stress

Rest

Stress

Rest

Stress

Rest

Stress

Rest

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Blood flow

	Flow (ml/g/min)				Reserve	
	Stress		Rest			
	mean	std dev.	mean	std dev.	mean	std dev.
LAD	3.19	0.74	1.52	0.34	2.11	0.32
LCX	2.86	1.25	1.44	0.51	1.92	0.37
RCA	1.66	0.81	1.22	0.33	1.30	0.38
Global	2.73	1.11	1.42	0.41	1.86	0.47

Intensity (Bq/ml)

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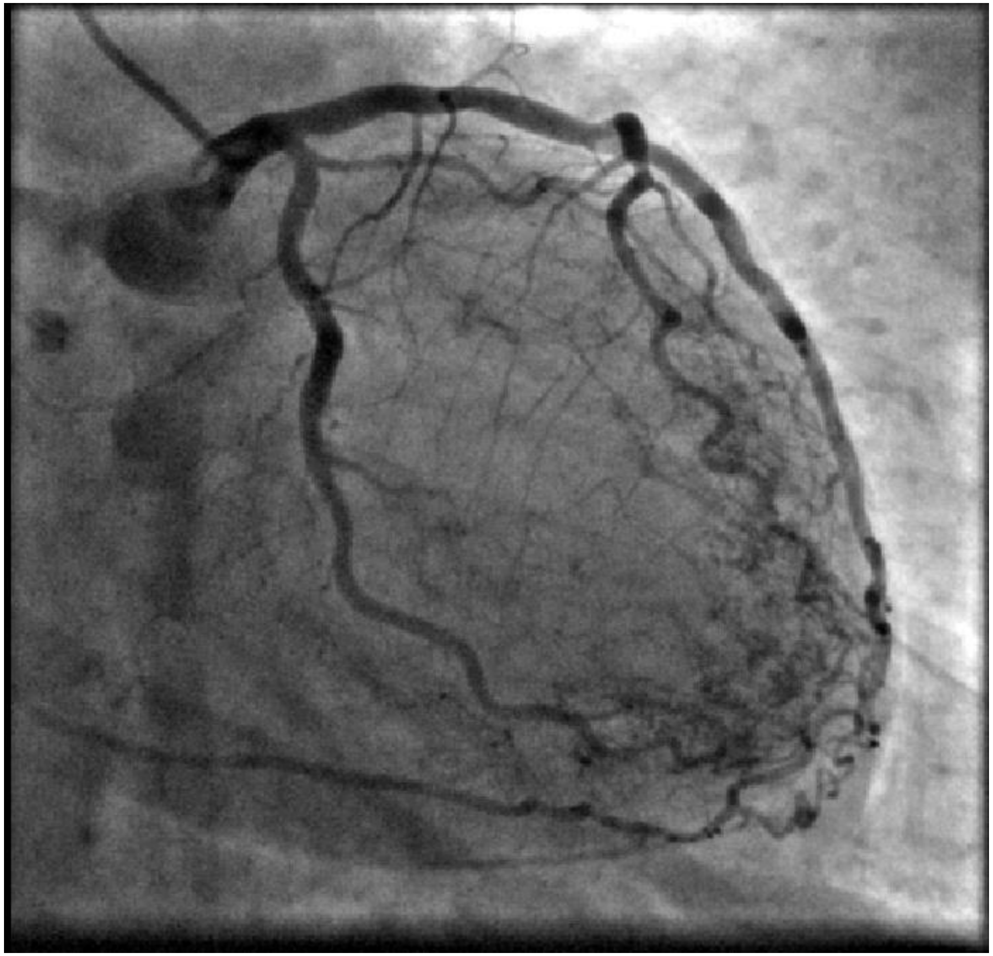
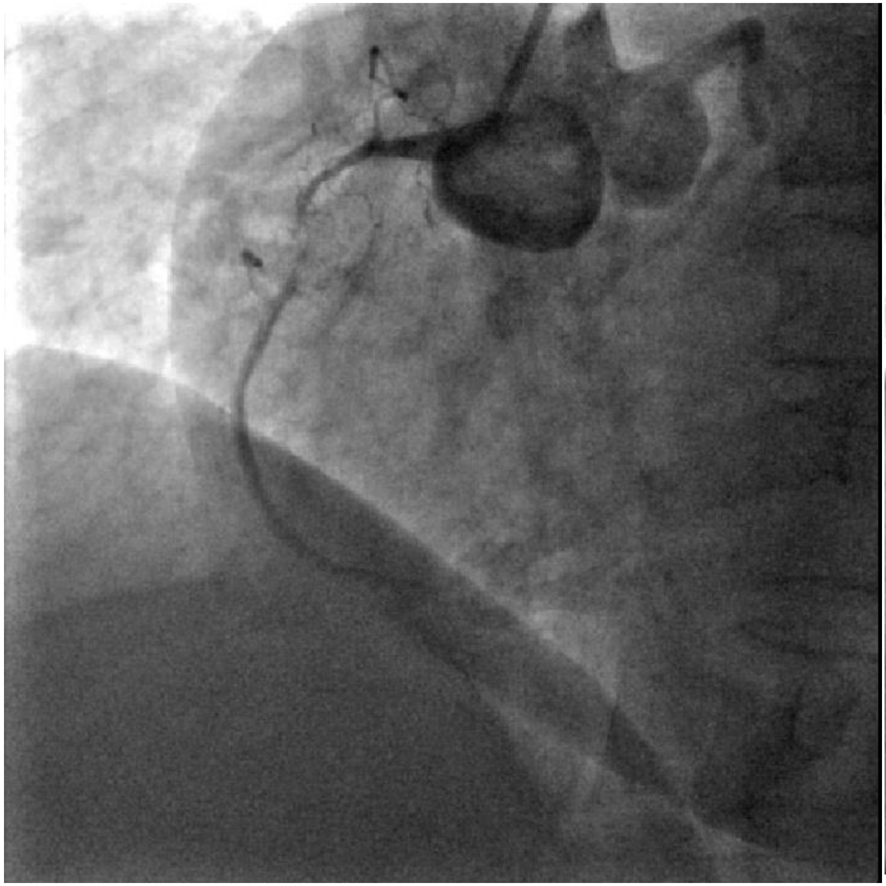
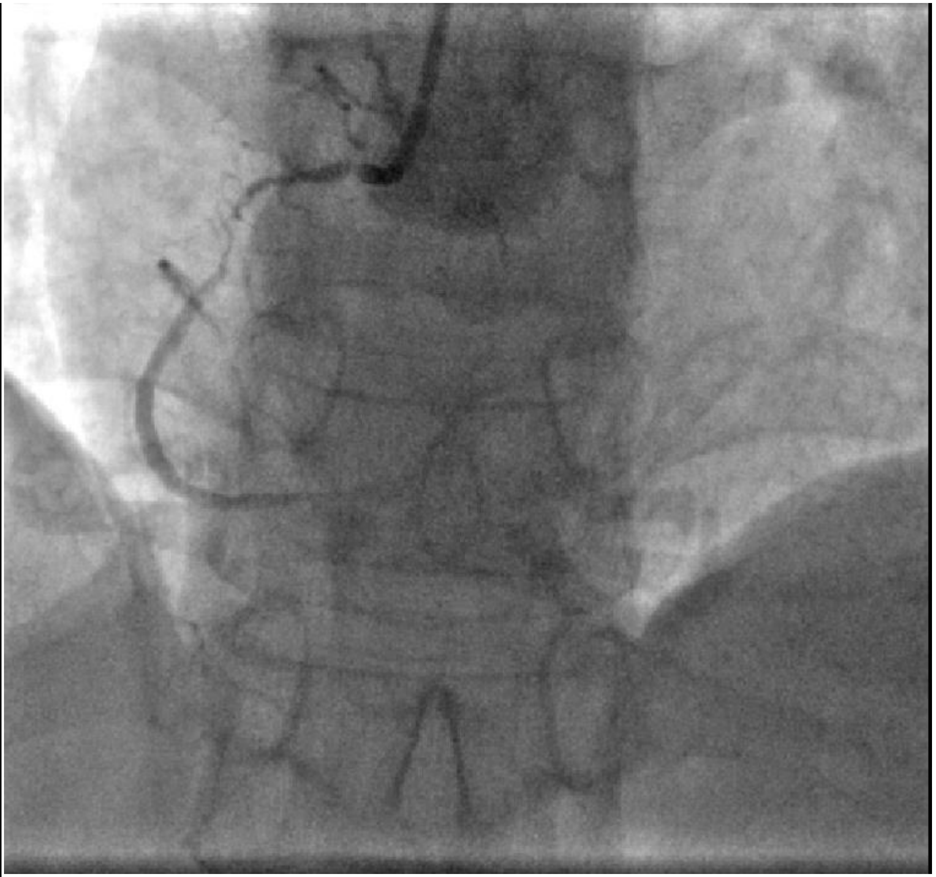
Left circulation

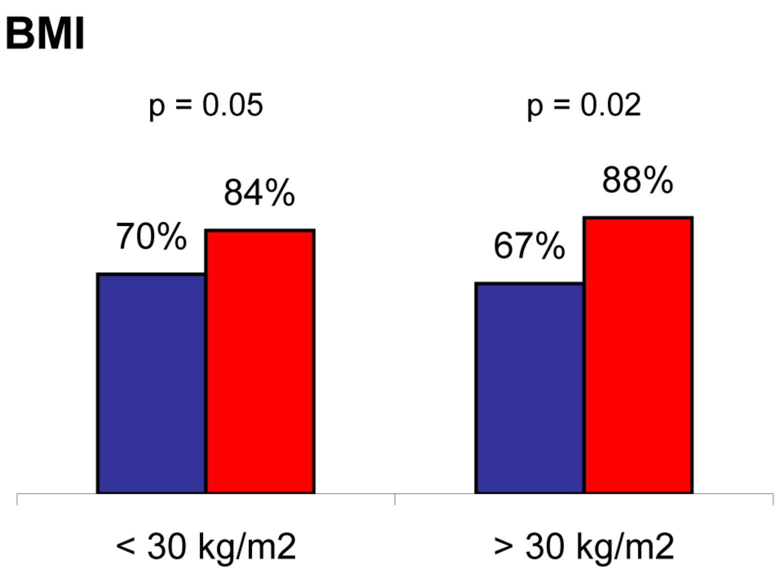


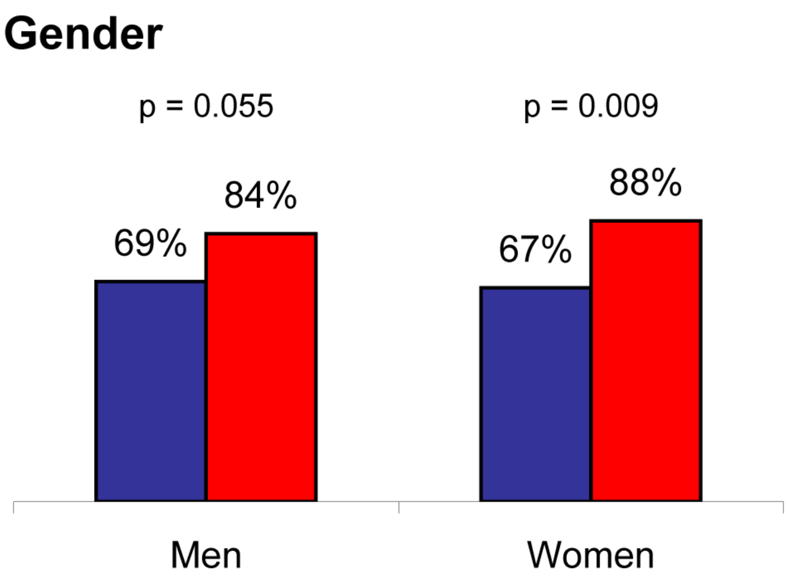
RCA





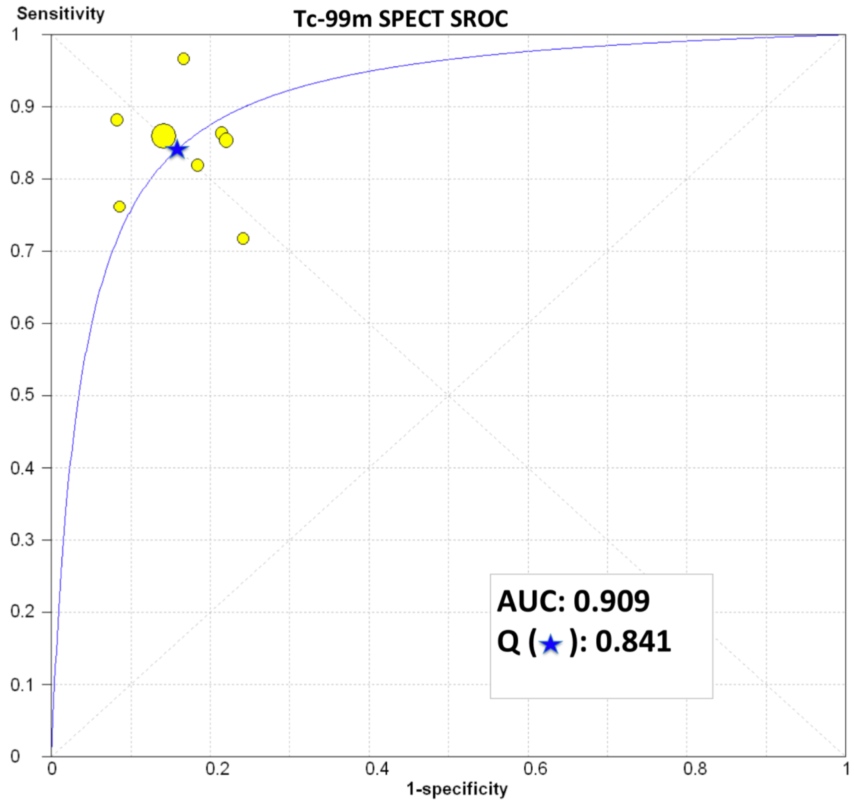
State of the art SPECT versus PET

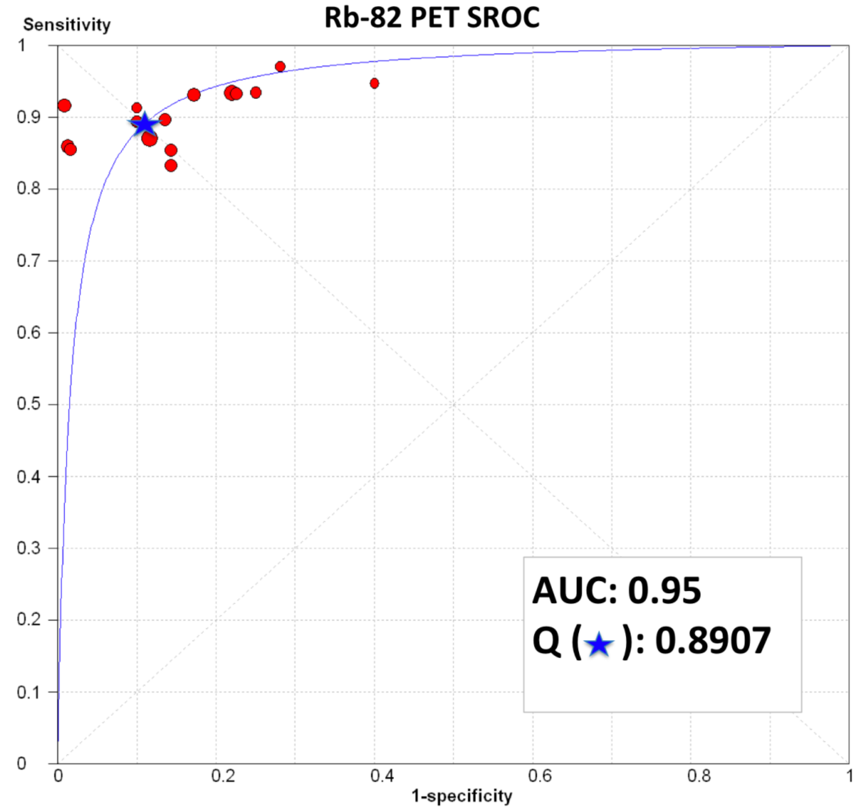




Bateman T, Heller GV, McGhie I et al. (2006). Diagnostic Accuracy of Rest/Stress ECG-gated Rubidium-82 Myocardial Perfusion PET: Comparison with ECG-gated Tc-99m-Sestamibi SPECT. J Nucl Cardiol. 13(1):24-33.

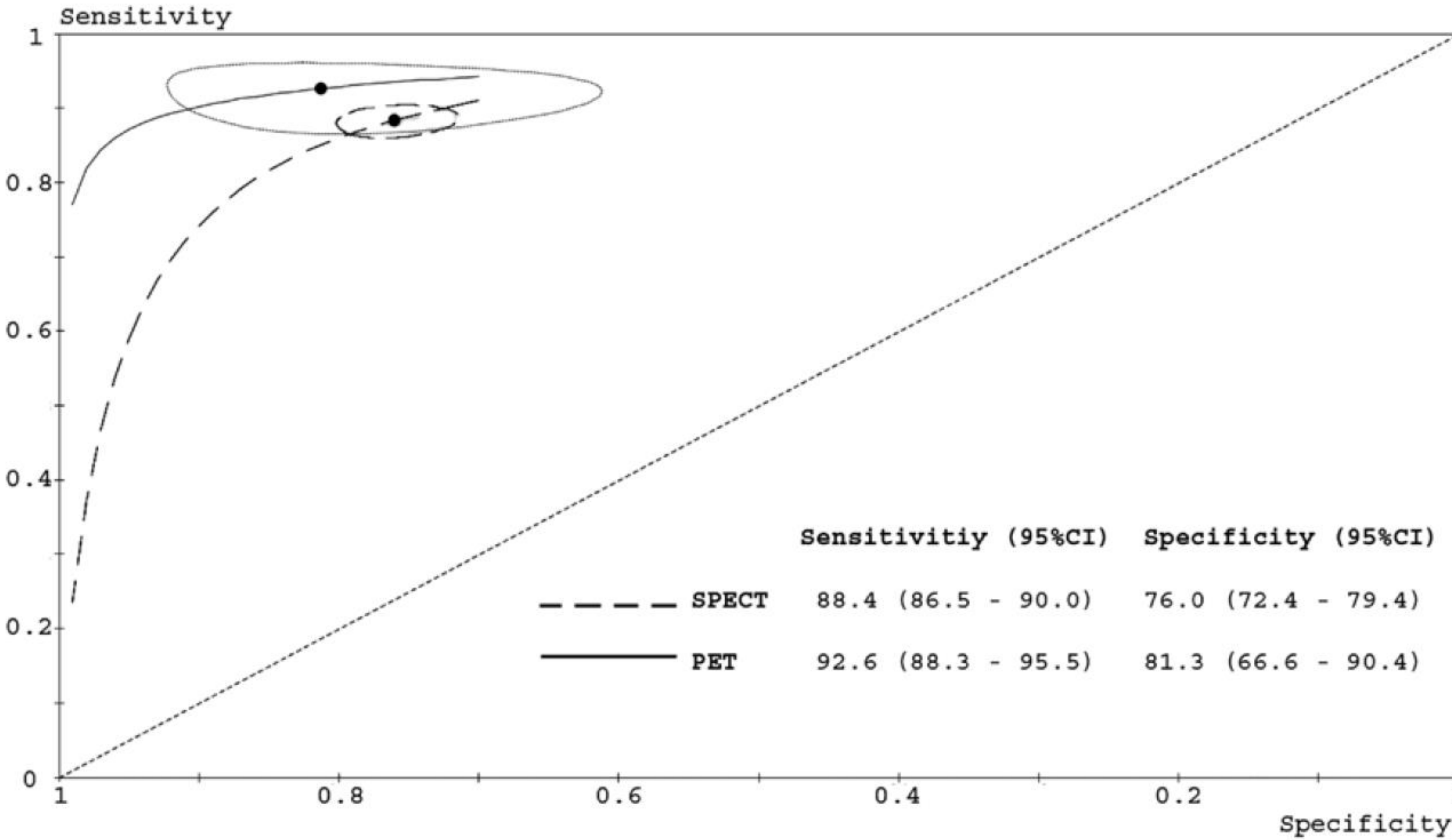
ROC – McArdle et al





McArdle et al. (2012). Does rubidium-82 PET have superior accuracy to SPECT perfusion imaging for the diagnosis of obstructive coronary disease?: A systematic review and meta-analysis. J Am Coll Cardiol. 60(18):1828-37.

ROC – Parker et al



Parker et al. (2012). Diagnostic accuracy of cardiac positron emission tomography versus single photon emission computed tomography for coronary artery disease: a bivariate meta-analysis. Circ Cardiovasc Imaging. 5(6):700-7.

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CLINICAL RESEARCH
Imag

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[1]Department of Cardiology, University of Missouri - Kansas City, Kansas City, MO 64111, USA; [2]Saint Luke's Mid America Heart Institute, 4401 Wornall Rd, 9th floor CV Research, Kansas City, MO 64111, USA; and [3]Cardiovascular Imaging Technologies, Kansas City, MO, USA

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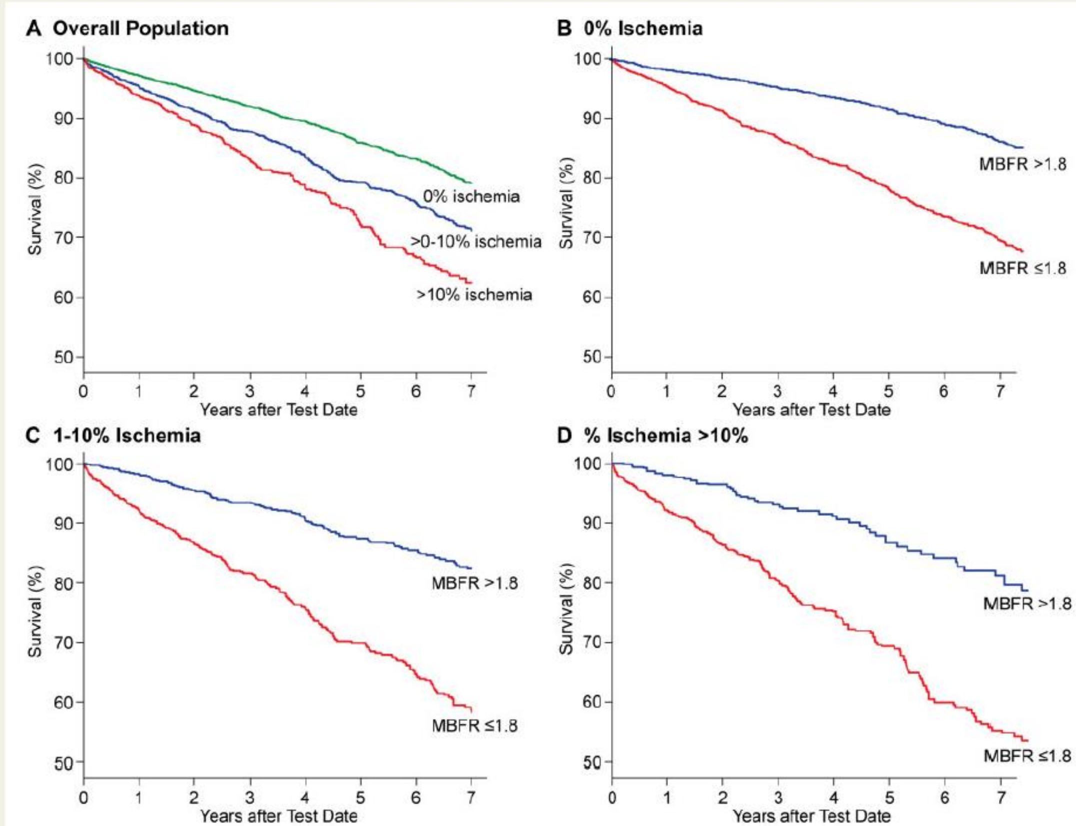

Figure 2 Kaplan–Meier unadjusted survival estimates as a function of percent ischaemic myocardium at baseline (*A*), and substratified by myocardial blood flow reserve within 0% (*B*), 1–10% (*C*) and >10% (*D*) ischaemia.

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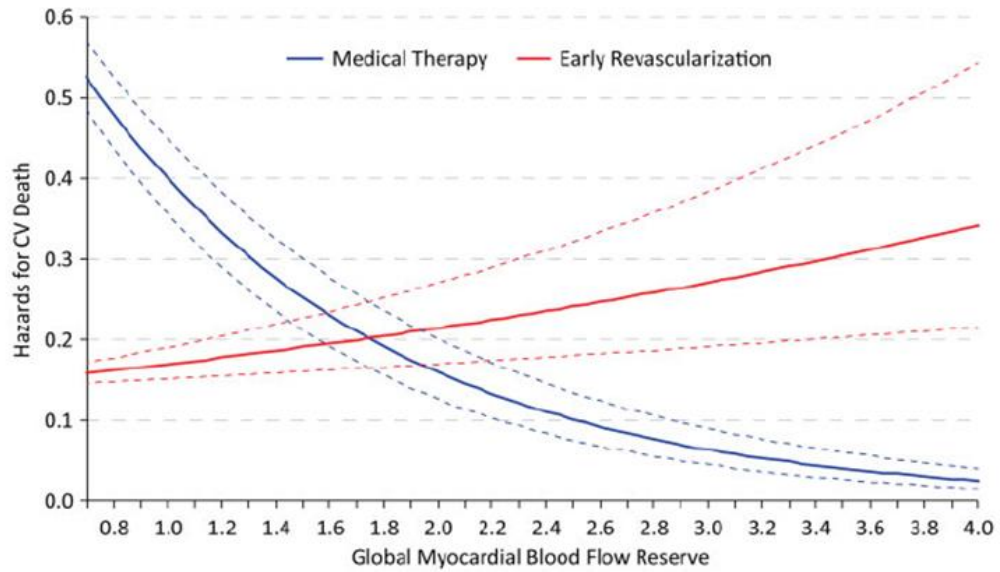

Figure 5 Hazards for cardiac death with early revascularization compared to medical therapy based on global myocardial blood flow reserve by positron emission tomography myocardial perfusion imaging.

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Radiation Dose to Patients (UK administered activity)

	Admin. activity	ED (mSv)	+CTAC
^{99m}Tc sestamibi **(RR)**	**400 MBq X 2 (S+R)**	**8**	
^{99m}Tc tetrofosmin **(RR)**	**400 MBq x 2 (S+R)**	**6**	
^{201}Tl	**80 MBq (Str+Redist)**	**16**	
^{82}Rb	**2×20 mCi**	**1.8**	**2.1**

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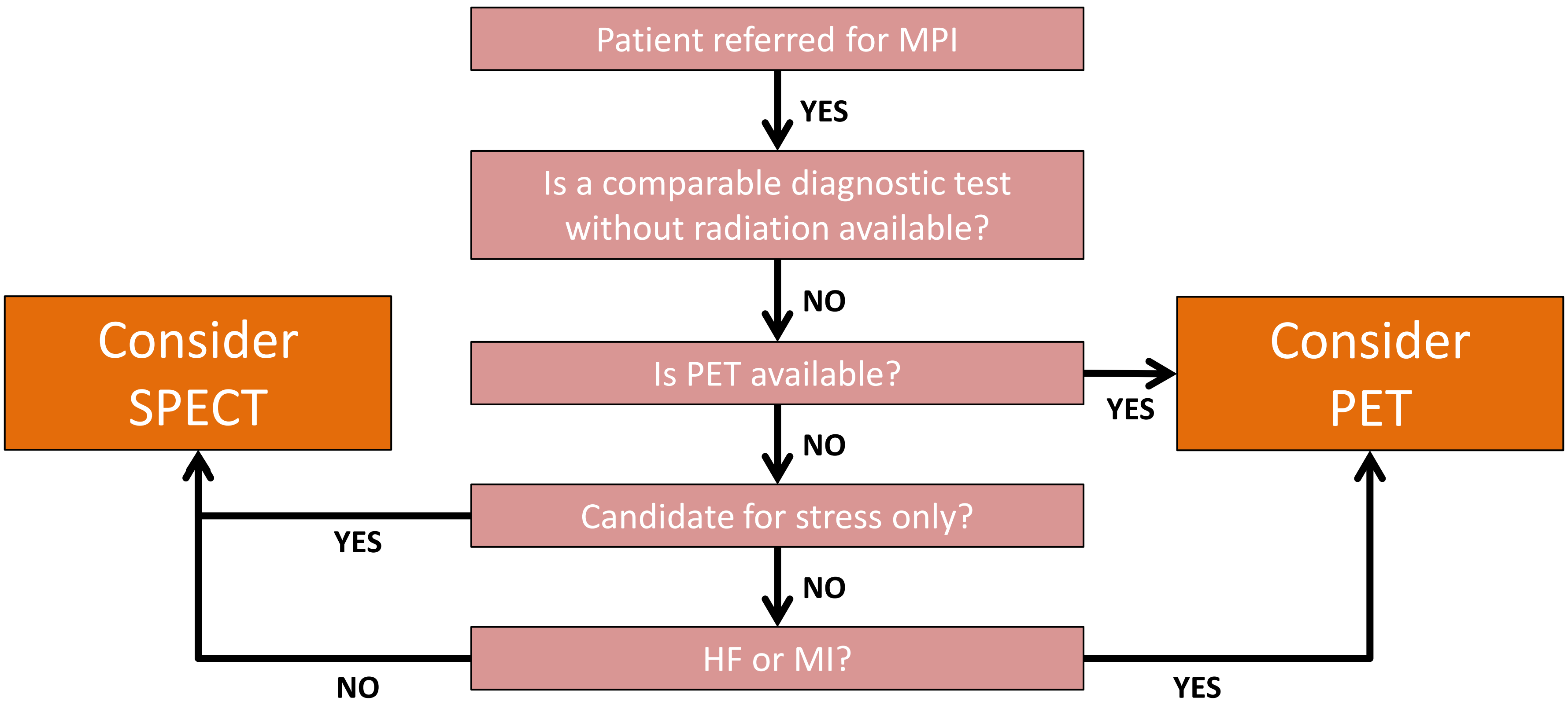
Dose reduction - 2010

ASNC INFORMATION STATEMENT

Recommendations for reducing radiation exposure in myocardial perfusion imaging



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Choice of SPECT vs PET

- SPECT Pro
  - Widely available
  - ‘Cheaper’ technology

- PET Pro
  - Rapid throughput
  - Fixed cost
  - Superior diagnostic accuracy
    - Reduced downstream costs
  - Societal benefit – reduced radiation to patients and staff