Role of CT Imaging for Cardiac Disease and Applications of Multi-detector CT

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Scope

- Cardiac Imaging – Challenges
- Coronary Artery Calcium Scoring
- Coronary CT Angiography
- Stents and Grafts
- LV and RV Function
- Valve Assessment
- Extended Protocols
- Summary

Cardiac imaging - Challenges

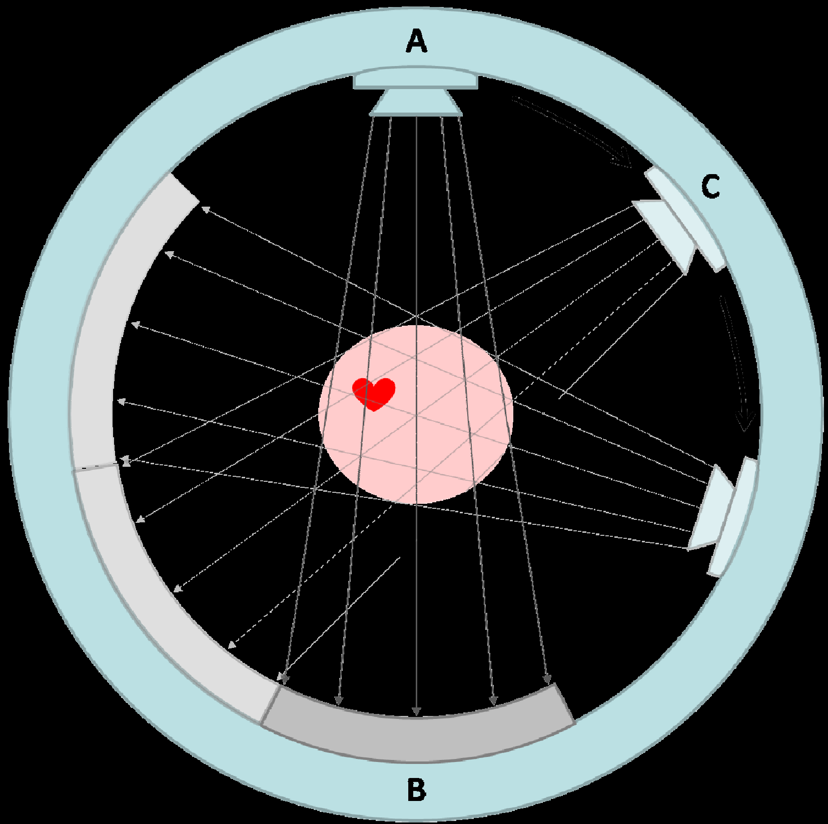
- Complex 3-D structures
- Complex motion
- Small structures must be resolved

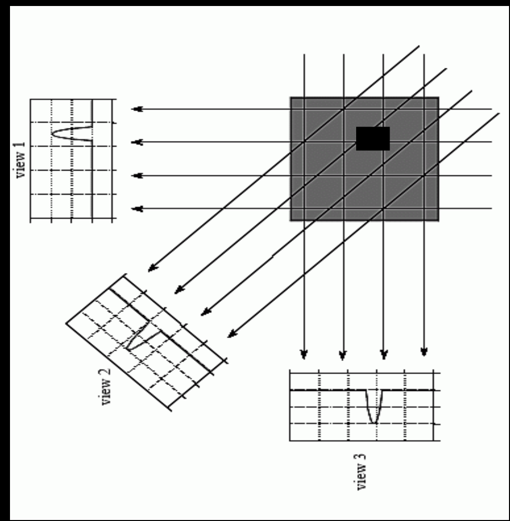
  (0.5 – 4mm)
- Significant inter-patient variation in anatomy

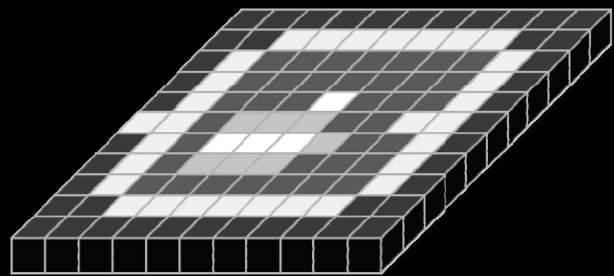
Options

- Appropriate test is determined by clinical question
  - Do we want to assess
    - Anatomy?
    - Function?
    - Viability?
- Appropriate tests might include:
  - Echocardiography
  - Cardiac MRI (CMR)
  - Myocardial Perfusion Scintigraphy
  - Cardiac Multi-detector Computed tomography (MDCT)
  - Invasive coronary angiography

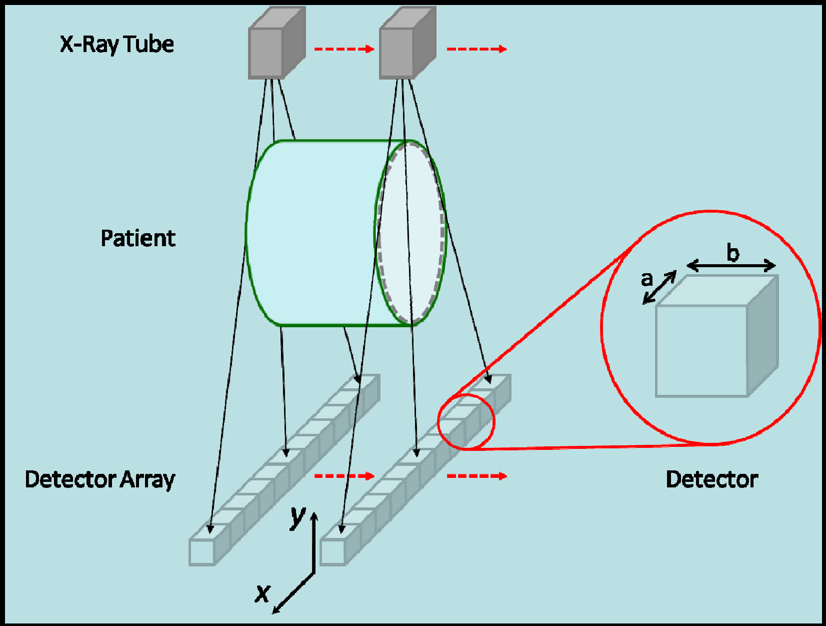
What is computed tomography?

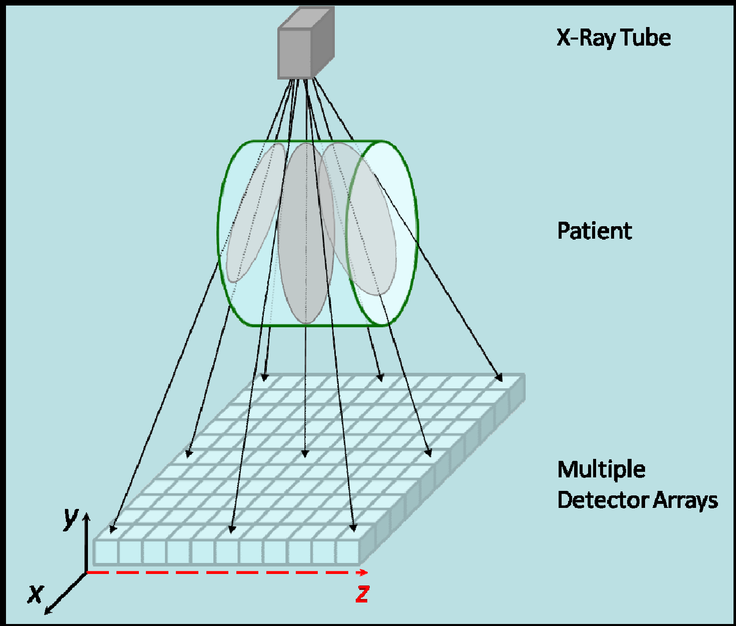


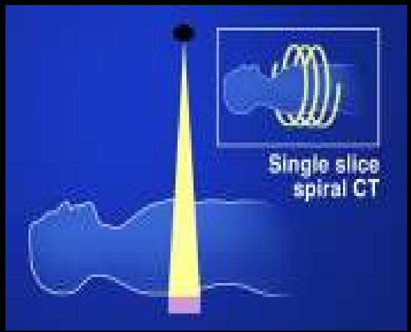


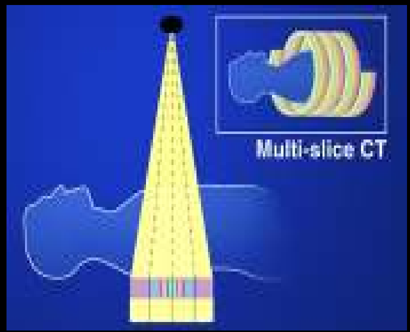


Single vs. Multi-detector CT







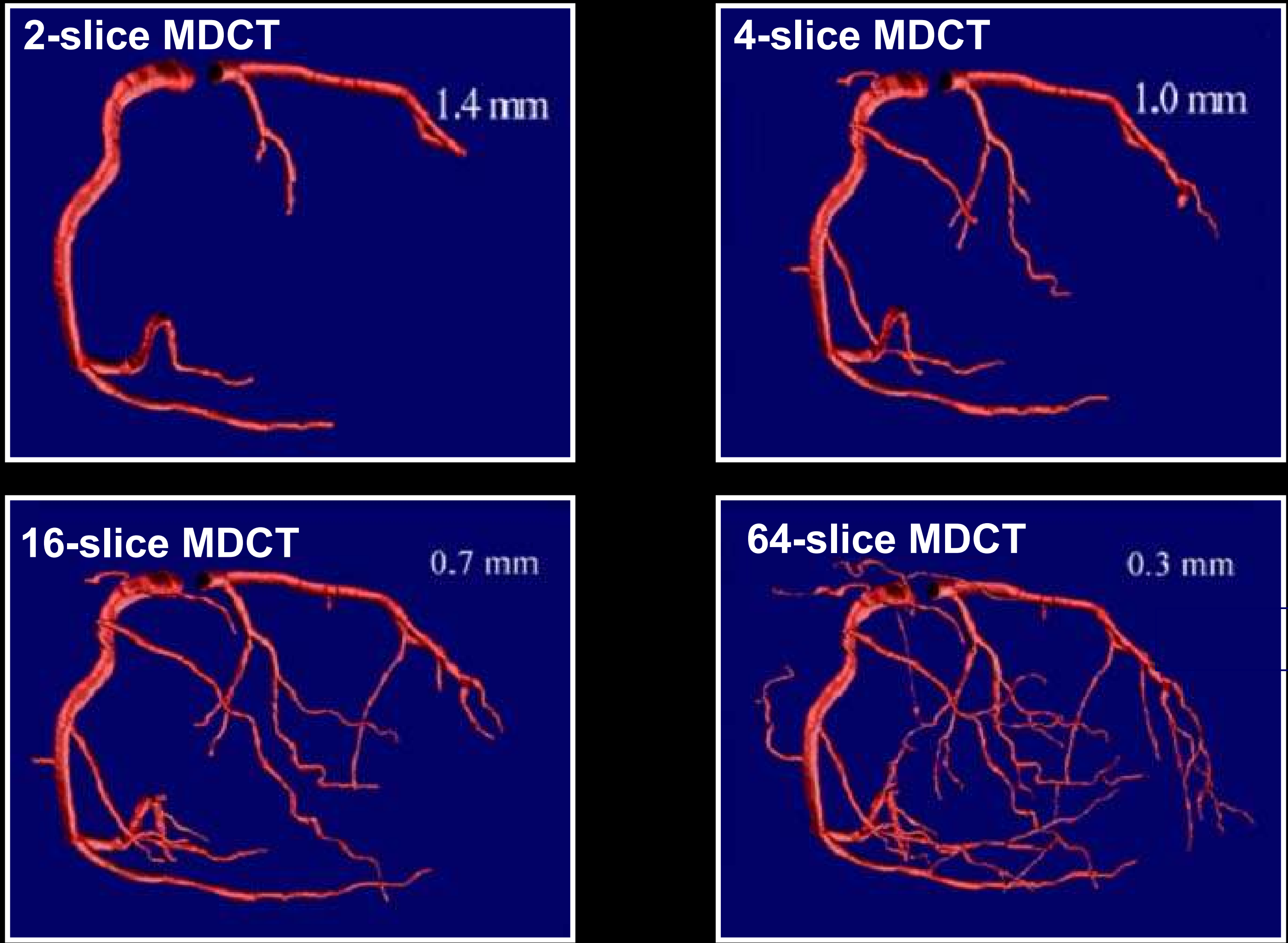


Cardiac CT Revolution

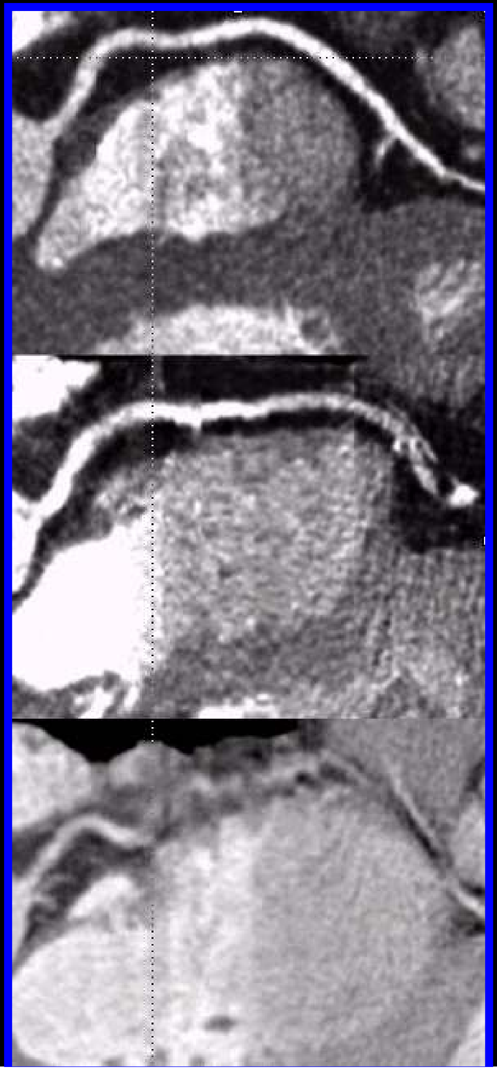
- EBCT – temporal resolution 100ms
  - Spatial resolution $(1.0mm)^{3*}$
- 4 MDCT (1998) - 250ms, $(1.0mm)^3$
- 16 MDCT (2002)- 250ms, $(0.7mm)^3$
- 64 -320 MDCT (2004-7) – 125-165ms, $(0.4mm)^3$
- 64 DSCT (2007)- 83ms, $(0.4mm)^3$
- 64 Dual Energy DSCT

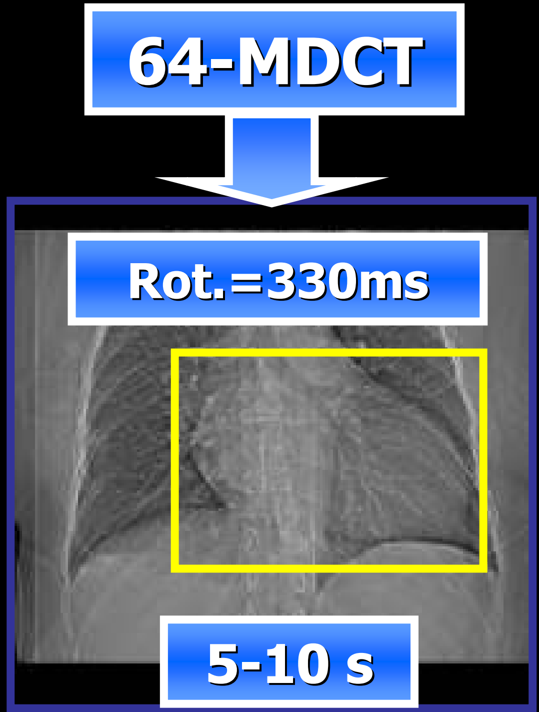
* No ability to retrospectively ECG-gate study

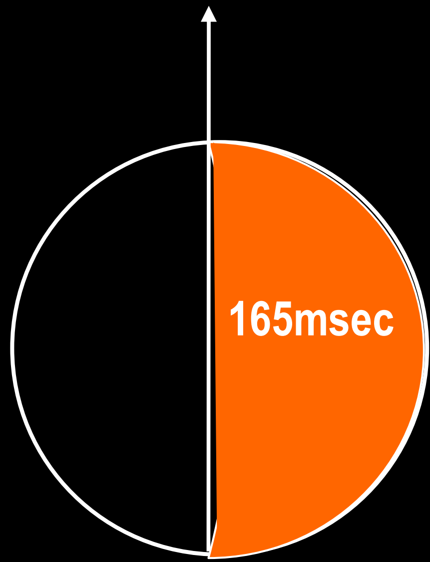
Spatial resolution



Temporal Resolution and its relationship to heart rate (64-MDCT)





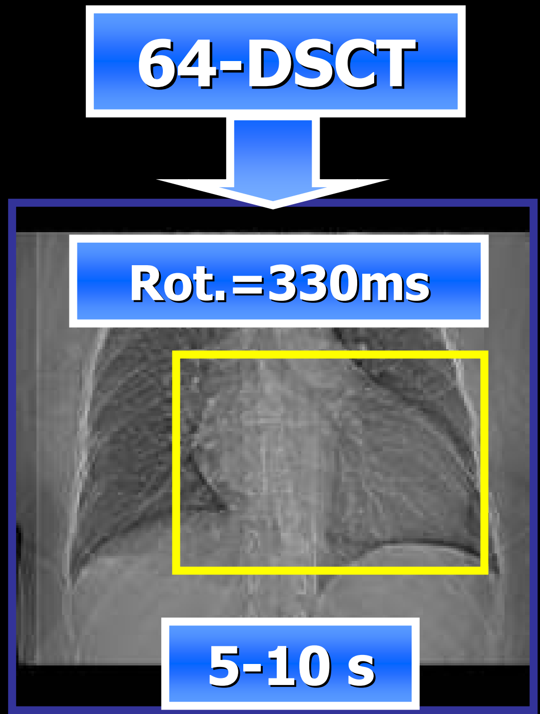


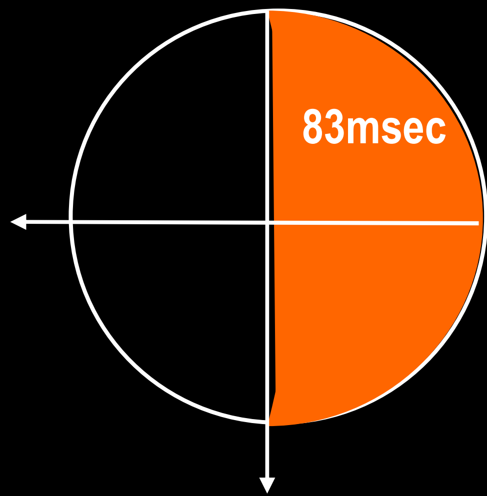
330 ms Gantry Rotation Time = half scan segment = temporal resolution of 165 ms

Flohr TG, Herz, 2003

Temporal Resolution and its relationship to heart rate (64-DSCT)

HR 100+

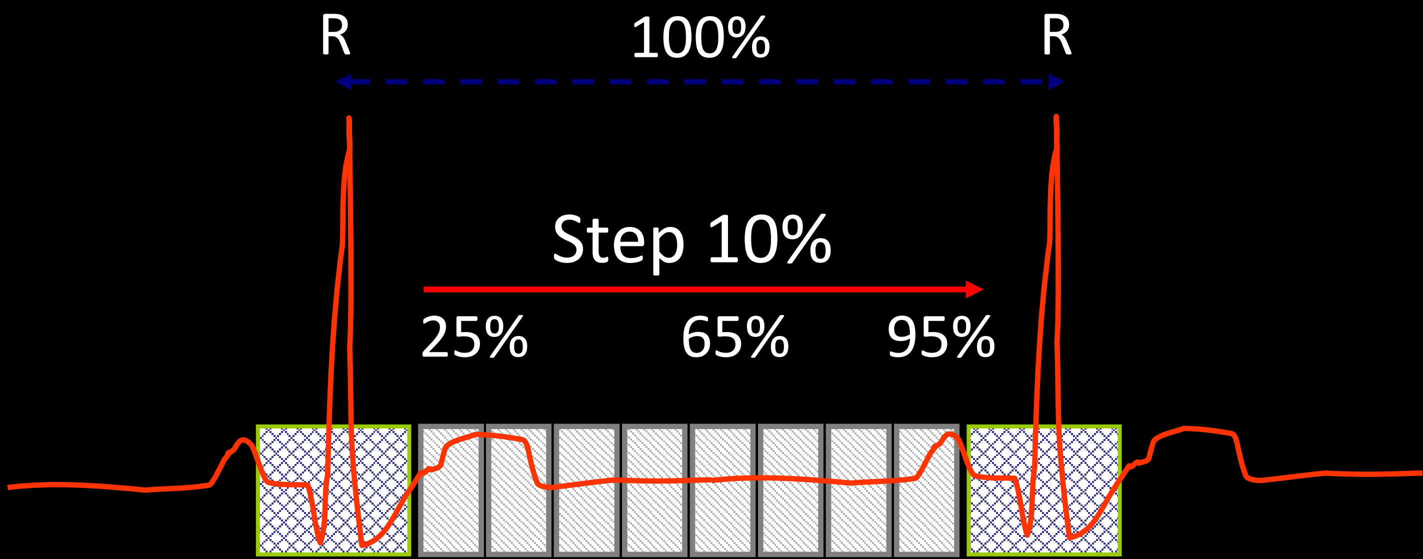




330 ms Gantry Rotation Time = 1/4 scan segment = temporal resolution of 83 ms

Adapted from Flohr TG, Herz, 2003

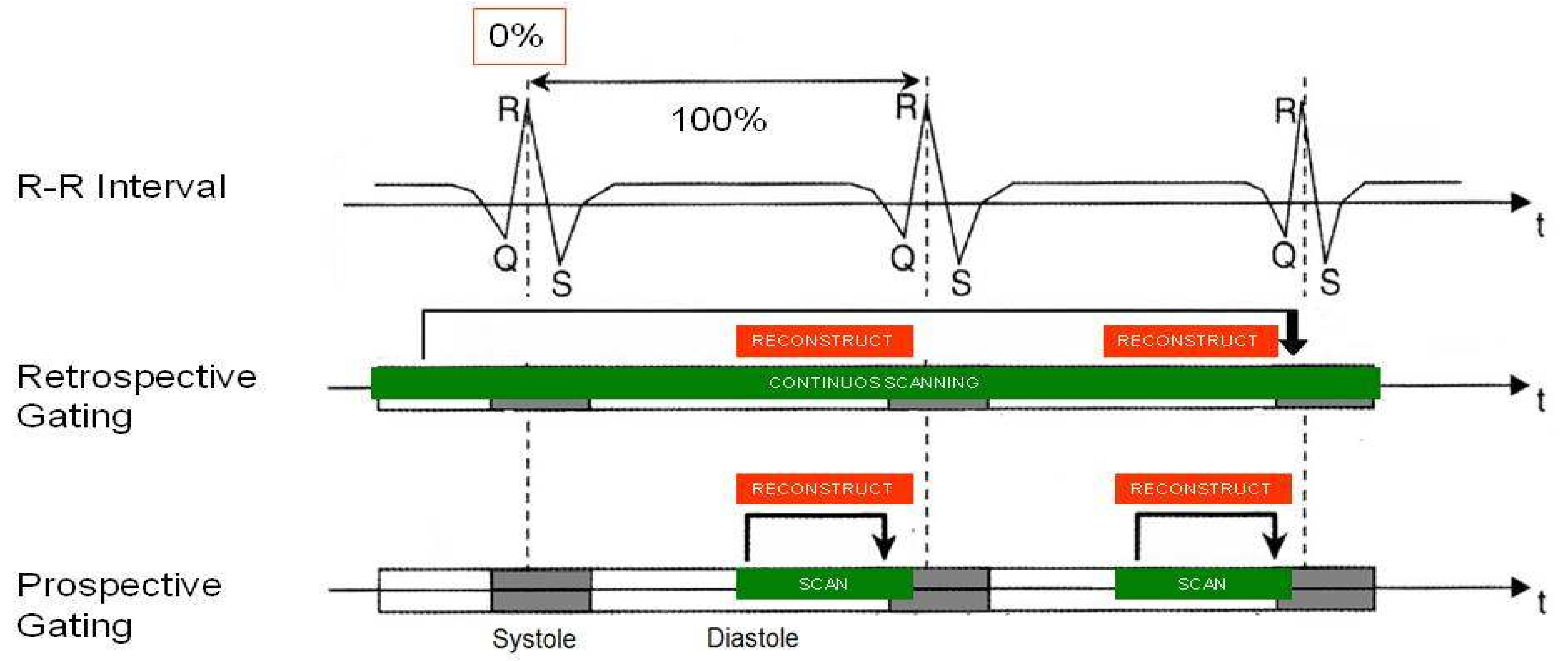
ECG Gating I



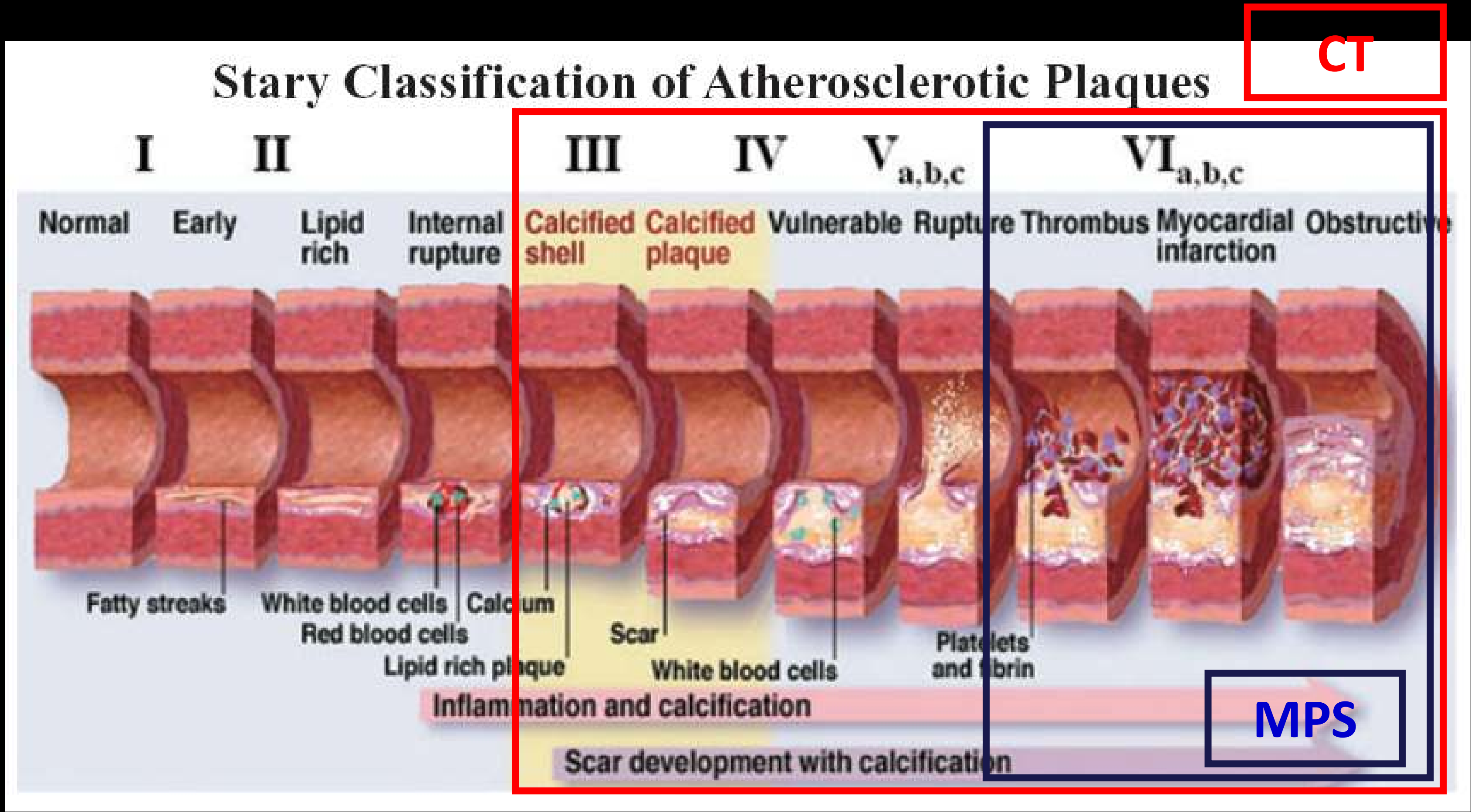
~ Systole

~ End-Diastole

ECG Gating II



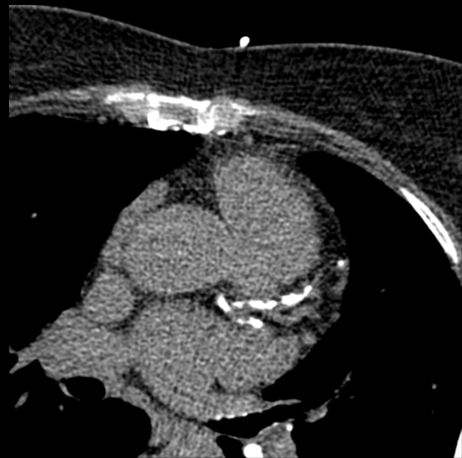
Spectrum of Coronary Artery Disease



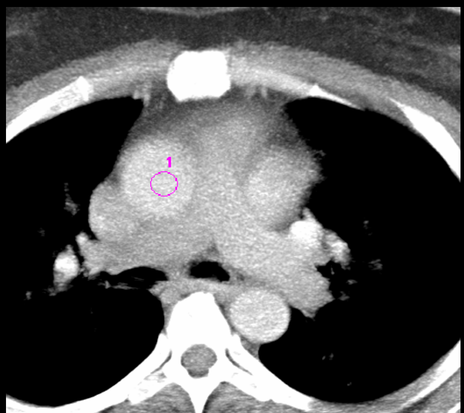
MDCT coronary angiography

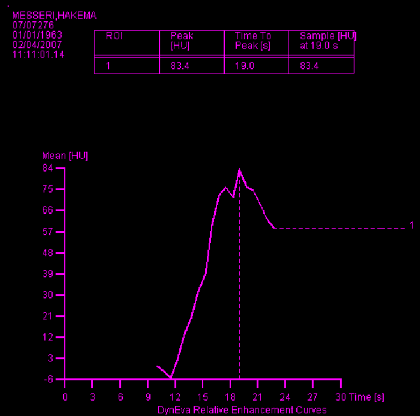
1. Scout

2. Coronary calcium scan



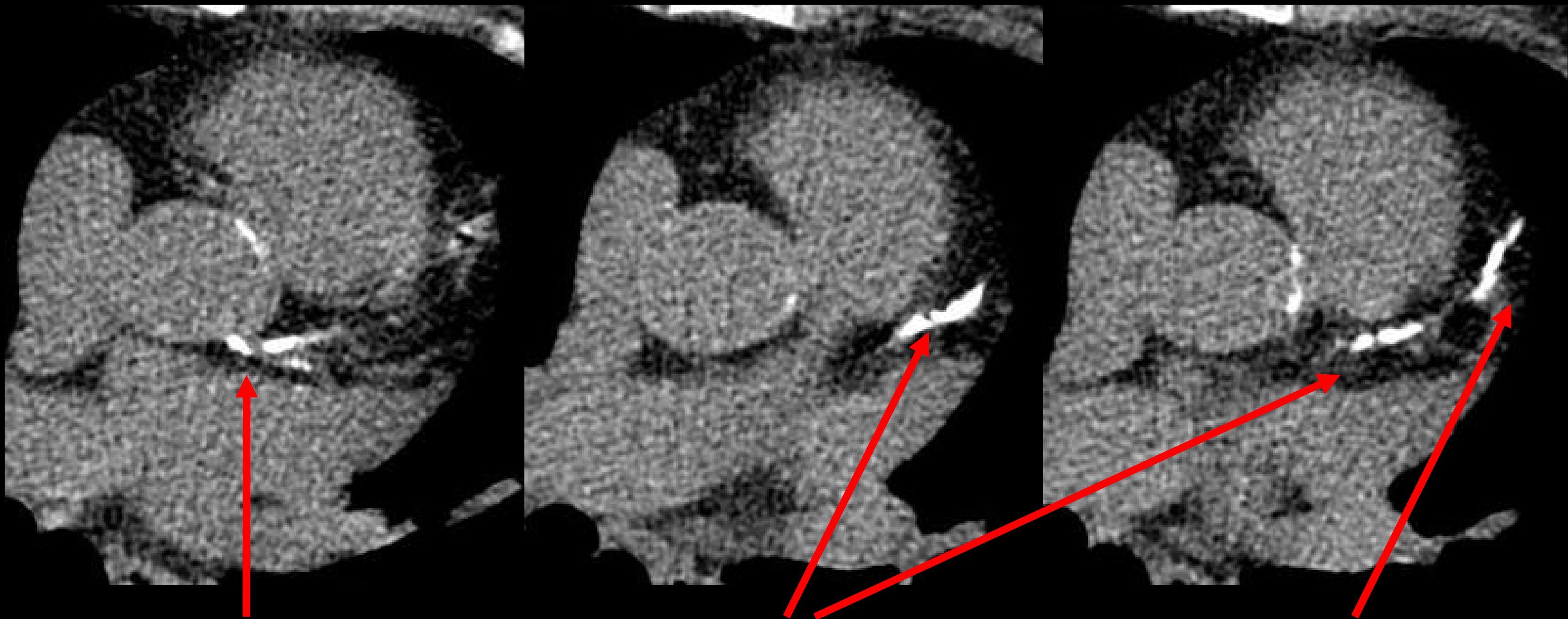
3. Test bolus/tracking





4. Main CT coronary angiogram

Coronary Artery Calcium Scoring



Left Coronary Artery Main Stem

Proximal Left Anterior Descending Artery

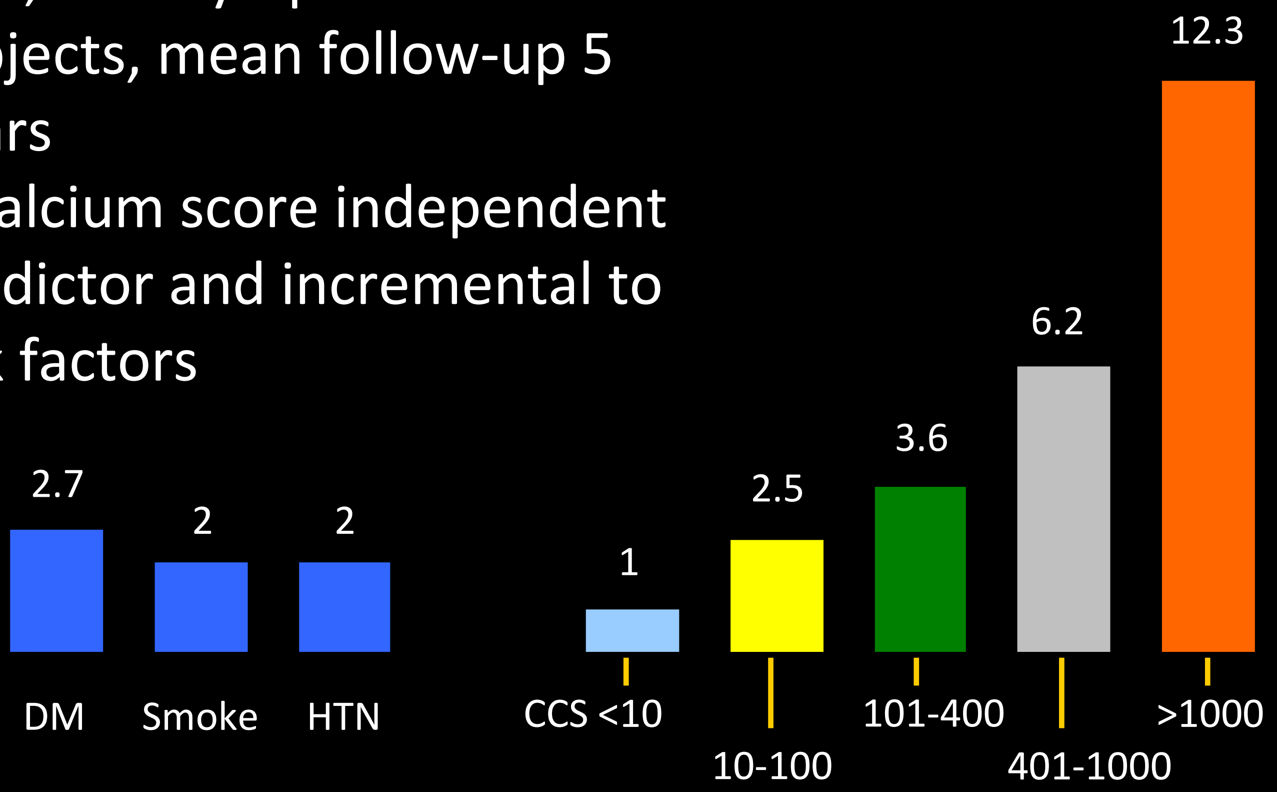
Mid Left Anterior Descending Artery

Coronary Calcium and Likelihood of Significant Stenosis

Total Score	Diagnosis	Clinical Interpretation
0	No identifiable atherosclerotic plaque. Very low cardio-vascular disease risk.	A ‘negative’ examination. Greater than 97% chance for absence of coronary artery disease.
1-10	Minimal plaque burden.	‘Significant’ coronary artery disease very unlikely.
11-100	Mild plaque burden.	Likely mild or minimal coronary stenosis.
101-400	Moderate plaque burden.	Moderate non-obstructive coronary artery disease highly likely.
Over 400	**Extensive plaque burden.**	**High likelihood of at least one ‘significant’ coronary stenosis.**

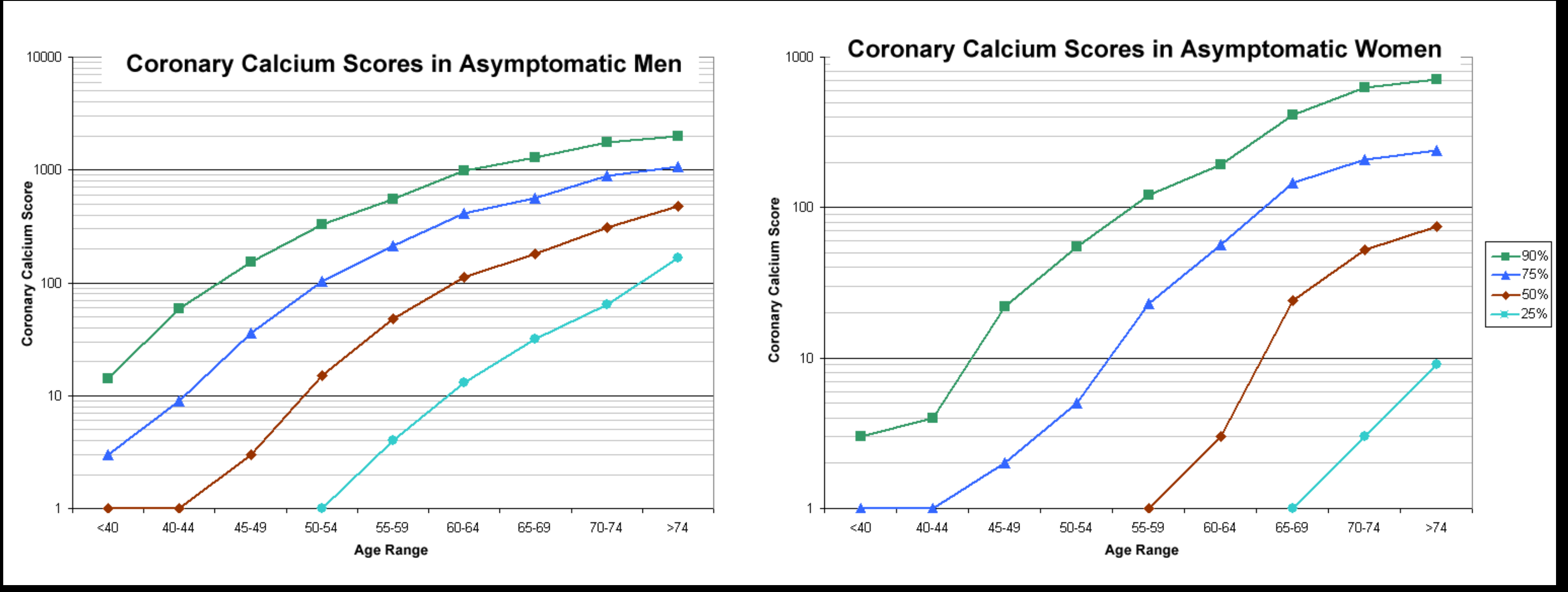
Coronary Calcium Scoring

- 10,377 asymptomatic subjects, mean follow-up 5 years
- Calcium score independent predictor and incremental to risk factors



Shaw LJ. Radiology 2003; 228: 826

Age, Gender & Coronary Calcium



Limitations of Coronary Calcium Scoring

- Measure of global atheroma burden
  - Cannot predict the location of discrete stenoses, only the likelihood of having at least one somewhere
- Although calcium predicts risk in populations, it does not necessarily indicate individual vulnerability
- The majority of data concerning coronary calcium scoring has come from predominantly male, asymptomatic populations

Diabetes and Coronary Calcium

- 589 patients with T2DM and no CHD
- Median follow up 4 years
- Primary outcomes: cardiovascular events

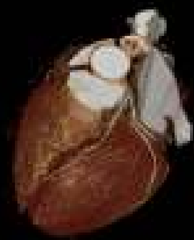
	P° Event Rate	Hazard Ratio	Adj Hazard Ratio
CAC 0-10	4	1	1
CAC 11-100	21	5.4	4
CAC 101-400	40	10.5	7.1
CAC 401-1000	45	11.9	8.4
CAC 1001-10000	75	19.8	13.8

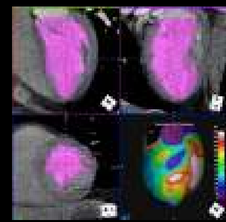
Elkeles *et al.* PREDICT EHJ 2008

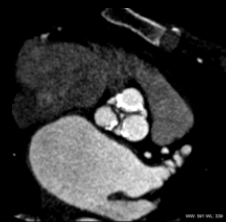
Renal Failure and Coronary Calcium

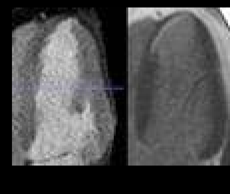
- Nakamura S *et al*. Clin J Am Soc Nephrol 2009
  - Intimal CAC present in both nonrenal and renal patients and linked to renal function and traditional risks
  - Medial calcification occurred only in CKD patients
- Bellasi A *et al.* J Nephrol 2009
  - Absent or low CAC at baseline is associated with minimal progression at 30 months in pts new to haemodialysis
  - Progression associated with poorer control of mineral metabolism
- Adirekkiat S *et al.* Nephrol Dial Transplant 2010
  - Sodium thiosulphate inhibits progression of CAC in pts on haemodialysis

The MDCT Angiography dataset



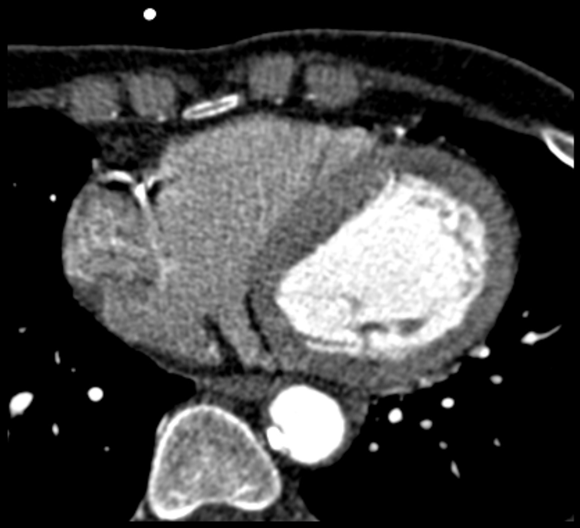


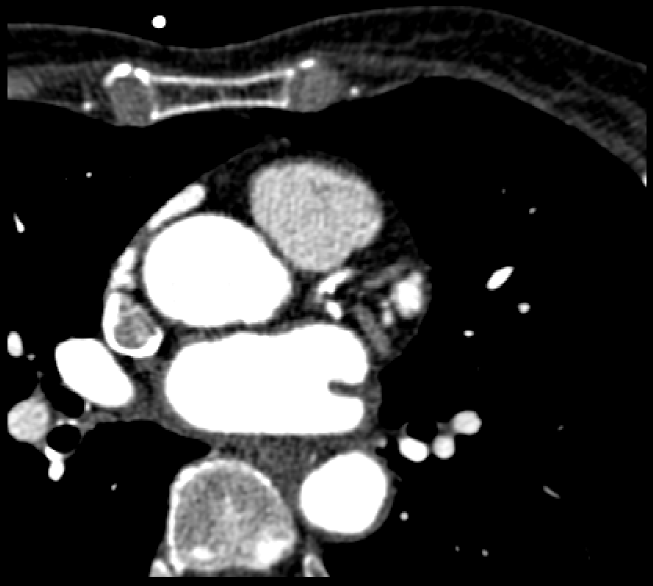




Reconstruction algorithms

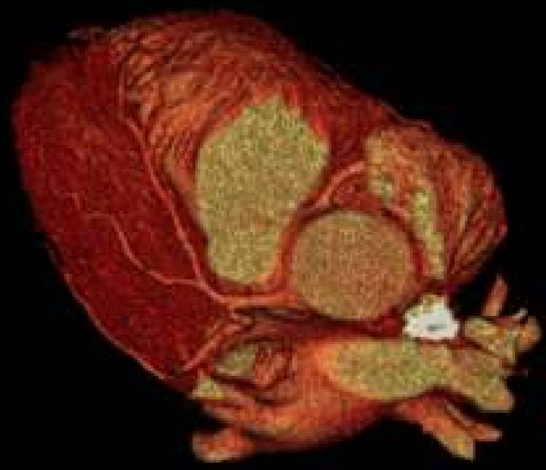
- Axial images (select best phase)





Reconstruction algorithms

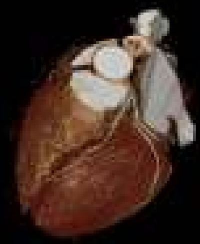
- Semi-automated to volume rendered
  - Crop and select coronary vessels



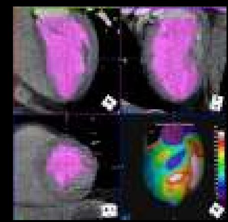
Reconstruction algorithms

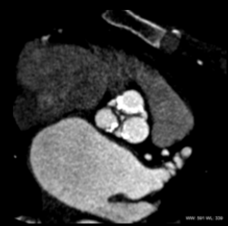
- Multi-planar reformats (MPR) - assessment

The MDCT Angiography dataset



1. Coronary lumenography and anatomy
2. Cardiac morphology
3. Ventriculography (left)
4. Valve assessment
5. First pass perfusion

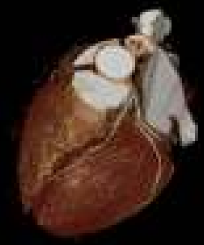




All in the same 5-10 second breath-hold study

*No additional radiation burden

The MDCT Angiography dataset



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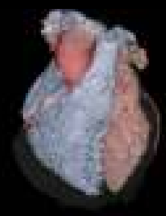
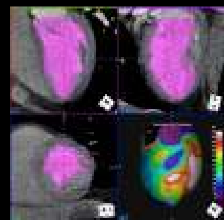
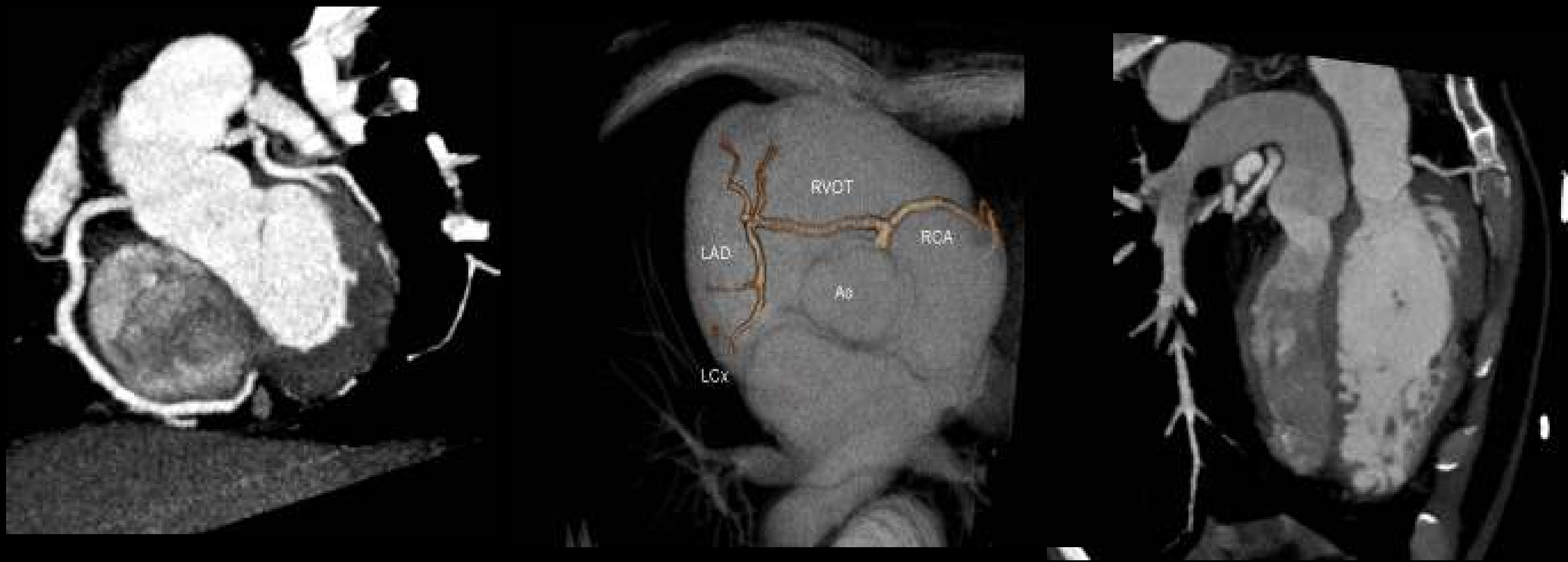






Nicol E D, Lyne J, Rubens M *et al*. *J Nucl Cardiol* 2007;**14(5)**:715-8

Nicol E D, Gatzoulis M A, Padley SP *et al*. *Clin Radiol* 2007:**62(6)**:518-27.

Image Interpretation I

- Axial Images
  - Raw data
  - 2-D
  - Good road map
  - Good for initial assessment of optimal phase

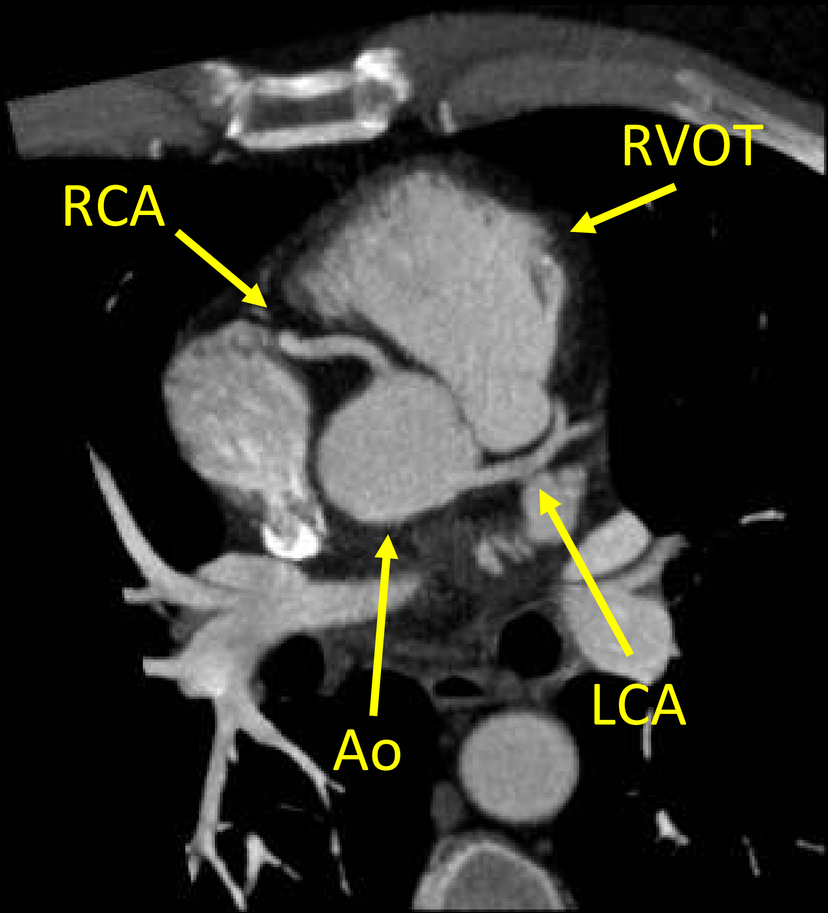


Image Interpretation II

Images

- Intuitive, coloured images, allows assessment of whole 3-D structures
- Good for communication of anatomy to non-radiologists
- Can "grow" coronary tree

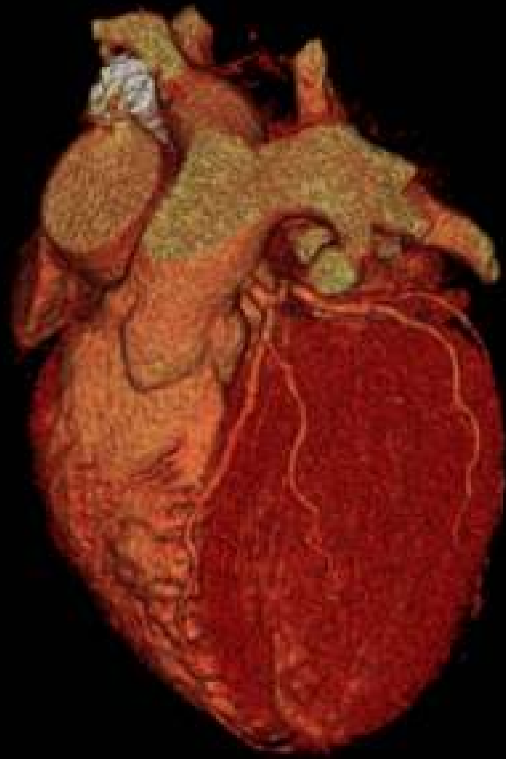
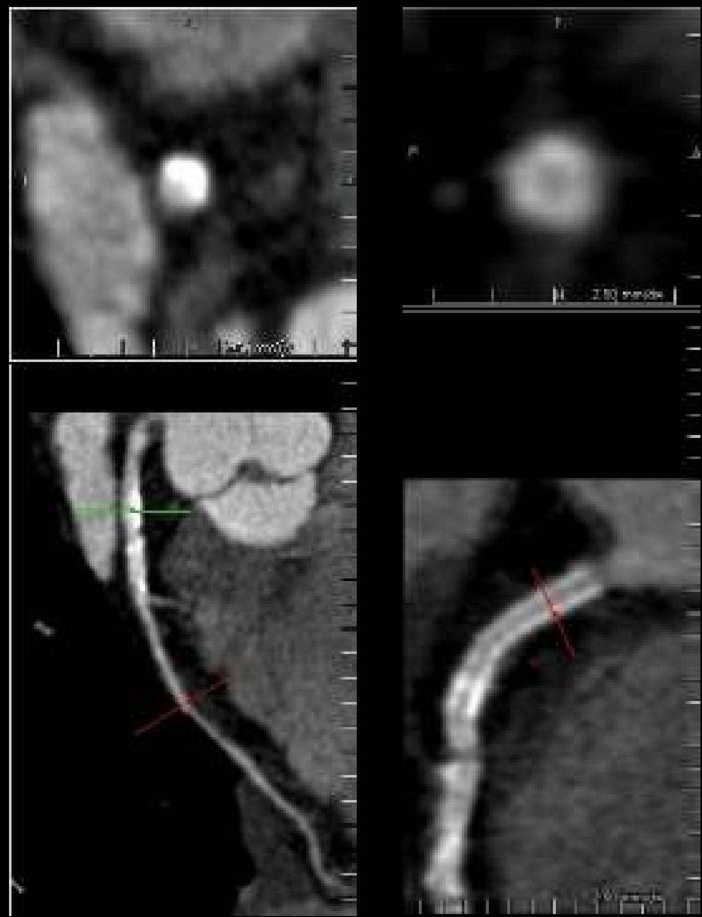
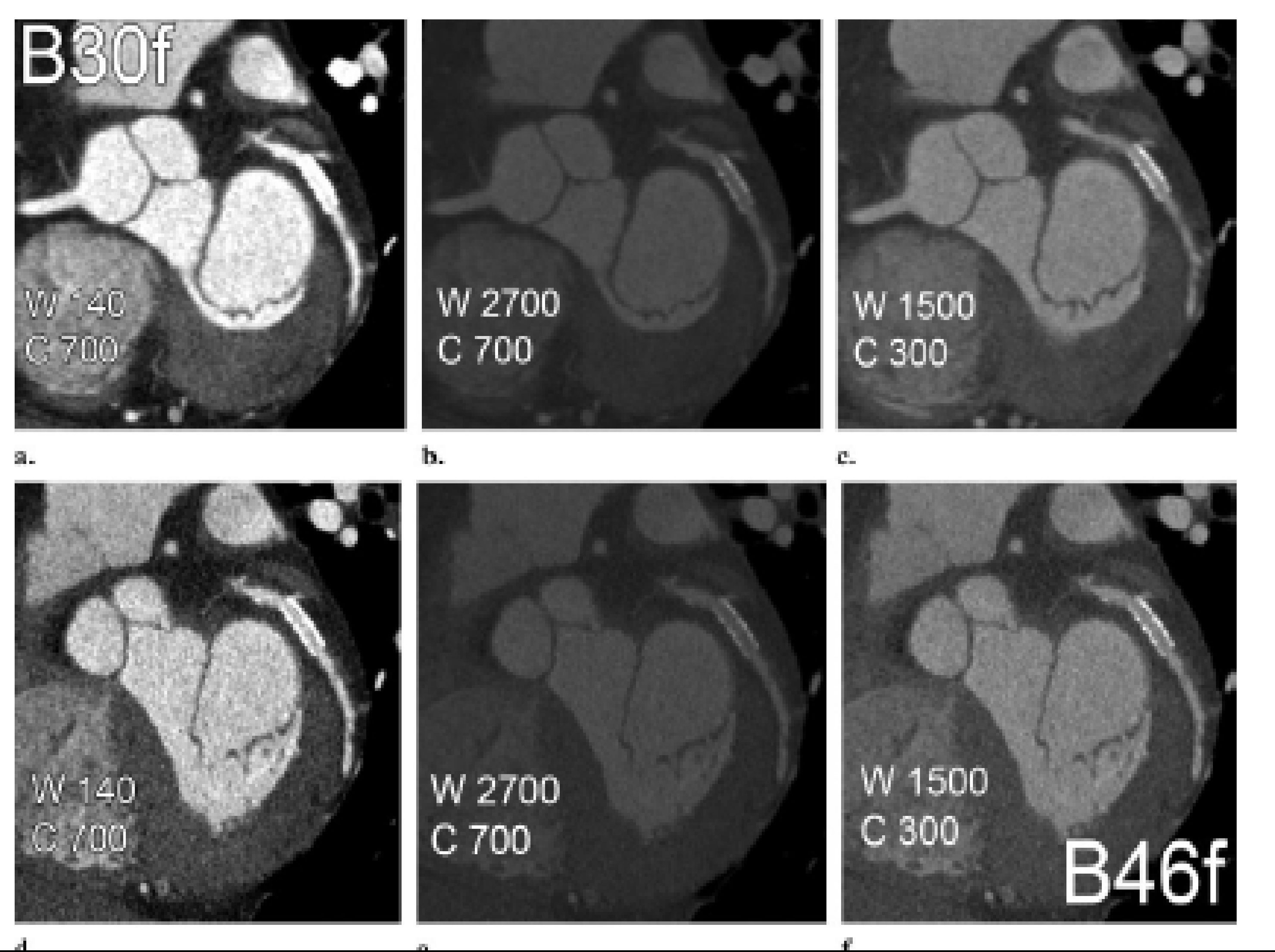


Image Interpretation III

- Curved multi-planar reconstruction (MPR)
  – Interactive, semi-automated oblique or curved vessels plotted from axial, sagittal or coronal images to show vessel in its entirety
  – 360° rotations enables visualisation of eccentric and circumferential stenoses
  – Accurate quantification of stenosis



Windowing

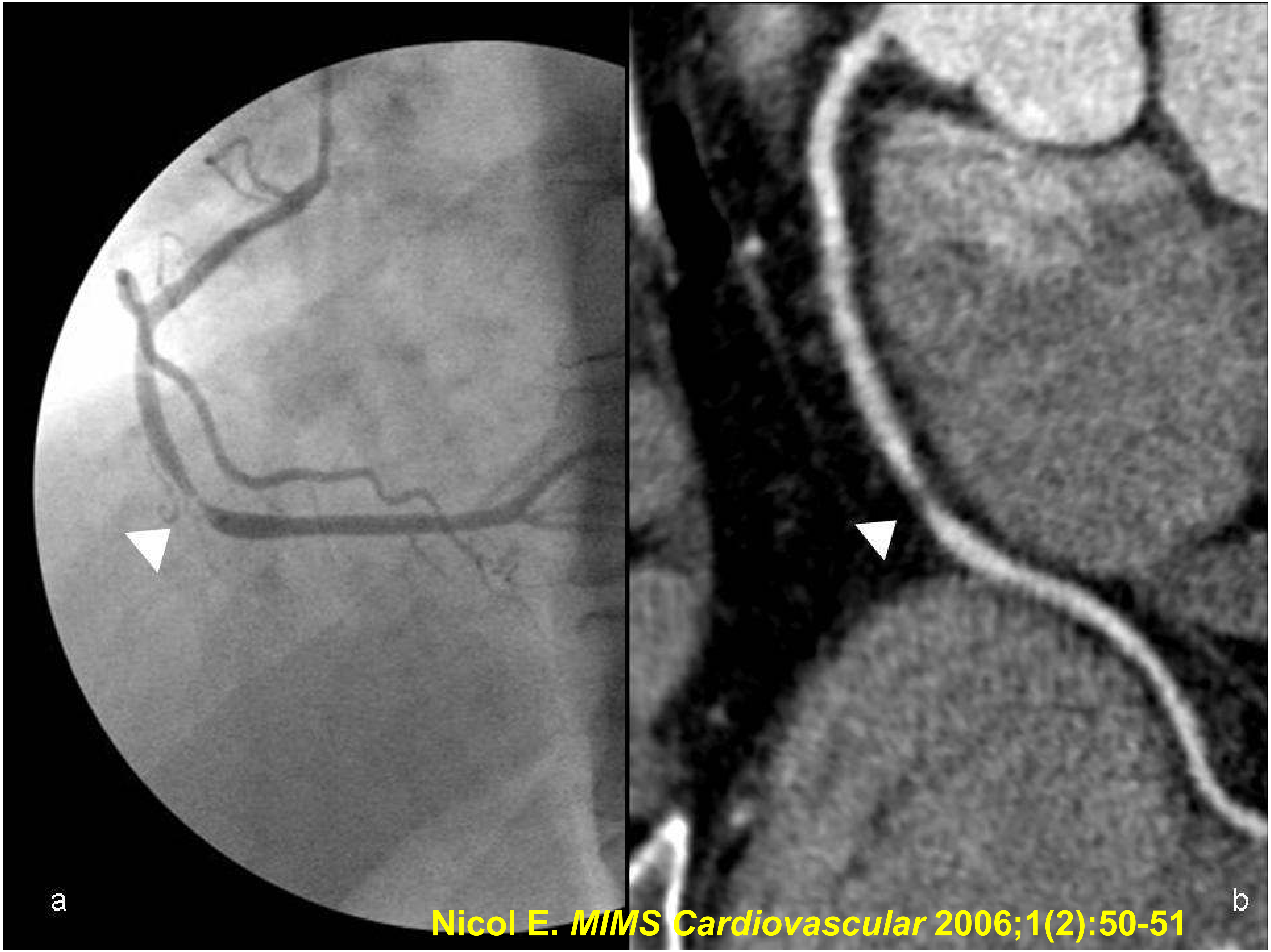


Pugliese et al. Radiographics 2006;26:887-904

Plaque morphology

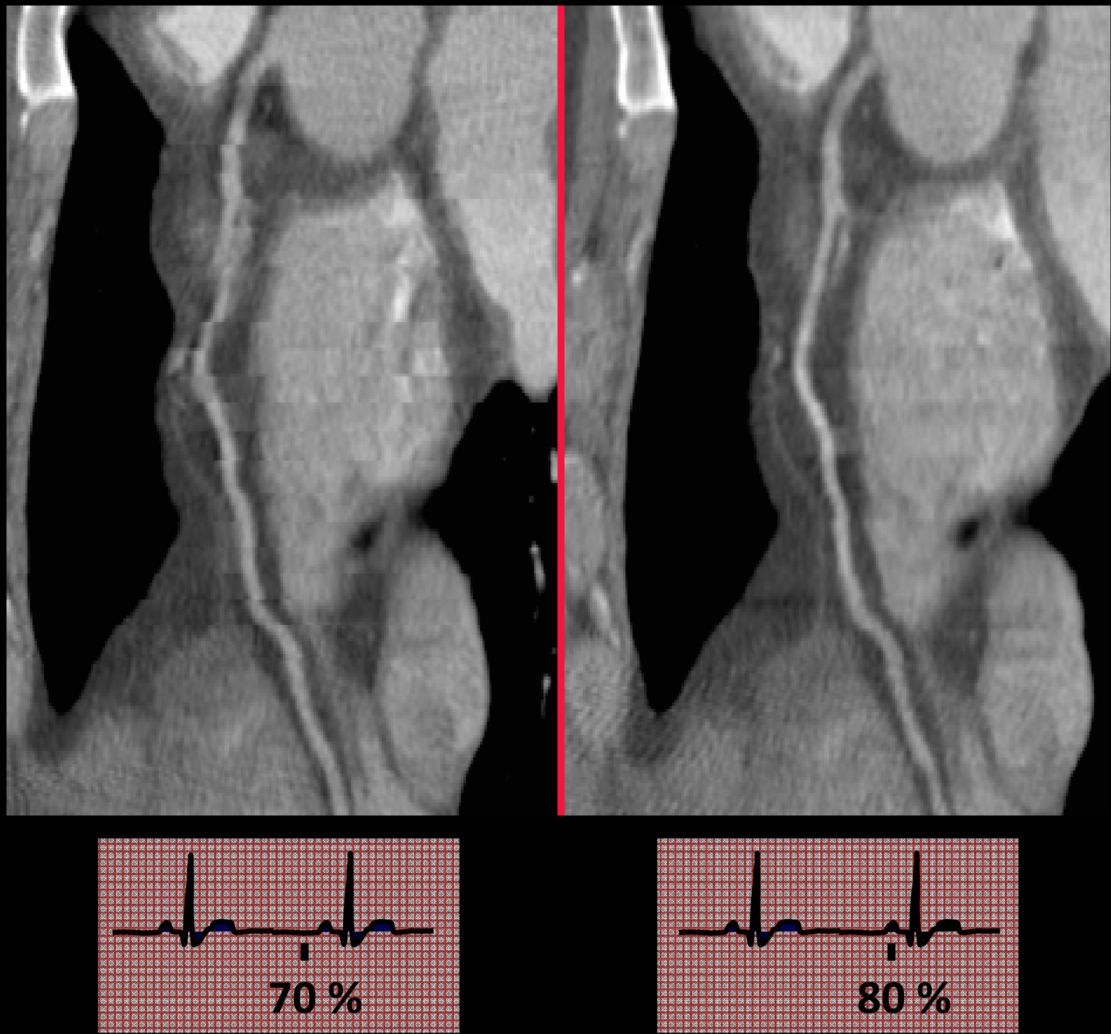
- Calcified
- Fibrous (soft)
- Mixed

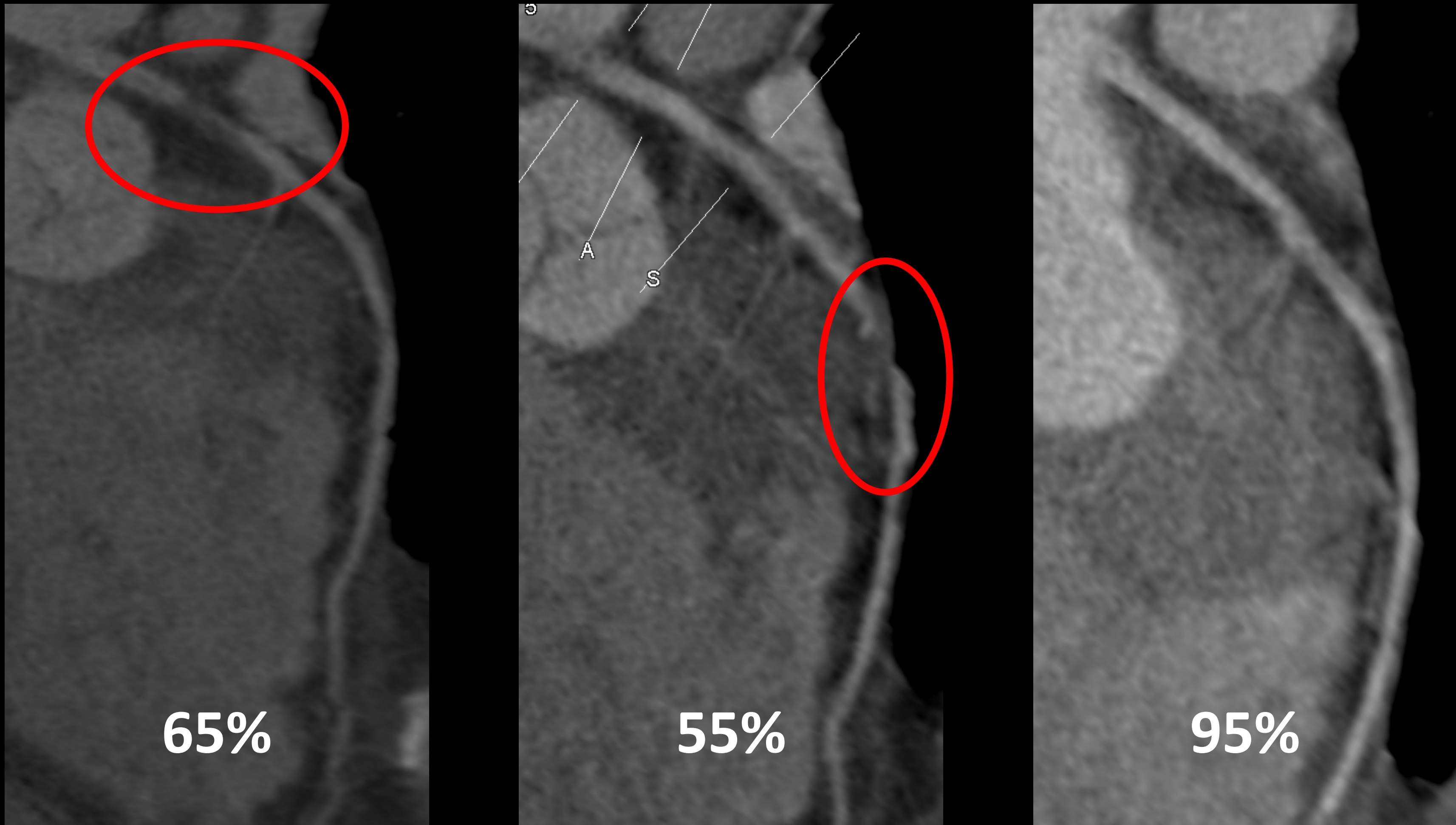
Nicol E. *MIMS Cardiovascular* 2006;1(2):50



Nicol E. *MIMS Cardiovascular* 2006;1(2):50-51

ECG Gating III




A
S
65%
55%
95%

Observer Variation

- CT coronary angiography highly reproducible across low, intermediate and high likelihood cohorts
- Inter- and Intra-observer agreements in >95% in all cohorts with non-eccentric calcium and mixed plaque morphology most common causes of disagreement[1]

Nicol E, Stirrup J, Roughton M, et al *JCAT* 2009;**33(2)**:161-68

MDCT vs. ICA

- Conventional angiography – $0.2mm^3$ spatial resolution, 20ms temporal resolution
  - Able to distinguish between lesions to within 10% at any heart rate
- MDCT coronary angiography – $0.4mm^3$
  - Able only to distinguish lesions within 30-50% (i.e. why studies use > 50% as positive)
  - With heart rate limitations

Results

Stenosis Detection: 64-slice CT vs. QCA

		Year	Pts	Eval %	Sens %	Spec %	Ppv %	Npv %
Mollet	Circulation	05	51	100	**99**	**95**	**76**	**100**
Raff	JACC	05	70	88	**86**	**95**	**66**	**98**
Leber	JACC	05	59	93	**73**	**97**	**-**	**-**
Pugliese	Eur Radiol	06	35	100	**99**	**96**	**78**	**99**
Schuijf	Am J Cardiol	06	60	99	**85**	**98**	**82**	**99**
Nikolaou	AJR	06	68	94	**82**	**95**	**95**	**97**
Ropers	Am J Cardiol	06	84	96	**93**	**97**	**56**	**100**
Scheffel	Eur Radiol	06	30	99	**96**	**98**	**86**	**99**
Muhlenbruh	Eur Radiol	07	51	95	**87**	**95**	**75**	**98**

Meta-analysis of ≥16-slice CTA

- 27 studies, 22798 coronary artery segments
- Median CAD prevalence 64%
- Within studies included, 10% of segments excluded from analysis as “un-assessable”

	Sens	Spec	PPV	NPV
Patient	96	74	83	94
Segment	81	93	68	97

Hamon *et al.* JACC 2006

Multi-centre Data

- 291 symptomatic patients, median age 59
- Referred for diagnostic invasive coronary angiography
- Significant stenosis if ≥50%
- Prevalence of significant stenosis 56%

	Sens	Spec	PPV	NPV
Patient	85	90	91	83
Vessel	75	93	82	89

Miller *et al.* CORE 64 (NEJM 2008)

Multi-centre Data

- 360 patients (aged 50-70) with angina
- Referred for diagnostic invasive coronary angiography
- Significant stenosis if ≥50%
- Prevalence of significant stenosis 68%

	Sens	Spec	PPV	NPV
Patient	99	64	86	97
Segment	88	90	47	99

Meijboom *et al.* JACC 2008

Effect of Pre-Test Probability

- 254 symptomatic patients → CTA and QCA
- Divided into high (>70%), intermediate (30-70%) and low (<30%) likelihoods of CAD
- Stenosis significant if >50%

	Low		Intermediate		High	
	CT+	CT-	CT+	CT-	CT+	CT-
Pre-Test Prob	13		53		87	
Post-Test Prob	68	0	88	0	96	17

Meijboom *et* al. JACC 2007

Stenosis severity and functional significance

- In the presence of a mild to moderate coronary artery stenosis, coronary blood flow (CBF) is maintained by compensatory vasodilatory regulation
- Resting CBF remains constant until epicardial luminal narrowing exceeds 85%-90% diameter
- During exercise or pharmacological stimulation both CBF and CFR usually increase when the lesion involves less than 50% of the luminal diameter
- Both parameters show a variable response for stenoses of intermediate severity (50%-70%) and a progressive reduction as stenosis severity

CTA vs. MPS

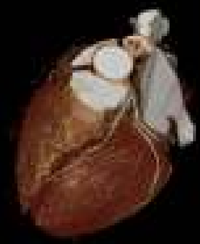
- 52 patients referred for MPS
- Low to intermediate CAD likelihood
- Comparisons at >50% and >70% stenosis for the detection of inducible ischaemia

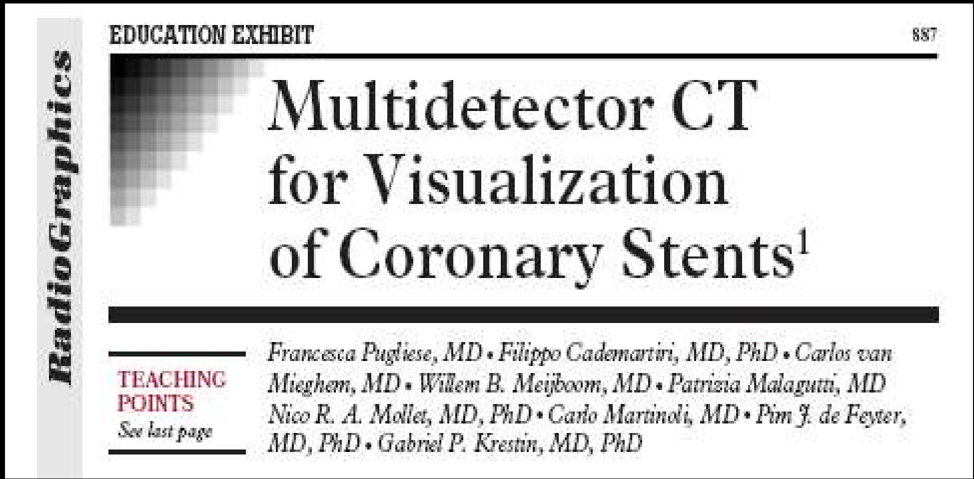
	Sens	Spec	PPV	NPV
CTA >50%	100	84	50	100
CTA >70%	86	98	86	98

Nicol *et al.* JNC 2008

Detection of 70% Stenosis is possible and reduces unnecessary ICA referrals but the literature and clinical practice continues to use 50%

Stent Assessment





RadioGraphics

EDUCATION EXHIBIT 887

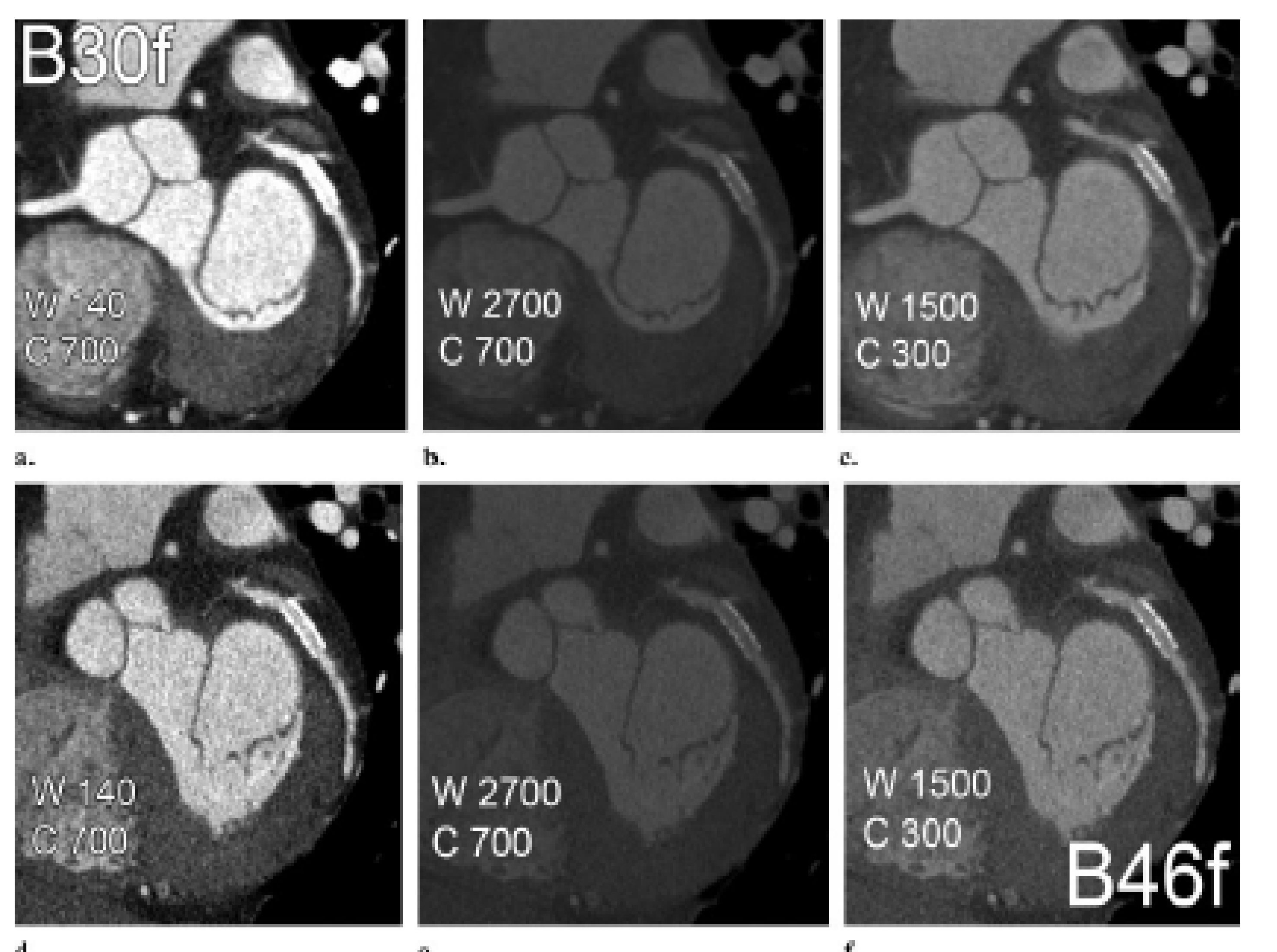
Multidetector CT for Visualization of Coronary Stents[1]

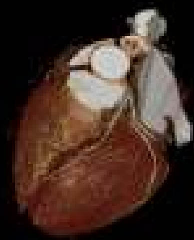
TEACHING POINTS
See last page

Francesca Pugliese, MD • Filippo Cademartiri, MD, PhD • Carlos van Mieghem, MD • Willem B. Meijboom, MD • Patrizia Malagutti, MD Nico R. A. Mollet, MD, PhD • Carlo Martinoli, MD • Pim J. de Feyter, MD, PhD • Gabriel P. Krestin, MD, PhD

- Affected by
  - Strut thickness
  - Stent coverage
  - Stent deployment

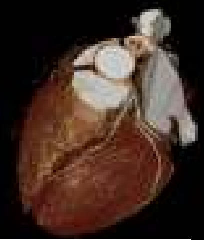
Windowing

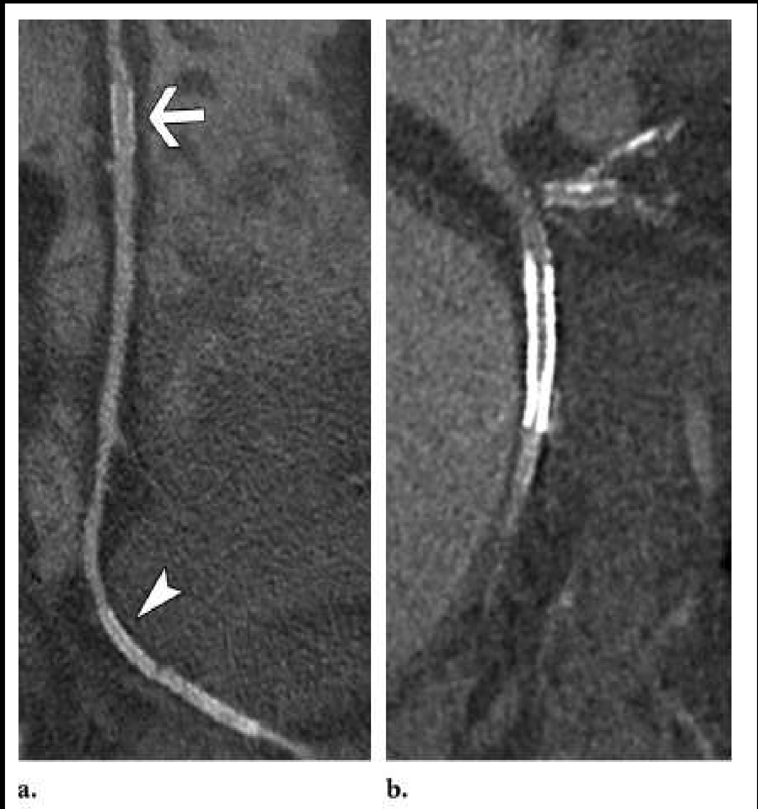


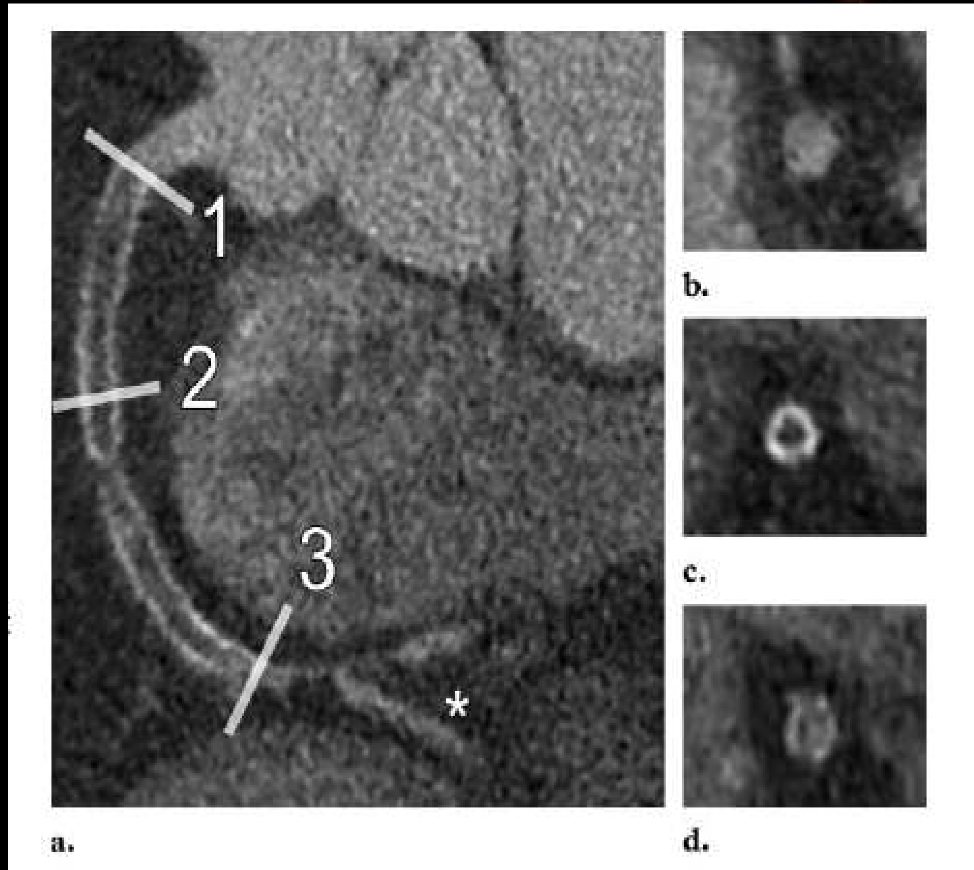


Pugliese et al. Radiographics 2006;26:887-904

Stent Assessment







Pugliese et al. Radiographics 2006;26:887-904

ORIGINAL ARTICLE

64- Versus 16-Slice CT Angiography for Coronary Artery Stent Assessment

In Vitro Experience

Harald Seifarth, MD, Murat Özgün, MD,* Rainer Raupach, PhD,† Thomas Flohr, PhD,† Walter Heindel, MD,* Roman Fischbach, MD,* and David Maintz, MD**

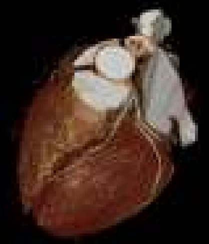


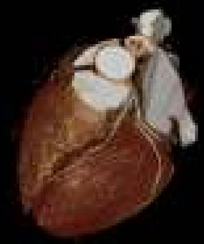
TABLE 1. Stent Type and Manufacturer as Well as the Material and Dimensions of the 15 Stents Used in the Study (Note That the Struts in the Nexus and S7 Stent Have an Ovoid Profile, Whereas the Profile of the Others Is Circular)

			Dimensions (mm)		
Stent Type	**Manufacturer**	**Material**	**Length**	**Diameter**	**Strut Thickness**
Arthos-Pico	AMG International	Cobalt-Cromium	18	3	0.074
Biodivysio	Abbott Vascular Devices	Stainless steel	19	3	0.091
Bx-Velocity	Cordis	Stainless steel	18	3	0.097
Driver	Medtronic	Cobalt-Cromium Alloy	18	3	0.09
Flex AS	Phytis	Stainless steel	7	3	0.08
MSM Coronary Stent	Micro Science Medical	Stainless steel Tantal coating	26	3	0.11
Nexus	Occam International	Stainless steel	19	3	0.091 × 0.124
NIR Primo	Boston Scientific	Stainless steel	32	3	0.1
S 7	Medtronic	Stainless steel	15	4	0.102 × 0.128
Sito Stent S	Sitomed	Stainless steel	28	2.5	0.110
Symbiot	Boston Scientific	Nitinol	20	4	0.07
Tantal Sandwich	Abbott Vascular Devices	Stainless steel Tantal	18	3	0.13
Taxus	Boston Scientific	Stainless steel	12	3.5	0.08
Tenax-complete	Biotronik	Stainless steel	15	3.5	0.08
Tsunami	Terumo	Stainless steel	30	3	0.14

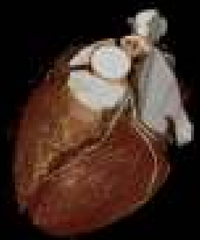
- In conclusion, we can state that the increase of spatial resolution with 64-slice CT results in superior visualization of the stent lumen and in-stent stenosis as compared with 16-slice CT, especially when the stent is orientated parallel to the x-ray beam. Nevertheless blooming artefacts caused by the metallic stent struts remain an important problem obscuring about one third of the vessel lumen on average.

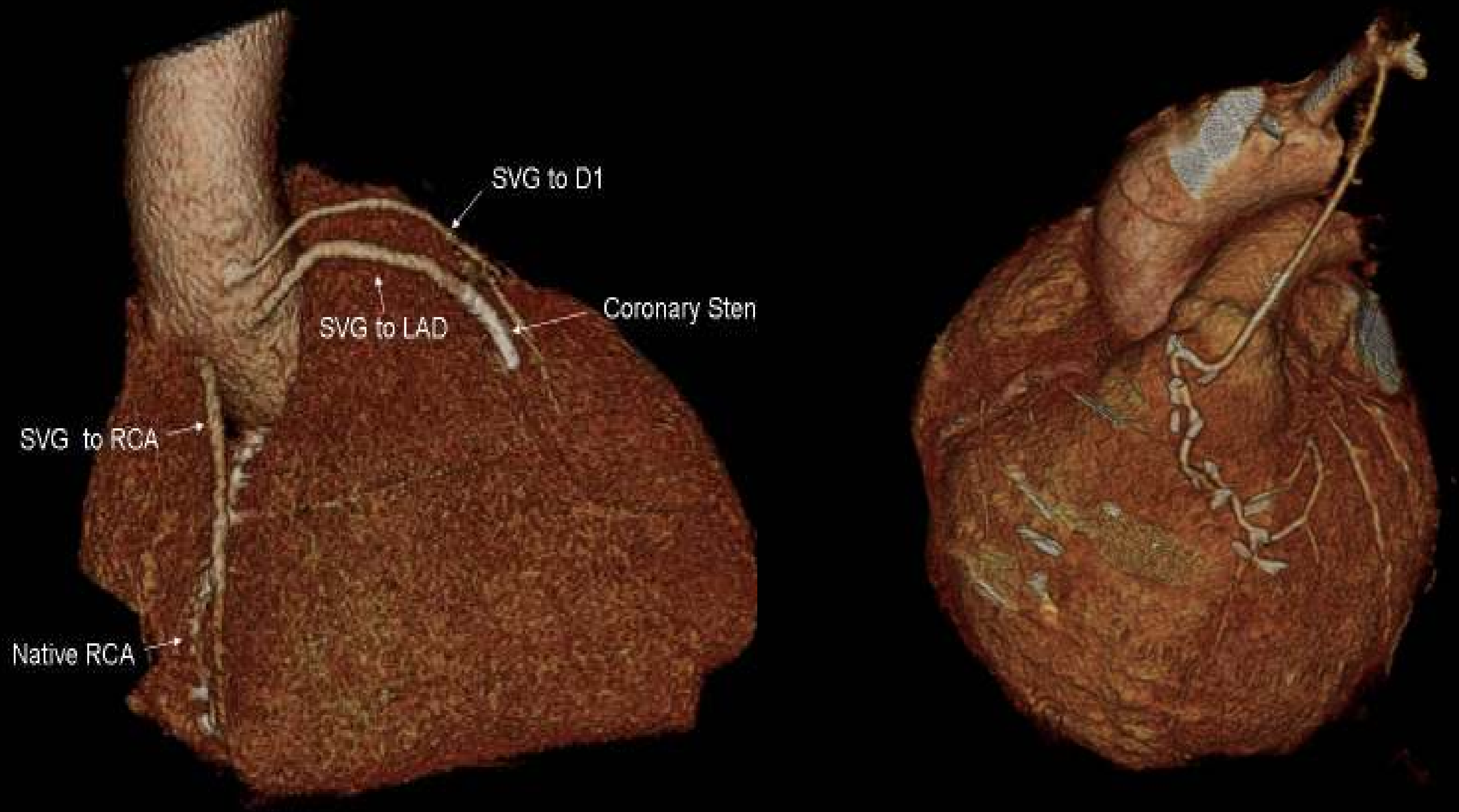
Siefarth et al. Invest Radiol. 2006 Jan;41(1):22-7

Iterative Reconstruction Technology



Graft Assessment

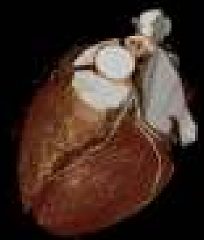




Multi-Detector Computed Tomography in Coronary Artery Bypass Graft Assessment: A Meta-Analysis

Catherine M. Jones, MBBS, BS, Thanos Athanasiou, MD, FECTS, Nicola Dunne, MBBS, Joanne Kirby, MbChB, Omer Aziz, MRCS, BS, Ahmed Haq, MBBS, Christopher Rao, BS, Vasilis Constantinides, MBBS, BS, Sanjay Purkayastha, MRCS, BS, and Ara Darzi, FRCS, KBE

Department of Radiology, City Hospital, Birmingham, Department of Biosurgery and Surgical Technology & Department of Cardiothoracic Surgery, Imperial College, St Mary's Hospital, London, Royal Berkshire and Battle NHS Trust, Reading, and Birmingham Heartlands Hospital, Birmingham, United Kingdom



Multi-detector computed tomography (MDCT) has become an alternative to coronary angiography in diagnosis of graft occlusion and stenosis after coronary artery bypass. A literature search was performed for studies comparing angiography to 8-slice, 16-slice, and 64-slice MDCT in the assessment of coronary grafts. In assessing occlusion, 14 studies produced pooled sensitivity of 97.6%, specificity of 98.5%, diagnostic odds ratio of 934.2, area under the curve of 0.996, and Q* of 0.977. Ninety-six percent of all grafts were visualized for occlusion assessment. Beta blockers, symptomatic status, and postoperative period did not significantly affect diagnostic performance. Stenosis assessment produced sensitivity of 88.7% and specificity of 97.4%. Eighty-eight percent of patent grafts could be assessed for stenosis. The diagnostic accuracy of MDCT approaches angiography for diagnosing graft occlusion and stenosis in patients with venous and arterial coronary bypass grafts. Our findings show that cardiac surgeons will need to interpret MDCT images of both native and grafted vessels soon in preparation for primary or re-do coronary bypass grafting procedures.

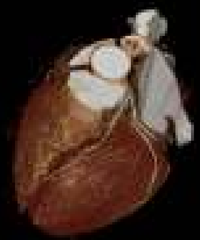
(Ann Thorac Surg 2007;83:341–8)

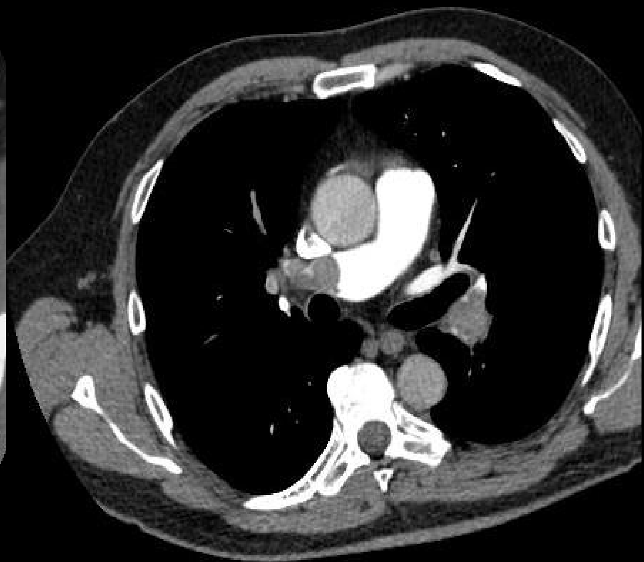
Table 2. Pooled Sensitivity and Specificity Results

Subgroup	Studies	Grafts	Pooled Sensitivity % (95% CI)	Pooled Specificity % (95% CI)	Diagnostic Odds Ratio (95% CI)	AUC (SE)	Q* (SE)
Occlusion	14	1,791	97.6 (95.3–99.0)	98.5 (97.7–99.1)	934.2 (436.4–1999.9)	0.996 (0.002)	0.977 (0.008)
Arterial	10	664	98.0 (89.6–100)	97.8 (96.3–98.8)	294.6 (92.5–938.4)	0.980 (0.010)	0.937 (0.018)
Venous	10	814	99.1 (96.8–99.9)	100.0 (99.4–100)	1831.1 (407.3–8231.2)	0.996 (0.003)	0.978 (0.010)
Stenosis	8	777	88.7 (79.0–95.0)	97.4 (95.9–98.4)	152.0 (64.0–360.7)	0.867 (0.081)	0.795 (0.079)
Arterial	4	245	90.9 (58.7–99.8)	98.3 (95.7–99.5)	65.7 (13.1–328.9)	0.807 (0.461)	0.742 (0.407)
Venous	6	348	85.2 (66.3–95.8)	97.2 (94.7–98.7)	158.1 (46.3–541.0)	0.916 (0.070)	0.849 (0.076)

AUC = area under the curve; CI = confidence interval; SE = standard error.

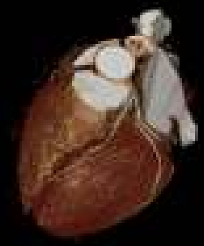
Emergency Cardiac CT



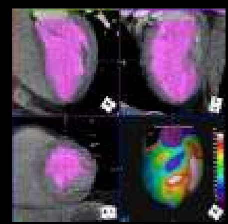


- CT Aortogram
- CT Aortogram + CTPA (Double rule out)
- CT Aortogram + CTCA (Double rule out)
- CT Aortogram + CTPA + CTCA (Triple rule out)

The MDCT Angiography dataset

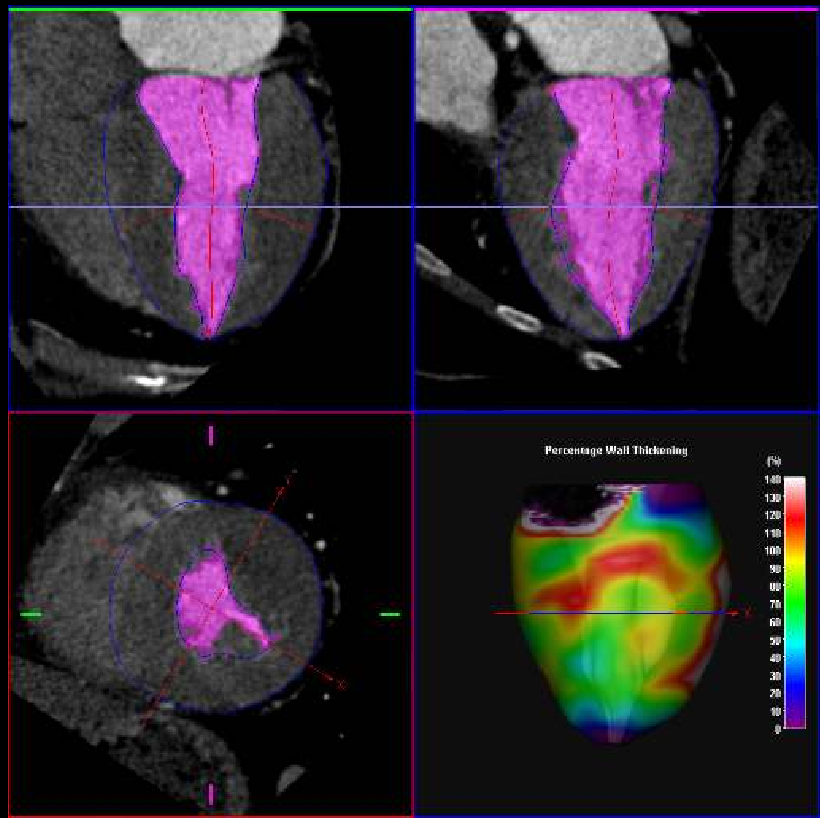


1. Coronary lumenography and anatomy
2. Cardiac morphology
3. Ventriculography (left)
4. Valve assessment
5. First pass perfusion

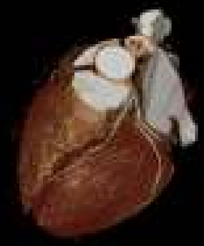


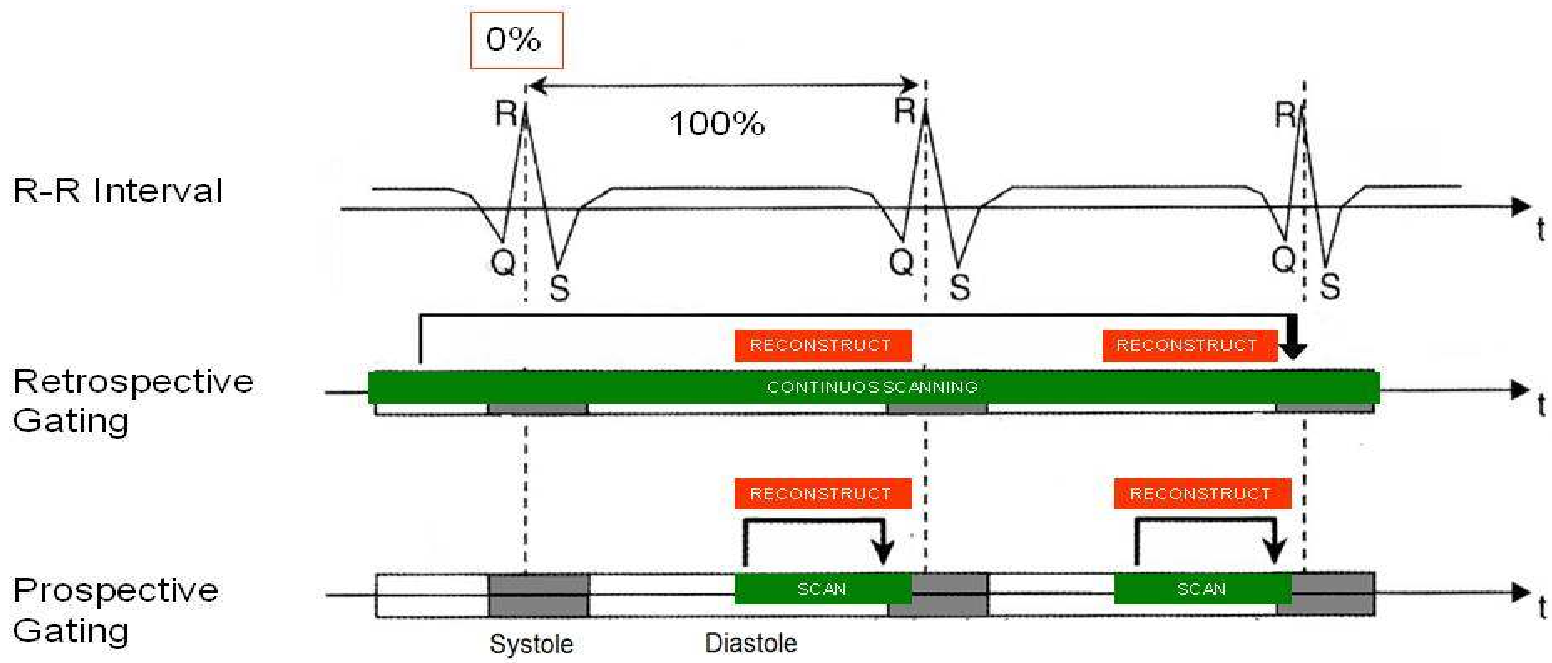
Time Volume Analysis

- Ability to perform 4D imaging
- Multiple (8-16) phases reconstructed
- Functional assessment of the left ventricle



ECG Gating




0%
100%
R
Q
S
t
R-R Interval
RECONSTRUCT
RECONSTRUCT
CONTINUOS SCANNING
Retrospective Gating
RECONSTRUCT
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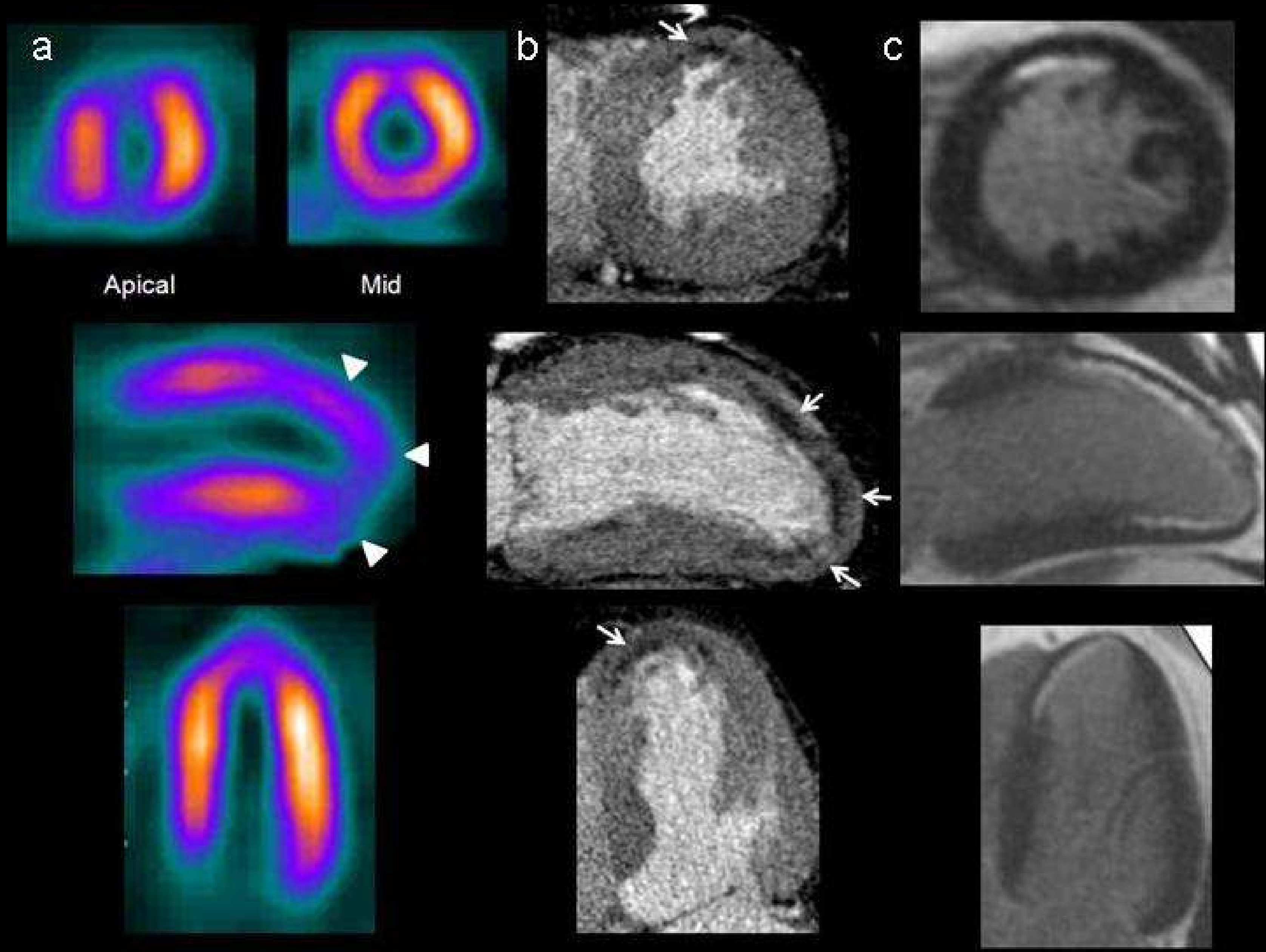
SCAN
SCAN
Prospective Gating
Systole
Diastole

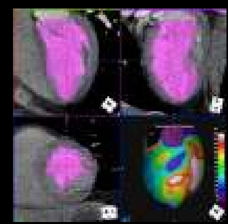


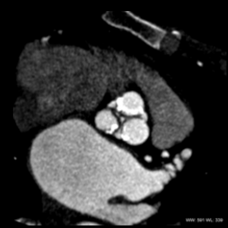
Nicol E D, Stirrup J, Lyne J. Br J Cardiol 2009; *Br J Cardiol*:**16(1);**43

MDCT v. CMR

- Pacemakers etc
- Claustrophobia

- No ionising radiation
- Flow data

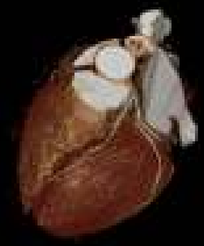


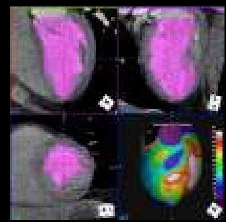
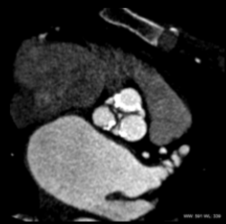


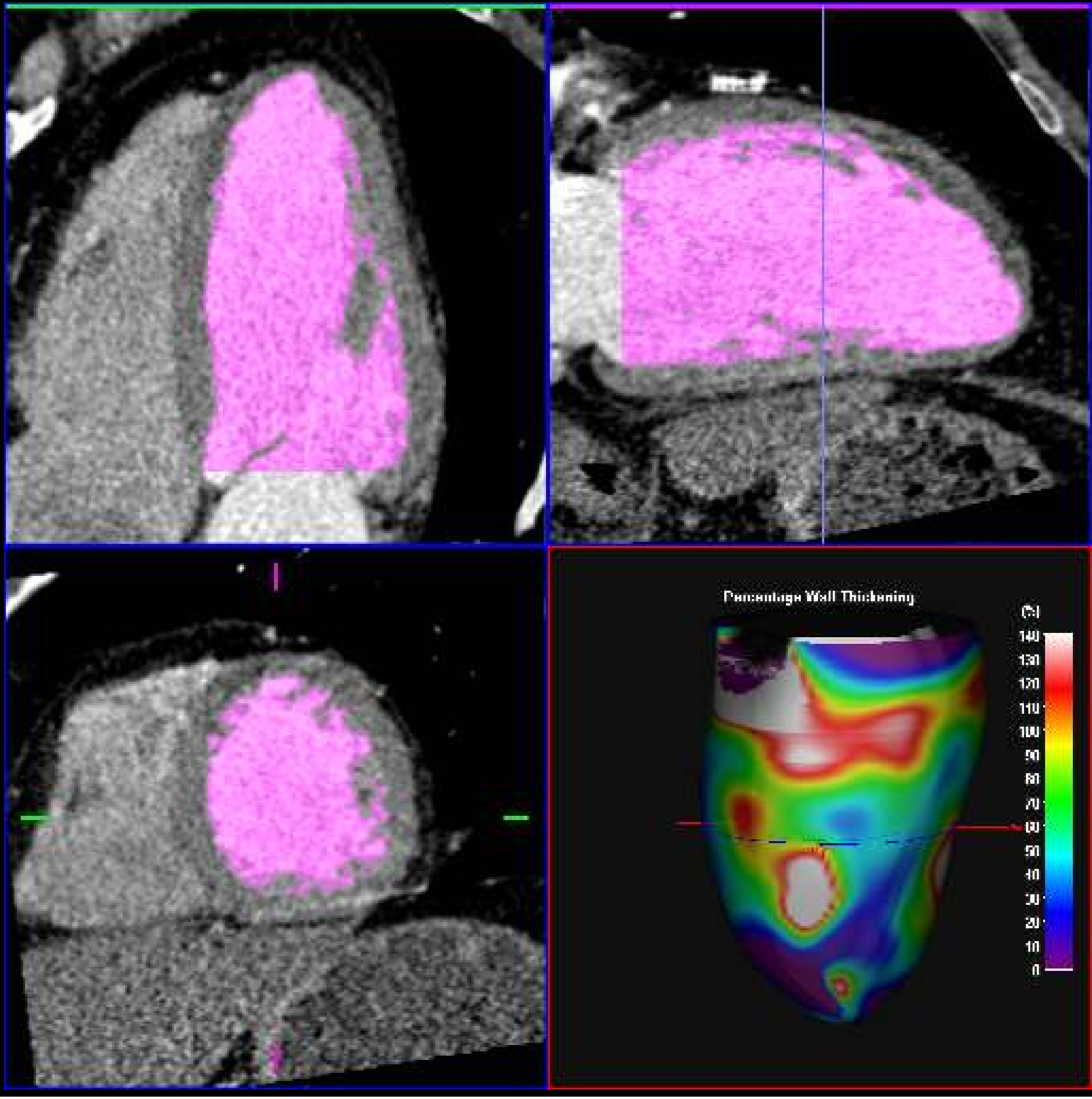
Suitable alternative to CMR

Devices/Debility/Claustrophobia/Availability/ Children?

	MDCT	CMR
Temporal Resolution	83-165ms	20ms
Spatial Resolution	0.4mm	0.7mm
Isotropic Pixels	Yes	No
Cardiac Cycles/Image	5-30	20-30
Flow data	No	Yes
Coronary angiography	Yes	+/-
Left Ventriculography	Yes	Yes
Right Ventriculography	+/-	Yes
Calcium Assessment	Yes	No
Thrombus Assessment	Yes	No

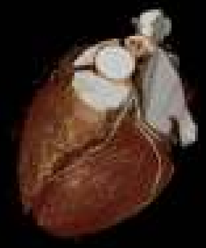


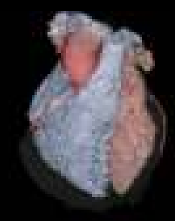



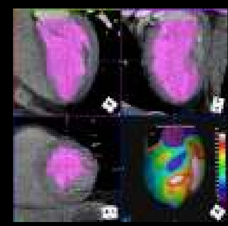


Percentage Wall Thickening
(%)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

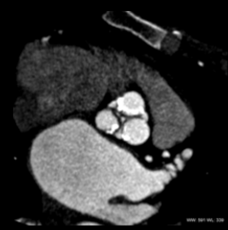
Ventriculography

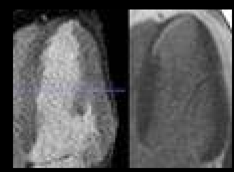
1. LV Function (EDV/ESV/SV)
2. Regional Wall Motion
3. Systolic wall thickening
4. LV mass







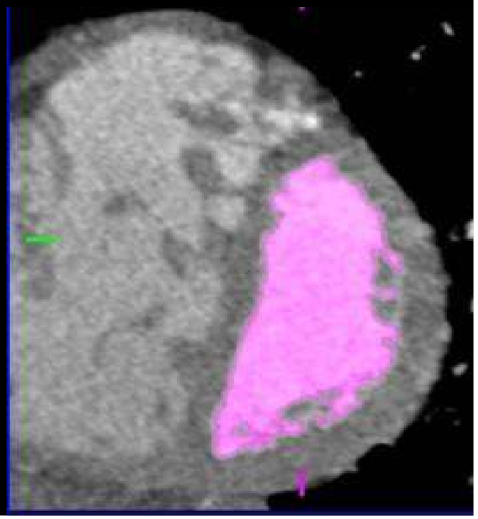




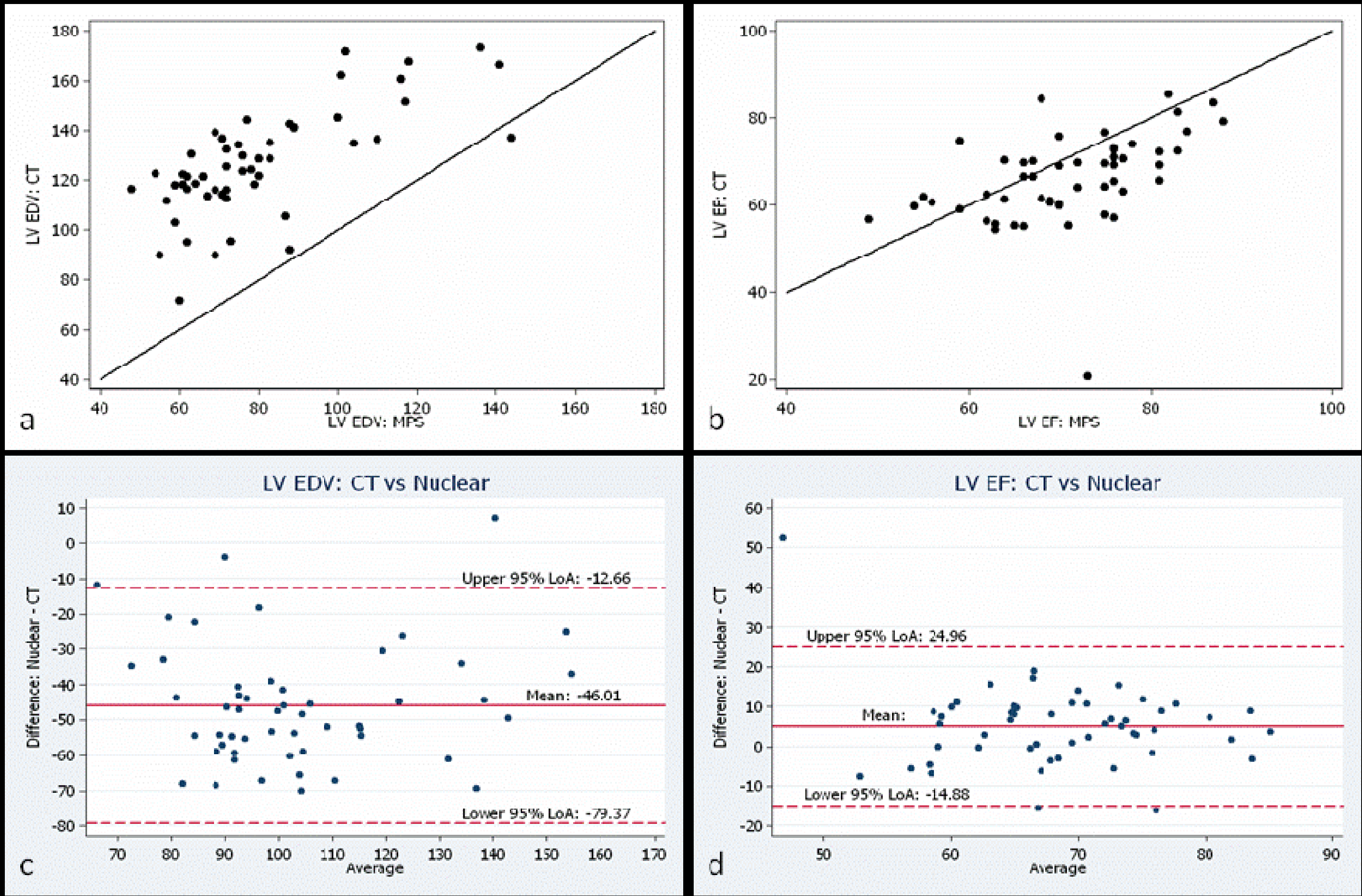
LV Function

- Well validated – tracing[1] and threshold[2,3]
- Normal[1,2] and congenital[3] subjects
- Straight forward – consistent contrast density through LV cavity

1. Dewey M et al, JACC 2006;48:2034-44
2. Mahnken et al, Eur Radiol 2006;16:1416-23
3. Nicol E et al, . *J Nucl Cardiol*. 2008 Jul-Aug;15(4):497-502. Epub 2008 Jun 30

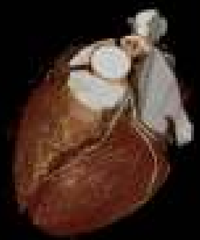


LV Function (CT vs. MPS)



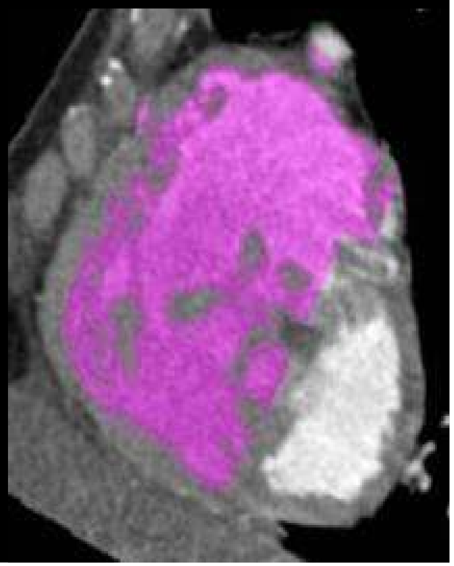
Nicol E D, Stirrup J, Underwood SR *et al.* 2008 Jul-Aug;15(4):497-502.

RV Function



- Only validated with tracing techniques [1 2]
- Single congenital study[3]
- Challenging – no consistent contrast density in RV cavity, outflow level
- Increased operator input and therefore variability

1. Dogan H et al, Radiology 2007;242:78-84
2. Delhaye D et al, AJR 2006;1597-64
3. Raman et al. Am J Cardiol 2005;683-86

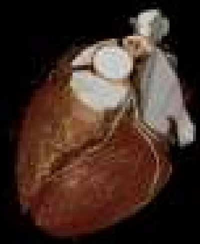


BiV Function in ACHD

If correlated against standard ranges for severe (<30%), moderate (30-50%) and mild (50-60%) ventricular dysfunction kappa values show moderate (κ = 0.52) and good (κ =0.62) correlation for LV and RV assessment respectively.

Nicol E. Kafka H, Stirrup J et al. Int J Cardiol 2008 Aug 5. [Epub ahead of print]

The MDCT Angiography dataset



1. Coronary lumenography and anatomy
2. Cardiac morphology
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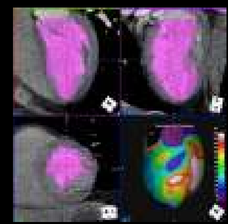
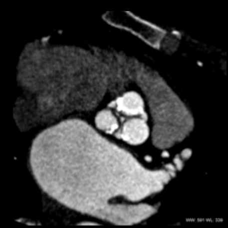
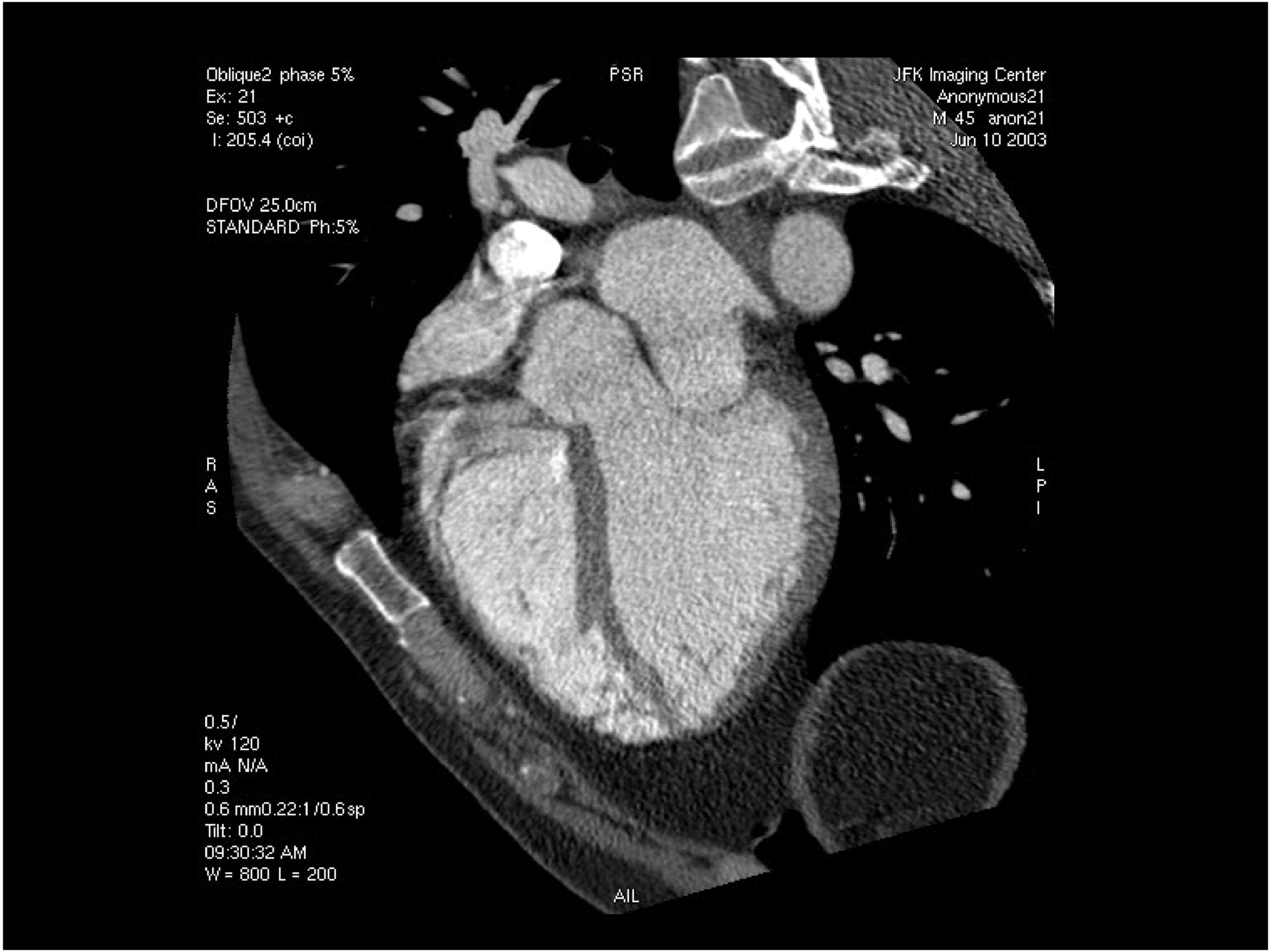
5. First pass perfusion







Oblique2 phase 5%
Ex: 21
Se: 503 +c
I: 205.4 (coi)
DFOV 25.0cm
STANDARD Ph:5%
PSR
JFK Imaging Center
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R
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kv 120
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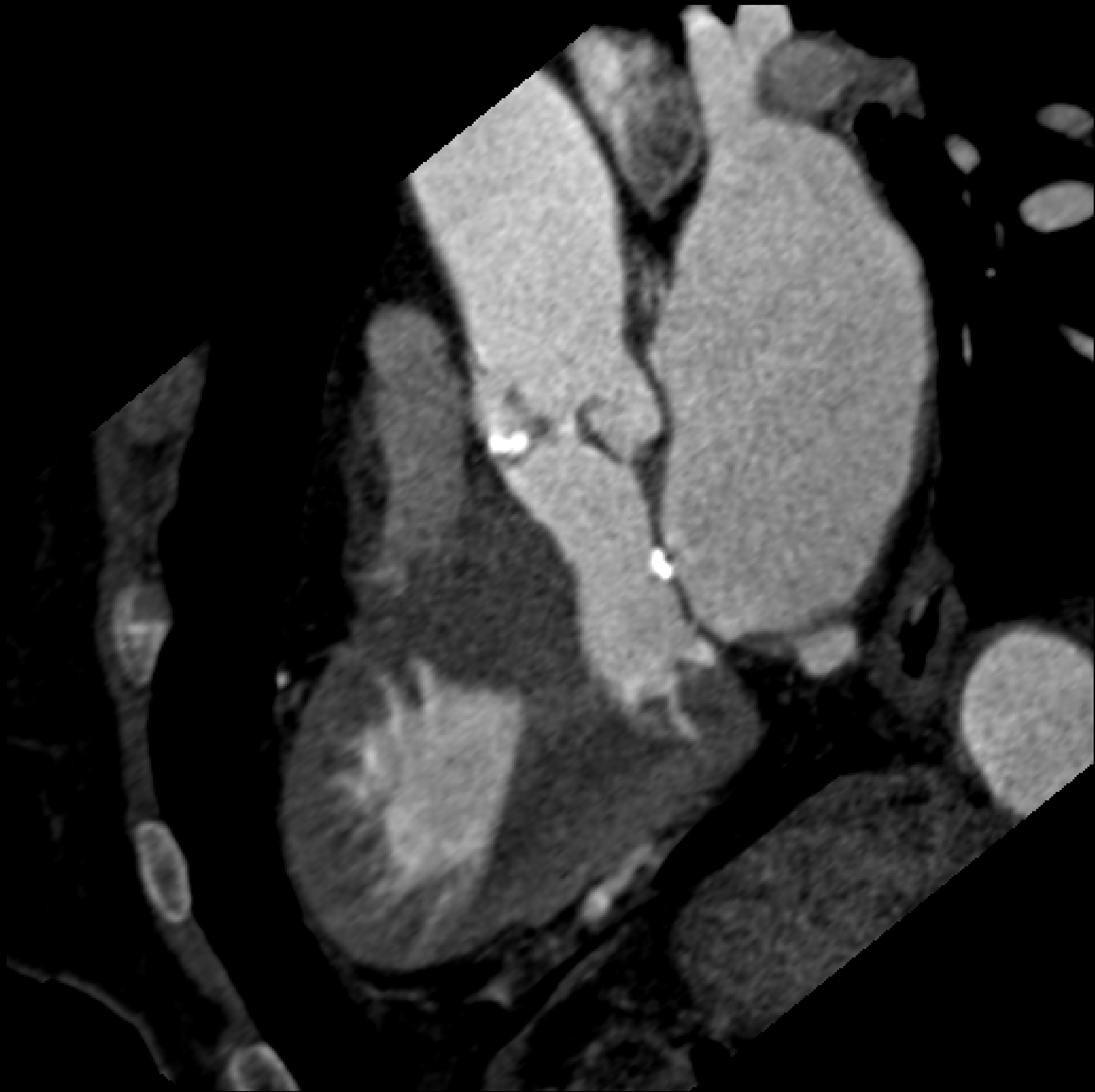
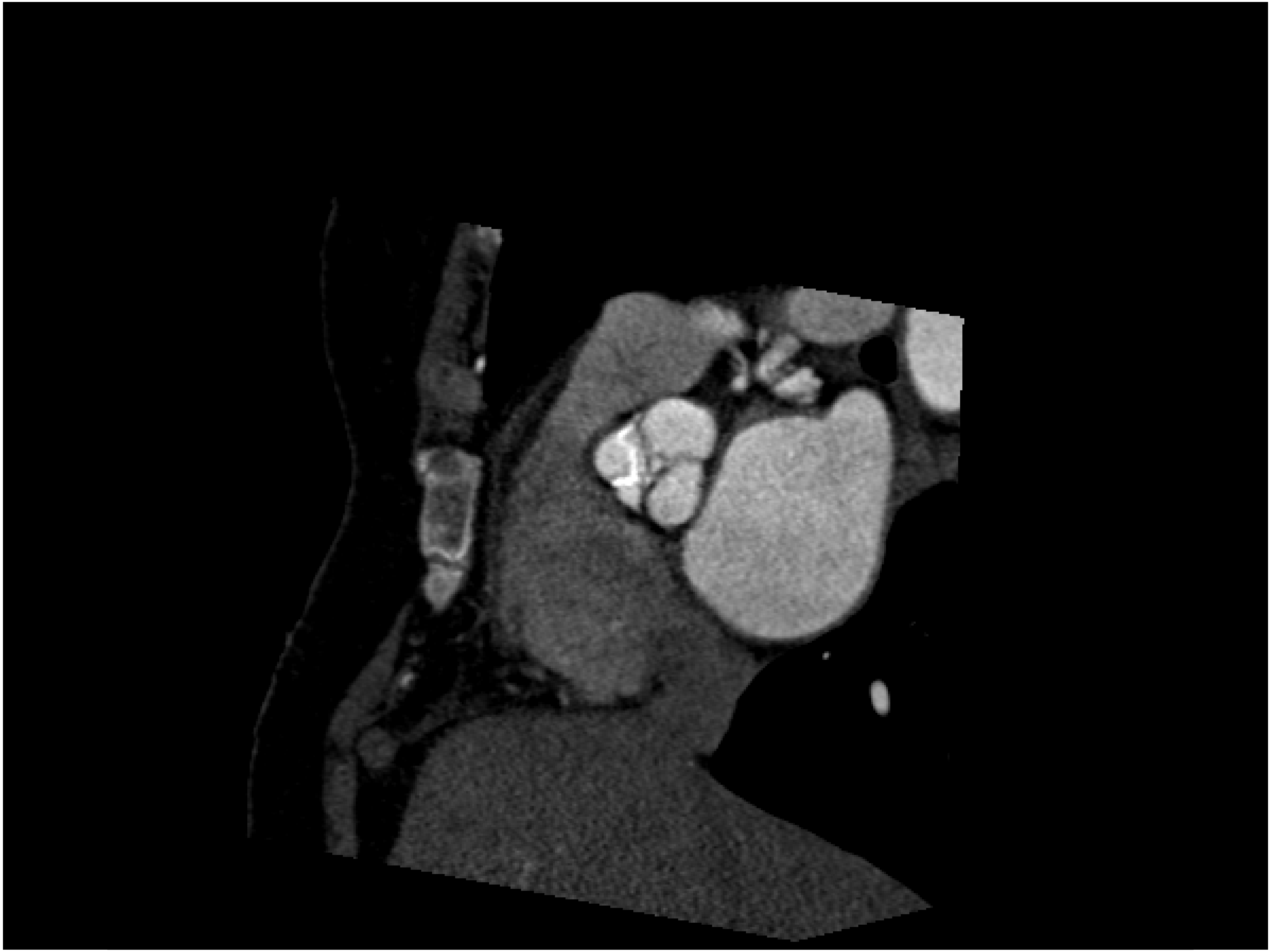
09:30:32 AM
W = 800 L = 200
AIL



Nicol E. *MIMS Cardiovascular* 2007;2(3):40-41



Nicol E. *MIMS Cardiovascular* 2007;2(3):40-41

Koos R, Mahnken A, Kuhl H, et al. Quantification of Aortic Valve Calcification Using Multislice Spiral Computed Tomography: Comparison with Atomic Absorbtion Spectroscopy. *Investigative Radiology* 2006;41(5):485-489

Bouvier E, Logeart D, Sablayrolles J-L, et al. Diagnosis of aortic valvular stenosis by multislice computed tomography. *Eur Heart J* 2006;27:3033-3038

Messika-Zeitoun D, Serfaty J_M, Laissy J-P, et al. Assessment of Mitral Valve Area in Patients with Mitral Stenosis by Multi-slice Computed Tomography. *J Am Coll Cardiol* 2006;48(2):411-413

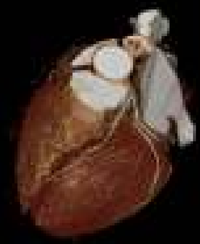
Feuchtner G, Dichtl W, Schachner T, et al. Diagnostic performance of MDCT for detecting Aortic Valve Regurgitation. *AJR* 2006;186:1676-1681

Jassal D, Shapiro M, Neilan T, et al. 64-slice Multi-detector Computed Tomography (MDCT) for Detection of Aortic Regurgitation and Quantification of Severity. *Invest Radiol* 2007;42(7):507-512

Alkadhi H, Wildermuth S, Bettex D, et al. Mitral Regurgitation: Quantification with 16-detector row CT- Initial Experience. *Radiol* 2006;238(2):454-463

Kim R, Weinsaft J, Callister T, et al. Evaluation of prosthetic valve endocarditis by 64-row multi-detector computed tomography. *Int J Cardiol* 2007;120:e27-29

The MDCT Angiography dataset



1. Coronary lumenography and anatomy
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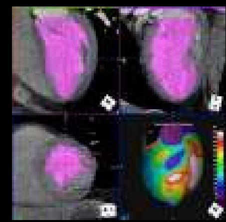
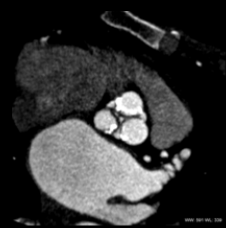
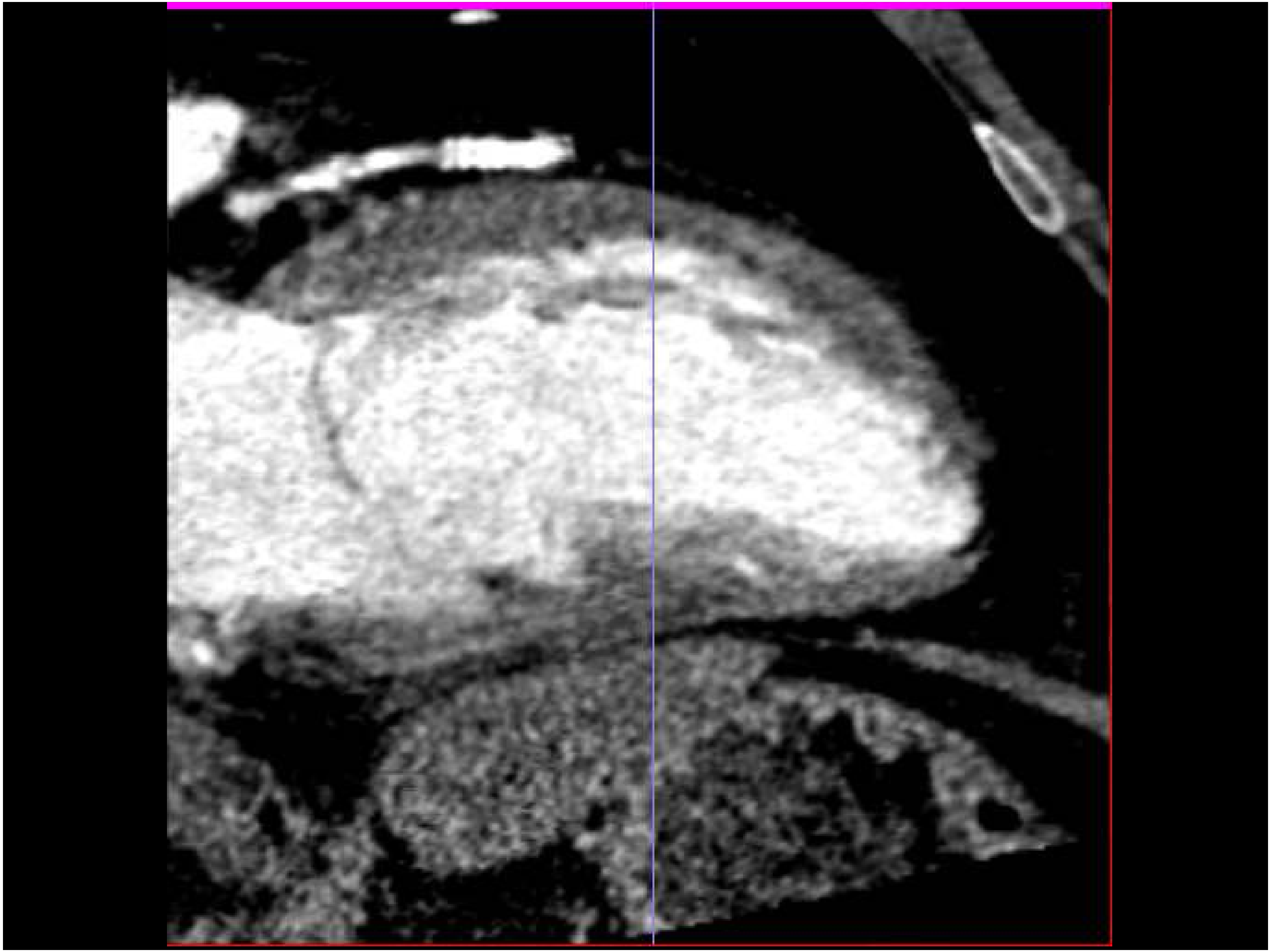
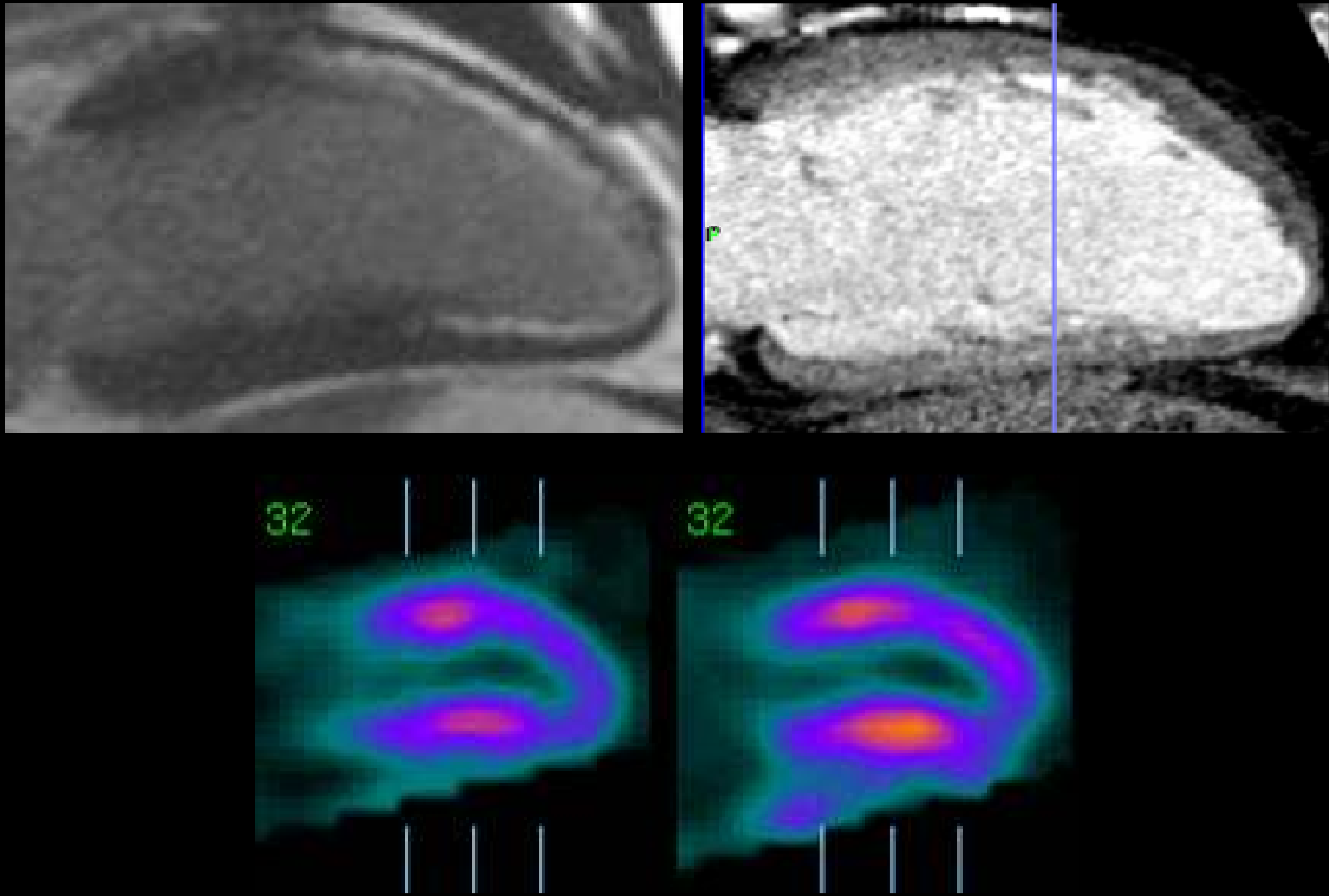


3. Ventriculography (left)
4. Valve assessment



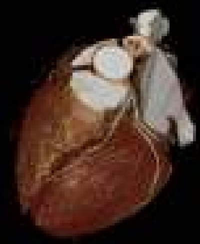
5. First pass perfusion



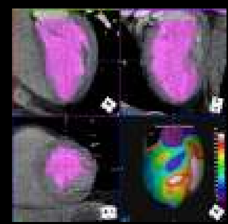


Nicol E. *MIMS Cardiovascular* 2007;2(2):44-45

First pass perfusion



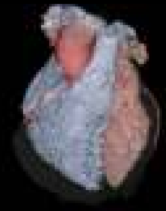
1. Areas of hypo-perfusion
2. No indication as to viability
3. May represent infarct region only if associated with lack of systolic wall thickening[1]

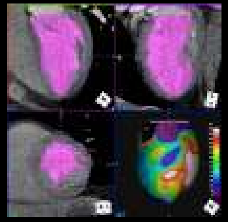


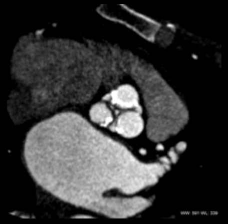
[1] Nicol E, Stirrup J, Reyes E et al 2008 Jul-Aug;15(4):497-502.

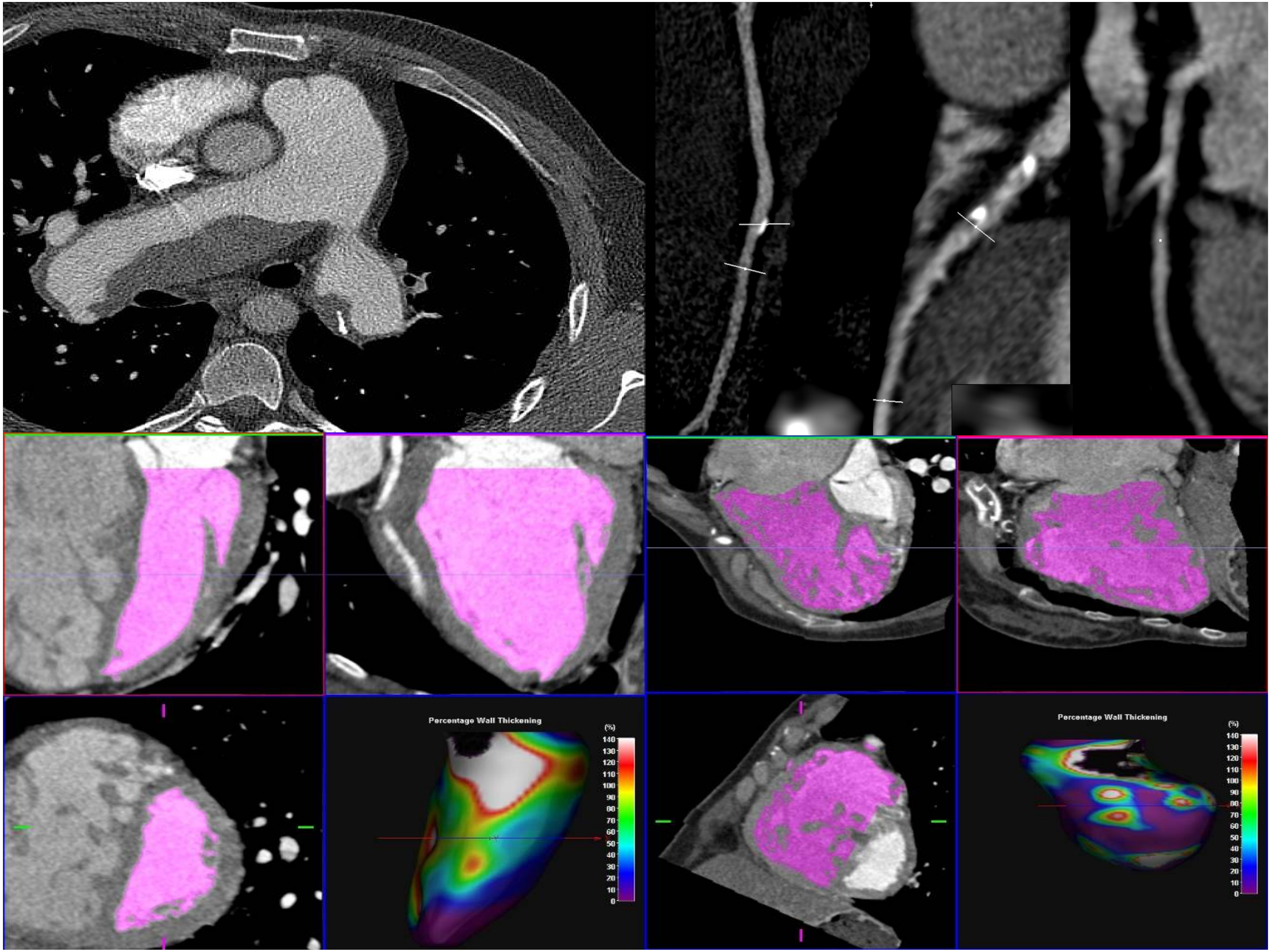
Extended Protocols

- Combined CTPA/CTCA

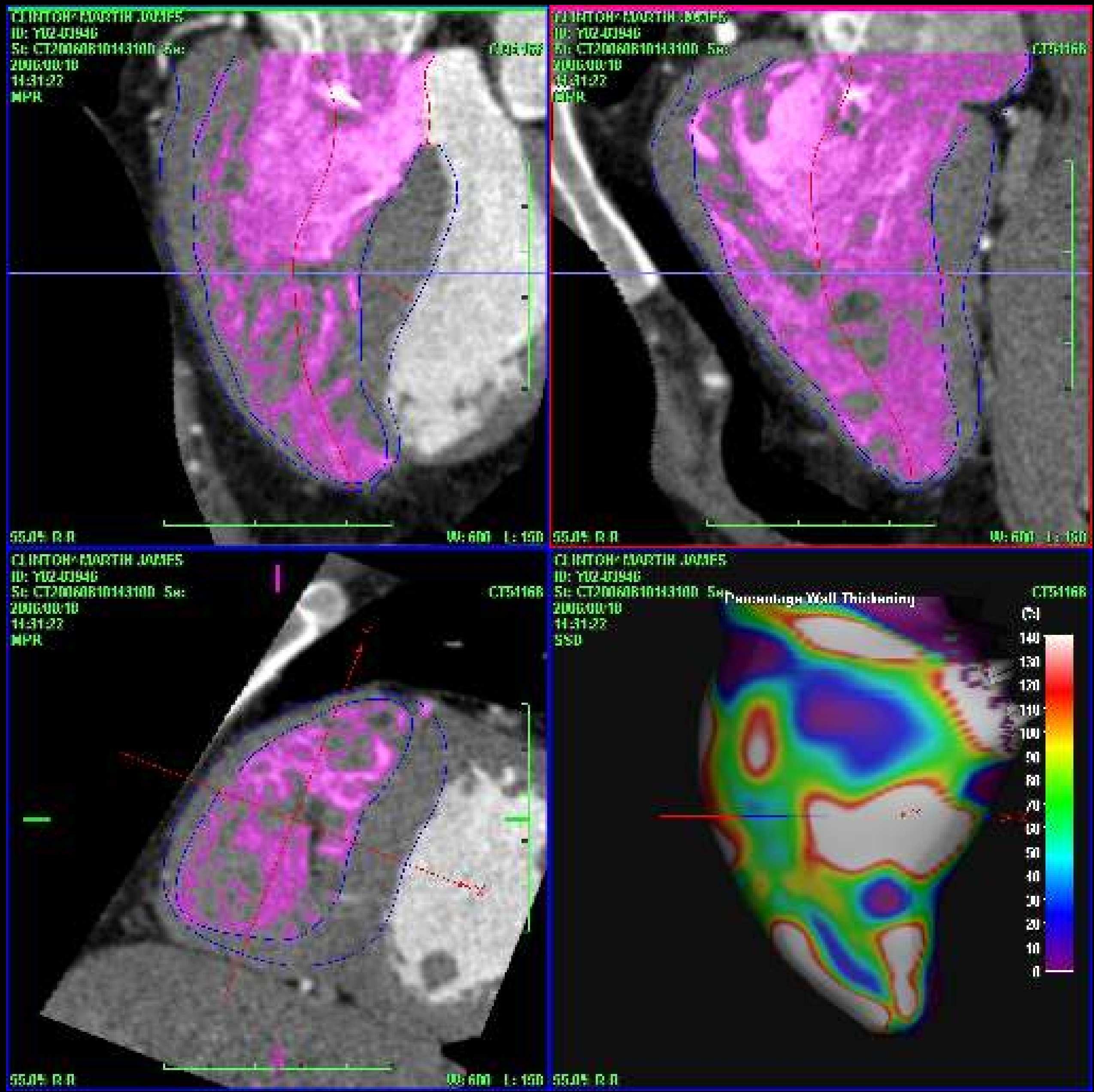








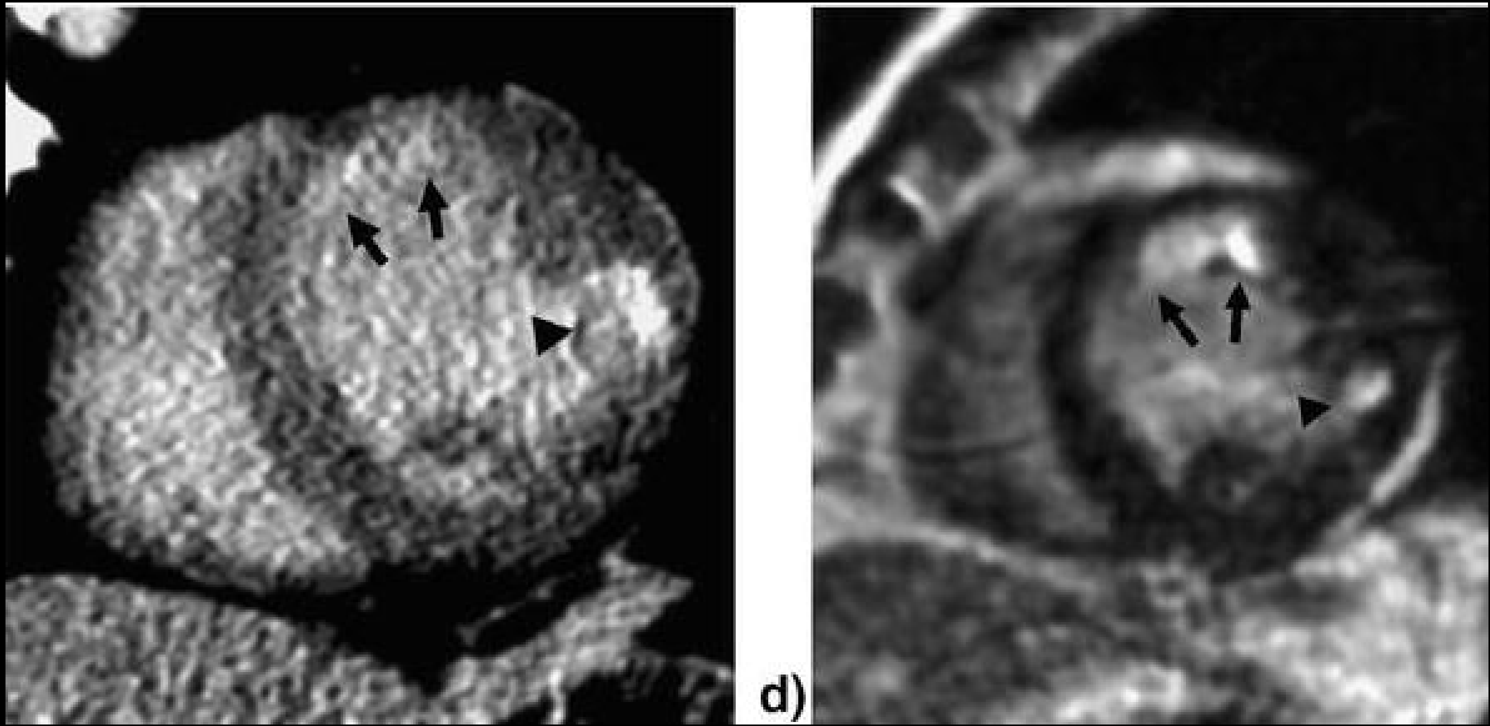
Percentage Wall Thickening
(%)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Percentage Wall Thickening
(%)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0



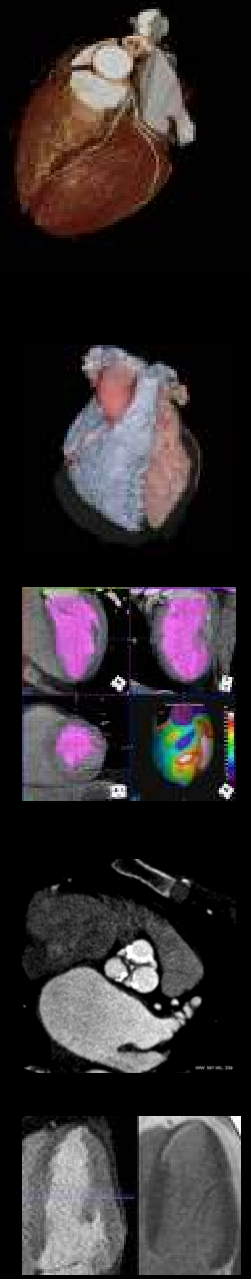
Nicol E, Kafka H, Stirrup J, et al. Int J Cardiol 2008

Extended Protocols

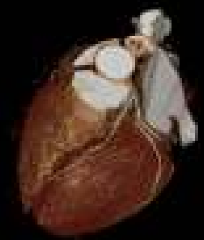
- Late pass perfusion



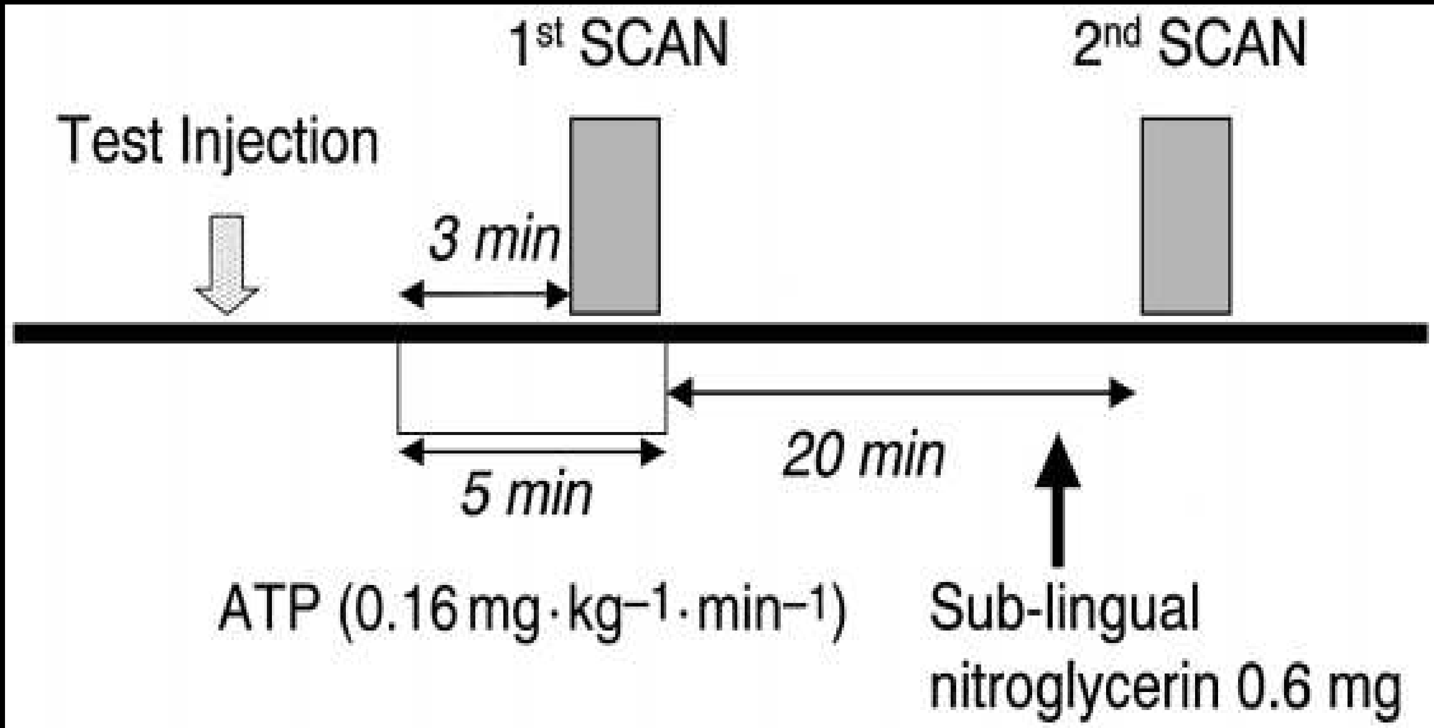
Mahnken AH et al. Eur Radiol (2007) 17: 994–1008



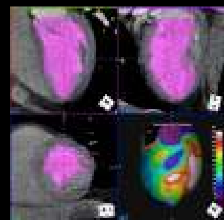
Extended Protocols



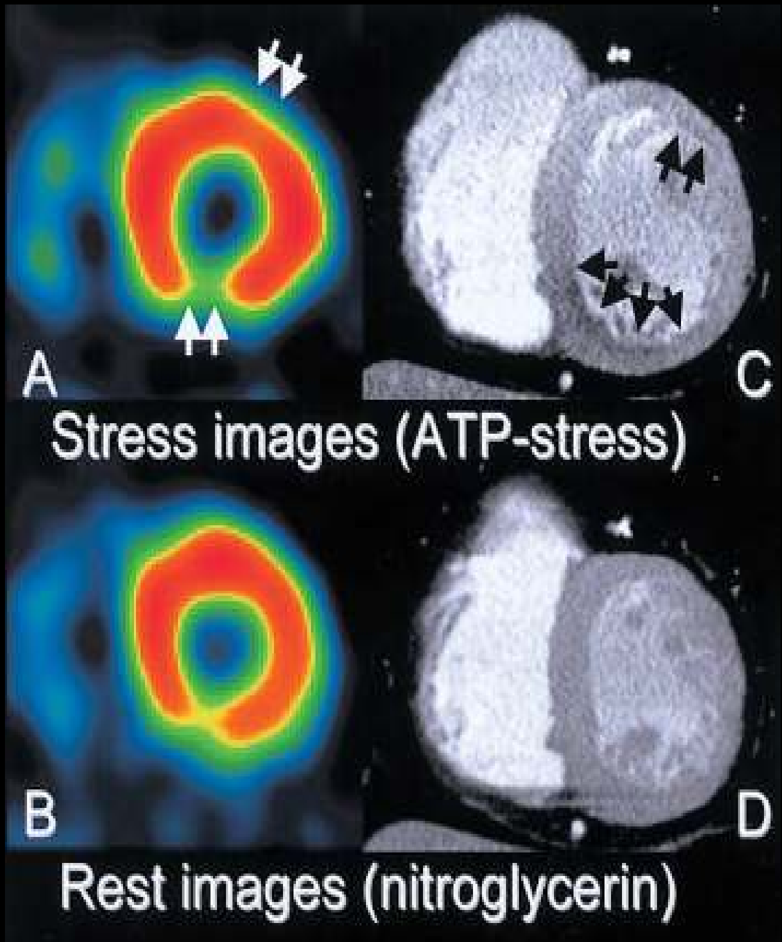
- Stress/Rest perfusion

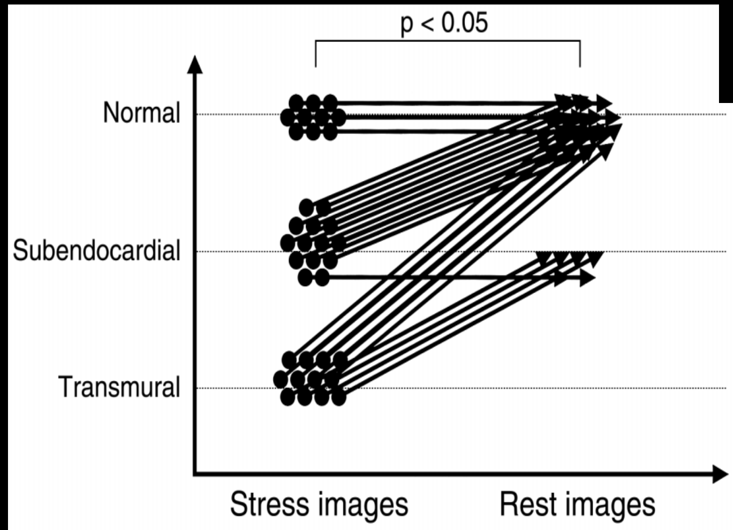


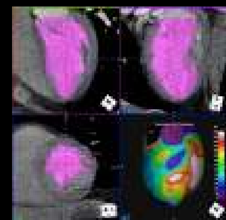
Kurata et al *Circ J* 2005; **69:** 550 –557

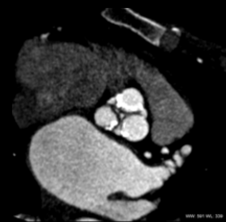


Extended Protocols







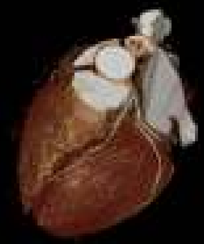


Agreement Between Perfusion CT and MPS

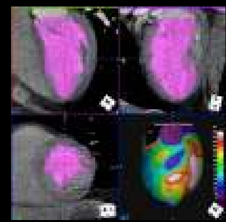
	MPS +/ve	***MPS -/ve***
PCT +/ve	*21*	*5*
PCT -/ve	*1*	*9*

Kurata et al *Circ J* 2005; **69:** 550 –557

Radiation Dose



- Diagnostic Angiography 2-6mSv
- PCI 5-40mSv
- Thallium (1 day) MPS 18mSv
- Thallium (2 day) 27mSv
- Technetium MPS 10mSv
- CTCA (retrospective gating) 6-18mSv*
- CTCA (prospective gating) 2-4 mSv

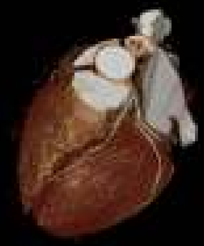


*2-4 mSv on 320MDCT single beat

Radiation Dose

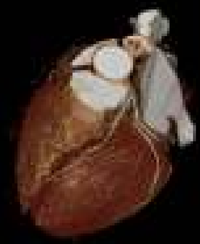
- Major criticism of CTA
- Industry drive to reduce dose
- Radiology community now favouring prospective gating (a retrospective step?)
- Loss of functional data
- Dose modulation now core in all new scanners
- Smart ECG recognition

Current CT Choices -2012



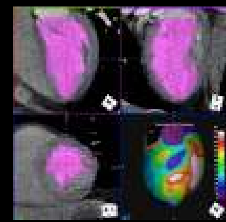
- 64 MDCT – All vendors
- 64 Dual Energy –Siemens/GE
- 64/128 Dual Source - Siemens
- 128 MDCT - Siemens
- 256 MDCT – Toshiba/Phillips
- 320 MDCT – Toshiba Aquilion One

Summary



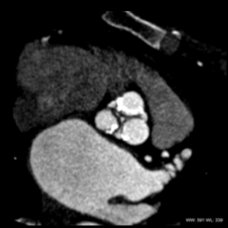
1. The MDCTCA dataset is more than just the coronary arteries

   - Coronary lumenography and anatomy
   - Ventricular function (Left)
   - Valve assessment
   - Perfusion (first pass)



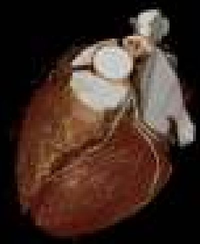
2. Extended Protocols may allow a comprehensive assessment of cardiac function

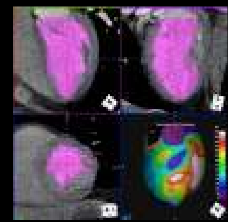
   - combined CTPA/CTCA (RV function)
   - late pass perfusion
   - rest/stress perfusion

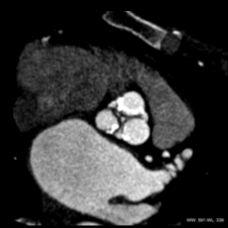


Controversy

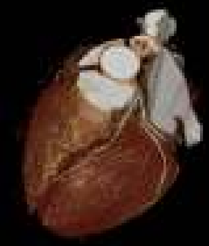
1. GTN or not
2. Prospective vs retrospective ECG gating
3. Increase detectors vs increased x-ray tubes vs increased rotation time
4. Most appropriate window levels
5. 50% or 70% cut-off
6. Role of acute CTCA in UK practice
7. Combined CT and functional imaging





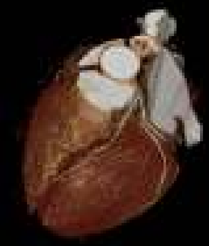


Acknowledgements



Dr Mike Rubens
Dr Simon Padley
Mrs Nina Arcuri
Miss Sally Copperthwaite
Dr Carl Schultz
Dr Jim Stirrup
Professor Richard Underwood
Professor Michael Gatzoulis
Professor Tim Evans
Prof Stefan Neubauer
Royal Air Force Medical Service

Questions



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