CARDIAC CT ANGIOGRAPHY

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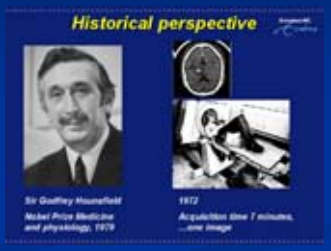
MAURITIUS

- 1.2 million population
- High prevalence and incidence of CAD
- 20 % of the population is diabetic
- Sedentary lifestyle and western diet
- Multiple risk factors

HISTORY OF CT

- CT brain 1972
- EBCT 1980's
- MSCT (4-slice) in 2004
- MSCT (64-slice) in 2006
- MSCT 128-slice, 256-slice, Dual Source
- 64 slice MSCT(in Mauritius, February 2007)



TECHNIQUE

- Toshiba Aquillion 64-slice
- 0.5 X 64
- KV/mA 120/400
- Carina to apex of the heart in normal routine cases and
- From manubrium to apex in CA=bypass cases
- 70-80ml@4-5ml/sec contrast [ultravist 370]
- 50ml @ 4-5ml/sec normal saline
- Oral/IV B-Blockers [Inderal] if HR >70-80/min
- With cardiac Gating/3phases data acquisition
- Each patient with cardiac score pre-angio

QUALITY

- Excellent 30%
- Good 30%
- Acceptable 30%
- Heavy calcification 9%
- Poor quality 1% (pt. compliance poor,motion artifacts)

REPORTED FINDINGS

- 1/3 normal
- 1/3 mild disease
- 1/3 significant lesions (subsequent cardiac cath.)

- Referrals for CTA
  a) 80% cardiologists
  b) 5% GPs
  c) 15% self- referral

COMMON INDICATIONS

Chest pain	20%
Diabetes	5%
Hypertension	10%
Abnormal Lipid profile	15%
Abnormal ECG/TMT	10%
Higher Risk factor/routine	15%
Pre-angiography	5%
Stent follow-up	5%
Bypass follow-up	5%
Congenital	<1%
Misc	9%

ACC GUIDELINES FOR CTA

Detection of coronary disease in the following settings:

1. Uninterpretable or equivocal stress test
2. Intermediate pretest probability of CAD, ECG uninterpretable or unable to exercise
3. Acute chest pain, intermediate pretest probability of CAD, no ECG changes and enzymes
4. New onset heart failure to assess cause
5. Evaluation of suspected coronary anomalies

AREAS OF UNCERTAINTY

- Coronary stents (frequent artifacts)

  ? 3.5mm and less than 3mm, stent type.
- Bypass grafts (good detection of stenoses and occlusions, but artifacts from clips from mammary graft and distal target vessels may be small or have pronounced calcifications can be challenging for CTA.

CT coronary angiography:

evolving clinical indications

1. *Patients with low to intermediate likelihood of CAD*
2. *Triage of patients with acute chest pain*
3. *Evaluation post-CABG or post-PCI*
4. *Difficult "lesion" subsets in the cathlab*

   - coronary anomalies

   - ostial lesions

   - bifurcation lesions

   - chronic total occlusions

1. Patients with low-to-intermediate likelihood of CAD

- Rationale: reduce the number of purely diagnostic angiograms
- Considering the risk, inconvenience of patients and significant costs of an invasive angiogram, CTCA may become an attractive alternative

	Non anginal chest pain		Atypical angina		Typical angina	
Age, y	Men	Women	Men	Women	Men	Women
30-39	4	2	34	12	76	26
40-49	13	3	51	22	87	55
50-59	20	7	65	31	93	73
60-69	27	14	72	51	94	86

Diamond and Forester

NEJM 1979

1. Patients with low-to-intermediate likelihood of CAD

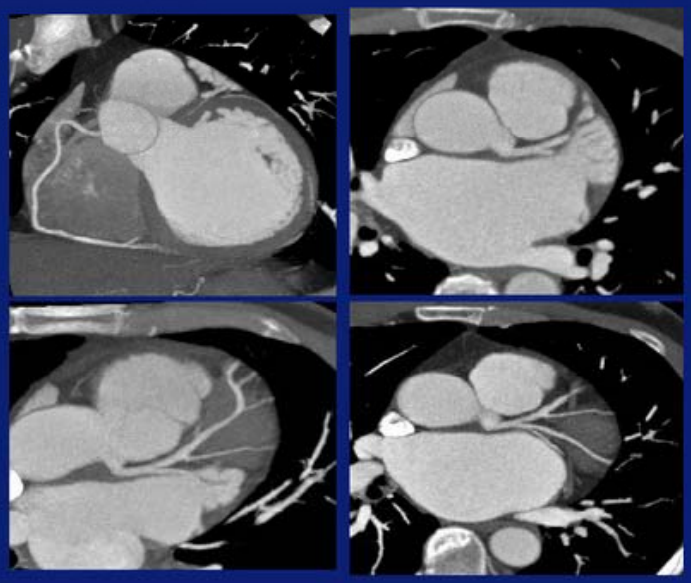
- Pre-operative CCA is recommended in most patients scheduled for valve surgery
- However relatively low prevalence of obstructive CAD ≈ 30%

ACC/ AHA guidelines, Circulation 2006

- Treadmill testing, stress echocardiography, scintigraphy ....lack accuracy

→ **preoperative CTCA for cardiac valve surgery**

Female patient, 46 years, severe mitral valve insufficiency, atypical chest pain.



Preoperative assessment of patients referred for valve surgery

- *N= 70 (145 screened; 35 CT related exclusion criterium)*
- *64-slice CT scanner*
- *Prevalence of sign CAD: 26%*
- *Sens. 100%, Spec. 92%, PPV 82% NPV 100%*
  True negatives: 48/70
  True positives: 18/70
  False positives: 4/70

Meijboom W, Mollet NR, Van Mieghem CAG et al., JACC 2006, 48: 1658-1665

2. Triage of patients with acute chest pain

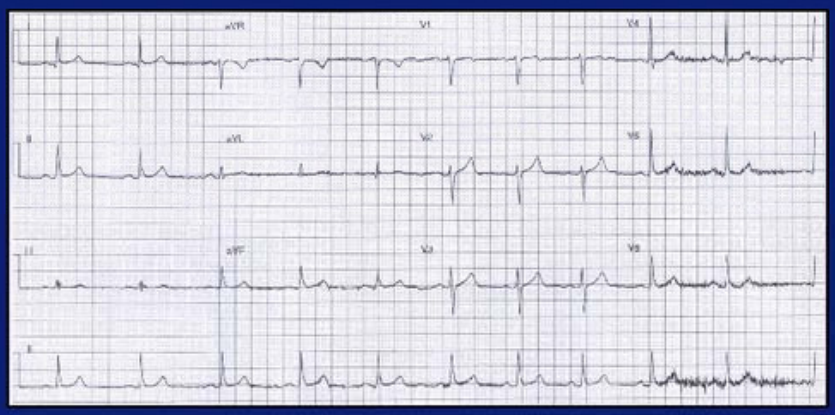
- ≈ 6×10^6 patients admitted for chest pain in EDs (USA)
- low treshold to admit chest pain patients, further testing
- ~ 2 to 10% of patients with an ACS are inappropriately sent home from the ED
- >60% of patients with acute chest pain who are admitted to the hospital do not turn out to have ACS

↓

CTCA for early triage?

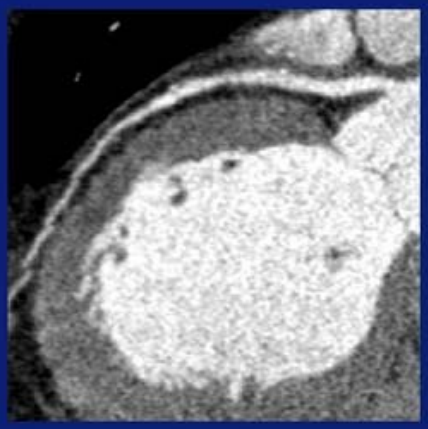
2. Triage of patients with acute chest pain

Male patient, 58 years, prolonged chest pain, no enzymes. Echo normal.



Male patient, 58 years, prolonged chest pain, no enzymes. Echo normal.

Erasmus MC



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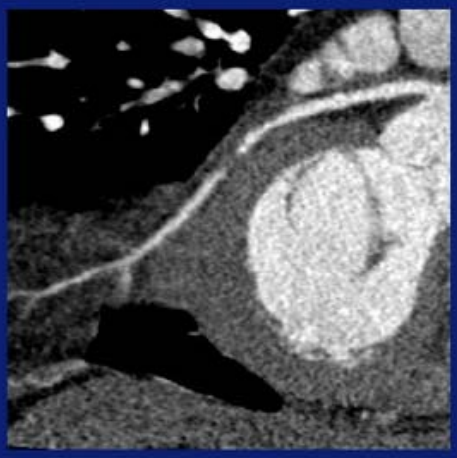
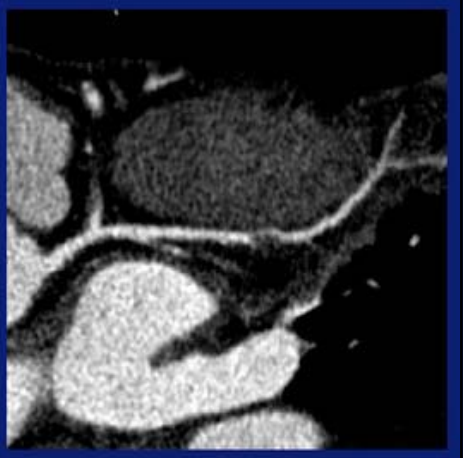
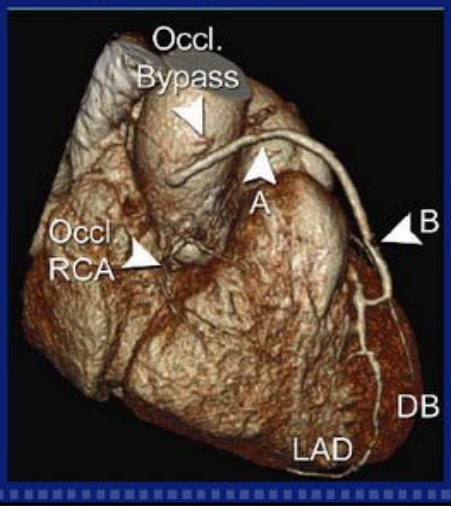


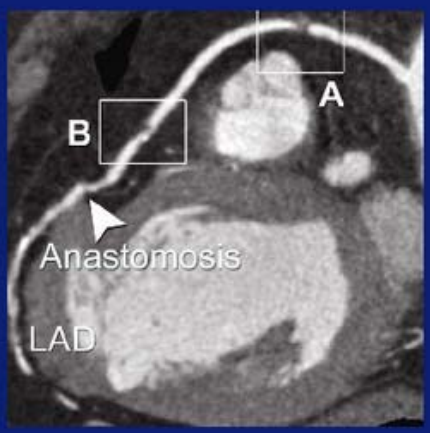


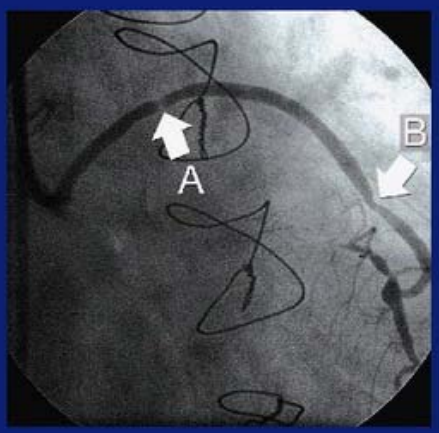
3. Evaluation of patients after coronary revascularization:

- Evaluation of bypass grafts

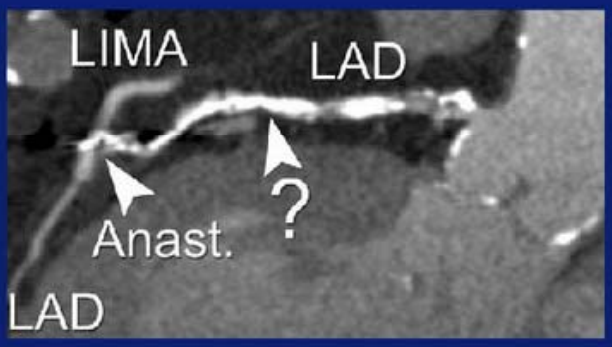


Evaluation of bypass grafts





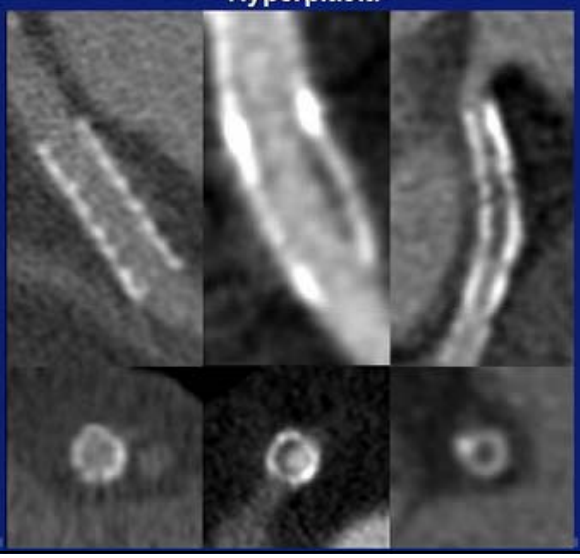
Evaluation of bypass grafts



- Presence of vascular clips, sternal wires, and graft orifice indicators complicate evaluation of grafts
- Before becoming clinically useful, MSCT must proof that grafts AND native vessels can be evaluated

CT Coronary Angiography Stent Imaging

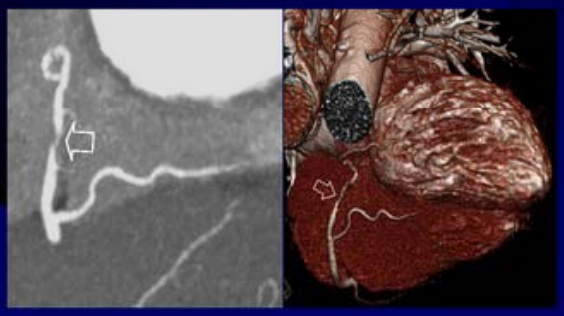
Erasmus MC



Interpretation - Image Parameters

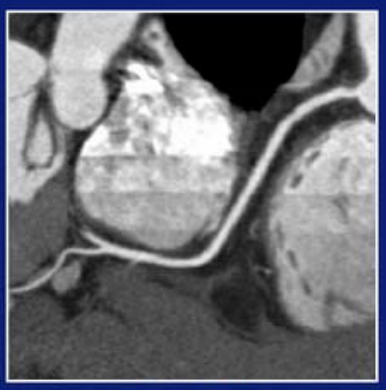
Invasive vs. Non-invasive Coronary Angiography

Angiography	64-MSCT / Dual source CT
0.2 x 0.2 mm^2	0.4 x 0.4 x 0.4 mm^3
8-10 ms	165 ms / 83 ms
Intracoronary contrast	I.V. contrast



Pugliese, Eur Radiol 2006; 16:575

Taking care in image acquisition is the most important step to assure good results…

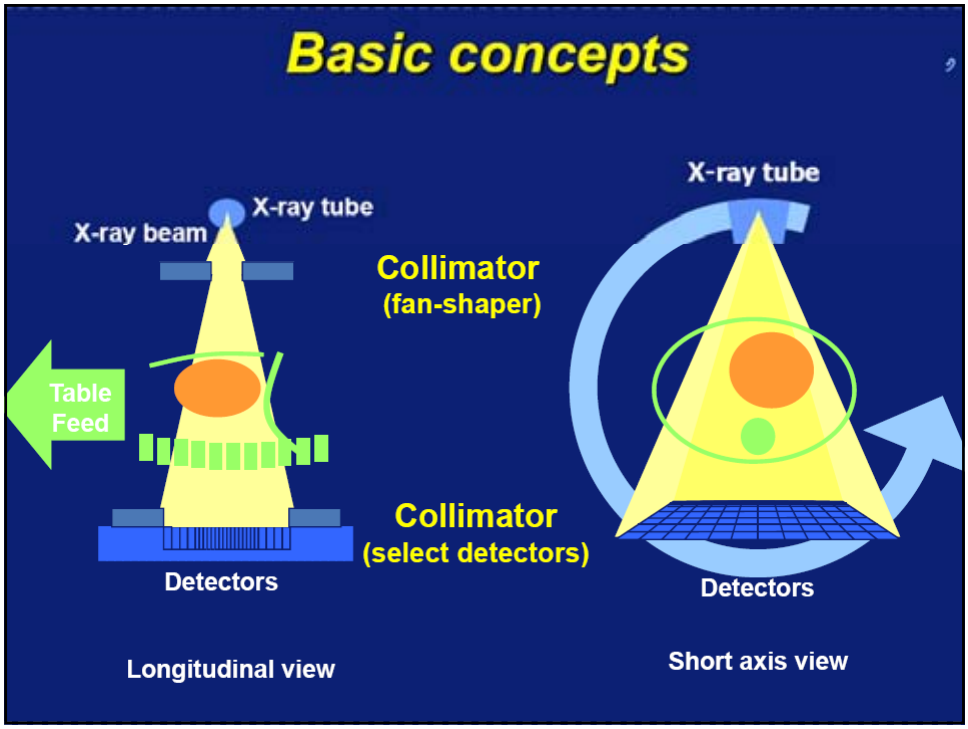


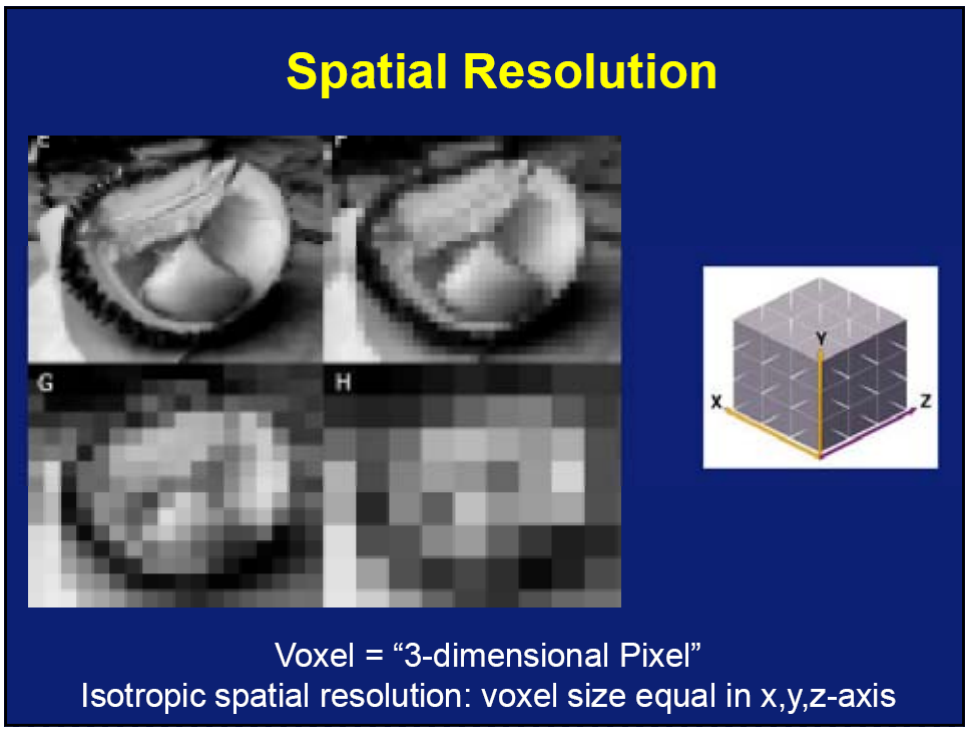
Good IQ

Meticulous preparation

Bad IQ

Adhere to your protocol


Basic concepts
X-ray tube
X-ray beam
Collimator
(fan-shaper)
Table
Feed
Collimator
(select detectors)
Detectors
Longitudinal view
X-ray tube
Detectors
Short axis view


Spatial Resolution
G
H
Y
X
Z
Voxel = "3-dimensional Pixel"
Isotropic spatial resolution: voxel size equal in x,y,z-axis

Temporal resolution

Definition: time required for data acquisition to reconstruct one image

~ 180 gantry rotation

Total cardiac exam: ~ 300 images

Fast coverage

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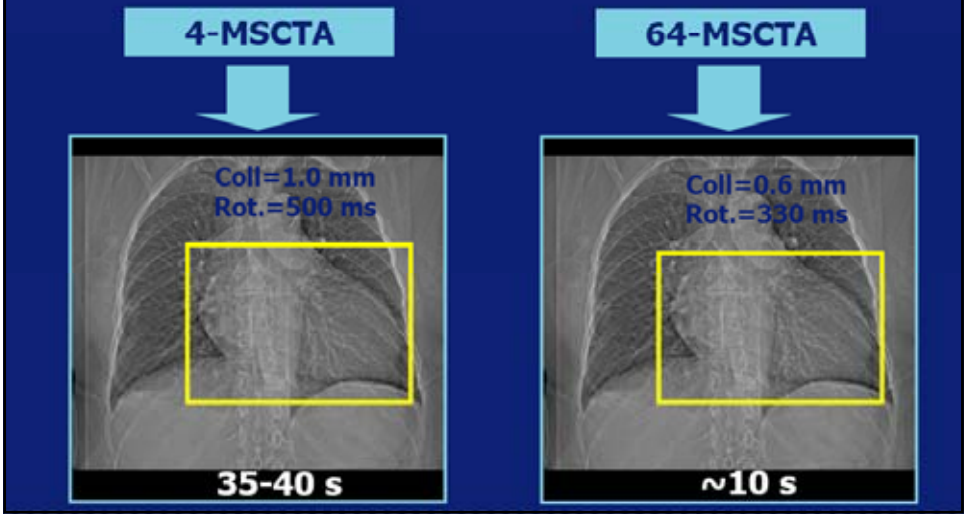
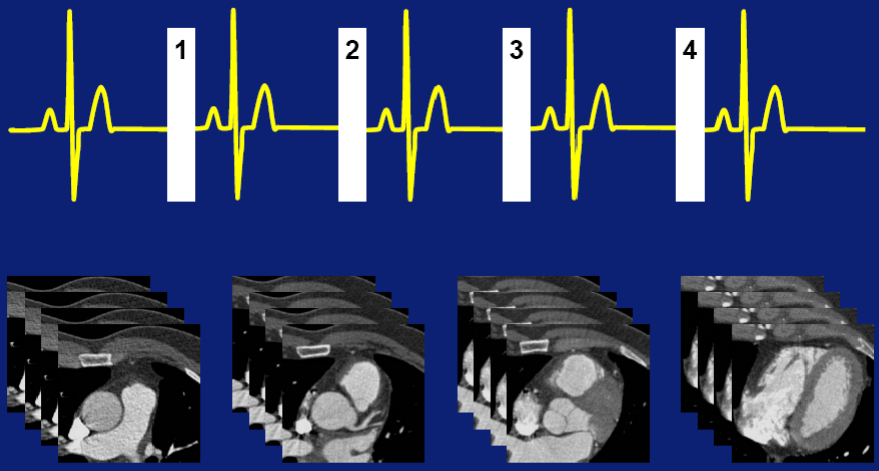
High resolution CT-CA

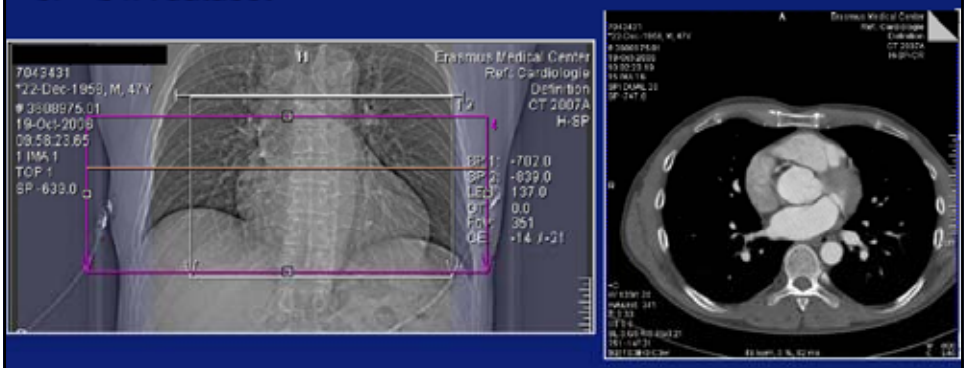


CT coronary angiography: synchronization with cardiac cycle



Three-step protocol

1. Localization of the heart and scan volume
2. Contrast agent transit time (test bolus/ bolus tracking)
3. CTA dataset



Incidental findings

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Aortic aneurysm

pulmonary nodule

Relevant extra-cardiac pathology in up to 10% requiring additional diagnostic tests or clinical follow-up…

Horton et al. Circ 2002; 106: 532
Hunold et al. EHJ 2001; 22: 1639

Erasmus MC

Three-step protocol

1. Localization of the heart and scan volume
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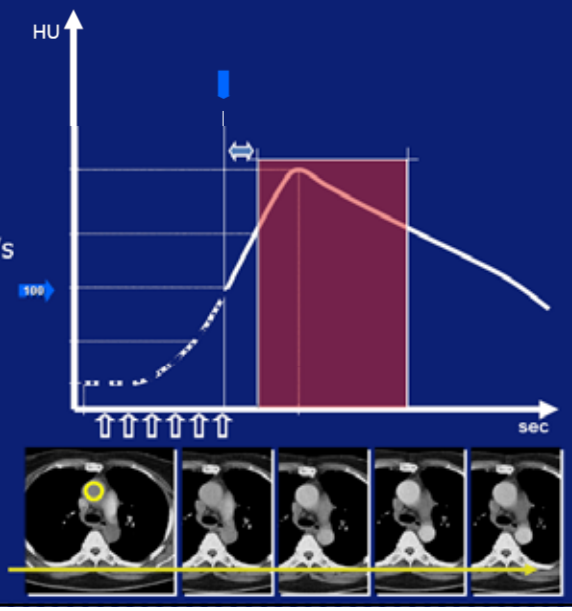
Erasmus MC

Contrast injection
100 ml Iomeron 400 @ 5 ml/s



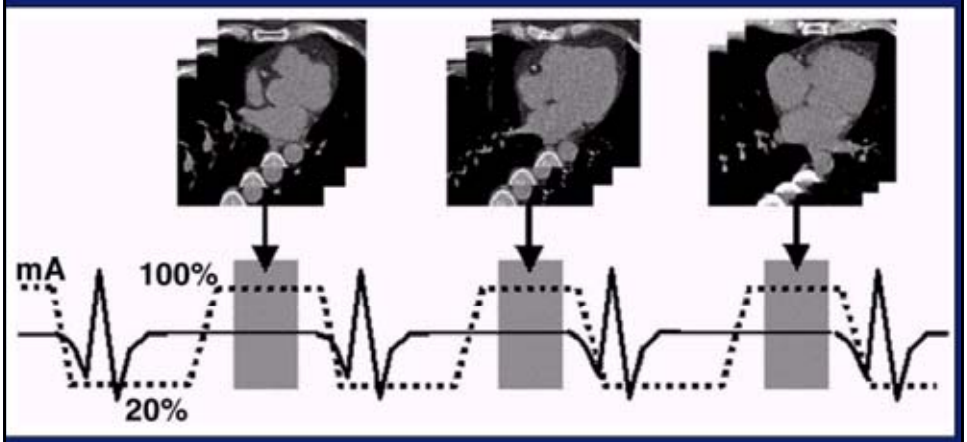
Erasmus MC

Three-step protocol

1. Localization of the heart and scan volume
2. Contrast agent transit time (test bolus/ bolus tracking)
3. CTA dataset

- Contrast: 70-100 ml; 5 ml/sec
- Breathhold
- Highest temporal resolution
- Highest spatial resolution
- 120 kV
- Rather high tube current (900 mAs)

Limit full radiation exposure to diastole: tube current modulation



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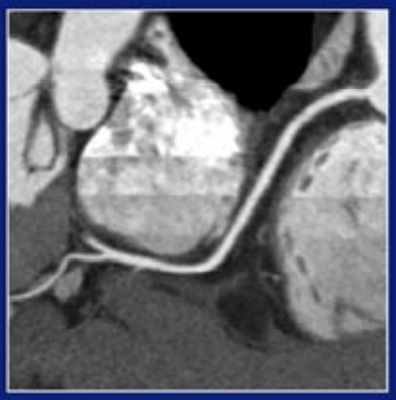

Good IQ

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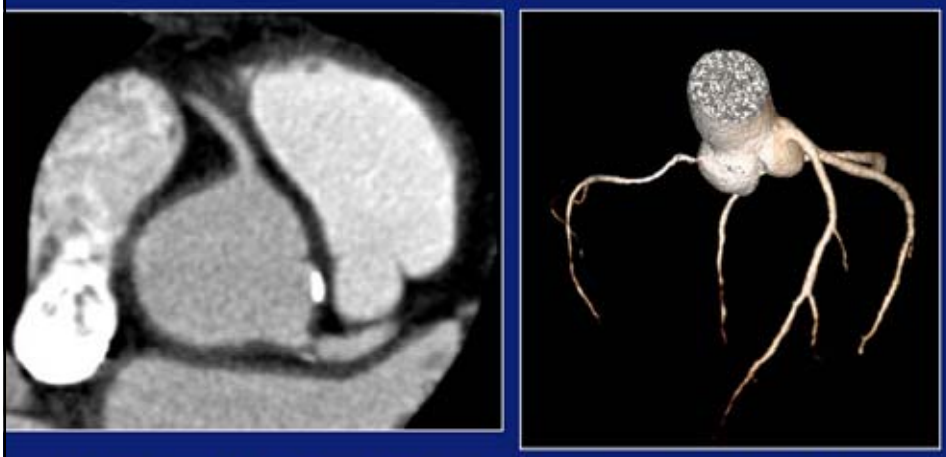
Bad IQ

Adhere to your protocol

Quality in cardiac CT…

Erasmus MC



… high quality raw data…not fancy postprocessing…

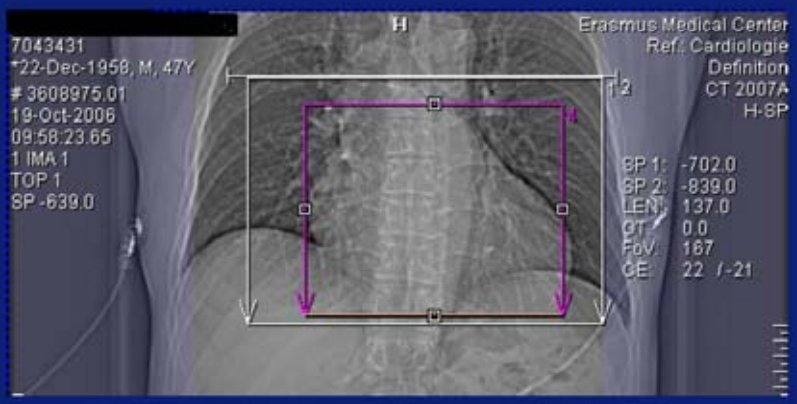
1. Patient preparation…

Erasmus MC

- explain the procedure to the patient
- make sure breathhold commands are followed/ understood

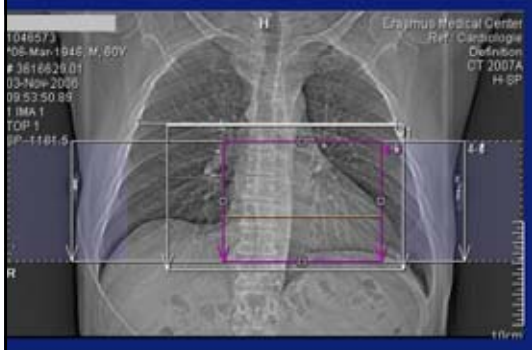
2. Data acquisition:

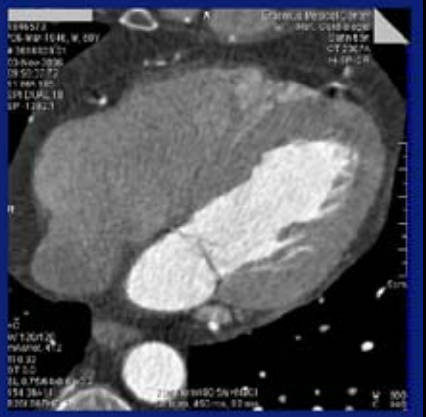
Localization of the heart and scan volume



3. Image reconstruction:

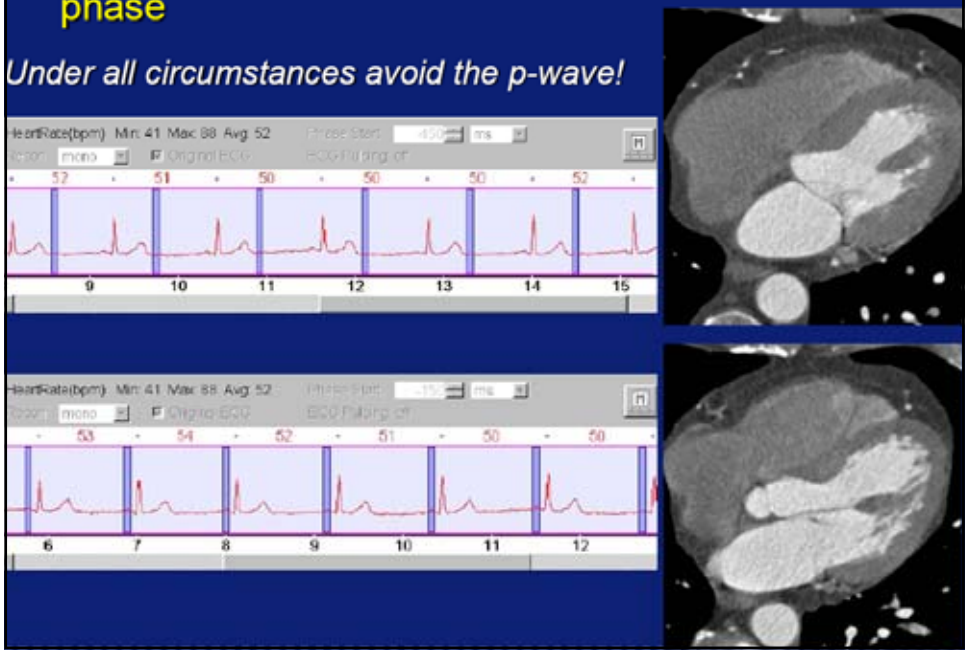
- Field of view: small



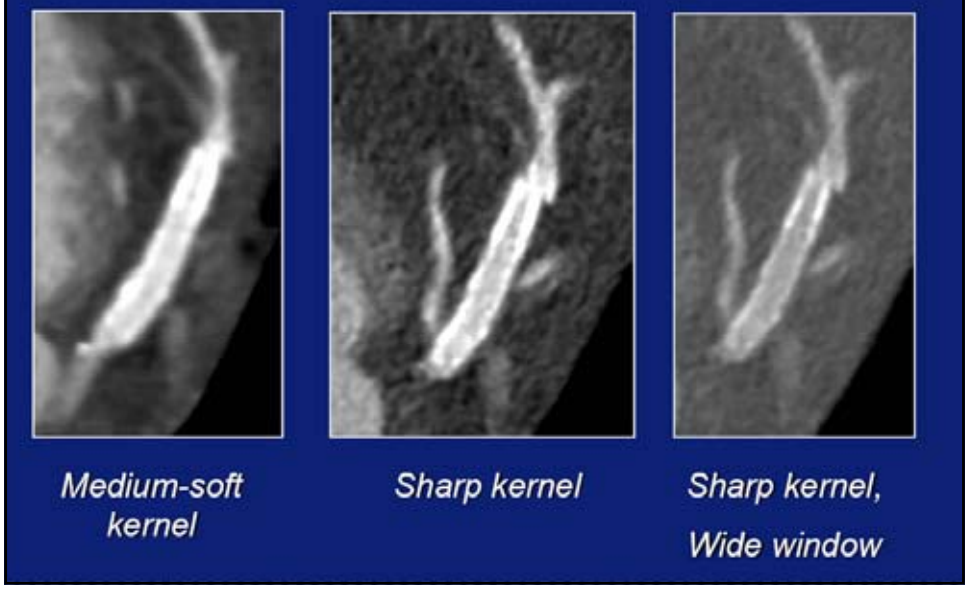


3. Image reconstruction: choosing the best cardiac phase

Under all circumstances avoid the p-wave!



3. Image reconstruction: try sharp Kernel filter for calcified vessels/ stents



Medium-soft kernel

Sharp kernel

Sharp kernel, Wide window

Will CT replace diagnostic cath?

Erasmus MC

DSCT:

0.4 mm spatial resolution

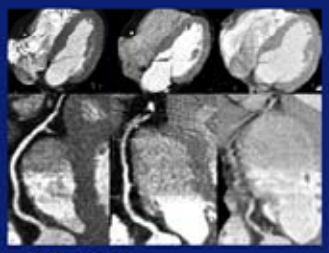
83 ms temporal resolution

Severe calcium

Invasive angio:

0.2 mm spatial resolution

10 ms temporal resolution



Motion

4. Difficult "lesion" subsets in the cathlab

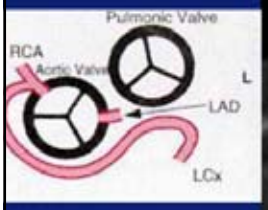
- Coronary anomalies

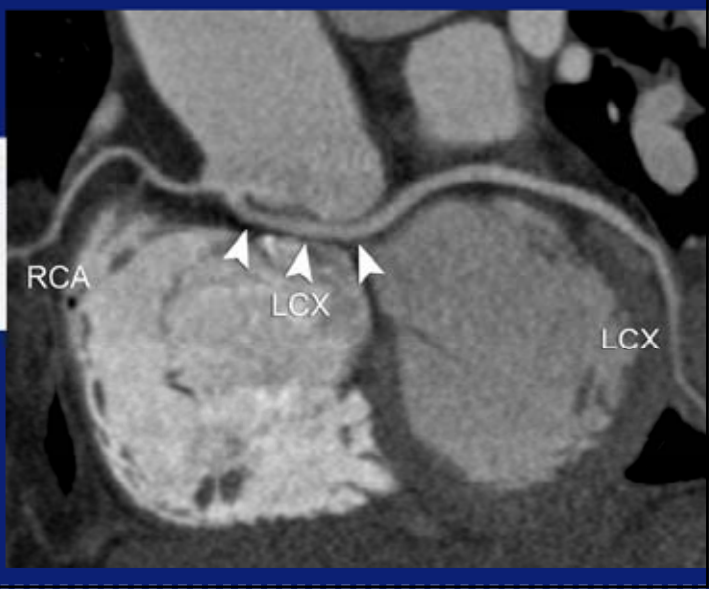
- Coronary anomalies affect ~1% of the general population
- *The majority of them are benign*
- *some types are associated with sudden cardiac death*
- *the 3D information as obtained with CT allows easy anatomical interpretation of coronary anomalies*

4. Difficult "lesion" subsets in the cathlab

- Coronary anomalies

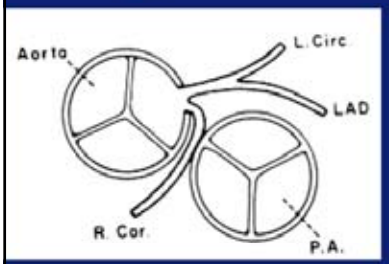
Benign

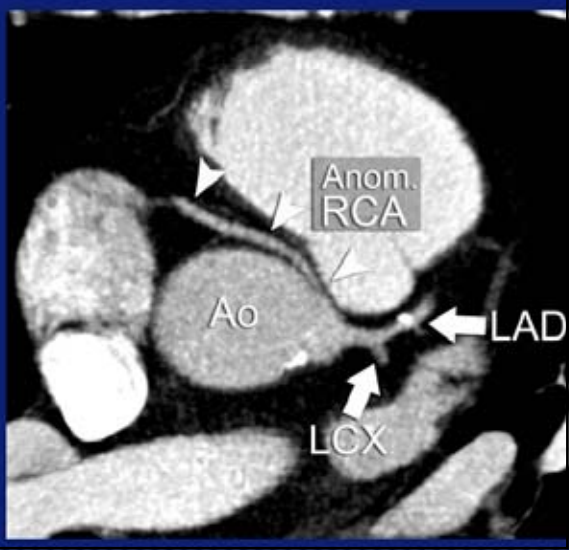




Coronary Anomalies

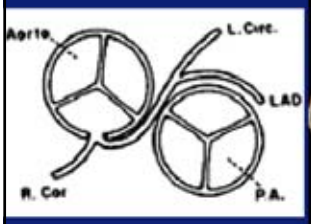
Malign





Coronary Anomalies
Malign

Erasmus MC



4. Difficult "lesion" subsets in the cathlab

- Bifurcation lesions

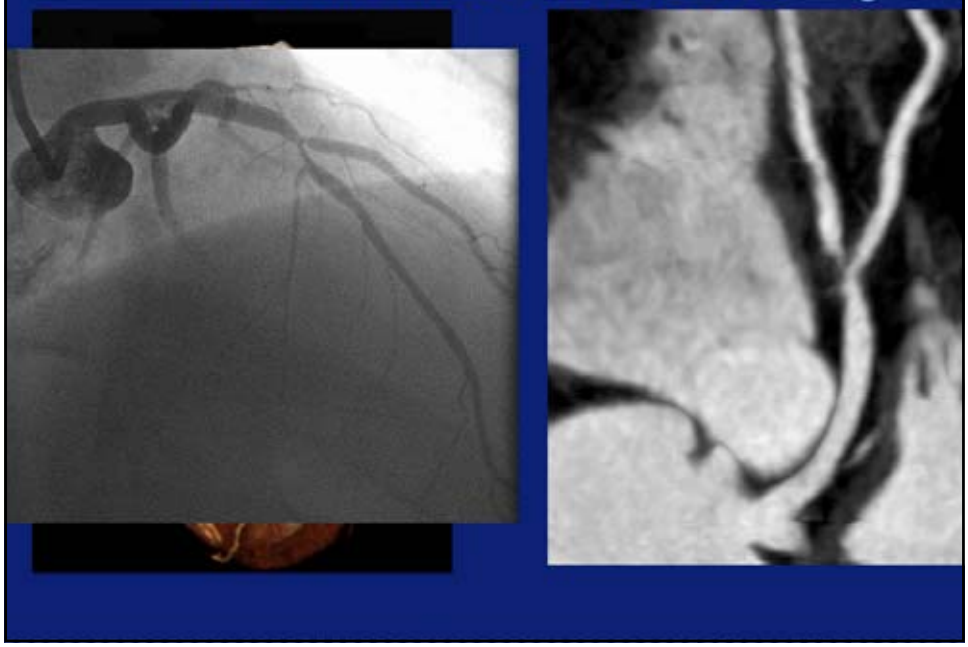
- A coronary BL is present in approximately 15% of coronary angioplasties

- ICA is regarded as the reference standard for the diagnosis of significant CAD and is used as the primary imaging technique for guidance during PCI

- Limitations of ICA: vessel overlap, foreshortening challenge the technique to accurately visualize coronary artery lesions, particularly at bifurcation sites

CTCA and bifurcation lesions

Erasmus MC



CTCA and bifurcation lesions

Erasmus MC

	1.0.0	0.1.0	1.1.0	1.1.1	0.0.1	1.0.1	0.1.1
							
CCA	10	8	8	5	5	8	2
CTCA lumen	10	7 1.1.0	8	4 1.1.0	5	8	2

Van Mieghem CAG et al., under review

CT-coronary angiography: "the end of the beginning"

Coronary CTA :

High negative predictive value to rule out stenoses

Lower positive predictive value

Patients with high pre-test probability are ***not*** the group of interest (PCI, CABG)

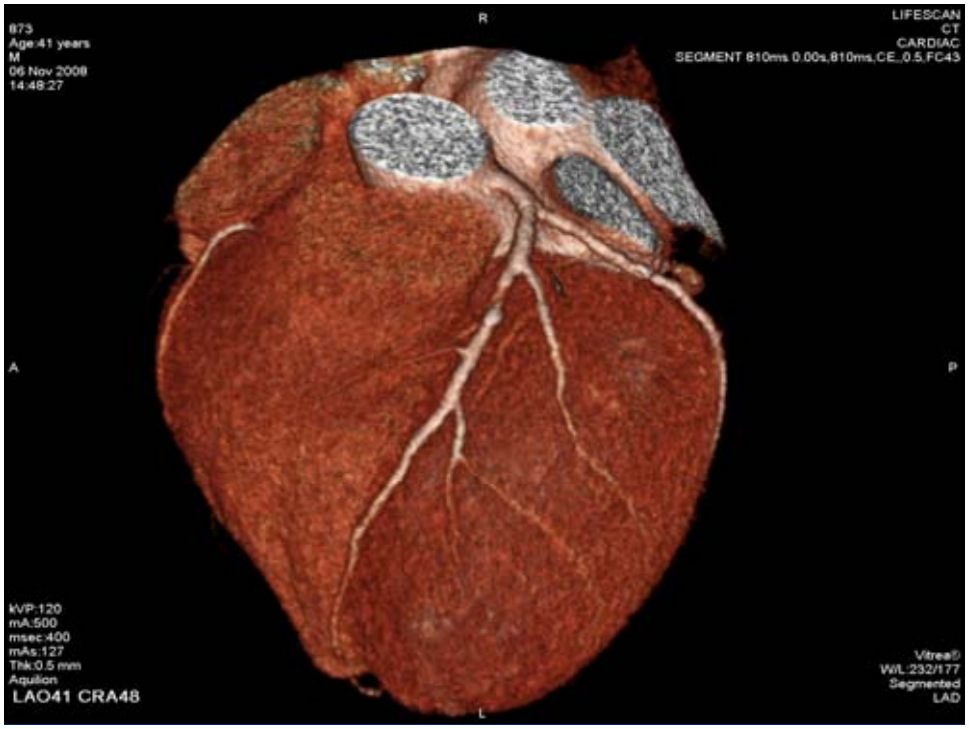
CT-coronary angiography: "the end of the beginning"

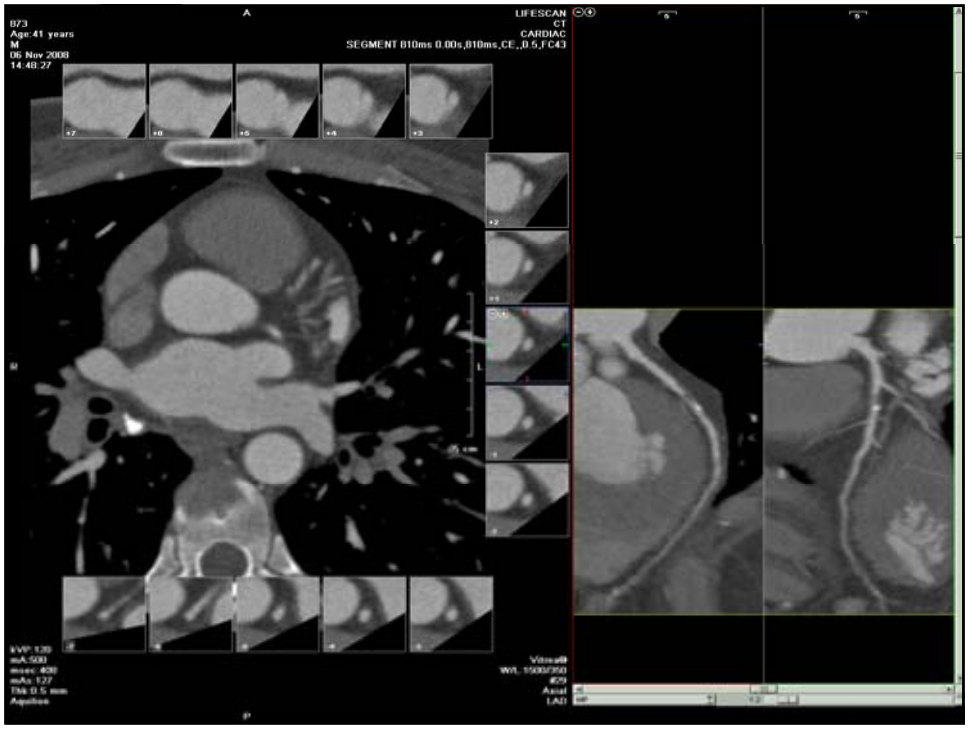
However:...

Possible clinical applcations:

- Rule out coronary stenoses (low- to intermediate probability of CAD):
  - outpatient clinic
  - ED (acute chest pain, low risk)
  - patients undergoing cardiac valve surgery
- Stent patency (large stents), bypass grafts
- Difficult lesion subsets (anomalies, bifurcations, CTOs, ostial lesions)
- Functional assessment (echo, MRI unsuitable)

A few Cardiac CT Scans


873
Age:41 years
M
06 Nov 2008
14:48:27
LIFESCAN
CT
CARDIAC
SEGMENT 810ms 0.00s,810ms,CE_0.5,FC43
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
LAO41 CRA48
Vitrea®
WL:232/177
Segmented
LAD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CARDIAC
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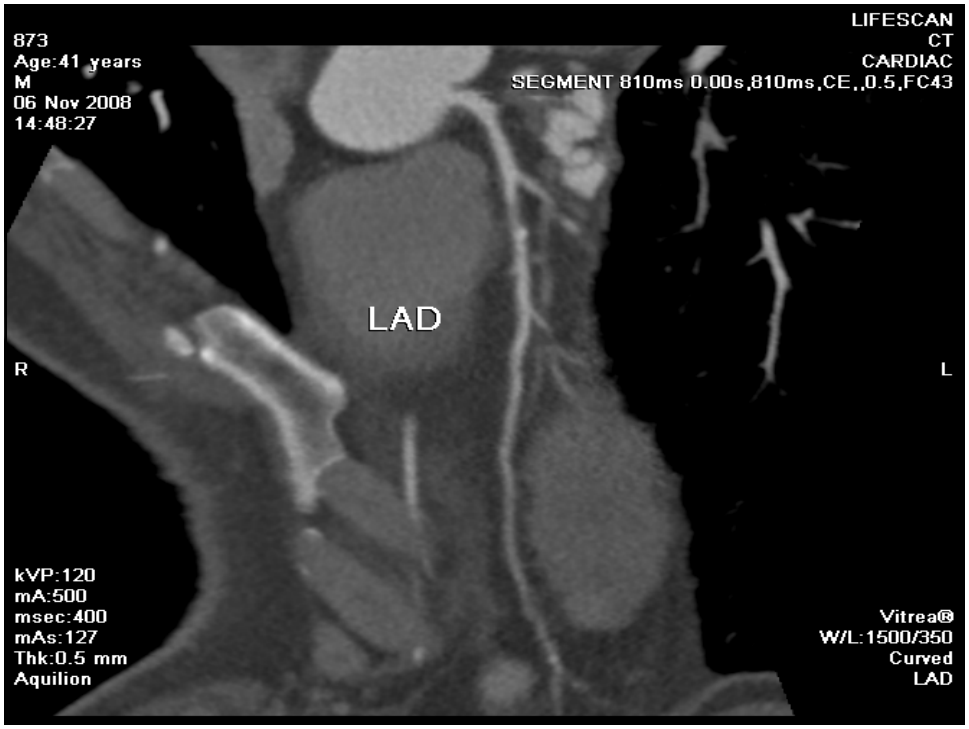
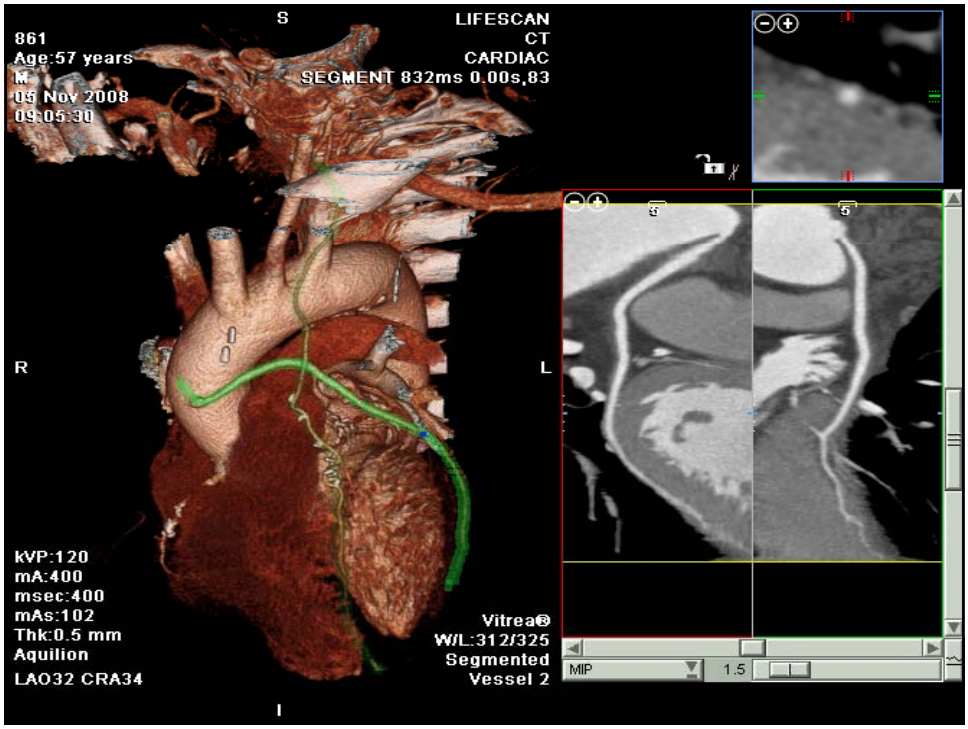
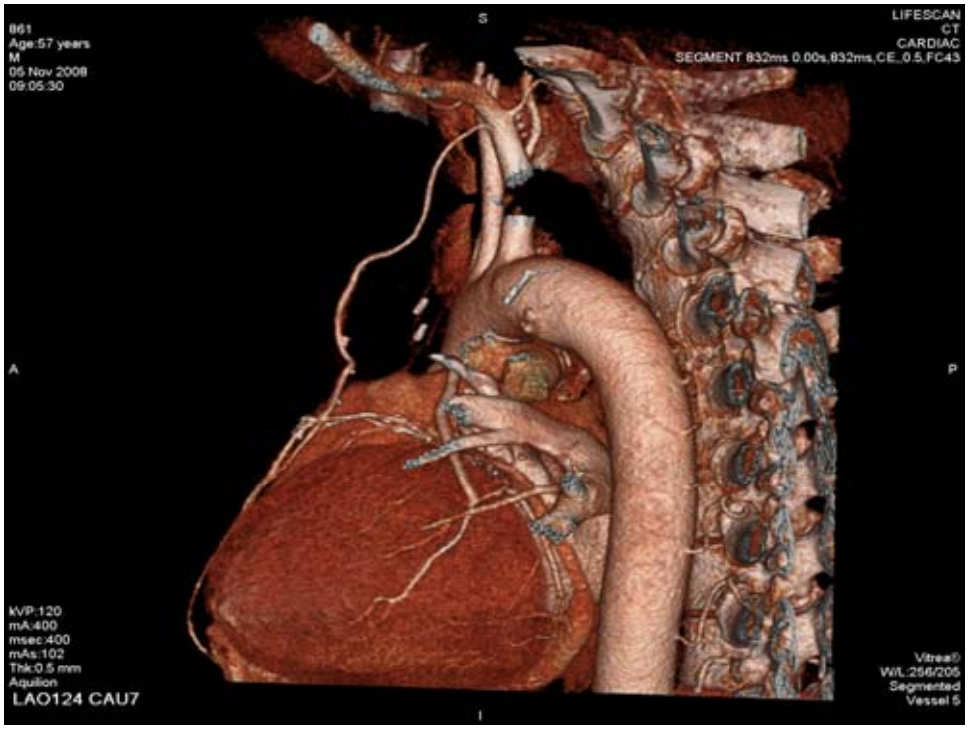
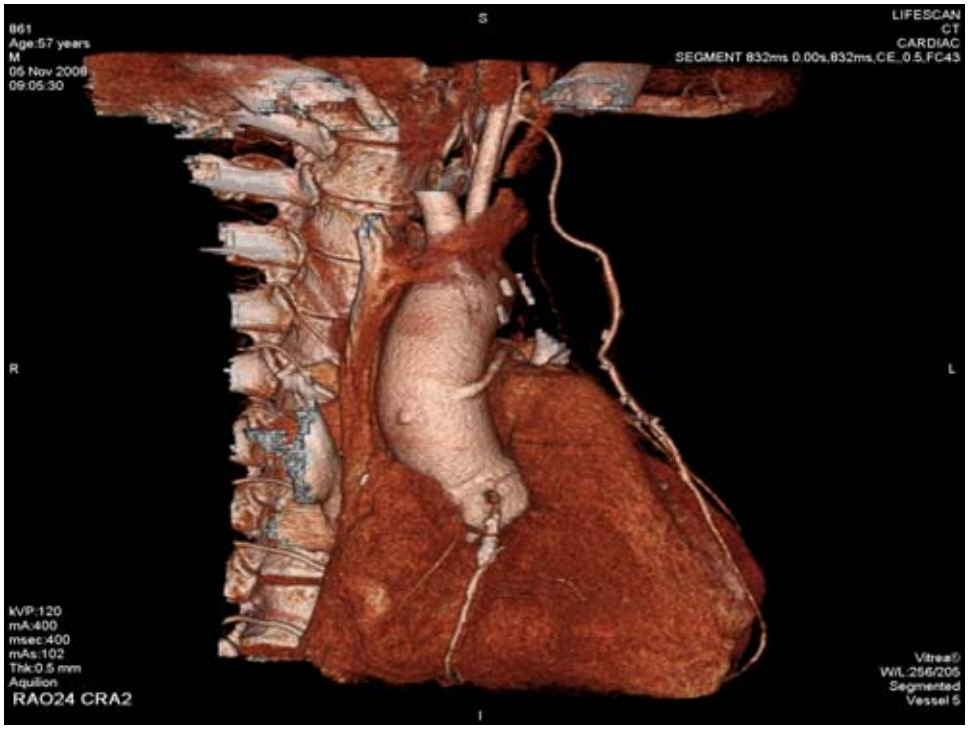
S
LIFESCAN
CT
CARDIAC
873
Age:41 years
M
06 Nov 2008
14:48:27
SEGMENT 810ms 0.00s,810ms,CE,,0.5,FC43
R
L
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
RAO30 CRA25
Vitrea®
W/L:232/177
Segmented
RCA
I

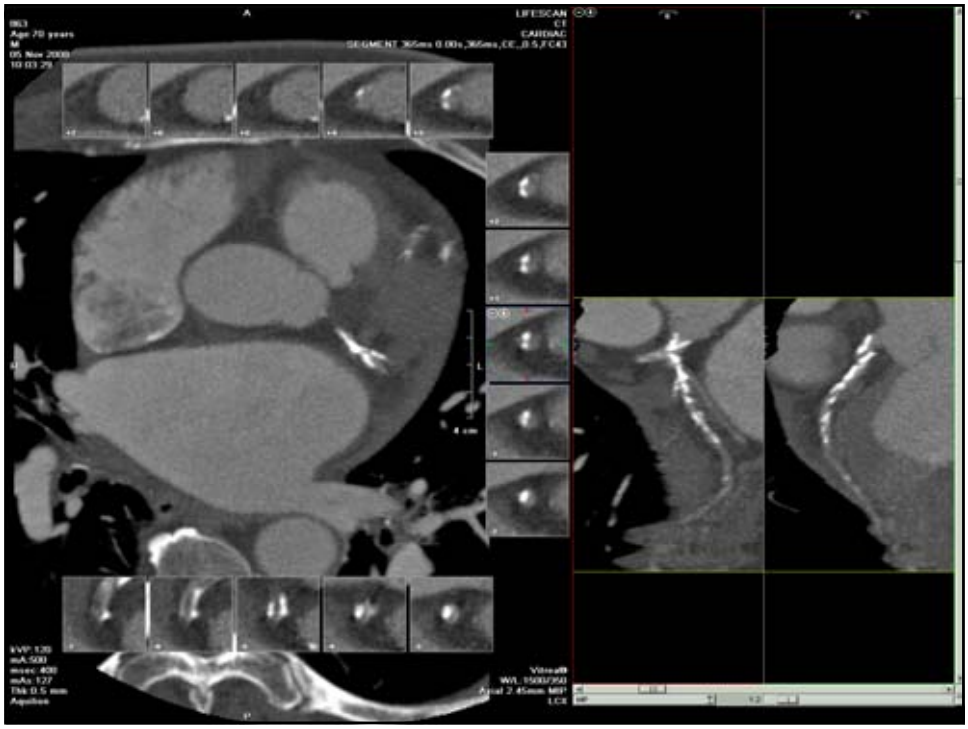

LIFESCAN
CT
CARDIAC
873
Age:41 years
M
06 Nov 2008
14:48:27
SEGMENT 810ms 0.00s,810ms,CE,,0.5,FC43
LAD
R
L
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
Vitrea®
W/L:1500/350
Curved
LAD


S
LIFESCAN
CT
CARDIAC
SEGMENT 832ms 0.00s,83
861
Age:57 years
M
05 Nov 2008
09:05:30
R
L
kVP:120
mA:400
msec:400
mAs:102
Thk:0.5 mm
Aquilion
LAO32 CRA34
Vitrea®
W/L:312/325
Segmented
Vessel 2
MIP
1.5
I

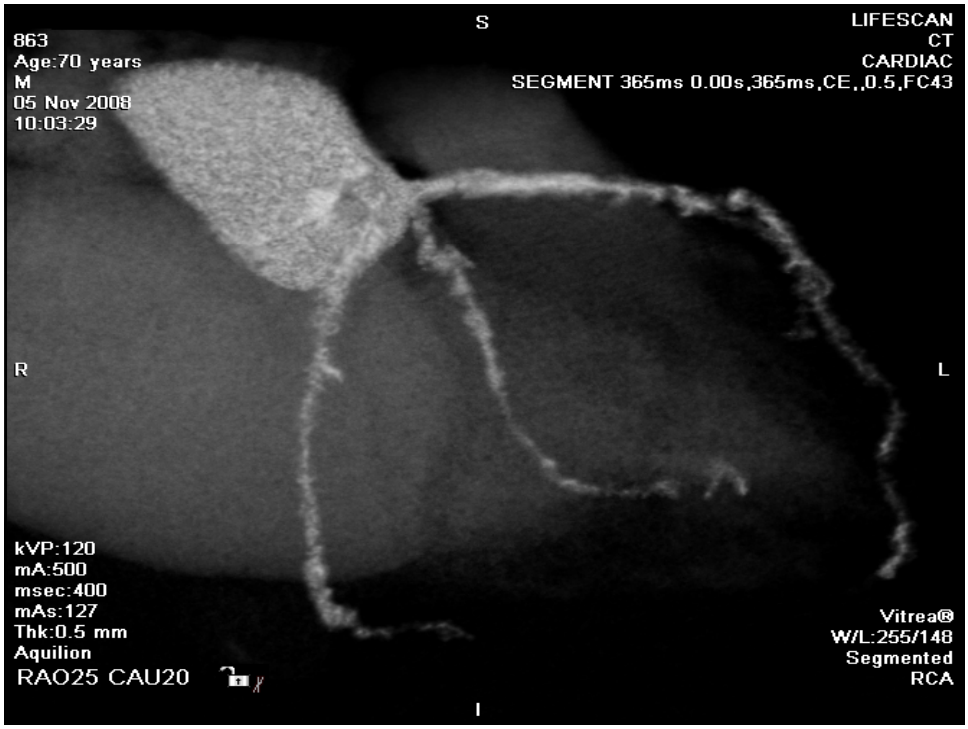

S
LIFESCAN
CT
CARDIAC
SEGMENT 832ms 0.00s,832ms,CE_0.5,FC43
861
Age:57 years
M
05 Nov 2008
09:05:30
A
P
kVP:120
mA:400
msec:400
mAs:102
Thk:0.5 mm
Aquilion
LAO124 CAU7
Vitrea®
W/L:256/205
Segmented
Vessel 5
I


S
LIFESCAN
CT
CARDIAC
SEGMENT 832ms 0.00s,832ms,CE_0.5,FC43
861
Age:57 years
M
05 Nov 2008
09:05:30
R
L
I
kVP:120
mA:400
msec:400
mAs:102
Thk:0.5 mm
Aquilion
RAO24 CRA2
Vitrea®
W/L:256/205
Segmented
Vessel 5


S
LIFESCAN
CT
CARDIAC
SEGMENT 832ms 0.00s,832ms,CE_0.5,FC43
861
Age:57 years
M
05 Nov 2008
09:05:30
R
L
I
kVP:120
mA:400
msec:400
mAs:102
Thk:0.5 mm
Aquilion
LAO0 CAU0
Vitrea®
W/L:256/205
Segmented
Vessel 5




863
Age:70 years
M
05 Nov 2008
10:03:29
R
LIFESCAN
CT
CARDIAC
SEGMENT 365ms 0.00s,365ms,CE_0.5,FC43
A
P
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
LAO75 CRA52
L
Vitrea®
W/L:255/148
Segmented
LAD


S
863
Age:70 years
M
05 Nov 2008
10:03:29
LIFESCAN
CT
CARDIAC
SEGMENT 365ms 0.00s,365ms,CE,,0.5,FC43
R
L
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
RAO25 CAU20
Vitrea®
W/L:255/148
Segmented
RCA
I


806
Age:46 years
M
23 Oct 2008
10:07:22
LIFESCAN
CT
CARDIAC
SEGMENT 776ms 0.00s,776ms,CE_0.5,FC43
A
P
kVP:120
mA:500
msec:400
mAs:127
Thk:0.5 mm
Aquilion
LAO113 CRA29
I
Vitrea®
W/L:247/133
Segmented
LAD

THANK YOU