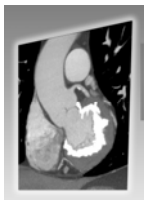
Noncoronary Cardiac MDCT

David A. Bluemke, M.D., Ph.D.
Professor, of Radiology and Medicine
Johns Hopkins University School of Medicine
Baltimore, Maryland


Disclosures

- Toshiba Grant support

Noncoronary Cardiac MDCT

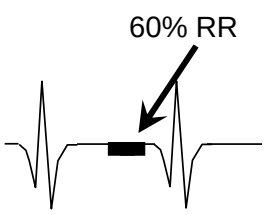
- LV function
- RV function
- Cardiac valve assessment
- Perfusion and viability

Left main: functional compression

Dodd et al, Circulation 2006 115; e7-8

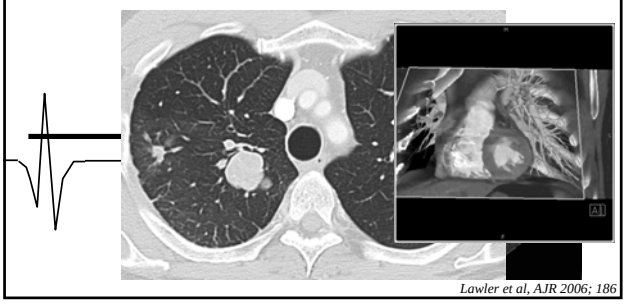
Background – LV function

- Coronary CTA: fixed delay time after R wave is chosen to <u>freeze motion</u>.



Background – LV function

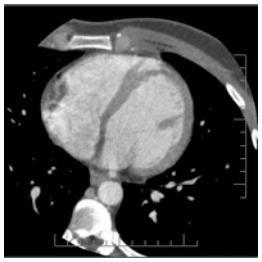
- 90% of the cardiac CTA information (and radiation dose) is discarded

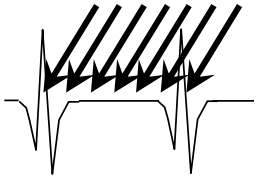


Lawler et al, AJR 2006; 186

Background – LV function

Instead, keep all of the intervening time points, and create a cine loop

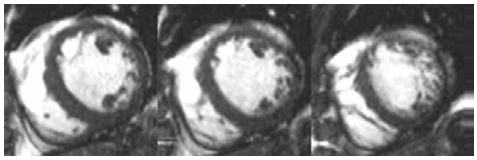




Axial images every 20 msec

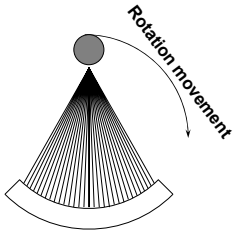
New slide: Temporal Resolution

- 60 bpm, 1 sec or 1000 msec per heart beat. Systole takes about 300 msec.
- MRI, echo, nuclear: 50 msec or less



Temporal Resolution Determined by Gantry Rotation Time

180 degrees of data needed for reconstruction

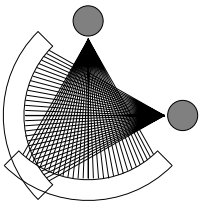


400 ms rotation

Temporal resolution for half scan = 200 ms

Dual source MDCT: twice as fast

Only 90 degrees of rotation needed



400 ms rotation

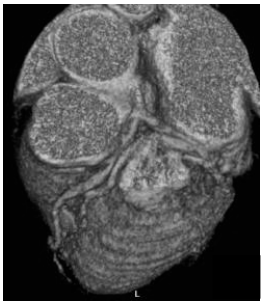
Temporal resolution for quarter scan = 100 ms

Improving Temporal Resolution - Adaptive Segmented Reconstruction

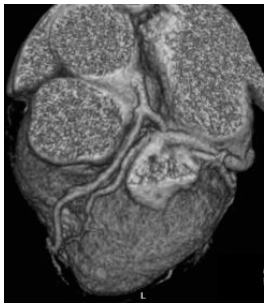
2 –5 segments from different heartbeats combined to produce 180 degrees of data

200 ms / 2 = 100 ms

Half vs Multisegment



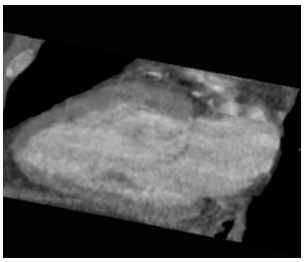
Half Reconstruction



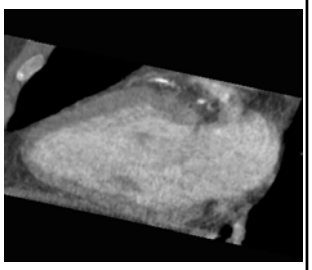
Segmented Reconstruction

Heart Rate = 93-95 bpm

Half vs. Multisegment – LV Function



Half Reconstruction

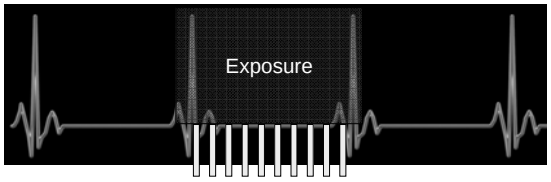


Multi-Segment

64 MDCT, JHU

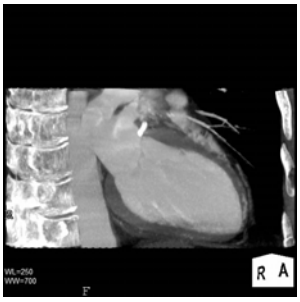
256* Detector MDCT

1 heartbeat imaging



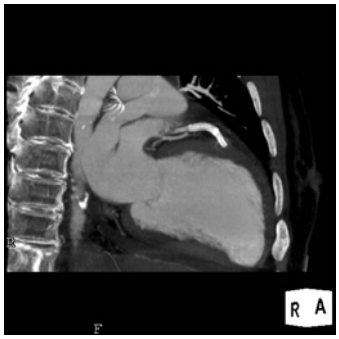
Reconstruction can be over the entire cardiac cycle for function analysis

256 MDCT Functional Analysis



Courtesy Prof Katada, Fujita Health University

256 MDCT Functional Analysis

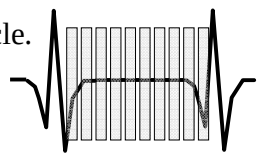


Courtesy Prof Katada, Fujita Health University

Steps for LV function analysis:

1. Reconstruct cardiac phases: 20 images, or every 5% of cardiac cycle.
2. Corresponds to images approximately every 50 msec.

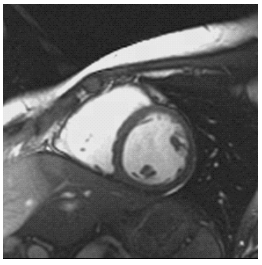
(Compare to actual temporal resolution of 100-200 msec).



1 2 3……20

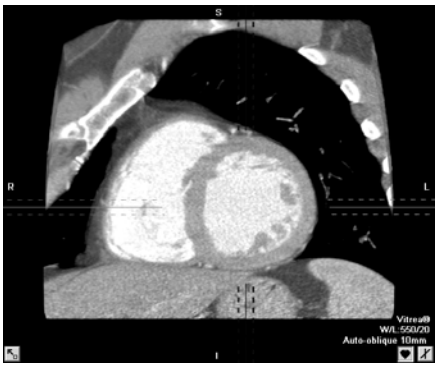
LV function: slice thickness

- Instead of 0.5 mm slices for CTA, use 5 mm slices (1000 images).
- MRI uses 6-8 mm slices at 1 cm intervals, ~ 250 images.



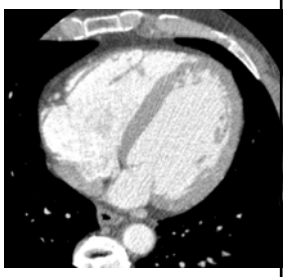
MRI: 8 mm slice thickness

0.5, 2, 5, 10 mm at ED

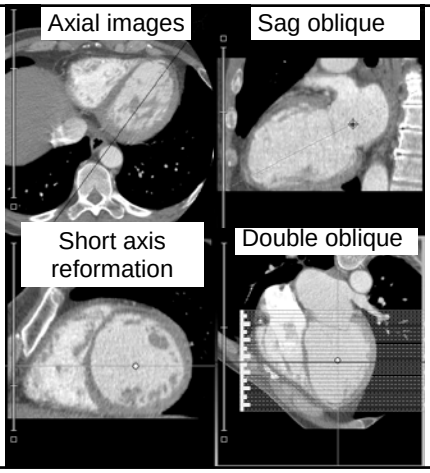


LV function – reformat

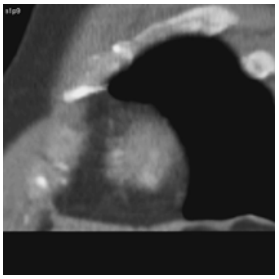
- MDCT images are acquired in the axial plane
- LV quantitative analysis usually performed in the short axis plane.



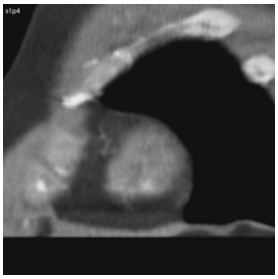
Axial images



Contouring: ED/ ES only (50 frames)



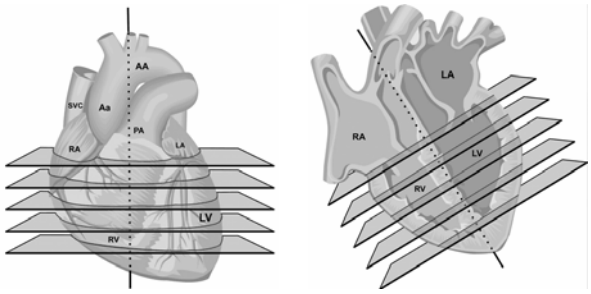
End diastole



End systole

Rob van der Geest, Univ Leiden

Reformation of the Left ventricle: Necessary?



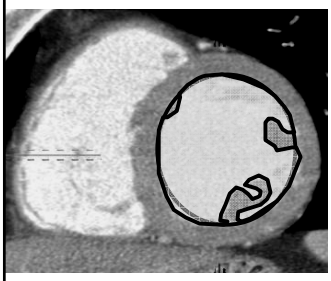
Juergens et al, AJR 2006; 186

Reformation of the Left ventricle: Necessary?

- LV volumes using axial MDCT were ~10% larger than those obtained by short axis
- Results in underestimation of EF with increasing dilatation of the LV
- Axial: 3 min savings in post processing time.

Juergens et al, AJR 2006; 186

Papillary Muscles

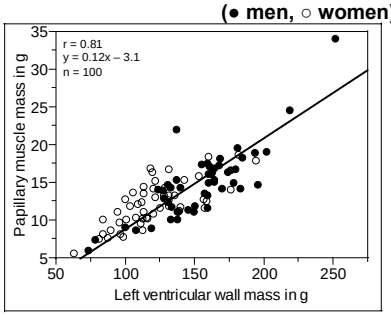


- Papillary muscle mass accounts for 8.9% of the total LV mass in both men and women
- Correlated with LV wall mass (r=0.81, p<0.001)*

J. Vogel-Claussen, JHU

Papillary Muscles

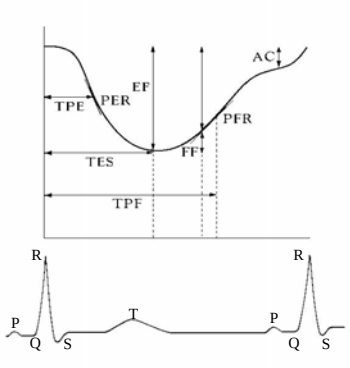
(● men, ○ women).



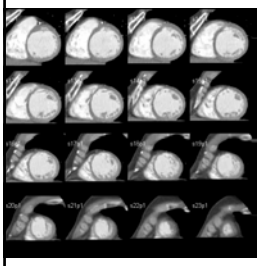
J. Vogel-Claussen, JHU

Parameters computed and displayed with ED,ES:

(a) ESV, EDV
(b) EF (%)
(c) SV
(d) CO
(e) Myocardial mass
(f) Filling rates
(g) Emptying rates

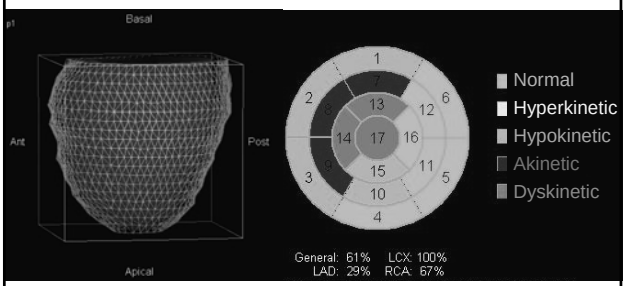


Data courtesy of Fujita Health University, Aichi, Japan

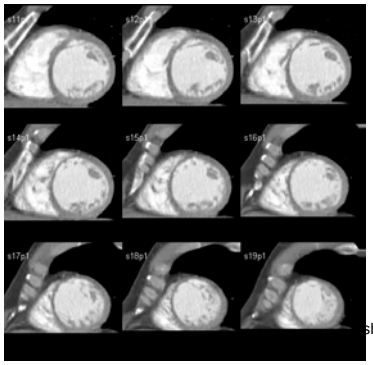


Body Surface Area:	1.89 m²
ED volume:	357.65 ml
ED volume/BSA:	189.04 ml/m²
ES volume:	241.32 ml
ES volume/BSA:	127.55 ml/m²
Stroke volume:	116.33 ml
Stroke volume/BSA:	61.49 ml/m²
Ejection fraction:	32.53 %

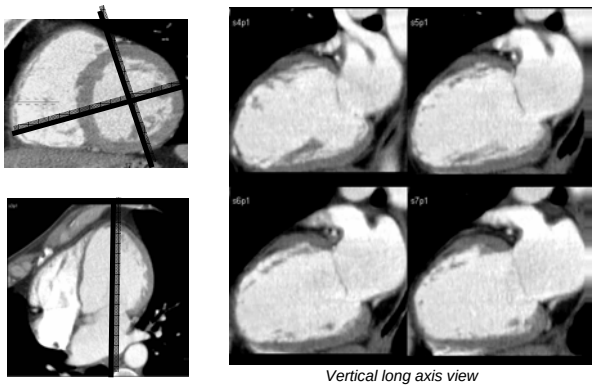
Regional Wall Motion Analysis



Example: septal infarct, CHF



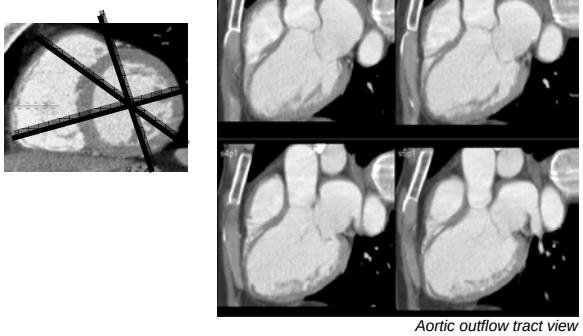
Example: septal infarct, CHF



Vertical long axis view

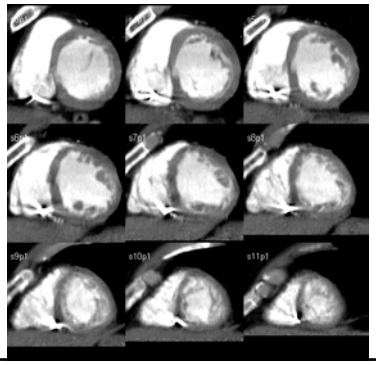
Horizontal long axis view

Example: aortic outflow tract

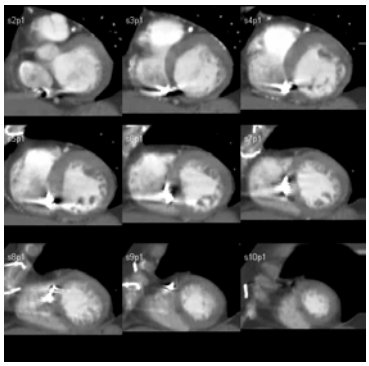


Aortic outflow tract view

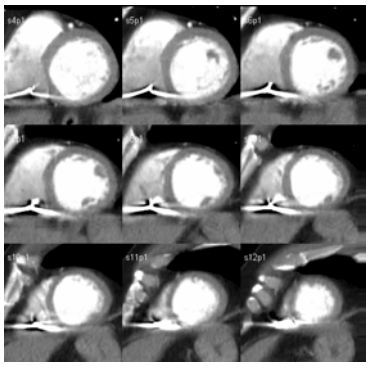
Example: Anterior wall motion abnormality

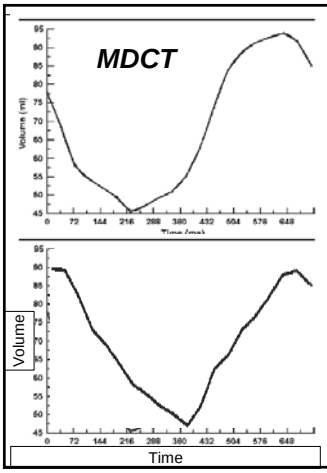


Example: CHF, AICD, inferior MI



Example: distal LAD infarction





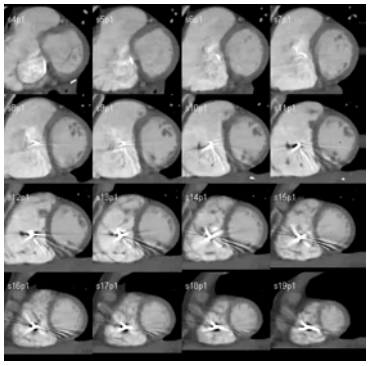
Mahnken, AH et al
Radiology 2005; 236:112
Modified from Fig 3

- Similar global volumes (EDV, ESV)
- Different time dependent parameters (PER, time to PER PFR, time to PFR)

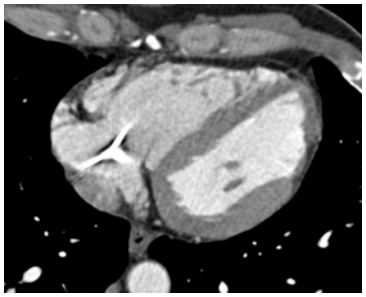
Pig infarct model, heart rate 72-106
Mean CT temporal resolution 150 msec

RV function

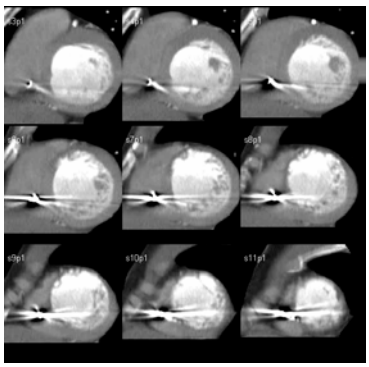
Example: ARVD RV evaluation



Evaluation of myocardial structure: ARVD



Pitfall: No Contrast in the RV



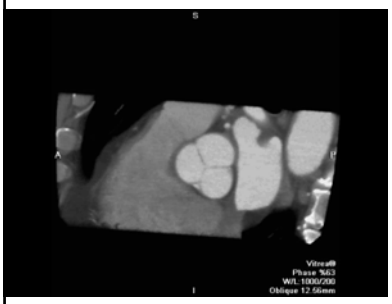
Valve evaluation

Why Evaluate Valve Function on MDCT?

Echo: AVA is not determined directly but calculated using the continuity equation.

- Echocardiography is operator dependent.
- Underestimation of severity due to failure to obtain a parallel angle between the Doppler beam and aortic jet.

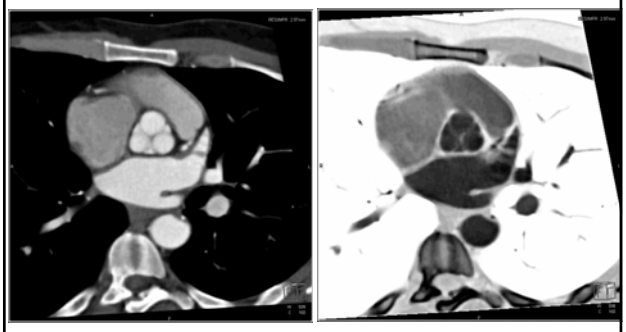
Benign cardiac tumors



Myxoma	41%
Lipom	14%
Papillary fibroelastoma	13%
Rhabdomyoma	11%

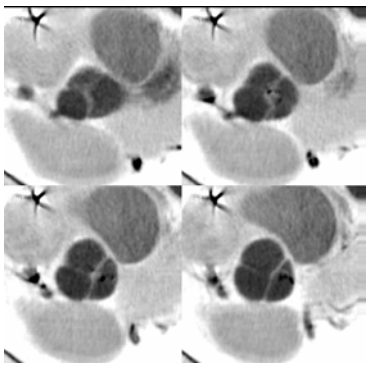
Lembcke et al, Circulation 2007 115; e3-6

4D 64 MDCT: Normal Aortic Valve

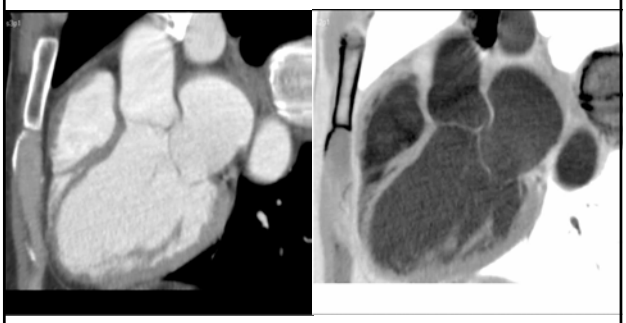


Vogel-Claussen J, et al. Cardiac valve assessment with MR imaging and 64-section multi-detector row CT. Radiographics. 2006 Nov-Dec;26(6):1769-84

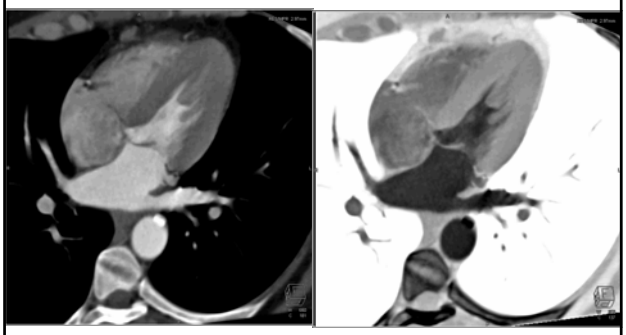
Aortic Valve Evaluation



Aortic/ Mitral Valve Evaluation



4D 64 MDCT: Normal Mitral Valve



J. Vogel-Claussen

MDCT: Assessment of Aortic Valve Area

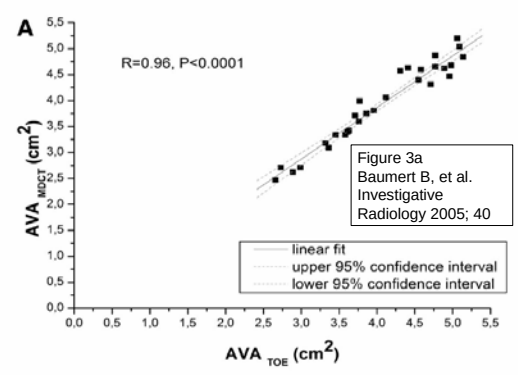
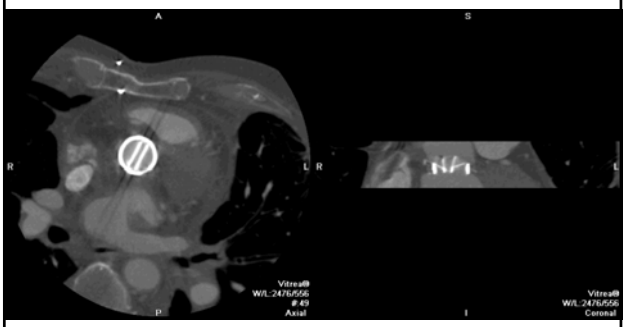


Figure 3a
Baumert B, et al.
Investigative
Radiology 2005; 40

Pathology – Calcified Aortic Valve

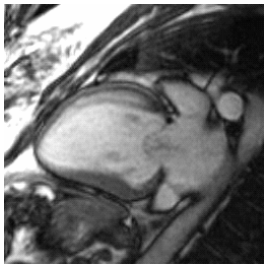
J. Vogel-Claussen

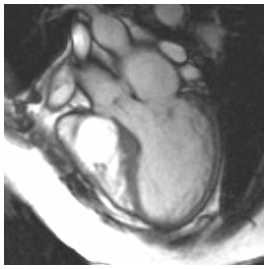
Artificial Aortic Valve Function



Courtesy: Toshiba America Medical Systems

MRI: valve regurgitation



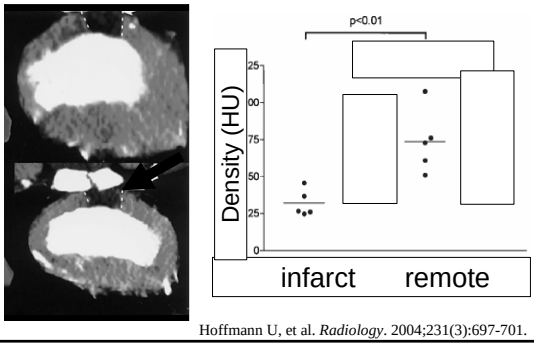


MDCT Perfusion and Viability Imaging

LV infarct, thrombus

Myocardial Viability by MDCT

Lower density in the area of infarction



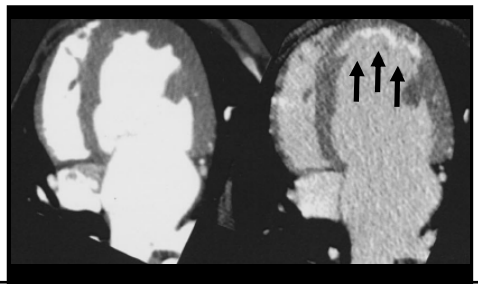
Hoffmann U, et al. *Radiology*. 2004;231(3):697-701.

Contrast-Enhanced Multidetector Computed Tomography Viability Imaging After Myocardial Infarction

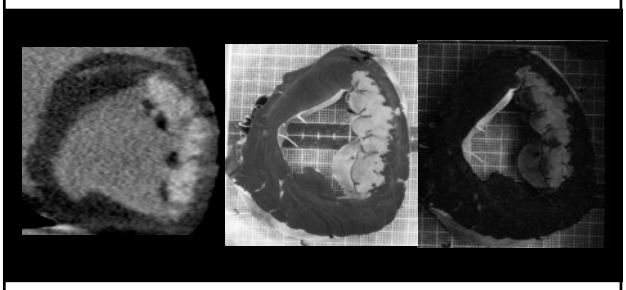
Characterization of Myocyte Death, Microvascular Obstruction, and Chronic Scar

Circulation 2006 113:394

Albert C. Lardo, PhD; Marco A.S. Cordeiro, MD, PhD; Caterina Silva, MD; Luciano C. Amado, MD; Richard T. George, MD; Anastasios P. Saliaris, MD; Karl H. Schuleri, MD; Veronica R. Fernandes, MD; Menekhem Zviman, PhD; Saman Nazarian, MD; Henry R. Halperin, MD, MA; Katherine C. Wu, MD; Joshua M. Hare, MD; Joao A.C. Lima, MD



MDCT Viability Imaging

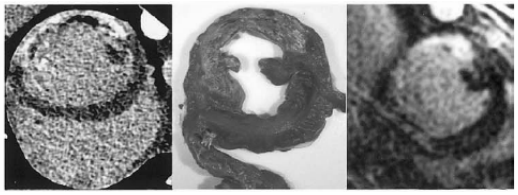


Lardo et al. Circulation 2005

Multislice Computed Tomography and Magnetic Resonance Imaging for the Assessment of Reperfused Acute Myocardial Infarction

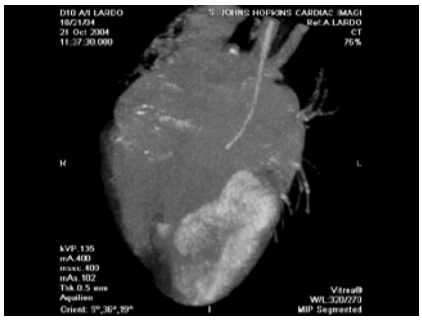
JACC 2006 48:144

Timo Baks, MD,*† Filippo Cademartiri, MD, PHD,*† Amber D. Moelker, MSC,* Annick C. Weustink, MD,† Robert-Jan van Geuns, MD, PHD,*† Nico R. Mollet, MD, PHD,*† Gabriel P. Krestin, MD, PHD,† Dirk J. Duncker, MD, PHD,* Pim J. de Feyter, MD, PHD, FACC*†



CT TTC MRI

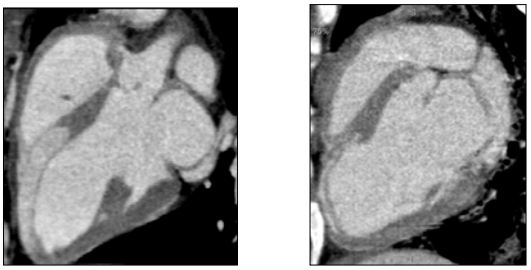
3D Visualization of Infarct Extent



adapted from A. Lardo

MDCT Infarct Imaging

90 min occlusion/reperfusion model

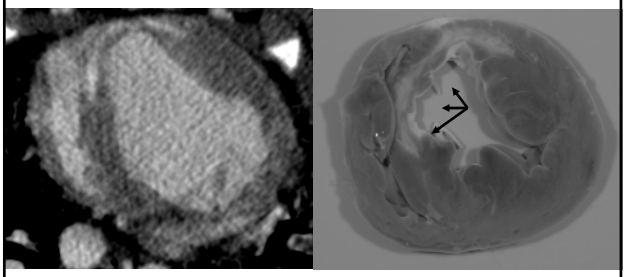


2 hrs 8 weeks

Lardo et al. *Circulation. 2004;110 (Supplement):III-522.*

Chronic Infarct Imaging

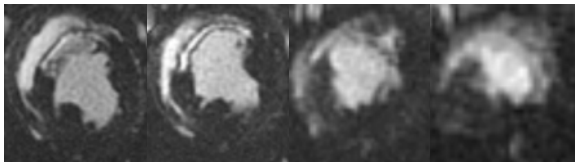
MDCT | Pathology



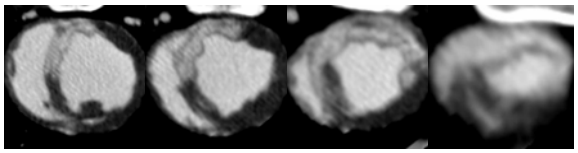
Infarct size = 128.8 mm^2 | Infarct size = 119.7 mm^2

Lardo et al. Circulation 2006; 113:394

MRI

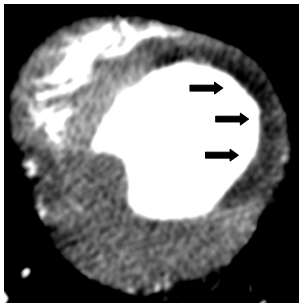


MDCT



adapted from A. Lardo

Helical MDCT Perfusion



Helical MDCT perfusion imaging in a canine model of LAD stenosis during adenosine infusion. (Gantry rotation time: 400 ms, Detector collimation: 0.5 X 32, tube current: 400 mA, tube voltage: 120 kV, Visipaque™ 2.5 ml/sec for 100 ml)

George RT, et al. AHA, 2006

Conclusions: Noncoronary MDCT

- LV and RV function "for free"
- Valve evaluation
- MDCT viability/ scar imaging as well as stress perfusion have now been demonstrated

Acknowledgements

- Al Lardo, Ph.D.
- Rich George, M.D.
- Elliot Fishman, M.D.
- João Lima, MD
- Jens Vogel-Claussen, MD
- Chloe Stephenson

MDCT for Cardiac Function

Thank you.

http://www.rad.jhmi.edu/mri/MRI_Info_RSNA.htm