MDCT: Noncoronary Applications

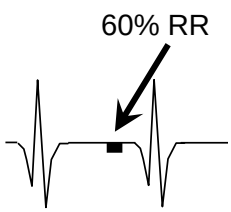
David A. Bluemke, M.D., Ph.D.
Associate Professor, Clinical Director, MRI
Departments of Radiology and Medicine
Johns Hopkins University School of Medicine
Baltimore, Maryland

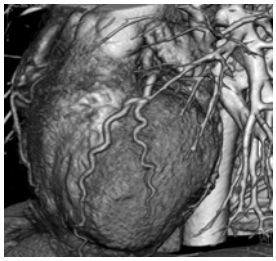
Noncoronary MDCT – Topics:

- LV mass
- Pericardial disease
- Congenital disease
- Pulmonary vein anatomy
- LV function
- Valve analysis
- Myocardial infarction, perfusion

Background – LV function

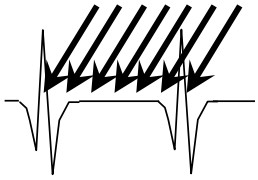
- Coronary CTA: fixed delay time after R wave is chosen to <u>freeze motion</u>.

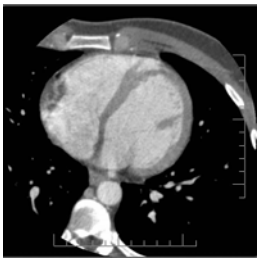




Background – LV function

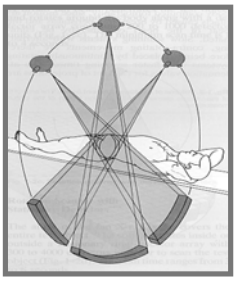
Keep all of the intervening time points, and create a cine loop





Axial images every 20 msec

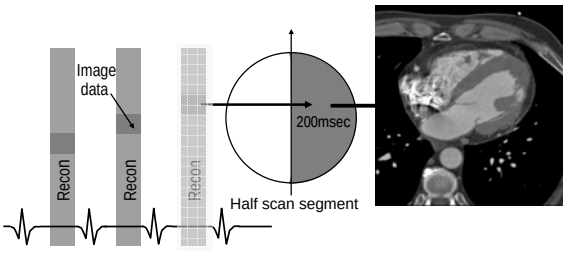
Temporal Resolution Determined by Gantry Rotation Time for LV cines



- Rotation speed: 330-500msec
- *1/2 scan:* 165-250 msec temporal resolution

1 cardiac cycle, gantry = 400 sec

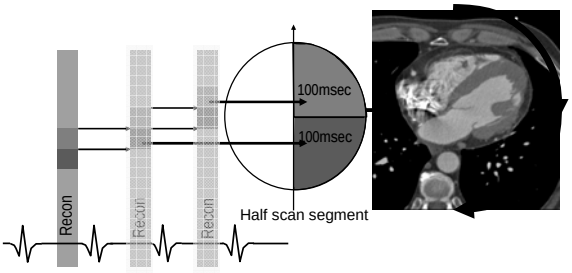
Single Segment Reconstruction



E.g.., Heart Rate < 65 bpm, min temporal resolution 200 ms

2 cardiac cycles, gantry = .4 sec

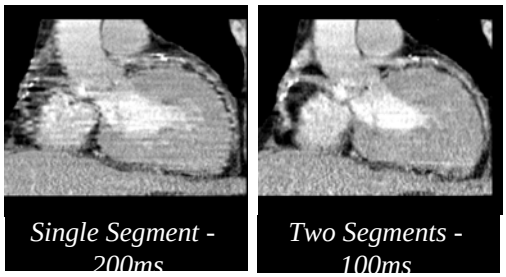
2 Segment Reconstruction



Heart Rate > 65 bpm, min temporal resolution 100 ms

Segmentation used to decrease motion artifacts in CTA

Heart rate ~94 bpm



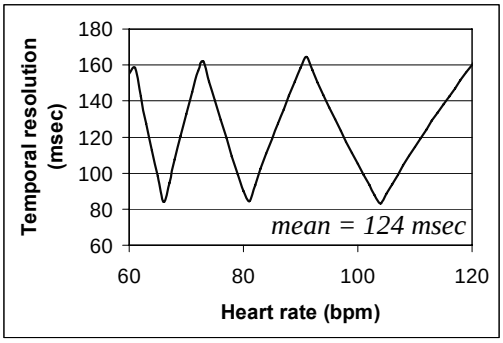
Single Segment - 200ms

Two Segments - 100ms

MDCT Temporal Resolution

- MDCT nonsegmented: 165-250 msec,
- *2 segment* MDCT @ 330 msec gantry rotation: *83 msec**
- MRI: 50 msec
- Echo, Nuclear: 25 msec or less

2 segments, 330 msec gantry rotation



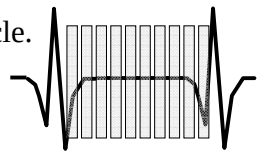
LV function

- Sophisticated segmentation algorithms are adaptive to heart rate, chosen 'automatically' (little user control) to optimize *CT angiography.*
- Higher segmentation factor beneficial for LV function evaluation.
- Raw data reconstruction available on some scanners; higher segmentation may improve temporal resolution.

Steps for LV function analysis:

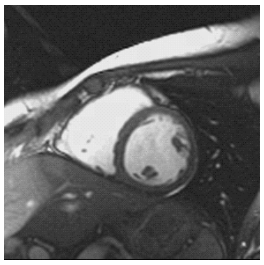
1. Reconstruct cardiac phases: 20 images, or every 5% of cardiac cycle.
2. Corresponds to images approximately every 50 msec.

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



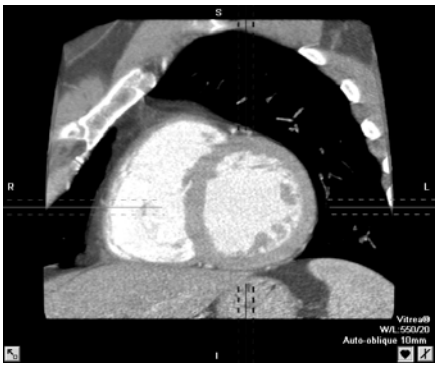
LV function: slice thickness

- 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.



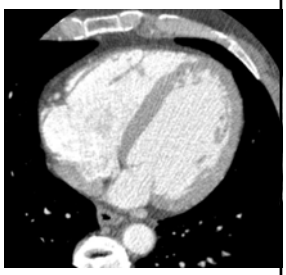
MRI: 8 mm slice thickness

0.5, 2, 5, 10 mm at ED

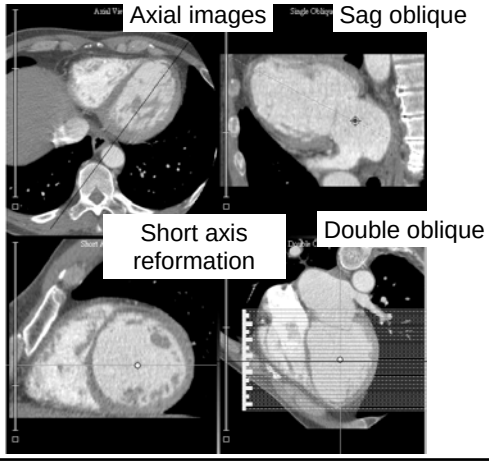


LV function – reformat

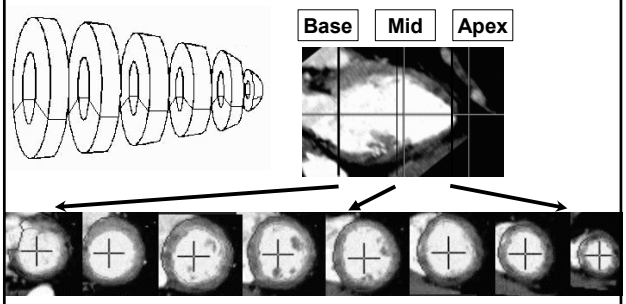
- MDCT images are acquired in the axial plane
- LV quantitative analysis usually performed in the short axis plane.

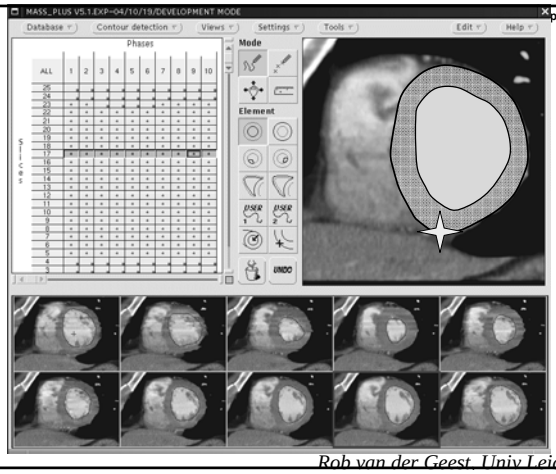


Axial images



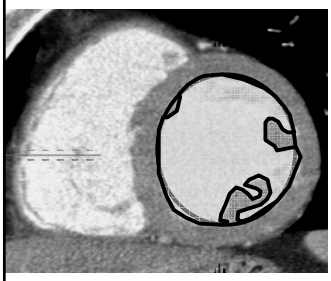
3D Volumetric Analysis of the LV





Rob van der Geest, Univ Leiden

Papillary Muscles

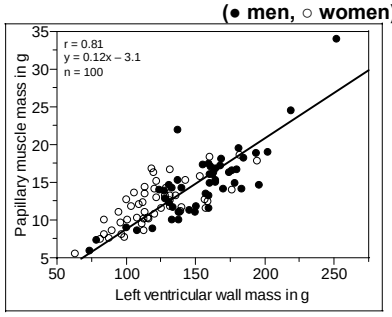


- Papillary muscle mass accounts for 8.9% of the total LV mass in both men and women
- Correlated with LV wall mass (r=0.81, p<0.001)*

J. Vogel-Claussen, JHU

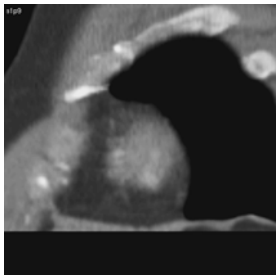
Papillary Muscles

(● men, ○ women).

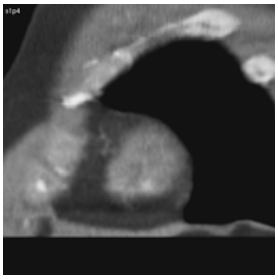


J. Vogel-Claussen, JHU

Contouring: ED/ ES only (50 frames)



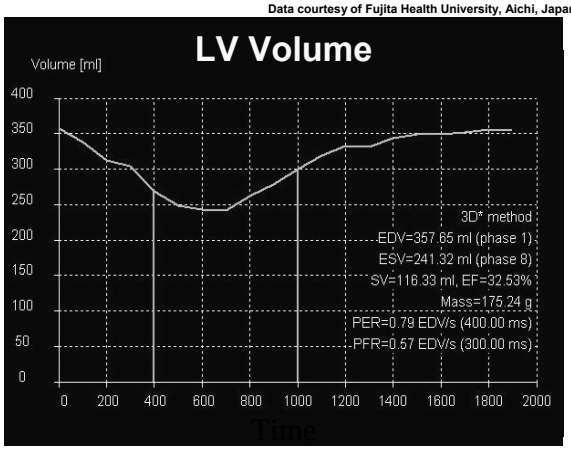
End diastole



End systole

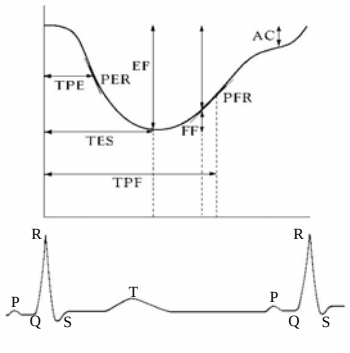
Rob van der Geest, Univ Leiden

Data courtesy of Fujita Health University, Aichi, Japan

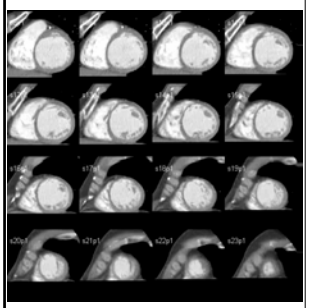


Parameters computed and displayed with ED,ES:

(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

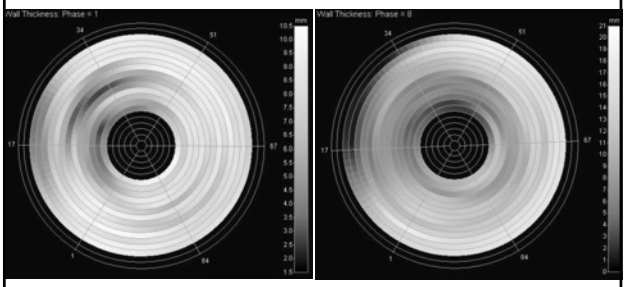


LEFT VENTRICULAR VOLUME RESULTS

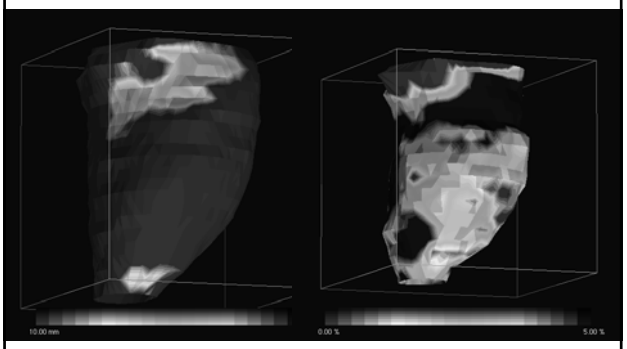
Body Surface Area:	1.89	m²
ED volume:	357.65	ml
ED volume/BSA:	189.04	ml/m²
ES volume:	241.32	ml
ES volume/BSA:	127.55	ml/m²
Stroke volume:	116.33	ml
Stroke volume/BSA:	61.49	ml/m²
Ejection fraction:	32.53	%
LV mass ED:	175.24	g
LV mass ED/BSA:	92.62	g/m²
LV mass ES:	190.67	g
LV mass ES/BSA:	100.78	g/m²
PER:	281.68	ml/s
PER/EDV:	0.79	EDV/s
TPER:	400.00	ms
TPER phase number:	5	
PFR:	203.55	ml/s
PFR/EDV:	0.57	EDV/s
TPFR:	300.00	ms
TPFR phase number:	11	

Data courtesy of Fujita Health University, Aichi, Japan

Wall thickness



ED wall thickness ES wall thickness



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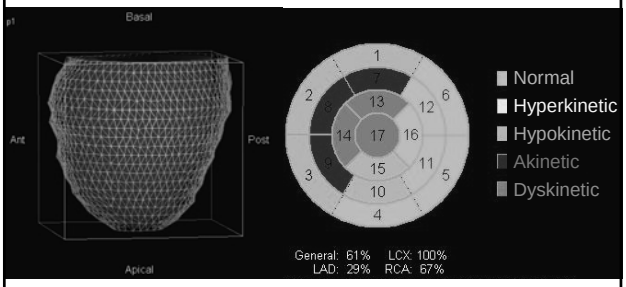
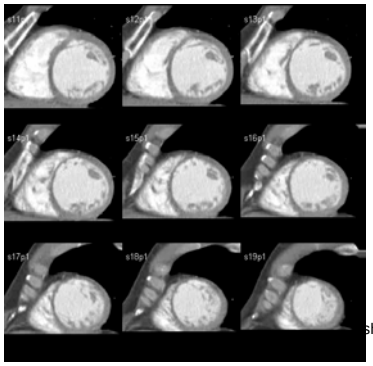
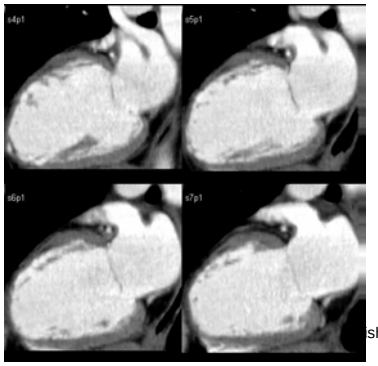
Regional Wall Motion Analysis



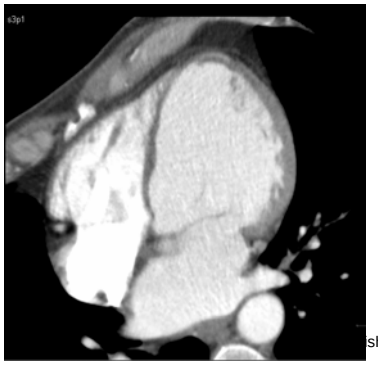
Example: septal infarct, CHF



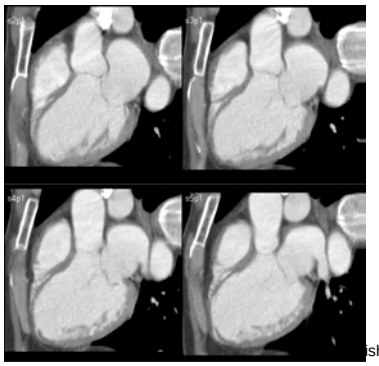
Example: septal infarct, CHF



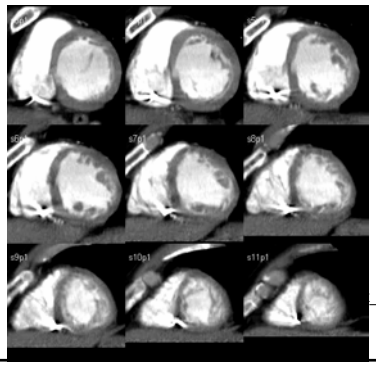
Horizontal long axis view



Example: aortic outflow tract



Example: Anterior wall motion abnormality



Data courtesy of Fujita Health University, Aichi, Japan

Radiology

Kai Uwe Juergens, MD
Matthias Grude, MD
David Maintz, MD
Eva Maria Fallenberg, MD
Thomas Wichter, MD, FESC
Walter Heindel, MD
Roman Fischbach, MD

Index terms:

Multi–Detector Row CT of Left Ventricular Function with Dedicated Analysis Software versus MR Imaging: Initial Experience[1]

- 4 slice scanner
- Temporal resolution 125-250 msec
- Comparable volumes, function compared to 32 msec temporal resolution MRI

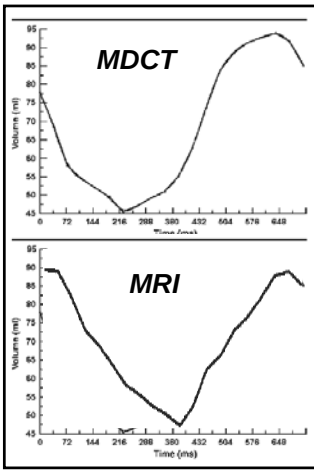
Data courtesy of Fujita Health University, Aichi, Japan

Time-effectiveness, Observer-dependence, and Accuracy of Measurements of Left Ventricular Ejection Fraction Using 4-channel MDCT

T. Boehm[1]
H. Alkadhi[2]
M. Roffi[3]
J. K. Willmann[1]
L. M. Desbiolles[1]
B. Marincek[1]
S. Wildermuth[1]

Fortschr Röntgenstr 2004; 176: 529 – 537

- slight underestimation of EF with MDCT, related to low temporal resolution (125 ms)
- 63 min processing time for MDCT



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

TABLE 1
Parameters of Global LV Function Determined with Multi–Detector Row CT and MR Imaging

Parameter	Multi–Detector Row CT*	MR Imaging*	Pearson *r* Value	*P* Value†
End-diastolic volume (mL)	104.8 ± 18.7	106.2 ± 19.6	0.98	>.05
End-systolic volume (mL)	57.2 ± 14.7	57.1 ± 14.5	0.99	>.05
Stroke volume (mL)	47.6 ± 7.4	49.1 ± 7.9	0.92	>.05
Ejection fraction (%)	46.1 ± 6.5	46.8 ± 5.9	0.97	>.05
Myocardial mass (g)	108.7 ± 23.7	109.6 ± 27.1	0.92	>.05
PER (mL/sec)	292.0 ± 124.5	229.4 ± 57.5	0.46	.04
PFR (mL/sec)	408.1 ± 180.5	331.0 ± 109.2	0.17	>.05
Time to PER (msec)	143.8 ± 59.3	122.8 ± 48.3	0.63	>.05
Time from end systole to PFR (msec)	282.9 ± 204.7	155.5 ± 83.4	0.27	.03

* Values are the mean ± standard deviation.
† Values were determined with the *t* test.

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

Table 1
Mahnken, AH et al
Radiology 2005; 236:112

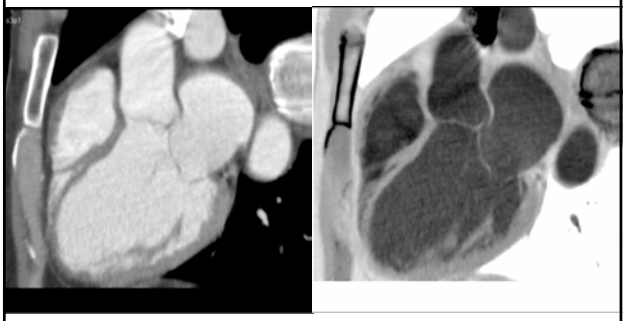
Valve evaluation

Why Evaluate Valve Function on MDCT?

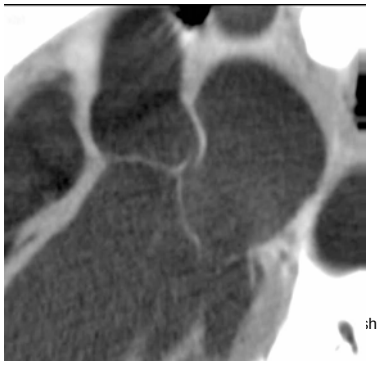
Echo: AVA is not determined directly but calculated using the continuity equation.

- TEE and TTE both operator dependent.
- Underestimation of severity due to failure to obtain a parallel intercept angle between the Doppler beam and aortic jet.
- MDCT: Noninvasive, nonoperator-dependent technique for direct measurement of AVA.

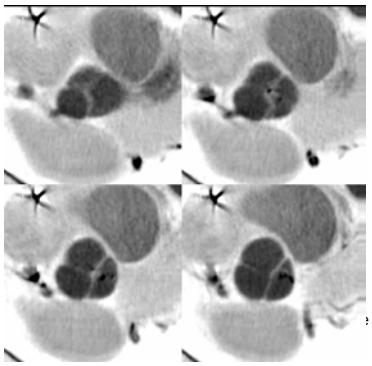
Aortic/ Mitral Valve Evaluation



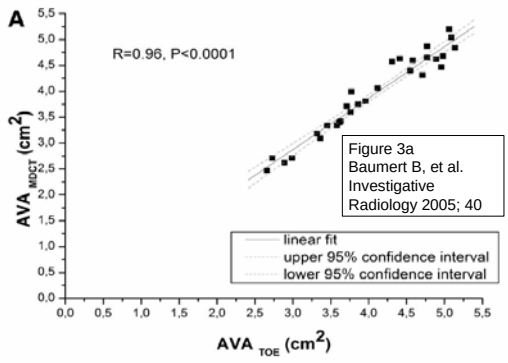
Aortic/ Mitral Valve Evaluation



Aortic Valve Evaluation



MDCT: Assessment of Aortic Valve Area



MDCT: Assessment of Aortic Valve Area

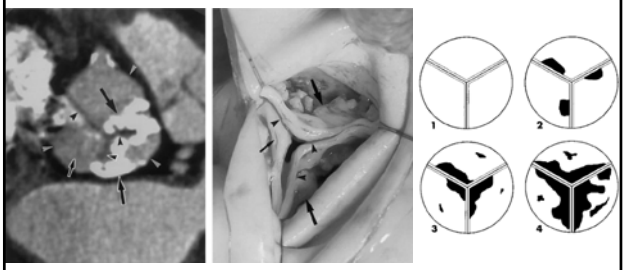
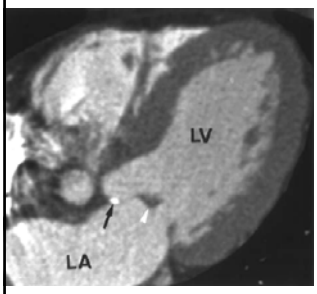


Figure 2
Willman, J, et al.
Radiology 2002; 225

MDCT: Assessment of Mitral Valve



Compared to Echo:
- Excellent correlation with valve leaflet thickness
- Excellent agreement with Mitral Annulus Calcification

Figure 3
Willman, J, et al.
Eur Radiology 2002; 12

MDCT: Assessment of Mitral Valve

Abnormal finding	MDCT *N*	Echocardiography *N*
Thickening of mitral valve leaflets		
<5 mm	4 (25)	4 (25)
≥5 mm	12 (75)	12 (75)
Mitral valve annulus calcification		
<5 mm	7 (78)	6 (67)
≥5 mm	2 (22)	3 (33)

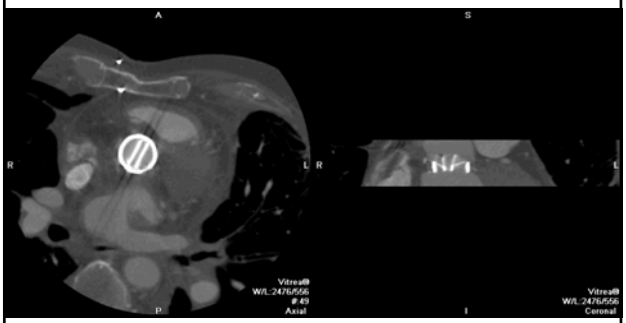
Numbers in parentheses are percentages

Table 3
Willman, J, et al.
Eur Radiology 2002; 12

MRI: valve regurgitation

Elliot Fishman, MD

Artificial Aortic Valve Function

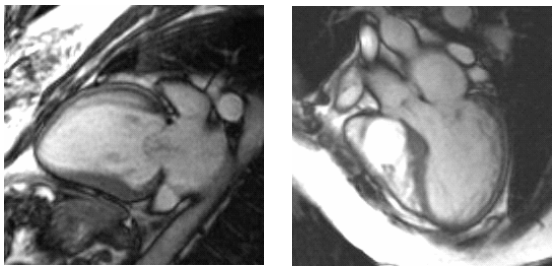


Courtesy: Toshiba America Medical Systems

MRI: valve regurgitation

Elliot Fishman, MD

MRI: valve regurgitation



MDCT Perfusion and Viability Imaging

MDCT Perfusion/ Viability Imaging Rationale:

- Potential to perform CTA, function and viability in a single 15-20 minute exam
- AICD, pacemakers, MRI contraindication
- High spatial resolution (0.4 mm) compared to 6-8 mm slice resolution for MRI.

adapted from A. Lardo

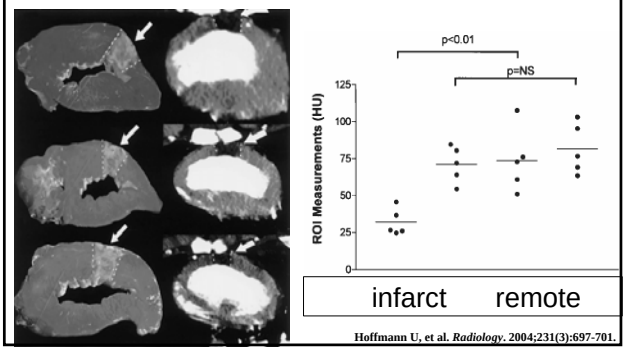
Acute Myocardial Infarction: Contrast-enhanced MDCT in a Porcine Model

Udo Hoffman, Ryan Millea,
Christian Enzweiler, Maros Ferencik, Scott Gulick,
Jim Titus, Stephan Achenbach, Dylan Kwait,
David Sosnovik, Thomas J. Brady
Radiology, 231:697-701, 2004.

- Porcine AMI model (N=7)
- 4 slice MDCT scanning
- 3 hours post-coronary ligation – LAD or LADD
- CT Infarct size 17 ± 6 % similar to TTC 14 ± 6 %

Myocardial Viability by MDCT

Lower density in the area of infarction



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

Characterization of Acute MI Using Contrast Enhanced MDCT

Albert C. Lardo, Marco Cordeiro, Veronica Fernandes, Andre Schmidt,
Menekhem Zviman, Joao A. C. Lima

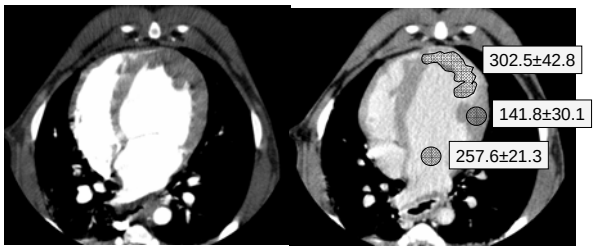
Circulation 2004;110 (Supplement):III-522

- Canine AMI model (N=7)
- 32 slice MDCT - 1 hour post-reperfusion.
- Imaging each 5 min up to 40 min post-contrast
- CT infarct size 24 ± 7 %, mean difference 4%
- r = 0.93 with TTC

adapted from A. Lardo

MDCT Infarct Imaging

Visipaque - 150 ml injection

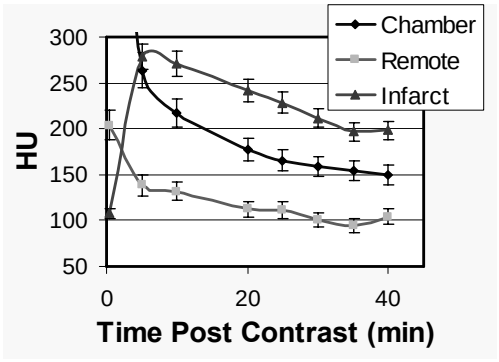


Post infarct
Post contrast 30 sec

Post infarct
Post contrast 5 min

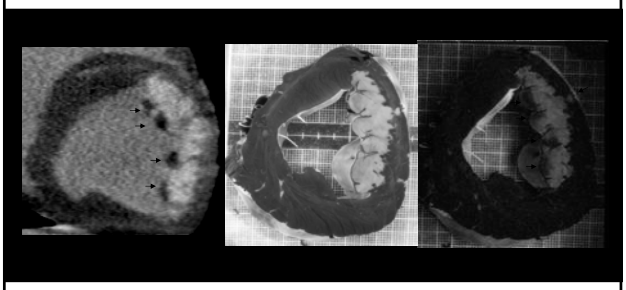
Lardo et al. Circulation 2005 (in press)

Infarct Enhancement



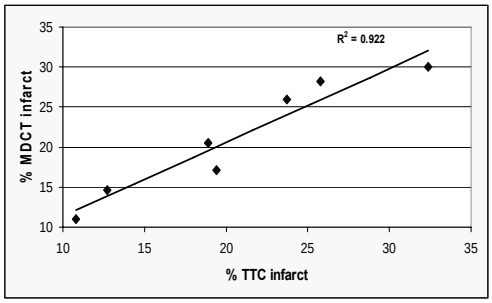
Lardo et al. Circulation 2005 (in press)

MDCT Viability Imaging



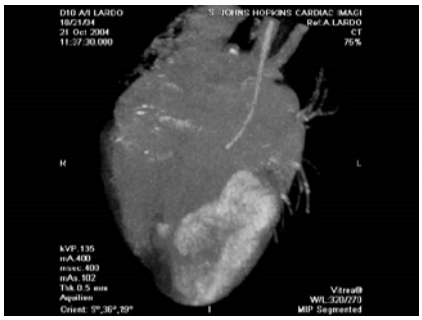
Lardo et al. Circulation 2005 (in press)

Comparison of MDCT and TCC Infarct Measurement



Lardo et al. Circulation 2005 (in press)

3D Visualization of Infarct Extent

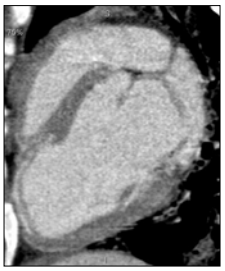


adapted from A. Lardo

MDCT Infarct Imaging

90 min occlusion/reperfusion model

2 hrs
2hrs

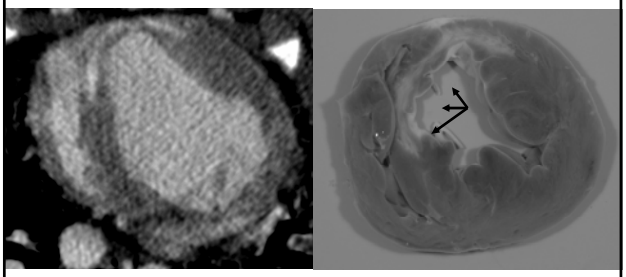


8 weeks
8 weeks

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

Chronic Infarct Imaging

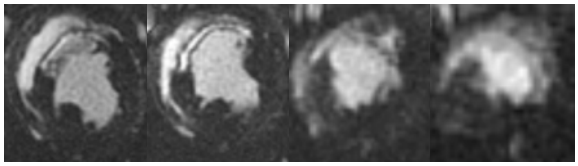
MDCT | Pathology



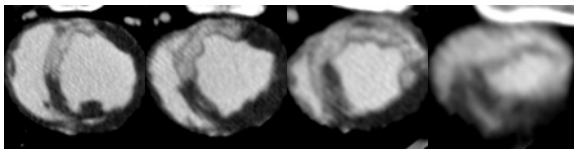
Infarct size = 128.8 mm^2 | Infarct size = 119.7 mm^2

Lardo et al. Circulation 2005 (in press)

MRI



MDCT



adapted from A. Lardo

Contrast Enhanced CT Imaging

60 minute occlusion/reperfusion model

5 days | 33 days | 67 days

Infarct = 21.22 cm2
Rim thickness = 0.4mm

Infarct = 10.41 cm2
Rim thickness = 1.4mm

Infarct = 8.38 cm2
Rim thickness = 2.5mm

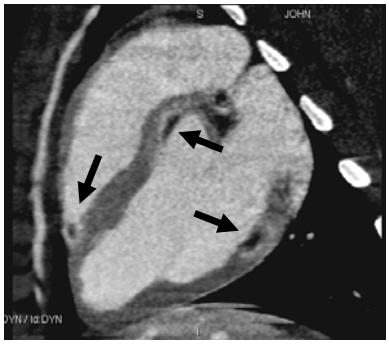
adapted from A. Lardo

Cardiac Ablation for Arrhythmia

- Catheter based treatment to kill electrically active viable cell islets
- Pre-procedural MDCT for anatomic correlation
- Visualization of RF ablation lesions

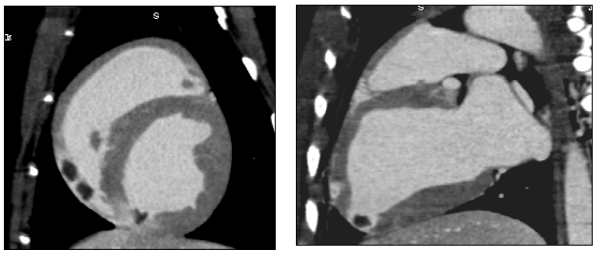
MDCT Lesion Appearance

5 minutes post contrast



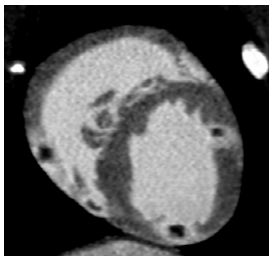
adapted from A. Lardo

CT Lesion Appearance



adapted from A. Lardo

MDCT Lesion Morphology



- Hypoenhanced core: coagulative necrosis and microvascular obstruction (contrast does not enter local microcirculation)
- Hyperintense periphery: edema, cell necrosis

adapted from A. Lardo

MDCT Perfusion Imaging

Requirements:

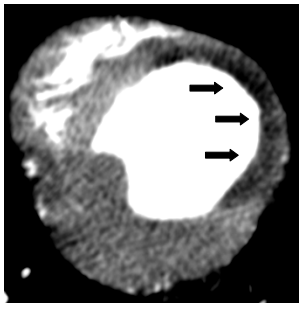
- Vasodilator (adenosine)
- During first-pass, contrast-enhanced MDCT.
- Rapid imaging from base to apex.

Possible Advantages:

- Simultaneous coronary imaging.
- Imaging of the entire LV

adapted from A. Lardo

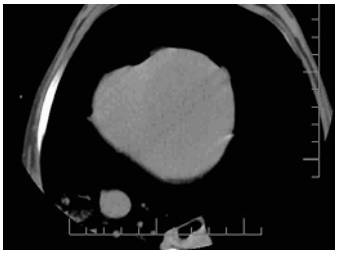
Helical MDCT Perfusion



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, 2005.
adapted from A. Lardo

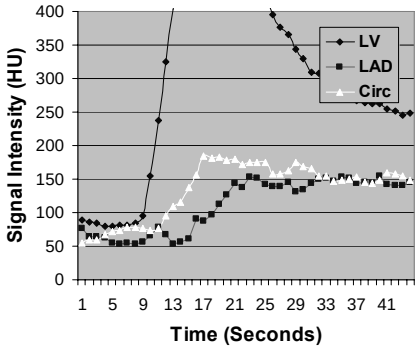
MDCT Dynamic Perfusion



Serial imaging of the mid-left ventricle over time in a canine model of LAD stenosis. (Detector collimation: 8 mm X 4, 120 kV, 150 mA, Visipaque™ 10 ml/sec for 3 seconds.)

George RT, et al. Work in progress.
adapted from A. Lardo

MDCT Perfusion



adapted from A. Lardo

Conclusions: Noncoronary MDCT

- Global and regional left ventricular function can be assessed by MDCT and coupled with coronary CTA.
- MDCT stress perfusion, viability and scar imaging has high spatial resolution, promising tool.

Acknowledgements

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Conclusion - MDCT

Potential for c*omprehensive* morphologic and functional assessment.