Ventricular Function Evaluation using MDCT

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Disadvantages of MDCT

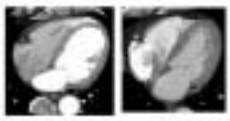
- Ionizing radiation
- Use of iodine contrast
- Limited temporal resolution (→83 ms)
- Cardiac motion artifacts in patients with fast heart rates or arrhythmia

Introduction

- MDCT has capability of bi-ventricular function evaluation.
- Small number of paper have been published for validation of MDCT for this purpose

Techniques of MDCT

- The same as in coronary CTA
- RV function
  - Injection of diluted contrast material mixed with saline is recommended following contrast bolus in full concentration



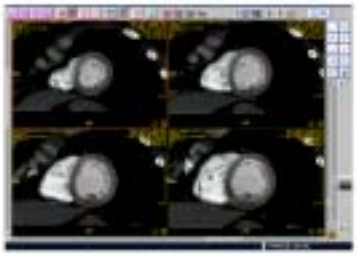
Advantages of MDCT

- Utilization of the same multiphase reconstruction data acquired for cardiac CT
- High contrast between ventricular cavity and myocardium
- Rapid acquisition of image data as compared with MRI and echocardiography
- Less susceptible to arrhythmia than MRI
- Capability of right ventricular evaluation

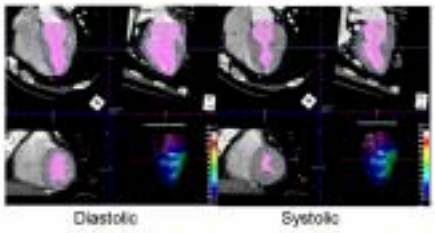
2 Different Semiautomatic Analysis Tools

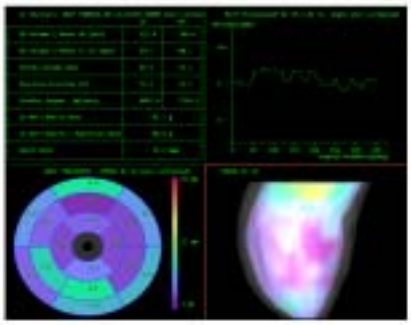
- Multiplanar short-axial image reconstruction
  - Simpson method
- 3D images
  - Threshold-based region growing algorithm
  - Sensitive to good contrast opacification
  - Delineation of trabeculae influenced by degree of contrast

Multiplanar Short-axial Image Reconstruction

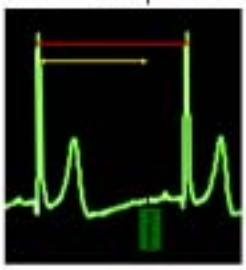


42/M with CABG, EF = 51%

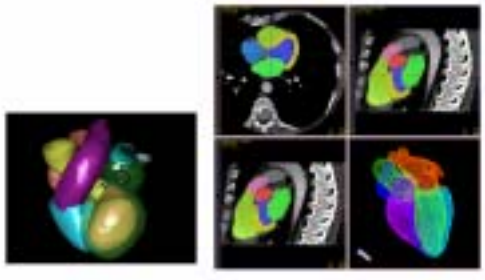




Phase Location and Image Reconstruction Window



Automatic Segmentation



- Multiphase reconstruction
  - 20 phases at every 5% of RR interval
  - Systolic phases (35-50%) at 5% interval
  - 35/40% and 95% reconstruction

- 2-phase reconstruction according to ECG wave (Im TH. AJR 2005;185:319-325)
  - ES: window is half way in ascending T wave
  - ED: window is at starting point of QRS complex
  - LVEDV, LVESV, SV, EF correlated well with multiphase reconstruction tech.
  - CT overestimation of EF by 2.9%± 8.7 cw echo

Comparison of MDCT with Other Imaging Techniques

Regional Wall Motion: MDCT vs. MRI

- 30 patients with MI, CAD, ARVD, DCMP.
- 252/266 (94.7%) of normal, 189/214 (88.3%) of decreased WM → correctly identified by CT
  - Sens 88%, spec 95% for WM abnormalities
- LV-WM scores were identical in 86.7% (k=0.809)
- CT underestimated degree of WM abn.
- Lower interobserver agreement in CT (66.5%) cw MRI (89.1%, p<0.01)

Fischbach R, et al. Eur Radiol 2006 Sep.

MDCT vs. Cine LV graphy

- Area-length methods for 2 techniques
- 22 patients with coronary artery disease
- LVEF: 60.1±11% vs. 69.9 ± 12.4% (r=0.76)
- Simpson's method for CT: mean difference with cine LVG = 11.5 ± 5.7%

Juergens KU. AJR 2002;179:1545-1550

LV Size and Function: Comparison among real-time 3D echo, 16-MDCT, and MRI

- 31 patients
- MRI: radial long axis images in 6 planes
- CT: images in 10% interval
- Real time 3D Echo: 4 wedge-shaped subvolumes

Sugeng L et al. Circulation 2006;114:651-661

16-slice MDCT and MRI

- 40 patients with CAD
- LV EDV and ESV were similar.
  - 134 ± 51 vs. 137 ± 57, r=0.92; 67 ±56 vs. 70 ±60, r=0.95
- LV EF were similar.
  - 55 ±21 vs. 56 ± 21, r=0.95
- Regional end-diastolic and end-systolic wall thickness were highly correlated (r=0.84), but lower than by MR (r=0.92).
- Values of regional wall thickening by MDCT (54 ± 30) and MR (51 ± 31) were similar (r=0.91).

Belge et al. Eur radiol 2006;16:1424-1433

- CT and RT3DE measurement in high correlation (r^2 >0.85) with MR
- CT overestimated EDV (26 ml) and ESV (19 ml) (p<0.05)
- RT3DE underestimated EDV (5 ml) and ESV (6 ml) with bias in EF, 0.3%.
- Variability in CT measurement was half of echo and MRI

Sugeng L et al. Circulation 2006;114:651-661

RV Fn in Adults with CHD: MRI-MDCT Comparison

- RVEF showed moderate agreement (45 ± 18 vs. 42 ± 17%, r = 0.86)
- RV volumes correlated well in 18 MRI-MDCT data pairs.
  - EDV : 170 ± 65 vs. 160 ± 56, r=0.93
  - ESV : 104 ± 65 vs. 97 ± 56, r=0.97

Raman et al. Am Heart J 2006;151:736-744

Materials and Methods

- ✓ Acquisition on the same day except 2 pts
  (14 and 18 days intervals)
- ✓ Mean heart rate
  CT : 66.9 bpm, 48 – 101
  MRI : 70.7 bpm, 47- 100
- ✓ No medication
- ✓ Approximated duration of post-processing
  CT : 5 – 10 min MRI : 15 – 20 min

40-slice MDCT Evaluation of Biventricular Function of the Heart : Comparison with MRI

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Materials and Methods

Short axis reformation images of MDCT
Short axis images using FIESTA sequence of cine-MRI

↓

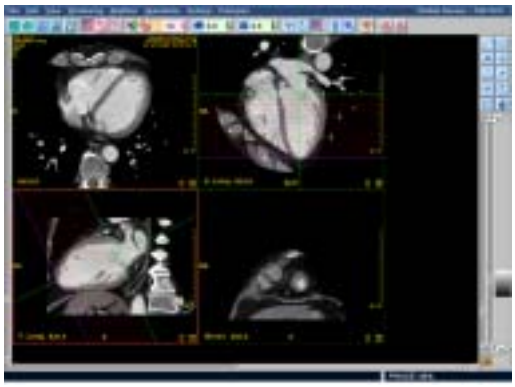
Semiautomated edge-detection software
(Cardiac Review)
Semiautomated contour detection technique
(MASS-plus)

↓

Manual correction by two independent observers

Materials and Methods

- ✓ 49 patients underwent both CT and MRI.
  (41 CABG; 6 previous MI)
- ✓ ECG-gated MDCT was performed using Philips 40-slice CT (Brilliance 40) with adaptive recon. Algorithm and dual-phase CM injection
- ✓ Cine MR imaging was performed using an 1.5 T scanner (GE Signa CV/i) and FIESTA sequence (Fast-imaging with steady-state acquisition)



Result

RV parameter	CT	MRI
EDV	123.68 ± 23.6	99.27 ± 28.3
ESV	59.12 ± 14.3	50.09 ± 19.4
SV	64.56 ± 17.5	48.4 ± 22.2
EF	51.97 ± 8.59	49.07 ± 11.6

24.4
9.0
15.1

Materials and Methods

- ✓ Left ventricular EDV, ESV, SV, EF, mass
  Right ventricular EDV, ESV, SV, EF
- ✓ Statistics
  Paired t-test / Wilcoxon's signed rank test
  Pearson's / Spearman's correlation analysis

Result

Correlation	LV	RV
Good	ESV, Mass (r=0.76, 0.92) (p<0.001)	
Moderate	EDV, EF (r=0.68,0.64) (p<0.01)	EDV, ESV (r=0.55, 0.42) (p<0.01)
Poor	SV (r=0.35) (p<0.05)	SV, EF (r=0.36, 0.17) (p<0.05)

Result

LV parameter	CT	MRI
EDV	108.12 ± 29.2	109.12 ± 29.9
ESV	38.16 ± 22.6	45.08 ± 25.5
SV	69.98 ± 15.9	64.04 ± 14.7
EF	66.14 ± 11.3	60.70 ± 12.4
LVM	90.36 ± 22.35	91.04 ± 23.1

6.9
5.9
5.4

Summary

- LV ESV, SV, and EF and RV EDV, ESV, and SV were significantly different ($p < 0.05$).
- LVEDV, LV mass and RVEF were not significantly different ($p > 0.05$).
- CT overestimated RVEF and LVEF compared with MRI with mean difference of 1.9%, and 5.4% respectively.

Conclusion

In comparison with MRI,

40-MDCT seems to allow reliable assessment of LV EDV, LVM, and RV EF and

rough estimation of LV ESV, LV EF, RV EDV, and RV ESV.

Limitation of Temporal Resolution (TR)

- 20 ms TR is needed to complete removal of cardiac motion artifact
- Duration of total electromechanical systole is 300 ms, minimal ventricular volume is maintained for 80-200 ms
- ESV may be overestimated due to TR
- Current system: gantry rotation 0.33 s, TR 83 ms (dual-source scanner)

LV Fn Analysis: MDCT vs. MRI

Authors	No. Pts	LVEDV		LVESV		EF		Mass	
		MD	CC	MD	CC	MD	CC	MD	CC
Kim (SMC)	48	-1.0	0.89	5.9	0.76	5.4	0.64	-0.6	0.92
Grude	30	14	0.80	17	0.89	-9	0.85		
Yamanaro	50	-0.4	0.97	1.1	0.99	-1.2	0.96	2.5	0.96
Henneberg	31	13.7	0.86	4.6	0.91	1.4	0.87	11.5	0.80
Koch	19	-4.2	0.98	-6.9	0.98	3.8	0.95		
Juergens	30	-8.2	0.93	-1	0.94	0.2	0.88		

MD = mean difference, CC = correlation coefficient

Time-dependent Change in LV Volume (MDCT vs. MRI in Pigs)

- Differs markedly because of limited temporal resolution of 16-slice MDCT
- Different peak emptying rate, peak filling rate, time to PER, and time to PFR.

Mahnken AH et al. Radiology 2005:236:112-117

Technical Considerations in MDCT

Effect of Image Reconstruction Window within Cardiac Phases, slice thickness, and interval of short-axial sections

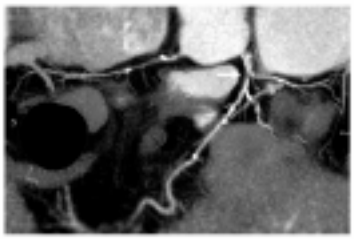
- Comparison of systolic volumes in 6 phases (30-55%, 5% interval) and 3 phases (35-55%, 10% interval)
- Comparison of 1-,2-, and 3-mm thick axial images
- Comparison of 10, 14, 30 short-axial sections

Suzuki S, et al. Circulation J 2006:70:289-296

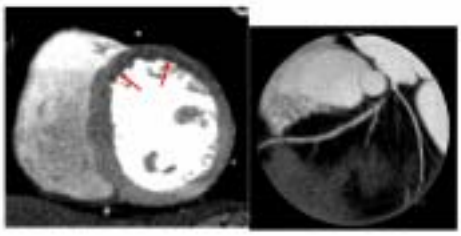
- 3 phases (10% interval): mean measurement error, −0.4%; standard error of estimate (SEE), 0.6%
- No difference between SEE of interobserver reproducibility and that of analysis with 30 sections (1, 2, 3 mm) and 14 sections (1, 2 mm)

Suzuki S, et al. Circulation J 2006;70:289-296

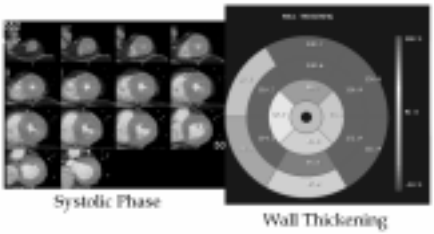
2-Vessel Disease (63/M)



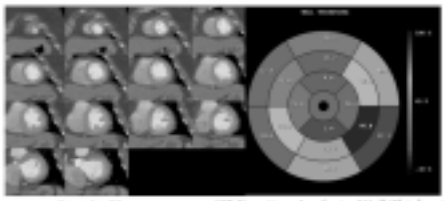
Perfusion Defect without MI (76/F)



MDCT Function Analysis: EF = 81%



Normal ECG, CT EF = 48%



Summary

- MDCT provides reliable information on biventricular function parameters in addition to that of coronary artery anatomy.
- New generation scanners with higher temporal resolution may enable more accurate analysis of global function and regional wall motion with decreased radiation dose.