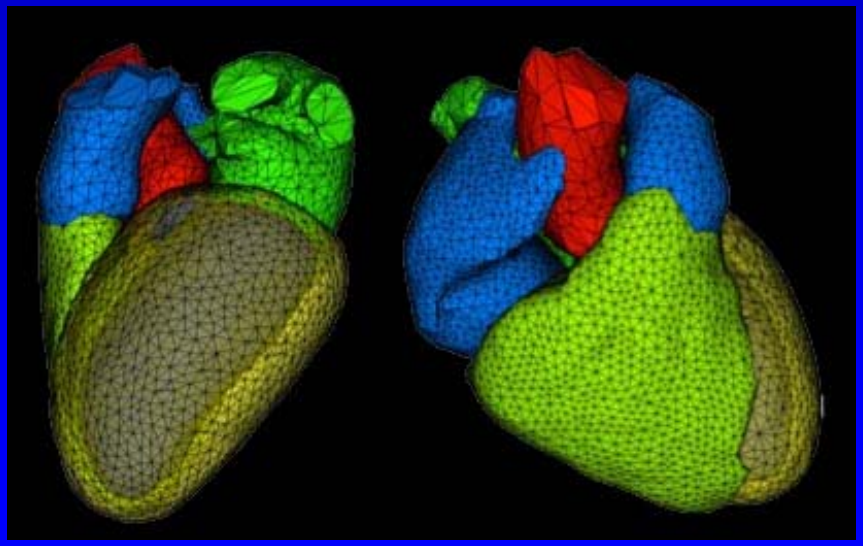
Can Single Phase Prospective Cardiac CT be Used to Detect Abnormal Cardiac Chamber Function?

Walker JR, Abadi S, Agmon Y, Carasso S, Aronson D, Lessick J.



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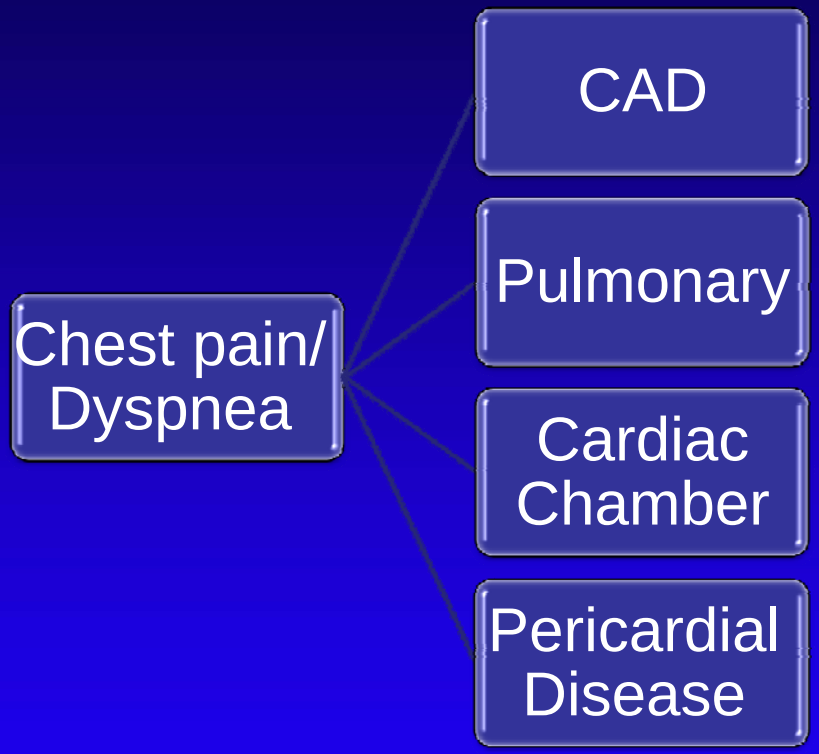
No conflicts of interest

Cardiac Computed Tomography Imaging
Background

- CT angiography is mainly used to rule out coronary artery disease (CAD) in patients with chest pain and/ or dyspnea. However symptoms may be related to other (non-coronary) disease

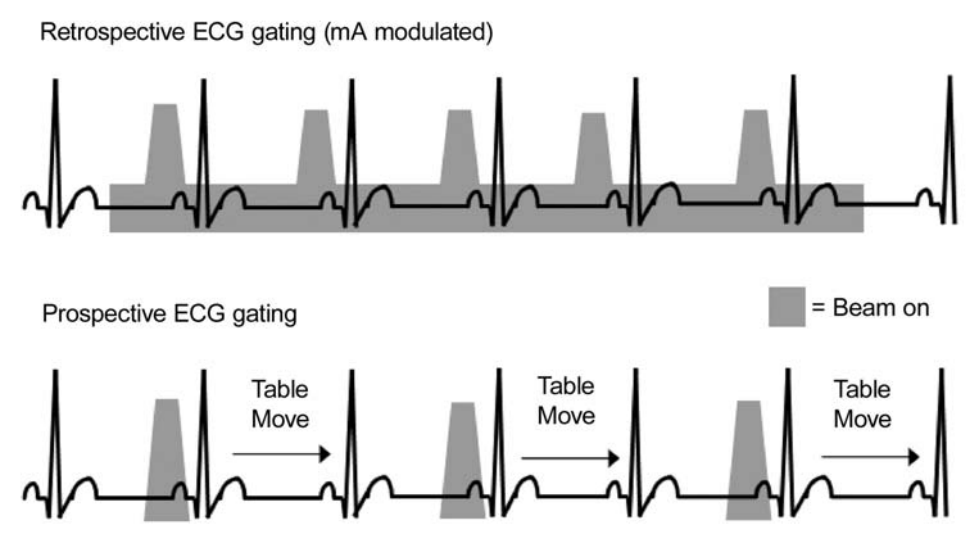
- In addition to coronary anatomical assessment, CT provides important diagnostic information regarding chamber function.



Hausleiter J et al. Image quality and radiation exposure with prospective ECG-triggered axial scanning for coronary CT angiography: The multicenter, multiventor, randomized protection-III study. JACC 2012;5(5):485-93.

Cardiac Computed Tomography Imaging
Background

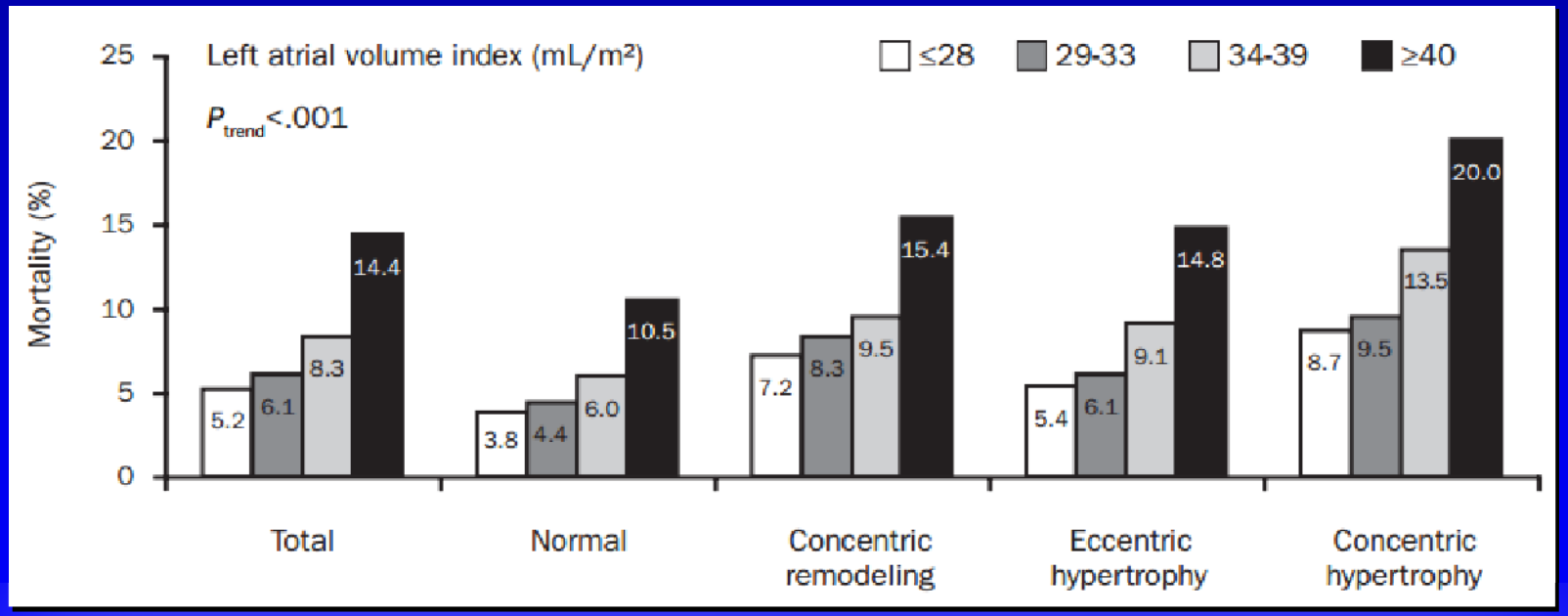
- New algorithms reduce radiation exposure while maintaining image quality utilizing a single Mid-Diastolic phase
- Opposed to retrospective ECG gating, prospective axial techniques or flash techniques scan a small portion of the cardiac cycle
- For single-phase techniques functional or volumetric evaluation is not currently possible.



Shuman WP, et al. Prospective versus retrospective ECG gating for 64-detector CT of the coronary arteries: comparison of image quality and patient radiation dose. Radiology August 2008 248:2 431-437

Value of LA and LV Chamber Volumes

- Both LV and LA volumes have well documented prognostic value as indicators of morbidity and mortality, even in the presence of a normal EF.
- Reduced EF has well documented prognostic value.



Patel DA et al, Mayo Clin Proc. 2011 86(8):730-7.

The Role of Cardiac CT in Routine Evaluation

Why not send everyone to Echocardiography?

- While echocardiography remains the choice for cardiac function assessment, the dual use of CTA and Echocardiography is not cost-effective.
- Volumetric assessment in CT using a single-phase may be a cost-effective, resource and radiation dose efficient method towards ruling out patients not requiring further cardiac chamber assessment.
- However, normal values for single phase mid diastolic volumes remain to be defined.

Objectives

1. To define normal values for the left ventricular (LV) and left atrial (LA) at diastasis

2. To determine the relationship between diastasis and the well characterized end-diastolic (ED) and end-systolic (ES) volumes

3. To determine whether use of these data can be used to identify patients with LV and LA enlargement, and LV dysfunction

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Methods

153 In-Patients

72 Normal

109 Consecutive

ECG Gated Cardiac CT

Phases

End-Diastole (0%)

End-Systole (40%)

Mid-Diastole (75%)

Angiography

Automated Volumes

Corrected Volumes

Angiography

Automated Volumes

Corrected Volumes

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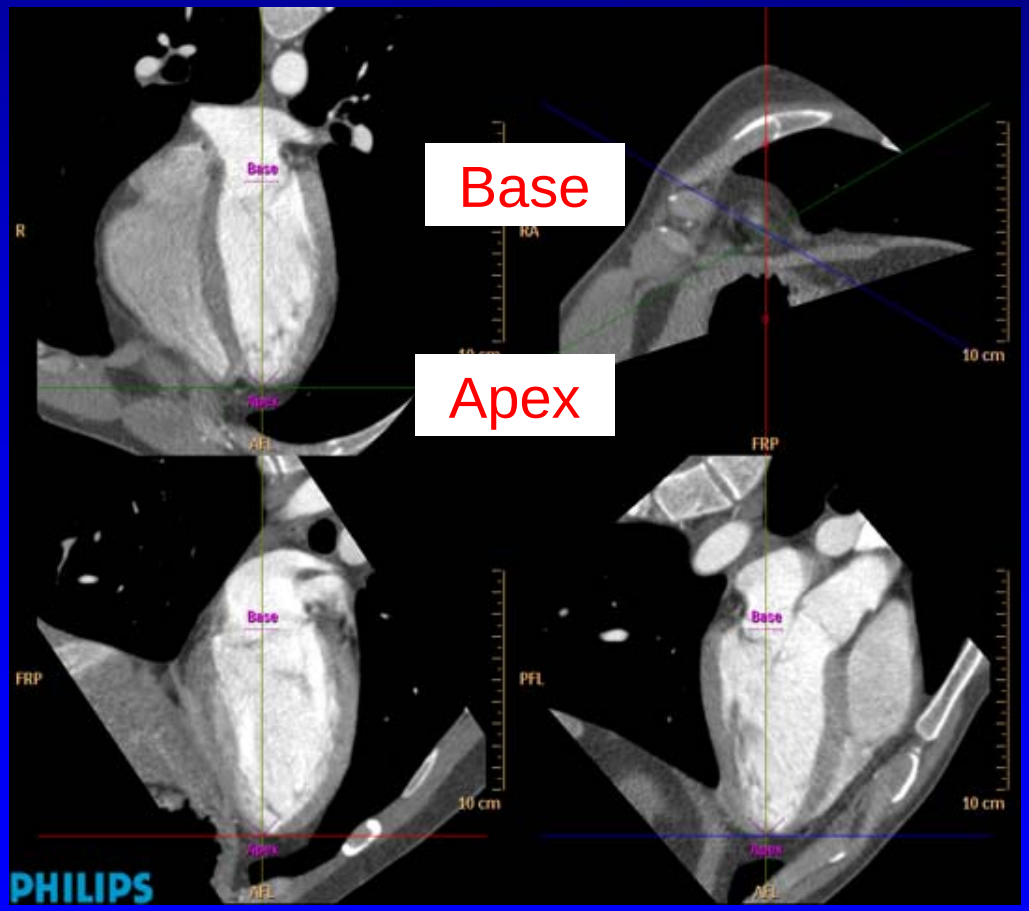
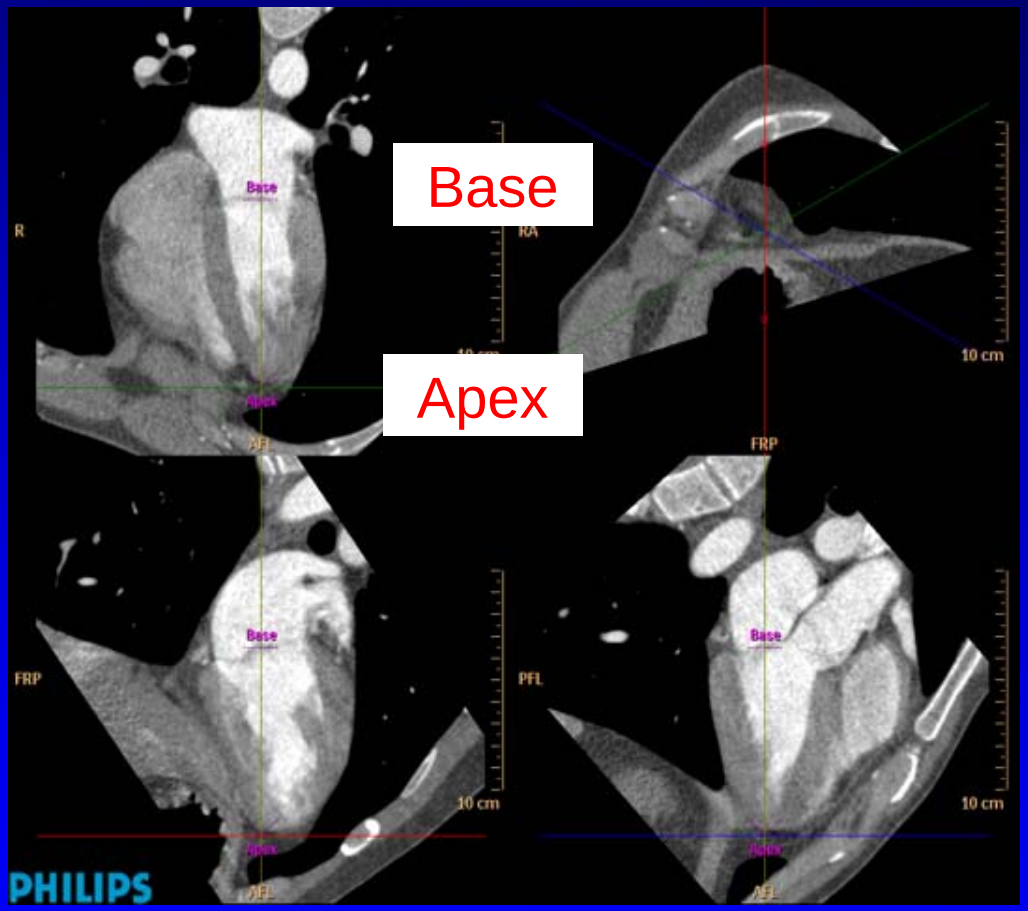
Methods

Volume tracing: Simpson's

End-Diastole: 0%



End-Systole: 40%



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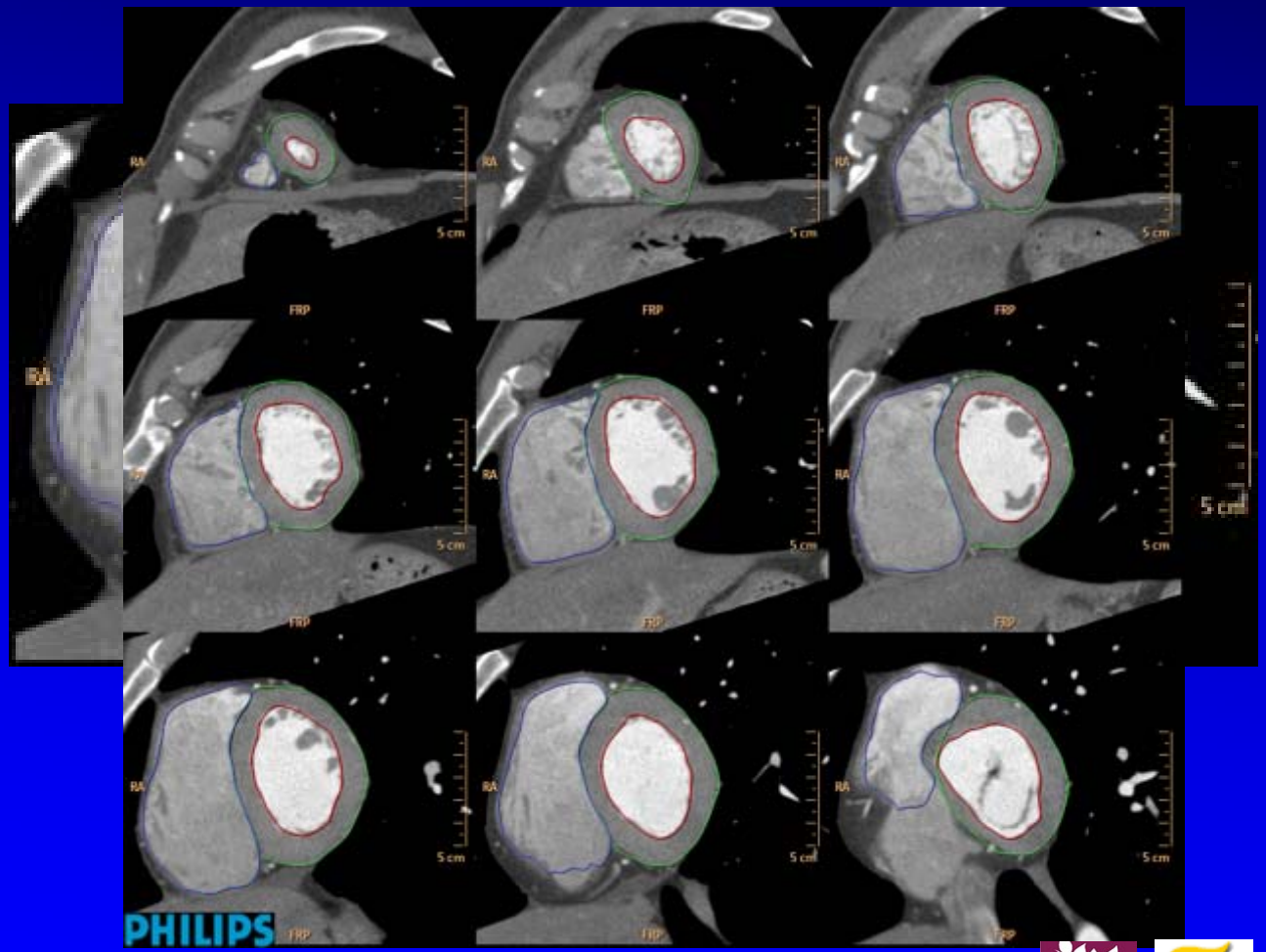
Methods

Volume tracing: Simpson's

- 9 slices from base to apex
- Excellent image quality
- Highly accurate in most cases, requiring minor tracing corrections

Automated Tracing



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Methods
Analysis

- Abnormal volumes defined as volumes >2sd above the mean.
- LV MD volumes compared to LVED (maximum) volumes.
- LA MD volumes compared to LAES (maximum) volumes.
- We also examined whether increased LV or LA MDV detect LV dysfunction (EF<45%)

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Results
Clinical Characteristics

Table 1. Clinical characteristics of study population.

Clinical characteristics	Normal (N=72)	Consecutive (N=109)
Age (years)	46.8±9.3	55.3±11.1
Gender-Male	71%	74%
BMI (kg/m^2)	27.3±4.6	28.8±4.7
Smoking history (%)	25 (53)	52 (48)
Hypertension (%)	0 (0)	55 (50)
Diabetes (%)	0 (0)	22 (20)
CAD	0 (0)	28 (26)
CHF	0 (0)	6 (6)

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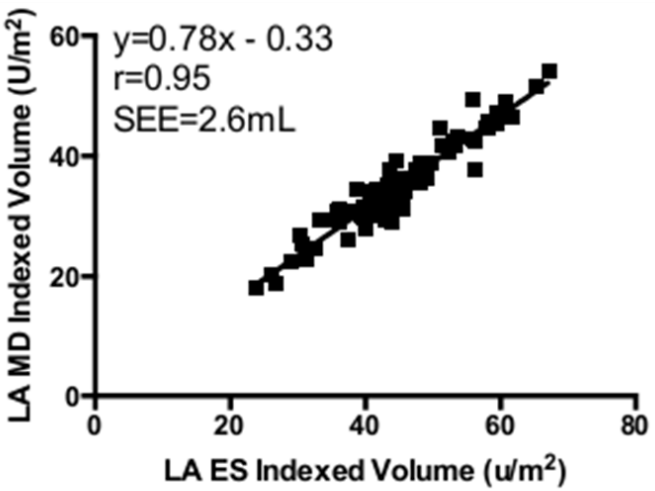
Results

Normal Volume Values

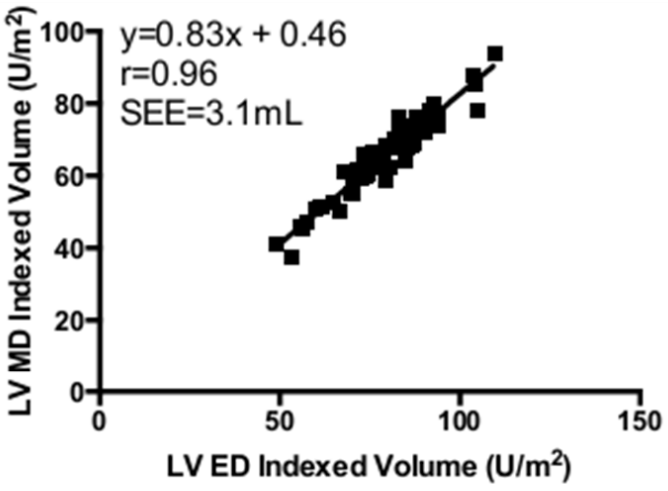
Table 1. Normal Values for All Age and Gender

Parameter	Mean [95%CI]	Indexed Mean [95% CI] U/m2
LVEDV (ml)	155 [101 : 209]	79 [56 : 103]
LVMDV (ml)	**128 [82 : 175]**	**66 [45 : 86]**
LAESV (ml)	88 [49 : 126]	45 [27 : 64]
LAMDV (ml)	**69 [37 : 101]**	**35 [20 : 50]**

A. LAMDVI vs LAESVI



B. LVMDVI vs LVEDVI



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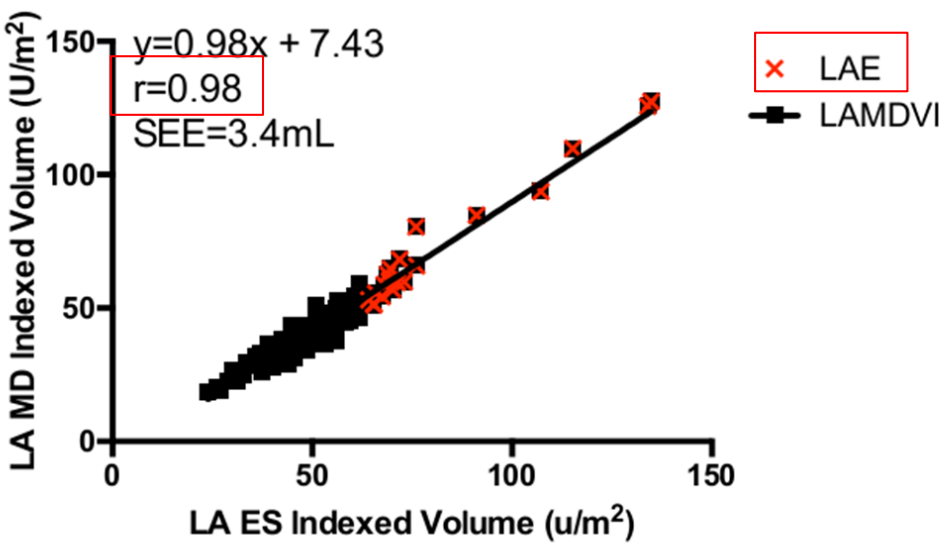
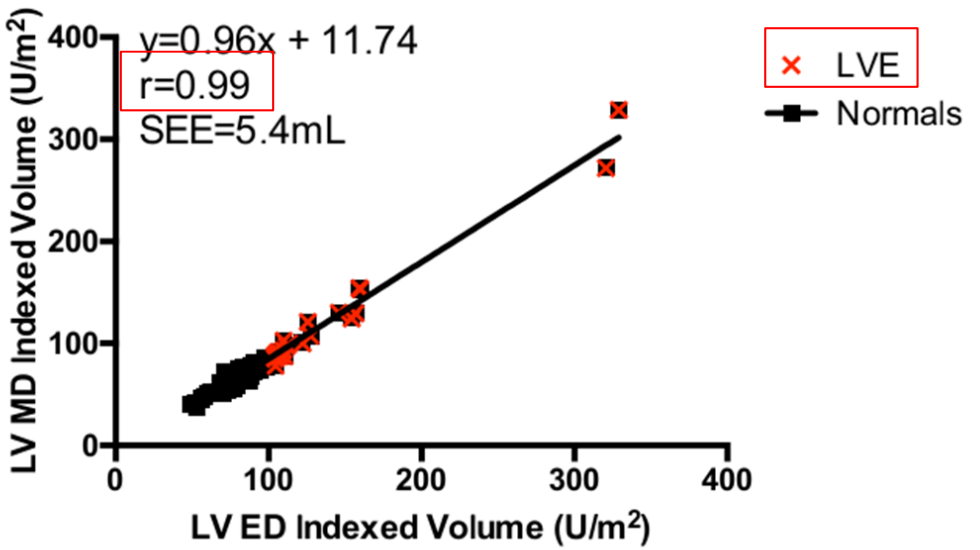
Results

Consecutive group LA and LV volumes

A. LAMDVI vs LAESVI



B. LVMDVI vs LVEDVI



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Results

Mid-diastolic Volumes to detect patients with LV or LA enlargement or LV dysfunction (EF<45%)

Table 2. LV/LA Enlargement	
Increased LV MDVI to detect LV Enlargement	
sensitivity	95% (20/21)
specificity	100% (88/88)
Increased LA MDVI to detect LA Enlargement	
Sensitivity	100% (20/20)
Specificity	93% (14/15)

Table 3. LV dysfunction	
Either LV MDVI or LA MDVI to detect LV dysfunction	
Sensitivity	93% (14/15)
Specificity	80% (75/94)

- Mid-diastolic LV/LA volumes can be used to screen for patients with abnormal Ejection Fractions.

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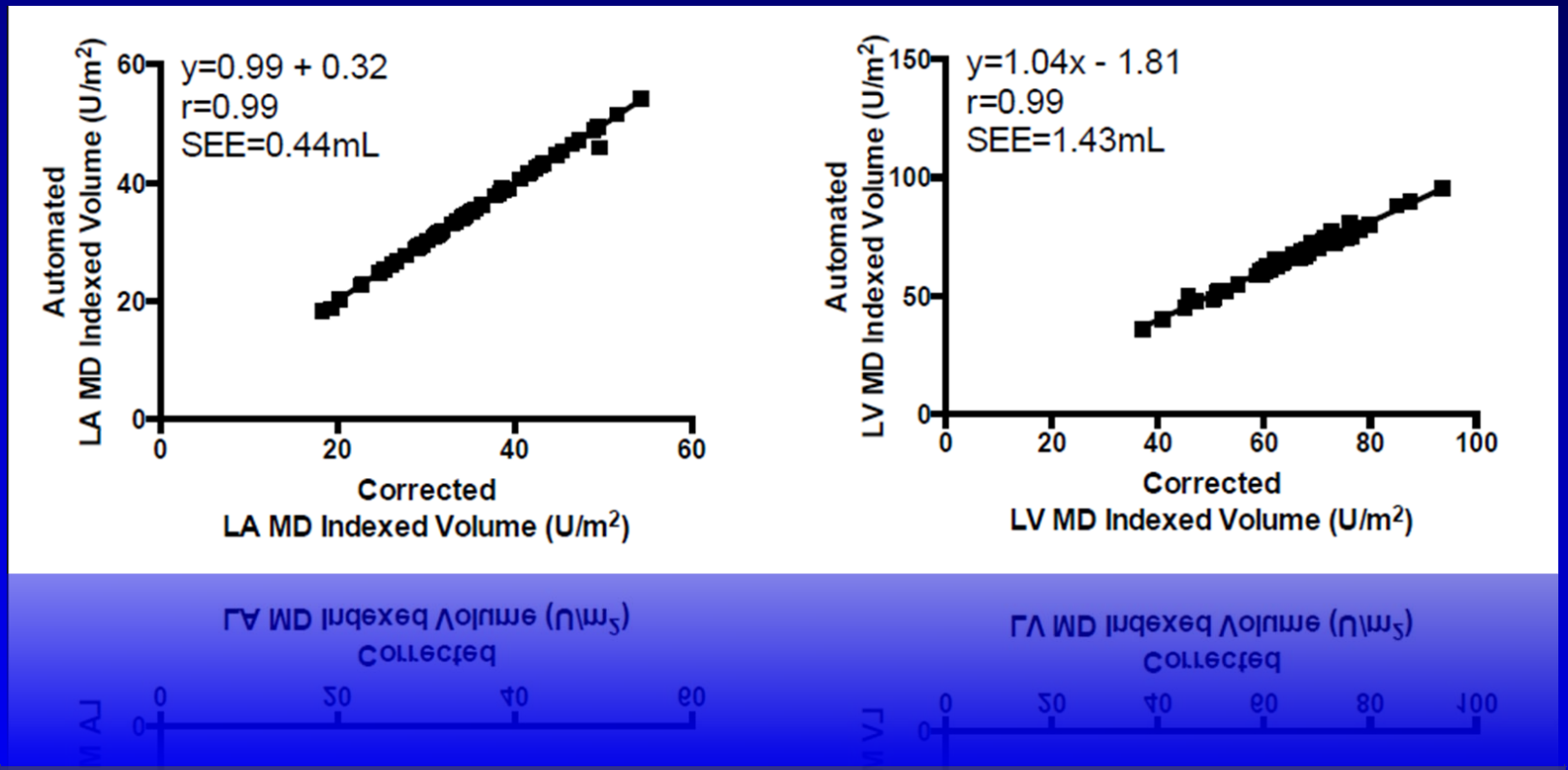
Results

Corrected vs Automated Volumes



Automated volume segmentation success rates	
LA MD	94%
LV MD	98%

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Conclusion

Our study demonstrated for the first time that a single mid diastole phase, as obtained in prospective cardiac CT scans, can be used to identify patients with cardiomegaly or LV dysfunction with a high degree of accuracy.

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Clinical Implications

- Evaluation of mid-diastolic volumes can provide valuable clinical information.
- Since it is simple and quick to do, it should probably be performed in all patients undergoing cardiac CT.
- Results can be used to decide which patients should be referred for echocardiography.

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Acknowledgements

- Supervisor: Dr. Jonathan Lessick
- Members of the Cardiology Dept at Rambam Health Campus

CARDIAC

Left and right ventricle assessment with Cardiac CT: validation study vs. Cardiac MR

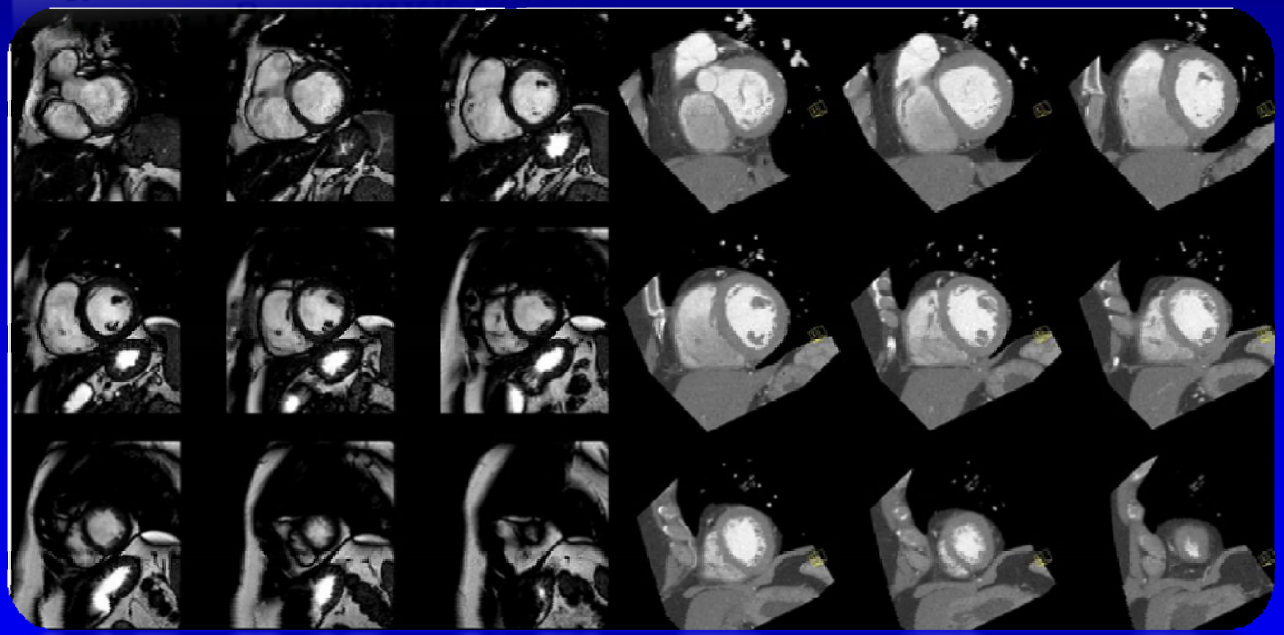
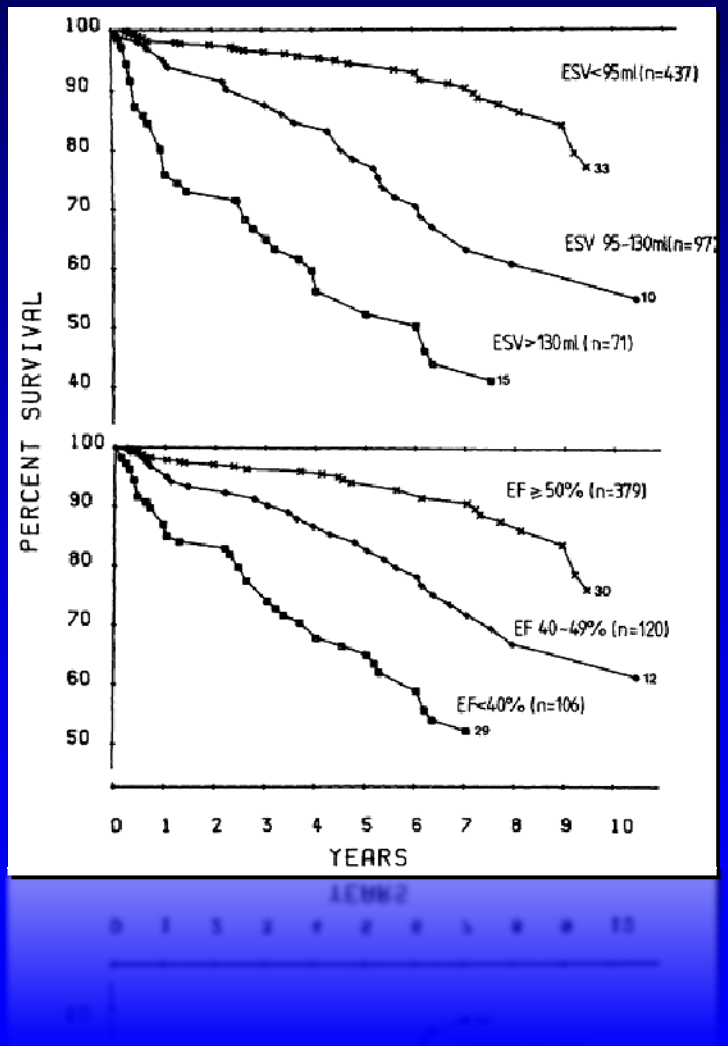


Fig. 1 Short Axis views of the Left and Right Ventricle by MR and CT. End-diastolic Short Axis views of the Left and Right Ventricle by MR and CT (MPR 8 mm thick reconstructions).

Maffei E, Messalli G, Martini C, et al. Left and right ventricle assessment with Cardiac CT: validation study vs. Cardiac MR. Eur Radiol. 2012 May;22(5):1041-9.

Value of LA and LV Chamber Volumes

- Abnormal volumes such as LV ESV and LV EDV as well as EF are correlated with morbidity and mortality risk
- Volumes are highly correlated with EF in both groups of patients with good and poor long-term prognosis.



White HD, Norris RM, Brown MA, et al. Left ventricular end-systolic volume as the major determinant of survival after recovery from myocardial infarction. Circ. 1987;76:44-51.

CARDIAC

Left and right ventricle assessment with Cardiac CT: validation study vs. Cardiac MR

Table 2 Ventricular function parameters

	MR	CT	p-value	r-value	95% LA (mean)
Left Ventricle					
EDV (ml/m^2)	76±25	74±21	>0.05	0.59	−47.3;53.9 (3.3)
ESV (ml/m^2)	38±23	37±19	>0.05	0.76	−66.2;71.4 (2.6)
SV (ml/m^2)	38±11	37±13	>0.05	0.44	−57.7;65.6 (3.9)
EF (%)	52±14	52±14	>0.05	0.73	−40.9;42.0 (0.6)
ED wall mass (g/m^2)	59±18	57±18	>0.05	0.76	−37.9;46.3 (4.2)
Right Ventricle					
EDV (ml/m^2)	80±23	84±25	>0.05	0.58	−50.2;39.9 (−5.2)
ESV (ml/m^2)	43±18	46±21	>0.05	0.70	−65.7;53.3 (−6.2)
SV (ml/m^2)	37±12	38±12	>0.05	0.55	−58.3;51.8 (−3.2)
EF (%)	47±12	47±12	>0.05	0.74	−38.4;42.2 (1.9)

The Table shows global ventricular parameters (Right and Left Ventricle) calculated with MR and CT. Parameters are expressed as mean ± SD

Maffei E, Messalli G, Martini C, et al. Left and right ventricle assessment with Cardiac CT: validation study vs. Cardiac MR. Eur Radiol. 2012 May;22(5):1041-9.