Assessment of Left Sided Filling Dynamics in Diastolic Dysfunction using Cardiac CT

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**Part of MD dissertation*

Conflicts of Interest

- None relating to the presentation
- Consultant for Samsung medical division

Background

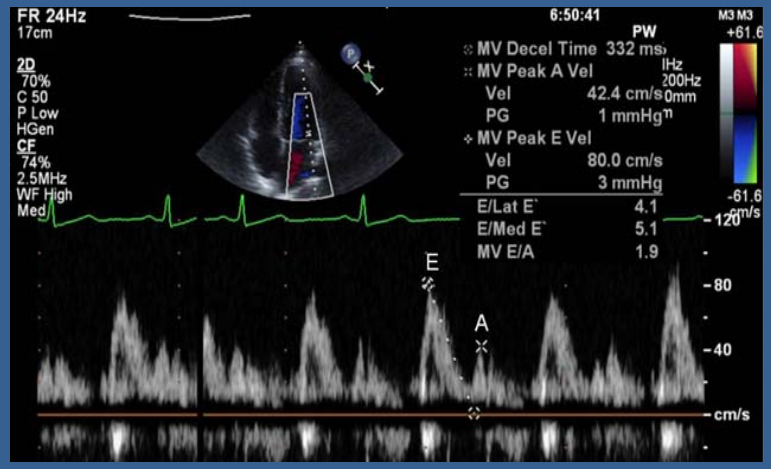
- Left ventricular (LV) diastolic dysfunction (DD) involves a complex interaction between LV and left atrial (LA) filling dynamics.
- Until now, it has not been possible to easily obtain simultaneous LV and LA volume curves to perform this analysis.

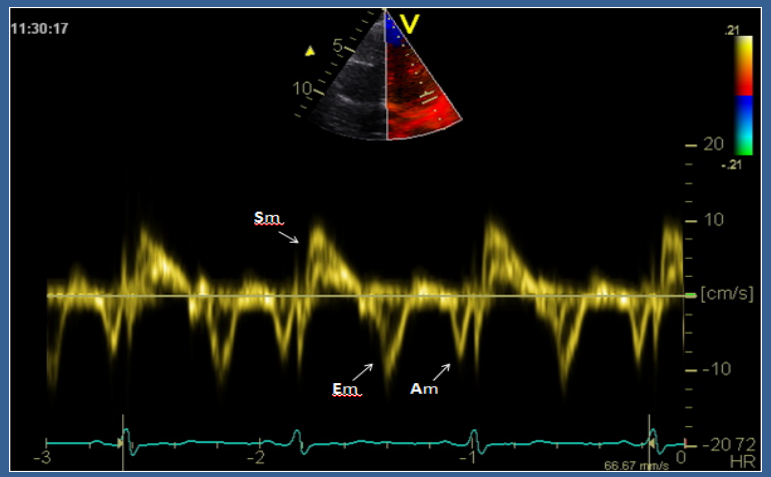
Aim

- To analyse CT-based filling dynamics in a group of patients with diastolic dysfunction and in a normal control group, compared to Echo-Doppler.
- To define the parameters which best differentiate between normal and abnormal diastolic function
- To obtain a better understanding of the pathophysiology of diastolic dysfunction

Methods I

- 40 patients with various grades of DD by echo-Doppler, using ASE criteria, and cardiac CTA within 1 month.
- 37 normal controls.





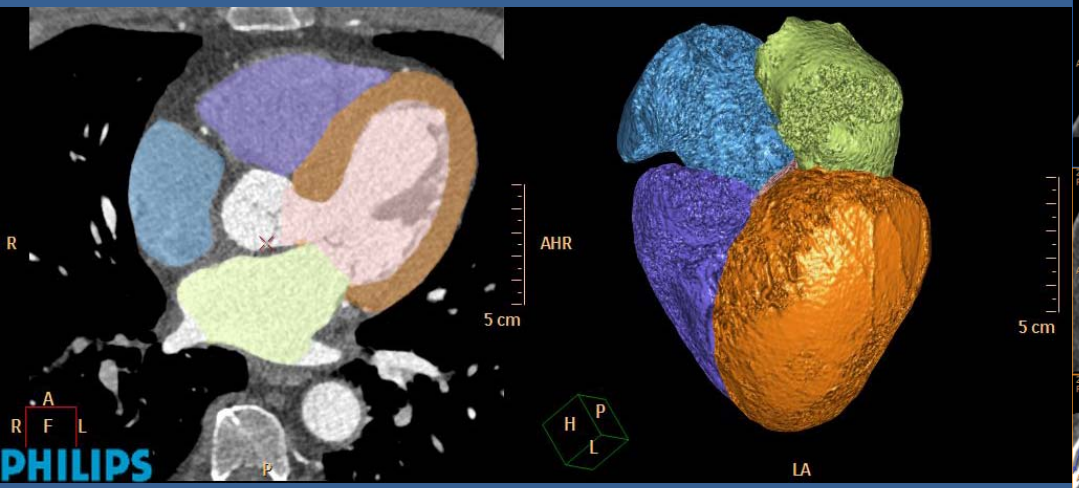
Patient Characteristics

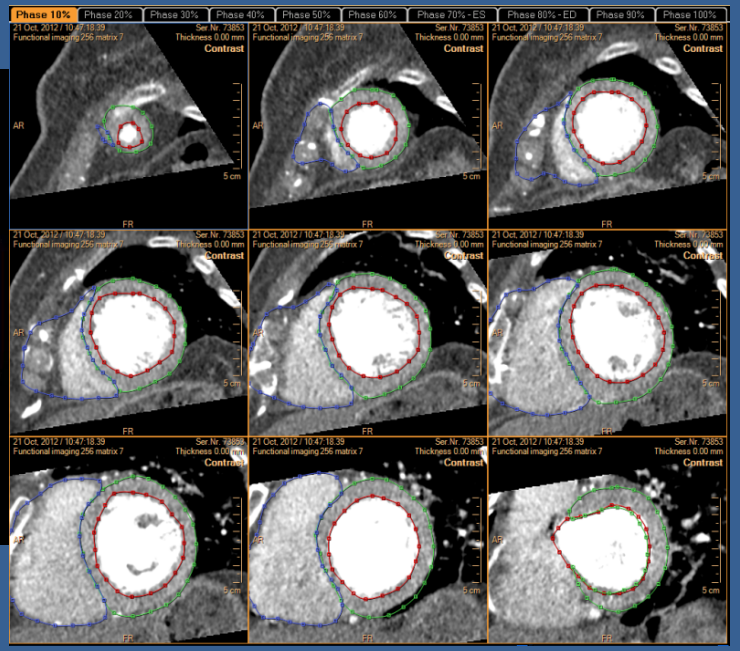
	Normals (37)	All DD (40)	Mild DD (10)	Mod DD (20)	Severe DD (10)
Age	57 ± 11	64 ± 12	63 ± 9	70 ± 9	52 ± 14
Male	51%	55%	60%	50%	60%
BSA	1.88 ±0.17	1.95 ±0.18	1.98 ±0.17	1.88 ±0.18	2.06 ±0.14
Diabetes	14%	40%	20%	45%	50%
HTN	46%	90%	100%	95%	70%
CAD	5%	55%	70%	40%	60%
FC>I	0%	45%	20%	45%	70%

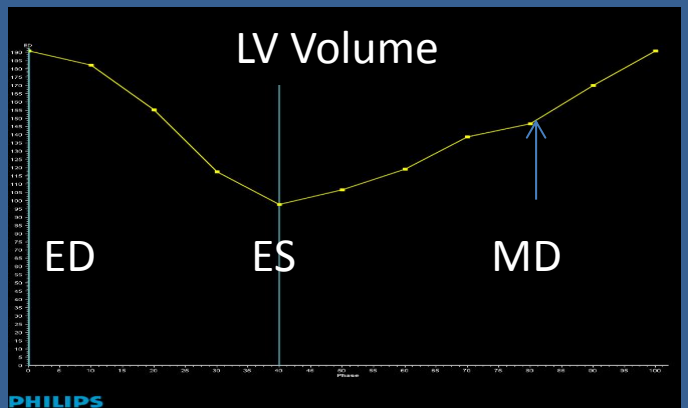
Methods II

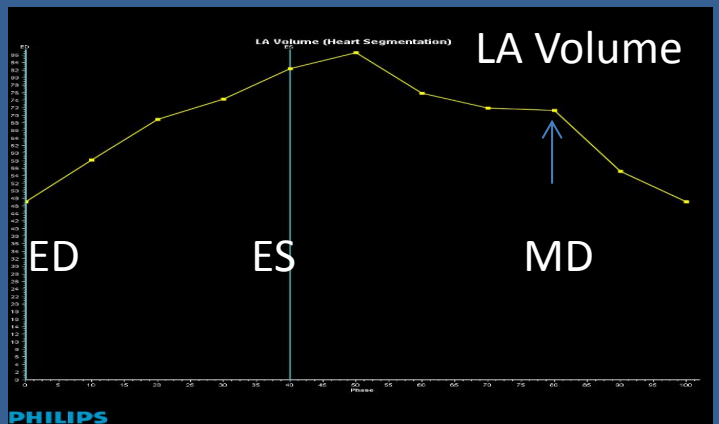
- LV and LA volumes were measured every 10% of the RR interval, using semi-automatic software, and end-diastole (ED), end-systole (ES) and mid-diastole (MD) identified.
- From these 3 volumes, systolic, early-diastolic and late-diastolic volume changes were calculated.

Segmentation of volumes

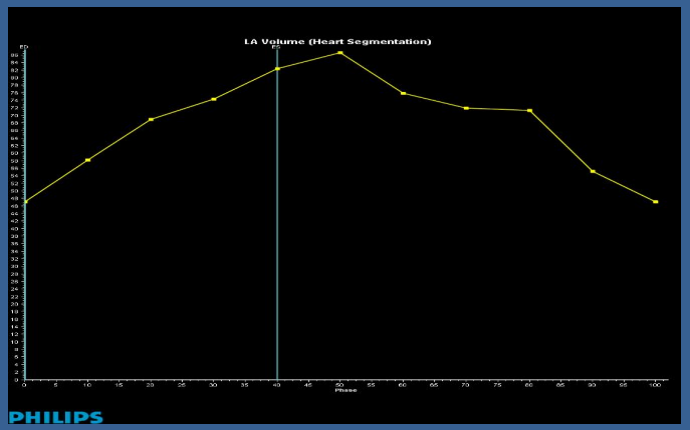








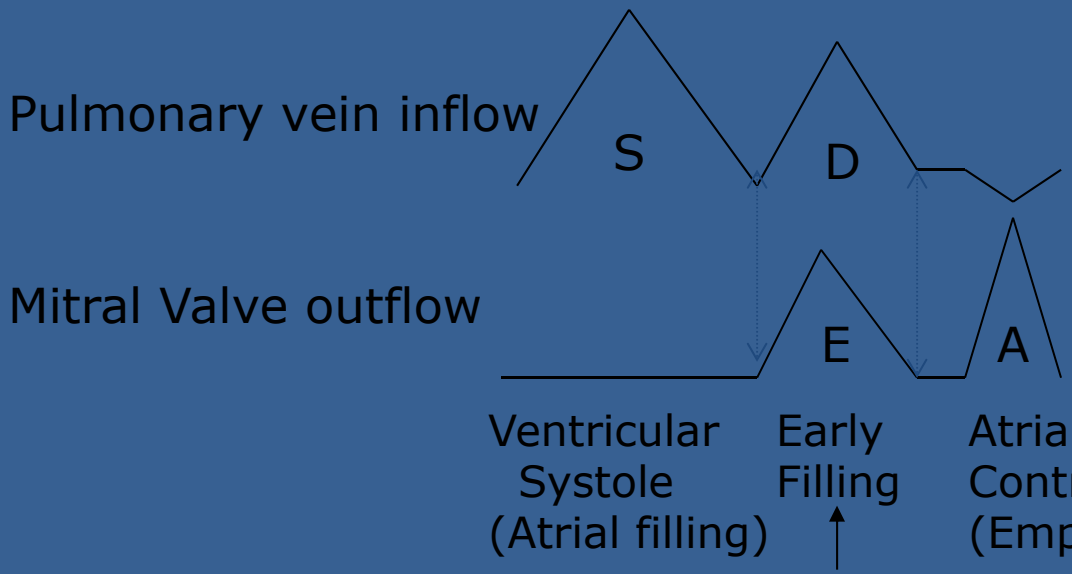
Left Atrial Function



Atrial filling:

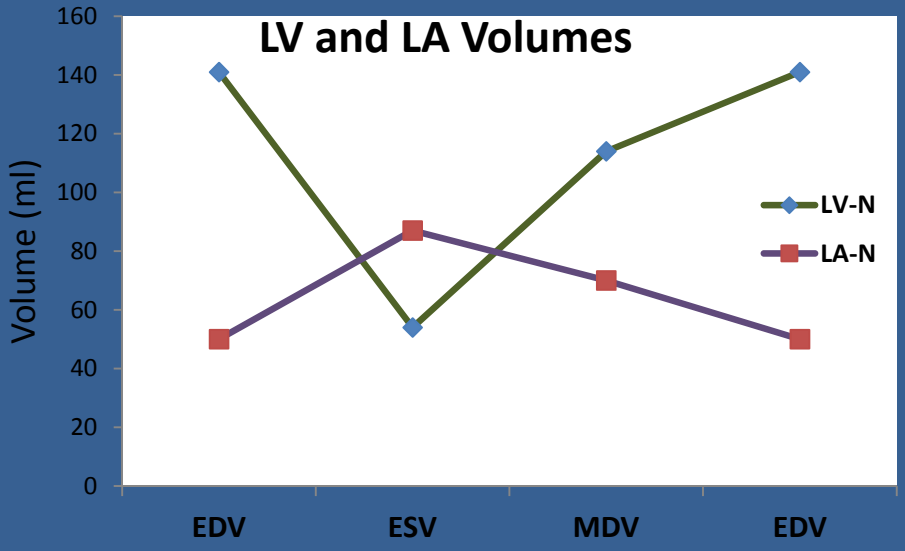
- Systolic filling volume (S)
- Diastolic filling and emptying volumes (D E)
- Atrial emptying volume (A)

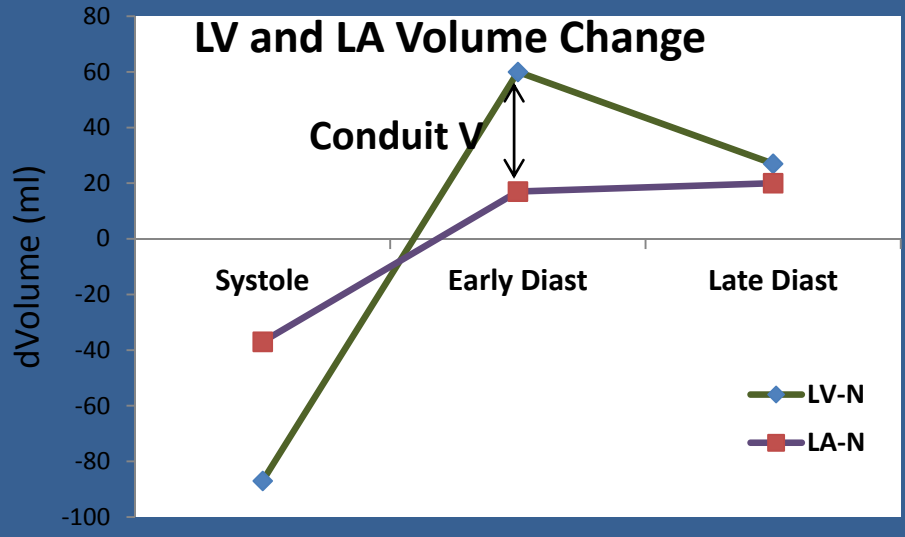
S= ΔAtrial V (ES-ED)
A= ΔAtrial V (MD-ED)
D= E – ΔAtrial V (ES-MD)
↘Ventricular early filling



Atrium fills & empties simultaneously

Atrial Function



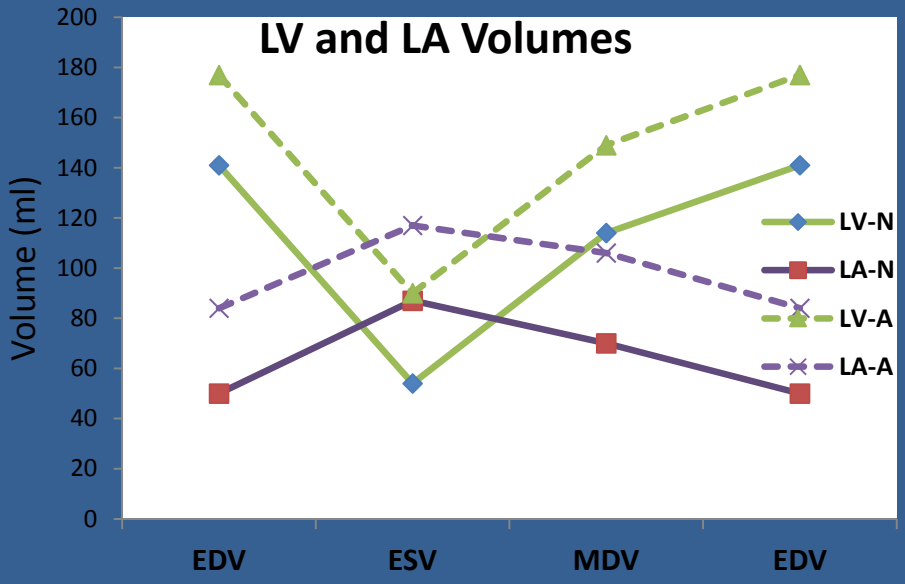


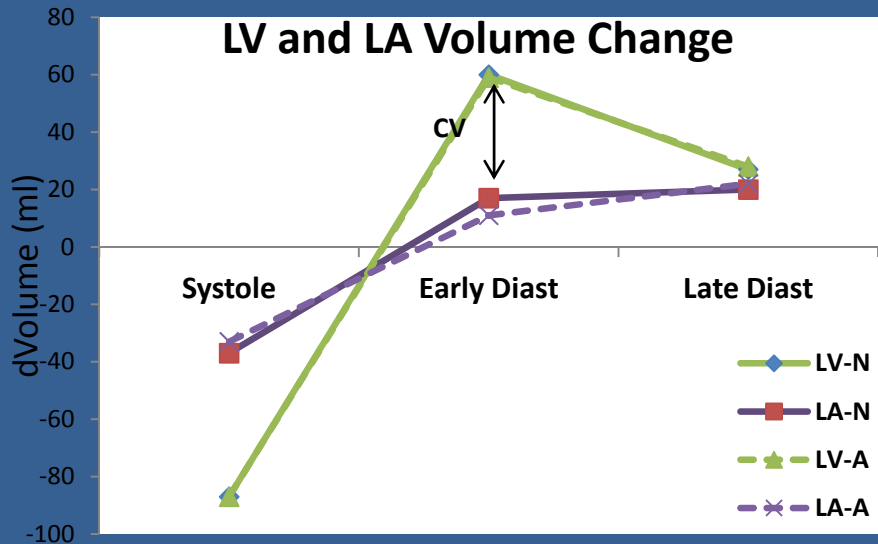
Results (Echo-Doppler)

Parameter	All Normals	DD-All	p (N vs.DD)	DD-Mild	DD-Mod	DD-Severe
Echo E/A	1.1±0.4	1.4±0.9	0.14	0.7±0.1	1.1±0.4	2.6±1.0
Echo E/E'	8.3±1.6	16.8±7.4	<0.001	11.1±3.3	17.8±6.2	20.2±9.8
E	72±10	87±9	<0.001	56±8	92±18	108±25
DT	203±44	195±56	ns	233±51	207±45	135±25
LA area	17±3	24±4	<0.001	20±3	25±3	27±3
Est. PAP	29±5	41±12	<0.001	30±6	39±9	52±12

DT=Deceleration time, LA=Left atrium, PAP=pulmonary artery pressure

Results – CT Volumes





Summary of Results - CT

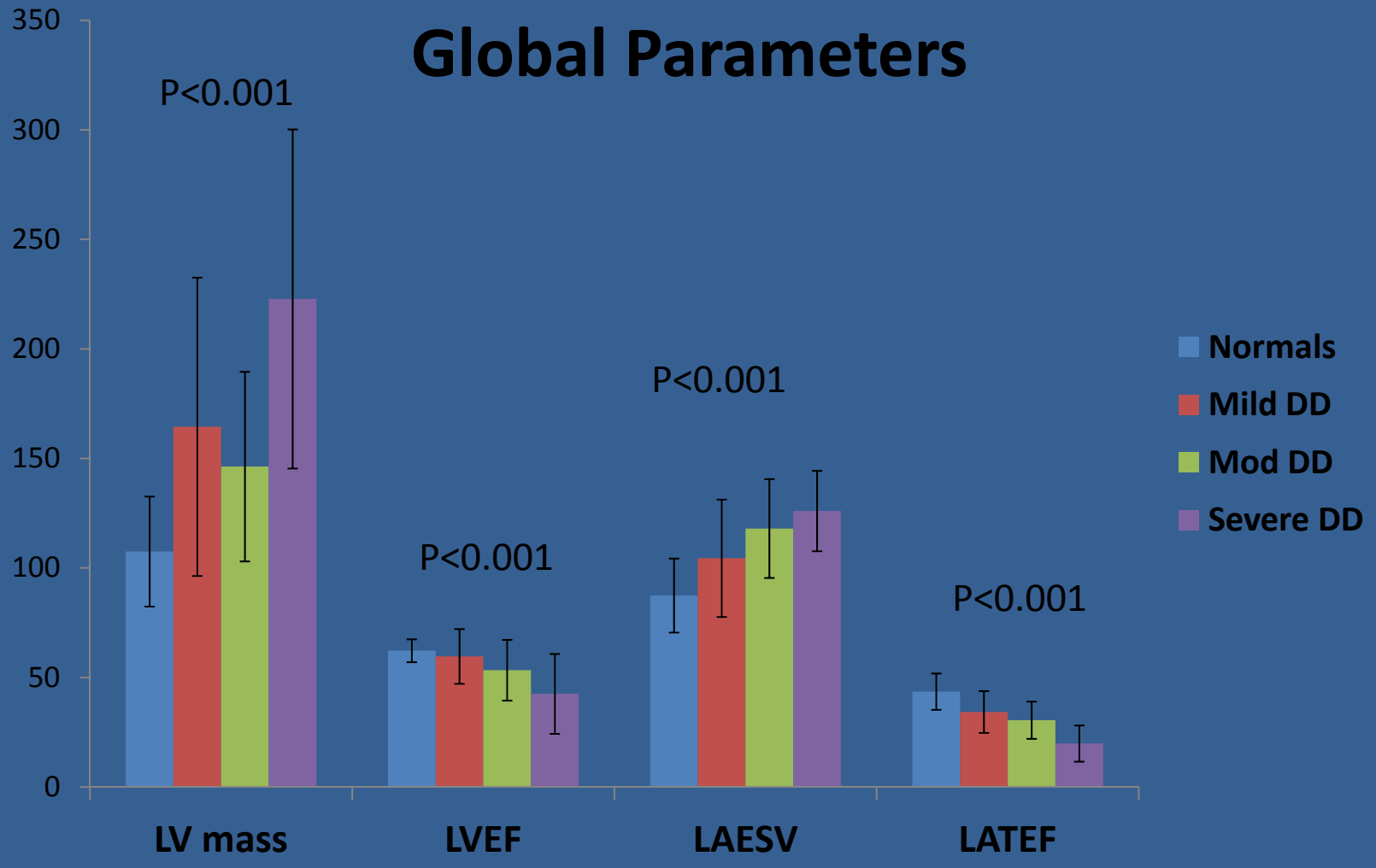
- Patients with DD had larger LV volumes and mass and lower ejection fraction (LVEF) than controls.
- They had significantly larger LA volumes and significantly worse LA function, manifesting as reduced early, late and total emptying fraction (LATEF) and increased conduit volume as a % early LV filling (%CV/E).

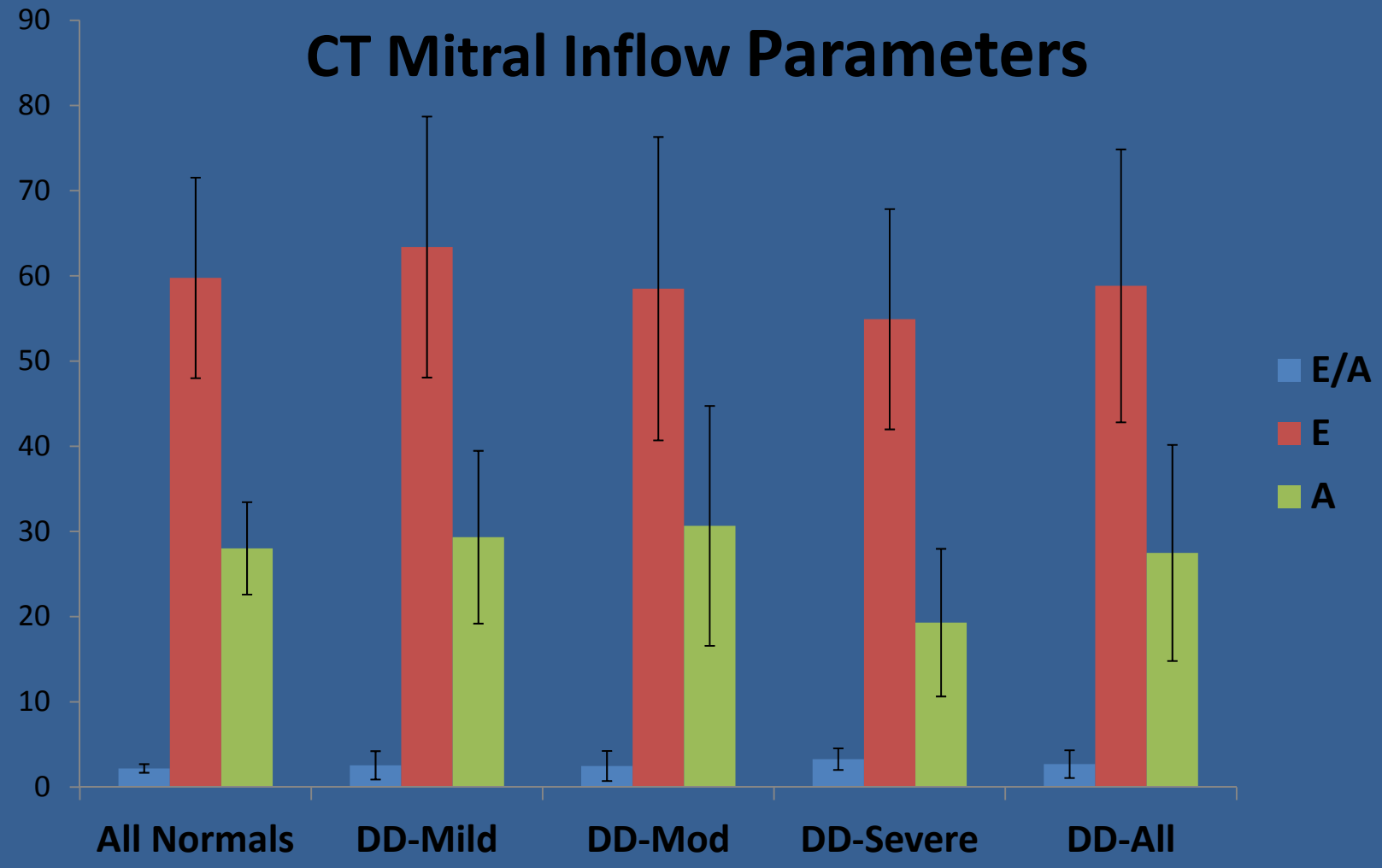
Results Table - CT

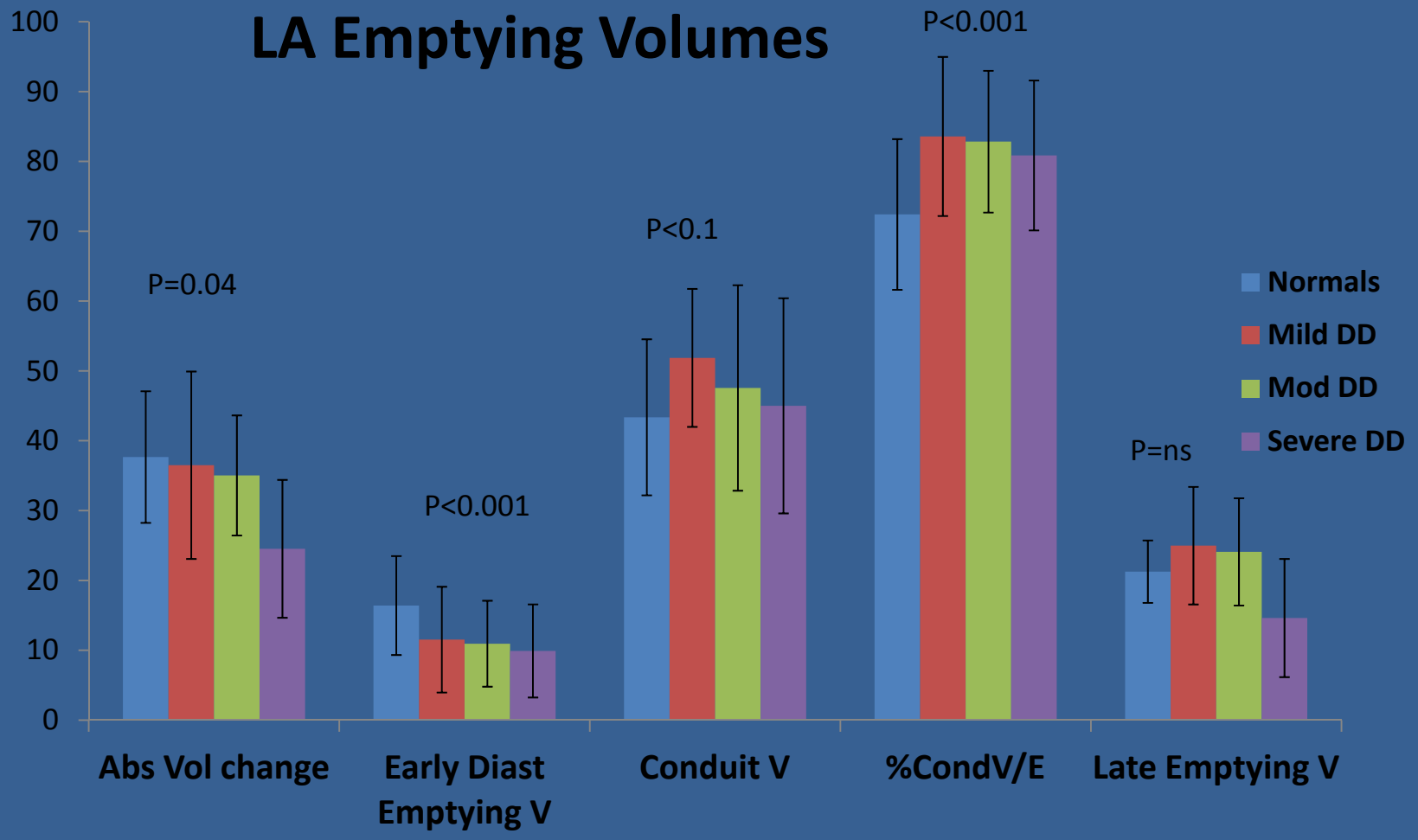
Parameter	All Normals	DD-All	p (N vs.DD)	DD-Mild	DD-Mod	DD-Severe
CT LAMDV	70±15	106±23	<0.001	93±20	107±23	116±21
CT LATEF	43.6±8.3	28.8±10.1	<0.001	34.3±9.5	30.5±8.5	19.9±8.3
LA EEV	16.4±7.1	10.8±6.5	<0.001	11.5±7.6	10.9±6.2	9.9±6.5
Conduit V	43.4±11.2	48.0±13.7	0.1	51.9±9.9	47.6±14.7	45.0±15.4
CT %CV/E	72±11	83±10	<0.001	84±11	83±10	81±11
LA AEV	21.3±4.5	21.9±8.9	ns	25.0±8.4	24.1±7.7	14.6±8.5
CT LV mass	108±25	170±66	<0.001	165±68	146±43	223±77
CT LVEF	62±5	52±16	<0.001	60±13	53±14	43±18

LAMDV=LA mid-diastolic volume, LATEF = LA total emptying fraction, %CV/E=conduit volume as % of early filling volume

Global Parameters




CT Mitral Inflow Parameters
90
80
70
60
50
40
30
20
10
0
All Normals
DD-Mild
DD-Mod
DD-Severe
DD-All
E/A
E
A


LA Emptying Volumes
100
90
80
70
60
50
40
30
20
10
0
P=0.04
P<0.001
P<0.1
P<0.001
P=ns
Normals
Mild DD
Mod DD
Severe DD
Abs Vol change
Early Diast Emptying V
Conduit V
%CondV/E
Late Emptying V

Presumed Pathophysiology

- ↑LVP and delayed LV relaxation in early diastole

  ↓

  LA elastic recoil reduced (reduced LA compliance)

  ↓

  Compensatory ↑ conduit V (and atrial kick)

  ↓

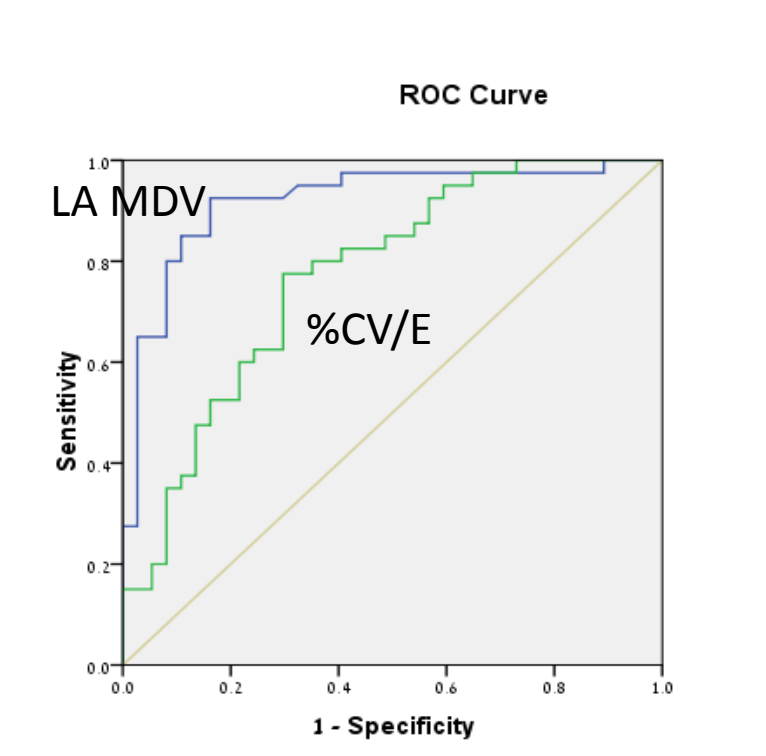
  ↑ratio CV/(LV E filling)

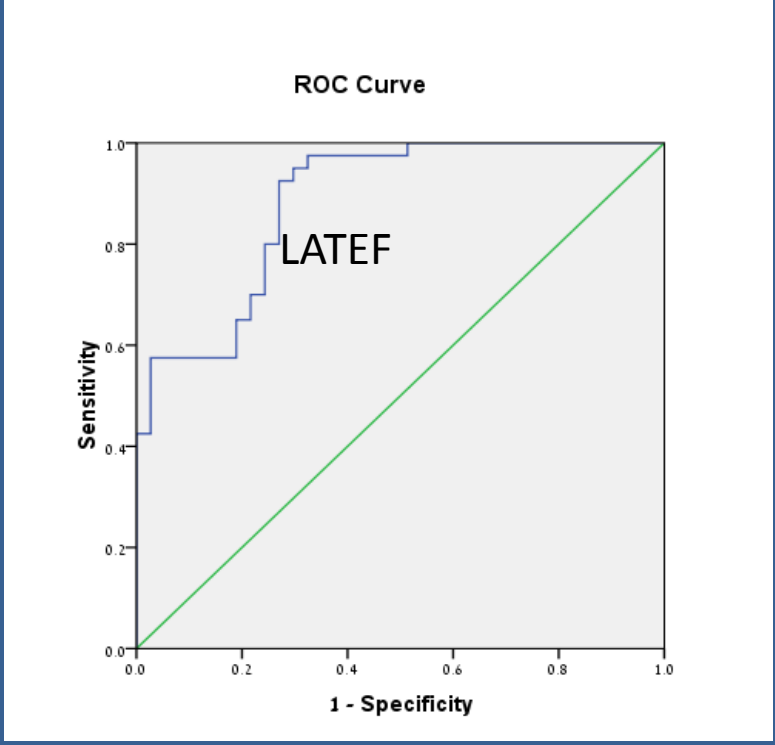
  ↓

  ↓Atrial kick d/t atrial systolic failure in advanced stage

ROC analysis: N vs. DD

- LA MD volume AUC =0.92
- LATEF AUC = 0.88
- %CV/E AUC = 0.77





Classification: Normal vs. Abnormal

- Logistic regression found LA MD volume, LV mass and early-diastolic emptying fraction to be independent predictors of DD.
- Logistic regression utilizing these parameters has 90% accuracy to separate between normal and abnormal diastolic function.

Conclusion

- Diastolic dysfunction is characterized by significant LA enlargement as well as reduced LA function, which worsens with worsening DD.
- CT can help detect and characterize DD, mainly via its effect on LA emptying dynamics.