Advantages of 3D full automated software in cardiac interventions

Prof. JL Zamorano

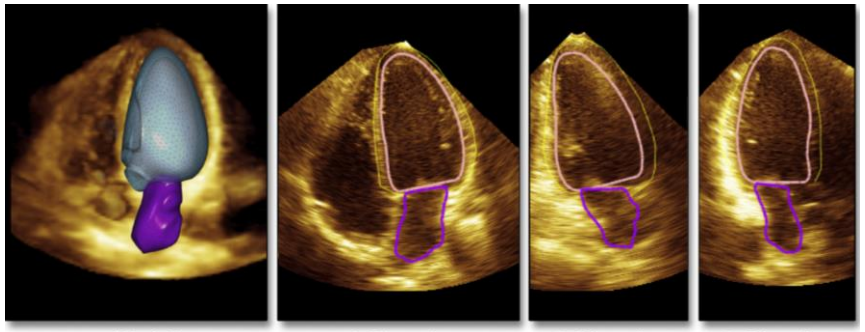
Hospital Universitario Ramón y Cajal

Fully Automated Quantification Software

- Adaptive analytical algorithm consists in knowledge-based **identification of global shape and specific adaptation of endocardial border**

- High frame rate single-beat 3DE images**, is accurate** when compared with conventional volumetric analysis of 4-beat full-volume data sets, thus avoiding is ‘‘stich’’ artifacts.

Medvedofsky D et al. *J Am Soc Echocardiogr*. 2017;30:879-885



Valve and & Cardiac chambers

Echocardiographic criteria for the definition of severe valve regurgitation: an integrative approach *(continued)*

(Adapted from Lancellotti et al.)

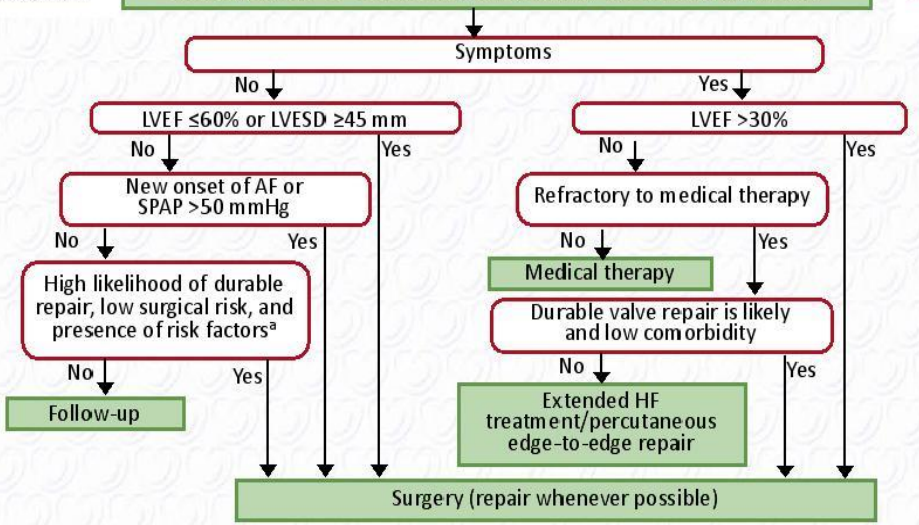
	Mitral regurgitation	
Quantitative	**Primary**	**Secondary**
EROA (mm^2)	≥40	≥20
Regurgitant volume (mL/beat)	≥60	≥30
+ enlargement of cardiac chambers/vessels	LV, LA	

Echocardiographic criteria for the definition of severe valve regurgitation: an integrative approach *(continued)*

(Adapted from Lancellotti et al.)

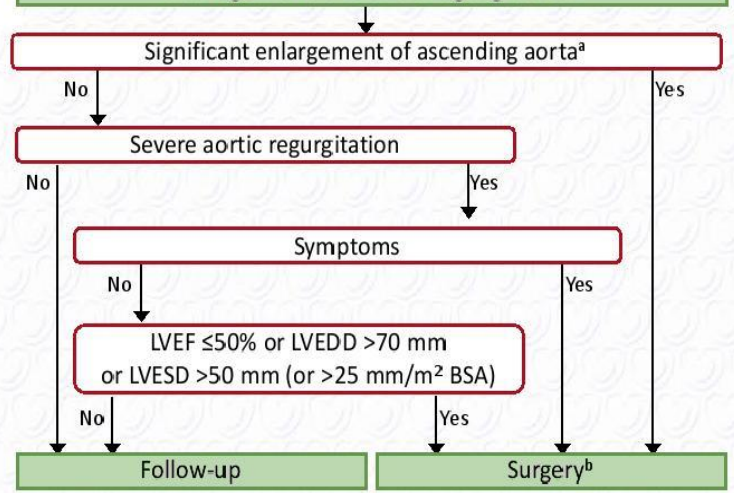
	Aortic regurgitation
Quantitative	
EROA (mm^2)	≥30
Regurgitant volume (mL/beat)	≥60
+ enlargement of cardiac chambers/vessels	LV

Management of severe chronic primary mitral regurgitation



[a] *LVESD ≥40 mm and one of the following present: flail leaflet or LA volume ≥60 mL/m² BSA at sinus rhythm*

Management of aortic regurgitation



[a] *See table of recommendations for definitions of aortic diameter*
[b] *Surgery should also be considered if significant changes in LV and aortic size occur during FU (see table)*

Implementation of 3D in the Echo Lab

- Time-consuming
- Requires training in 3DE analysis
- Accuracy varies with expertise
- Reproducibility varies among individuals

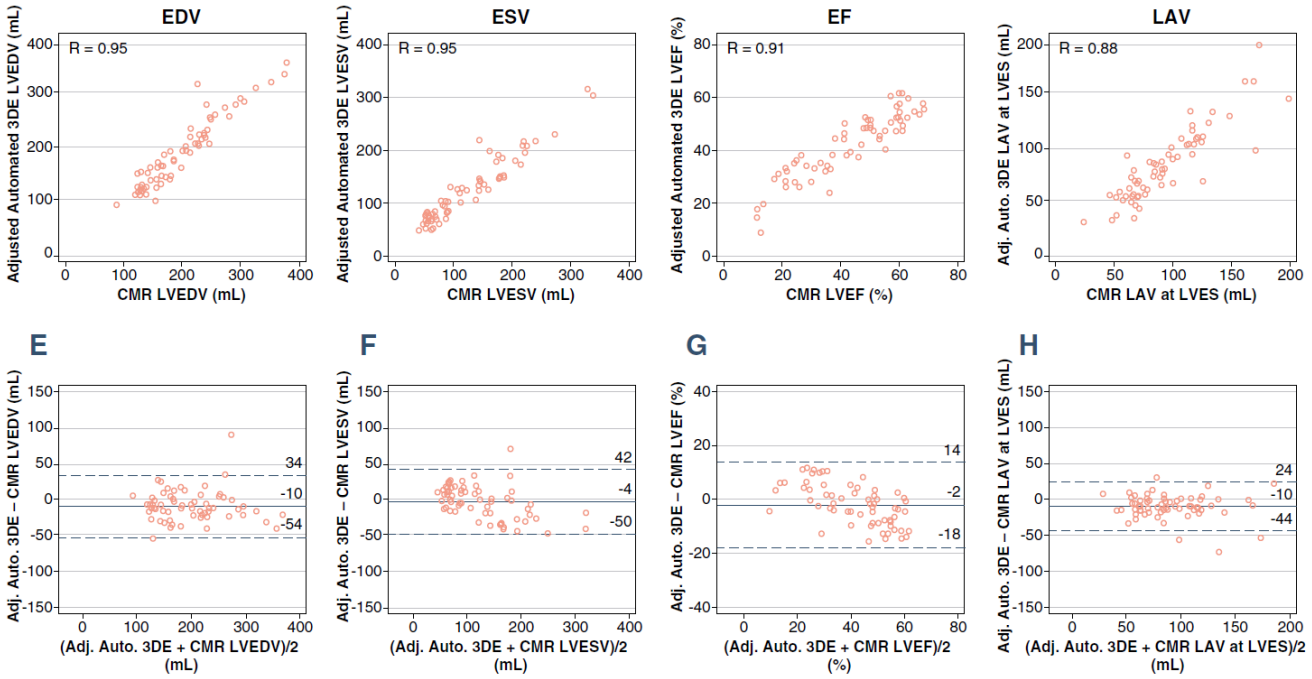
Ideal Automated Analysis Program

- Accurate
- Fast
- Minimal user interaction
- Reproducible

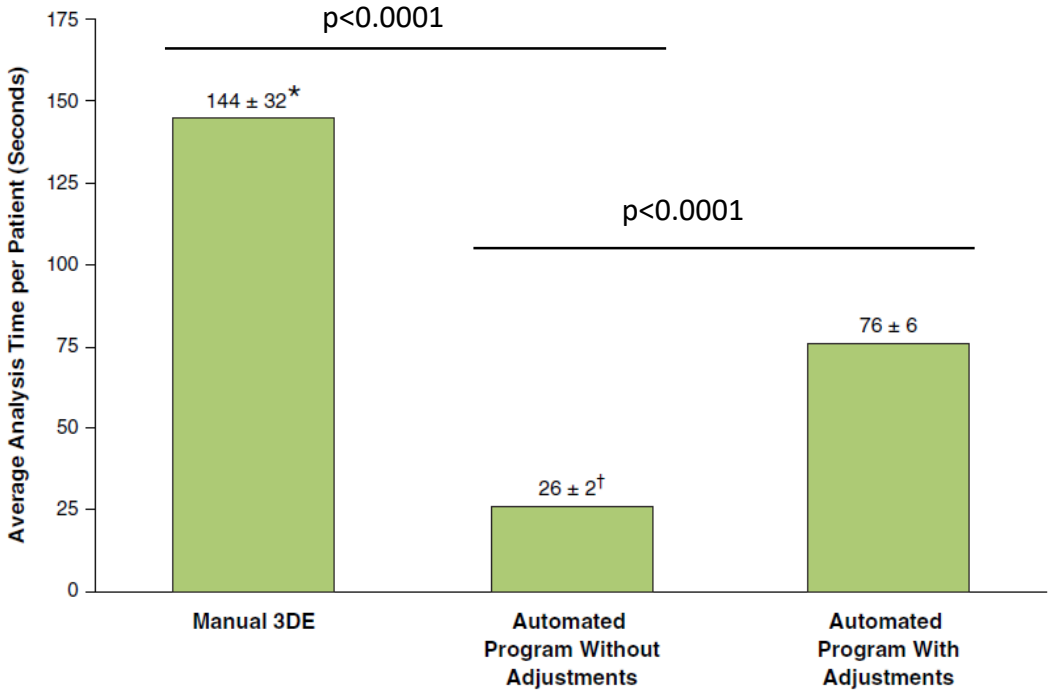
Correlations and time analysis

Correlations between HM manual 3D TTE measurements were strong (r = 0.87 to 0.96).

Automated 3DE vs CMR



3DE Time Analysis



Bias of manual 3 DE compared with CMR: **EDV -54; ESV: -37; EF: 2; LAV: -33**

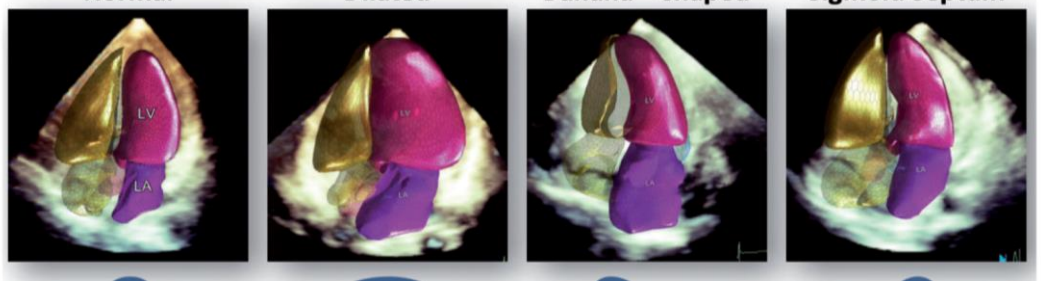
Tsang W et al. *JACC Cardiovasc Imaging*. 2016;9:769-782

Three-dimensional echocardiographic quantification of the left-heart chambers using an automated adaptive analytics algorithm: multicentre validation study

Diego Medvedofsky[1], Victor Mor-Avi[1]*, Mihaela Amzulescu[2], Covadonga Fernández-Golfín[3], Rocio Hinojar[3], Mark J. Monaghan[4], Kyoko Otani[5], Joseph Reiken[4], Masaaki Takeuchi[5], Wendy Tsang[6], Jean-Louis Vanoverschelde[2], Mathivathana Indrajith[4], Lynn Weinert[1], Jose Luis Zamorano[3], and Roberto M. Lang[1]†

[1]University of Chicago, Medical Center, Chicago, Illinois, USA; [2]Saint-Luc University Hospital, Brussels, Belgium; [3]University Hospital Ramón y Cajal, Madrid, Spain; [4]King's College Hospital, London, UK; [5]University of Occupational and Environmental Health, Kitakyushu, Japan; and [6]Toronto General Hospital, University of Toronto, Toronto, Ontario, Canada

- **Prospective validation in a multicentre setting**
- **Comparison of automated measurements made by six participating sites with and without corrections against reference values generated by Core Lab**



- **180** patients were included divided into four group according to the biplane 2DE LVEF (group 1<_20%, group 2= 21–40%, group 3= 41–55%, group 4 >55%)

Clinical characteristic of the study patients

	Hypertension (0 = no, 1 = yes)		Coronary artery disease (0 = no, 1 = yes)		Cardiomyopathy (0 = no, 1 = Ischemic, 2 = Idiopathic)		Valvular heart disease (0 = no, 1 = yes)		Congenital heart disease (0 = no, 1 = yes)		Arrhythmia (0 = no, 1 = yes)	
	#	%	#	%	#	%	#	%	#	%	#	%
0	86	48%	120	67%	66	37%	160	89%	176	98%	151	84%
1	94	52%	60	33%	54	30%	20	11%	4	2%	29	16%
2					60	33%						

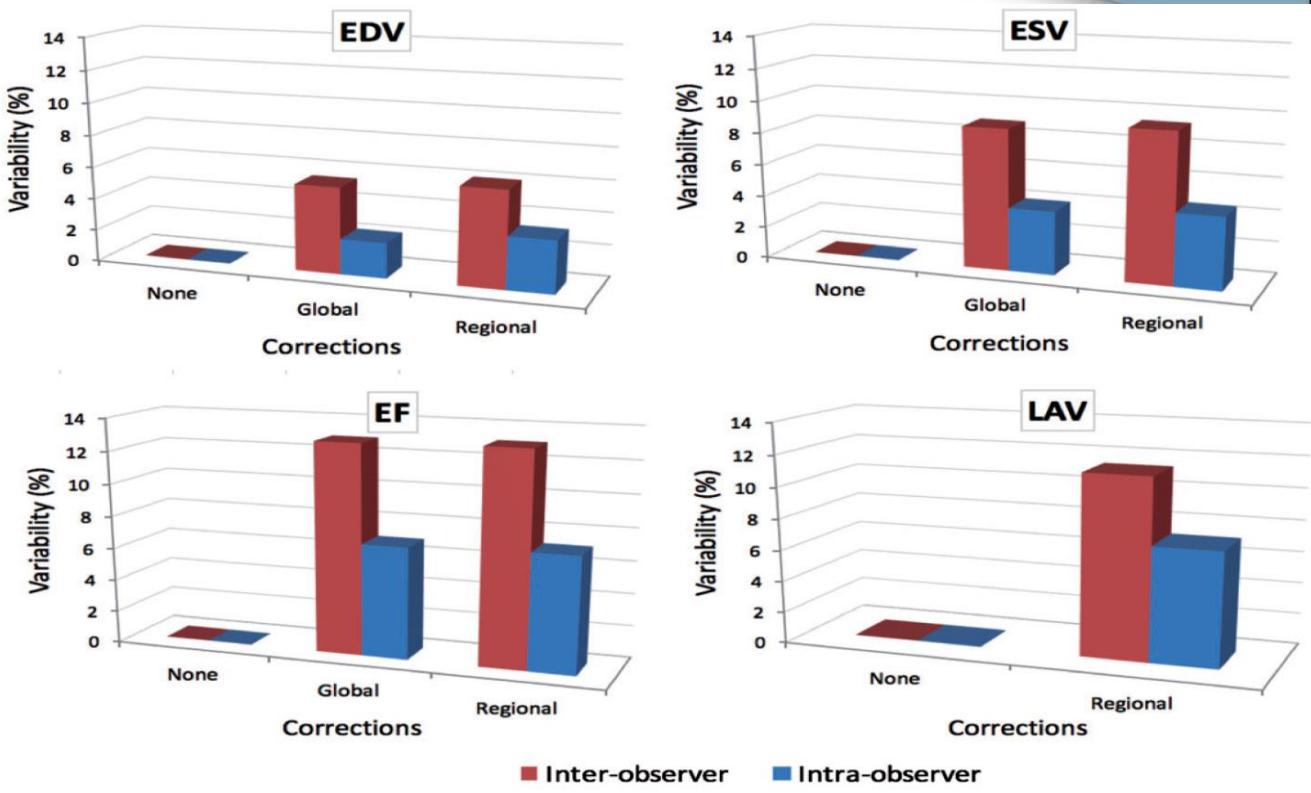
Medvedofsky D et al. *Eur Heart J Cv Imaging*. 2017[]

Results of multicenter validation study

- Experienced readers in differents part of the world can obtain accurate and reproducible automated measurements

- Border correction was deemed necessary in the majority of patients, however, the fully automated analysis was accurate and with endocardial border editing, the accuracy improved only slightly on the average

Automated 3DE Intra and inter observer variability



Comparison of the Sites' HM to the Core Lab's HM (N=180)

	EDV (ml)	ESV (ml)	EF (%)	LAV (ml)
Core Lab's HeartModel values without corrections	190 ± 75	126 ± 71	37 ± 13	80 ± 32
Sites' HeartModel values without corrections	190 ± 75	126 ± 71	37 ± 13	80 ± 32
Bias (% mean) ± SD	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Core Lab's HeartModel values with corrections	206 ± 80	133 ± 78	39 ± 15	89 ± 35
Sites' HeartModel values with corrections	198 ± 80	127 ± 77	40 ± 15	79 ± 32
Bias (% mean) ± SD	-5 ± 7	-6 ± 12	3 ± 17	-12 ± 8*

Medvedofsky D et al. *Eur Heart J Cardiovasc Imaging*. 2017]

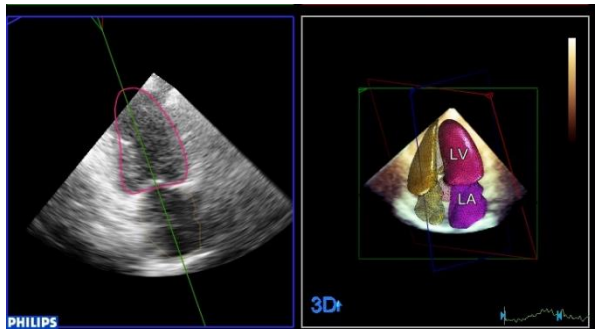
Application of 3DE automated quantification in pre MitraCLip implant

Patients with severe MR usually show relevant remodelling of left chambers causing limitation in the evaluation of geometry and function of both left atrium and ventricle performed with bi- and tridimensional standard analysis

Patients with indication of Mitraclip (n=32) were screened

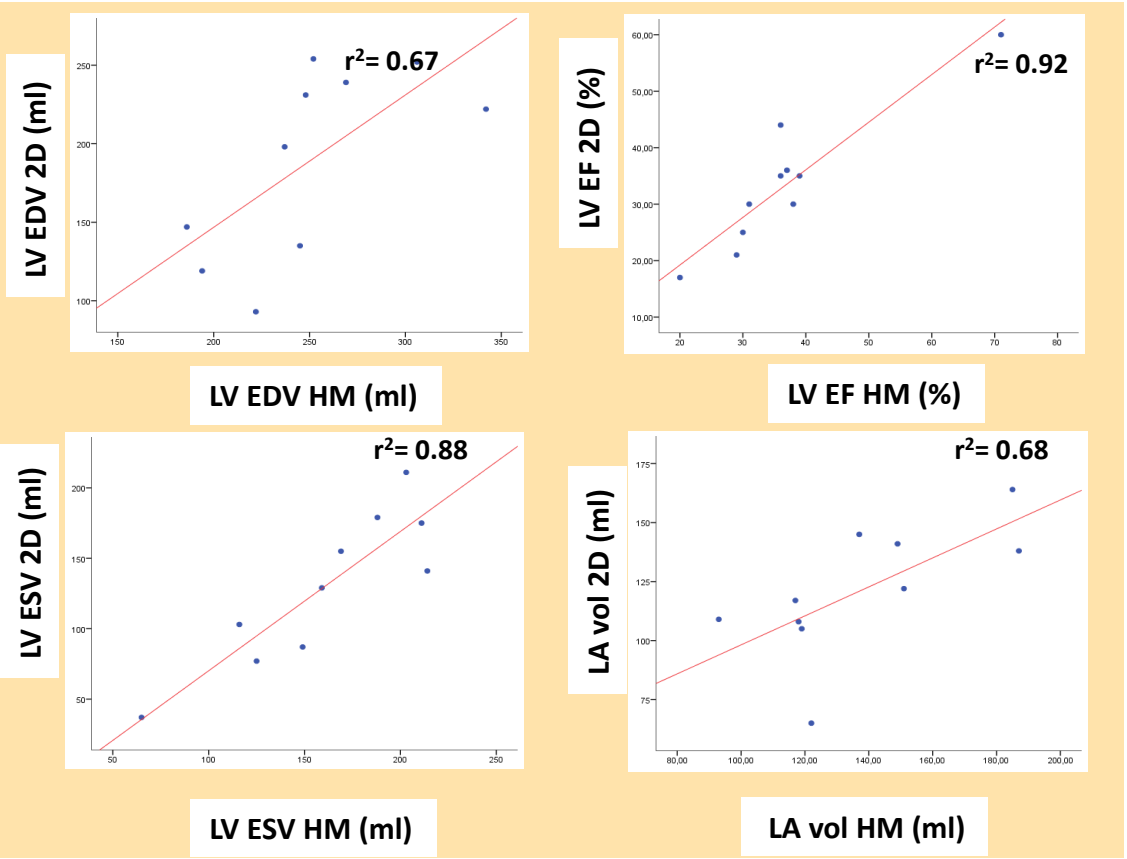
All patients underwent a complete standard echo and 3D automated quantification (Heart Model) for the evaluation of geometry and function of LV and LA

Variables	Study Population
Sex (M/F)%	80.6(25)/(6)19.4%
Age(years)	75.4 ± 8.5
NYHA class Class II Class III-IV	 23.4% 77.8%
Afib (%)	52%

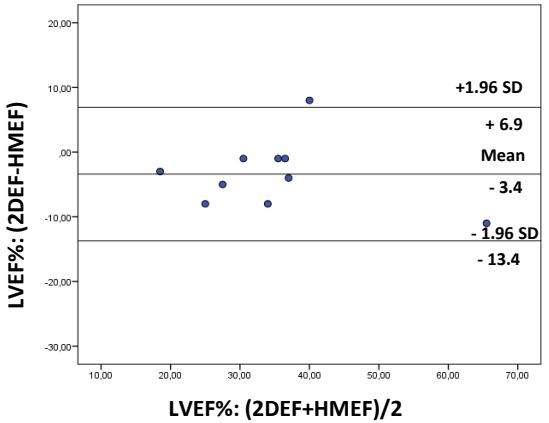


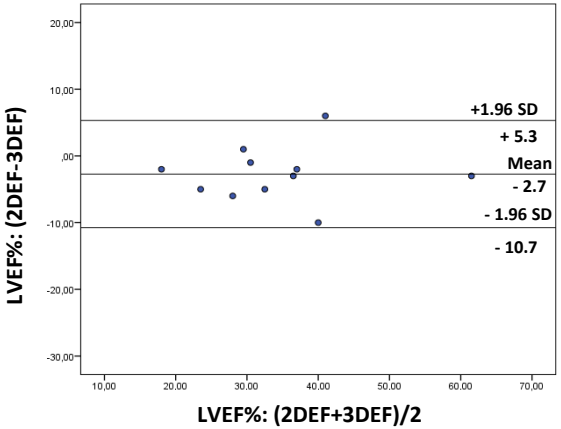
Unpublished data

Correlation between 2D and 3D automated quantification



Bland-Altman analysis of 2D, Manual 3D & automated quantification



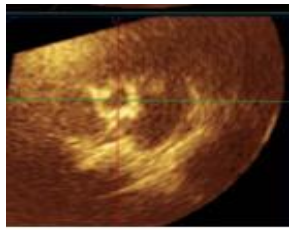


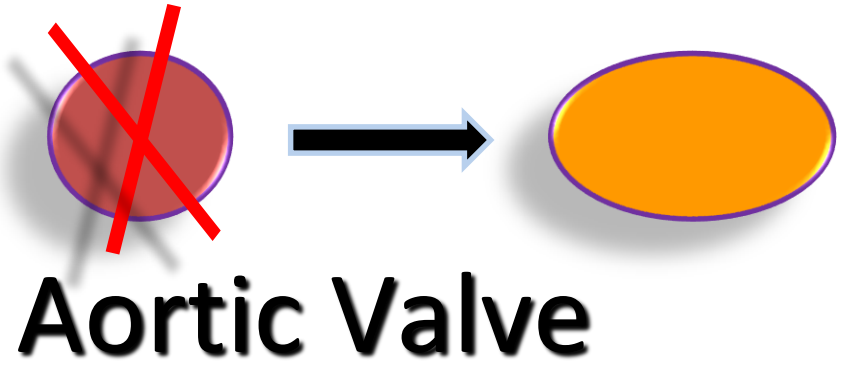
AO STENOSIS

RT3DE imaging improves the accuracy of the quantification of aortic stenosis.

- Planimetry of the aortic valve with RT3DE images showed good agreement with the standard 2D TEE technique, flow-derived methods, and cardiac catheterization data with the advantage of improved reproducibility.

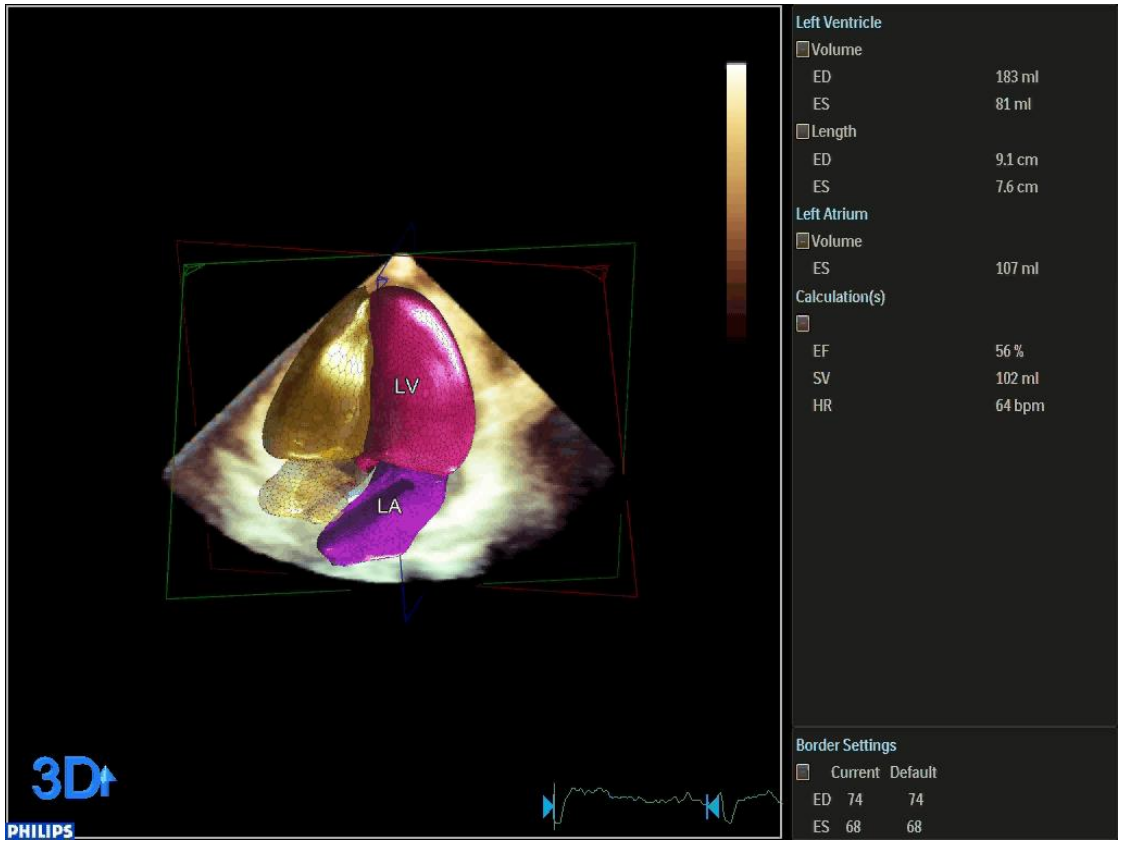
- Analysis of RT3DE revealed that in half of the subjects, the **LV outflow tract cross section is not round but rather elliptical.**

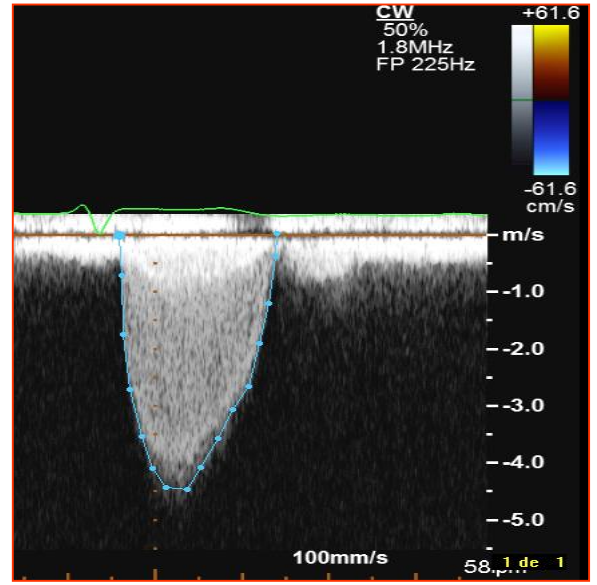




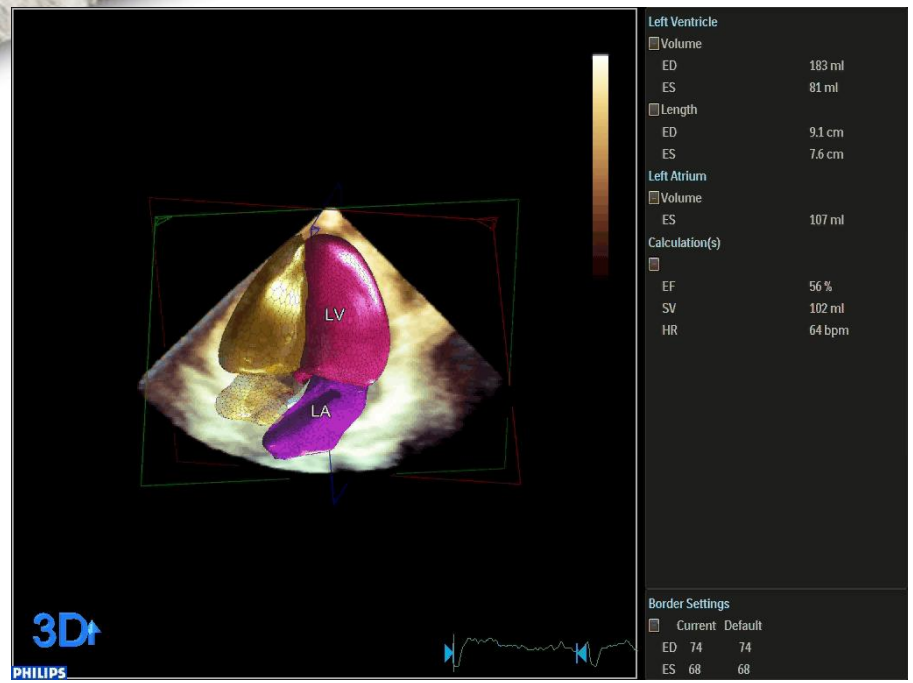
Heart. 2007;93:801– 807.

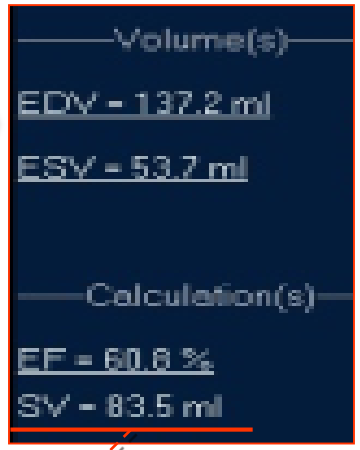
Aortic area with RT 3D echo ?



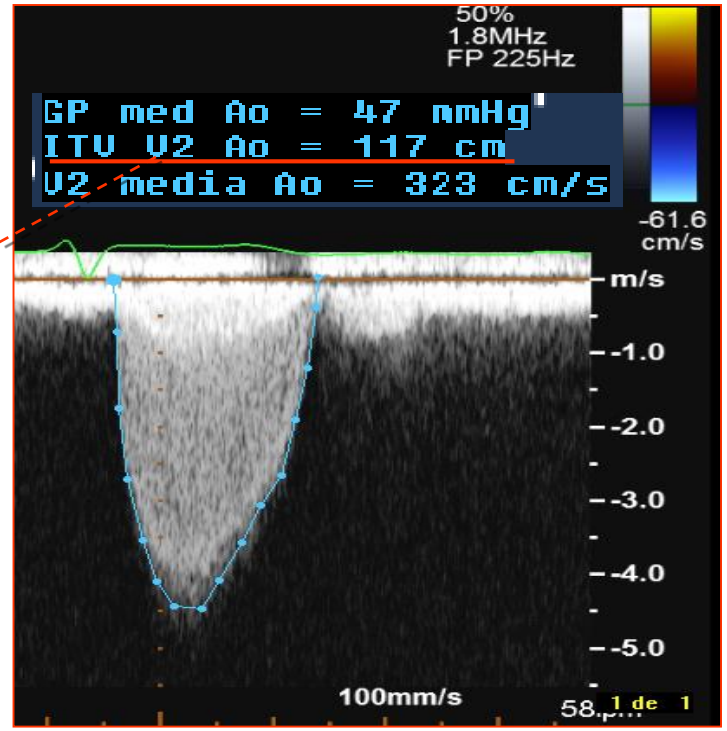


Aortic area: RT3D-Doppler hybrid approach



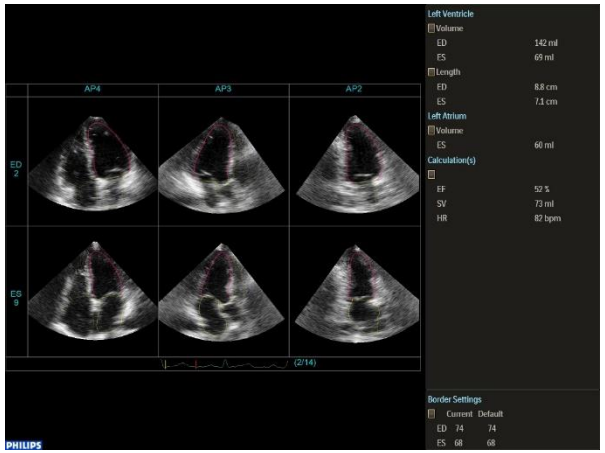


$$\text{Aortic area} = \frac{SV_{3D}}{TVI_{Ao}}$$



3D full automatic software in the evaluation of aortic stenosis severity in TAVI patients

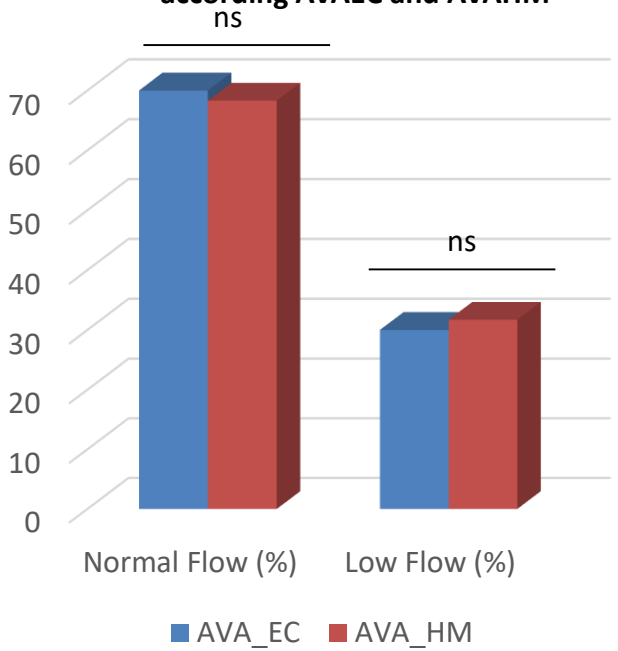
Stroke volume and valvular area analysis are strongly recommended for a correct evaluation of AS, especially in patients with reduced flow but severe AS.



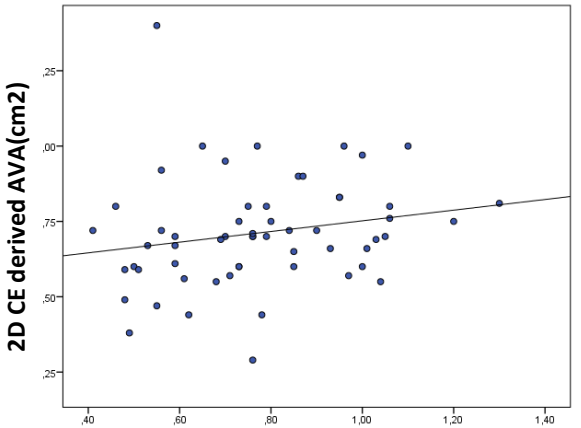
METHODS:

- **88 consecutive patients undergoing TAVI (mean age 83.4 ± 6.84; 61.8% female)**
- **AVA was calculated by conventional CE (AVACE) and by CE calculated from the stroke volume obtained by 3D analysis (AVAHM).**
- **Feasibility of 3D full automatic software was** of **73.6%** in our study population

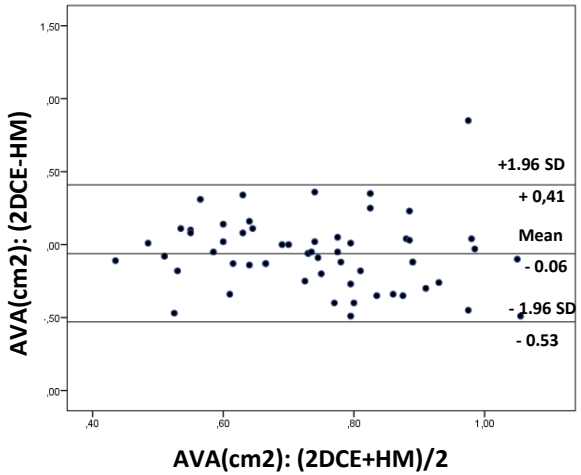
Determination of LF and NF patients according AVAEC and AVAHM



Bland-Altman analysis of AVA by 2DCE or 3D automated quantification



HM derived AVA(cm2)



AVA(cm2): (2DCE+HM)/2

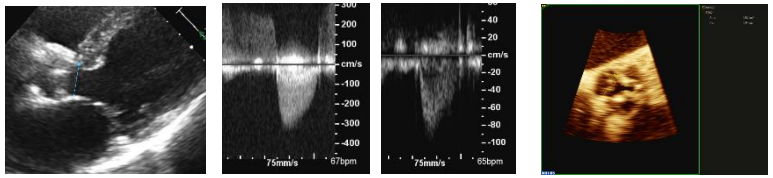
Unpublished data

3D full automatic software in the evaluation of aortic stenosis severity in TAVI patients.

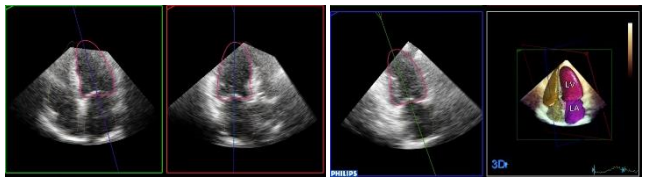
The aim of our study was to evaluate the usefulness of a new 3D automatic quantitative software for aortic valve area (AVA) assessment compared to transesophageal echocardiography (TEE) 3D planimetry in patients undergoing TAVI.

METHODS:

- 18 consecutive patients undergoing TAVI were prospectively included
- AVA was calculated by conventional CE (AVACE) and by CE calculated from the stroke volume obtained by 3D analysis (AVAHM).
- 3D planimetry of the aortic valve area was performed (AVA3DP) in all patients by TEE the day before or the same day of the procedure
- Patients with very poor acoustic window and those studies that needed boundary correction were excluded.



Images for AVA calculation by CE and 3D TEE planimetry



3D- images and automated volumes calculation by Heart Model software

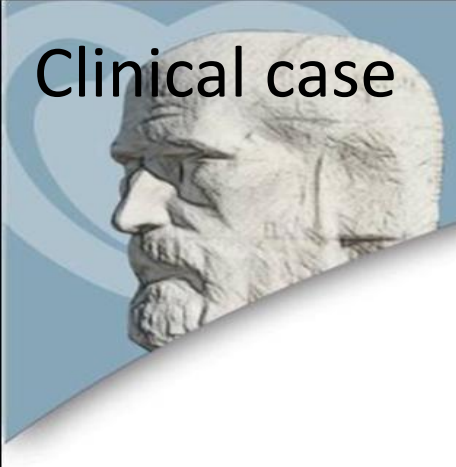
RESULTS:

- 18 patients were included (mean age 84±4 years, 20% men). A moderate significant correlation was obtained between AVA3DP and AVAHM (**r=0,53, p<0,05**) but no between AVA3DP and AVACE.
- Acquisition and imaging post-processing for 3D images required less than 2 minutes in all cases.

AVA CE (cm2)	AVA 3DP (cm2)	Mean difference (cm2)	P value
0,72	0,64	0,08	0,028
AVA HM (cm2)	**AVA 3DP (cm2)**	**Mean difference (cm2)**	**P value**
0,68	0,62	0,06	0,29

C. Fernandez-Golfin et al EuroEcho Imaging Leipzig 07 – 10 December 2016

Clinical case



MITRAL REGURGITATION

56 years old male

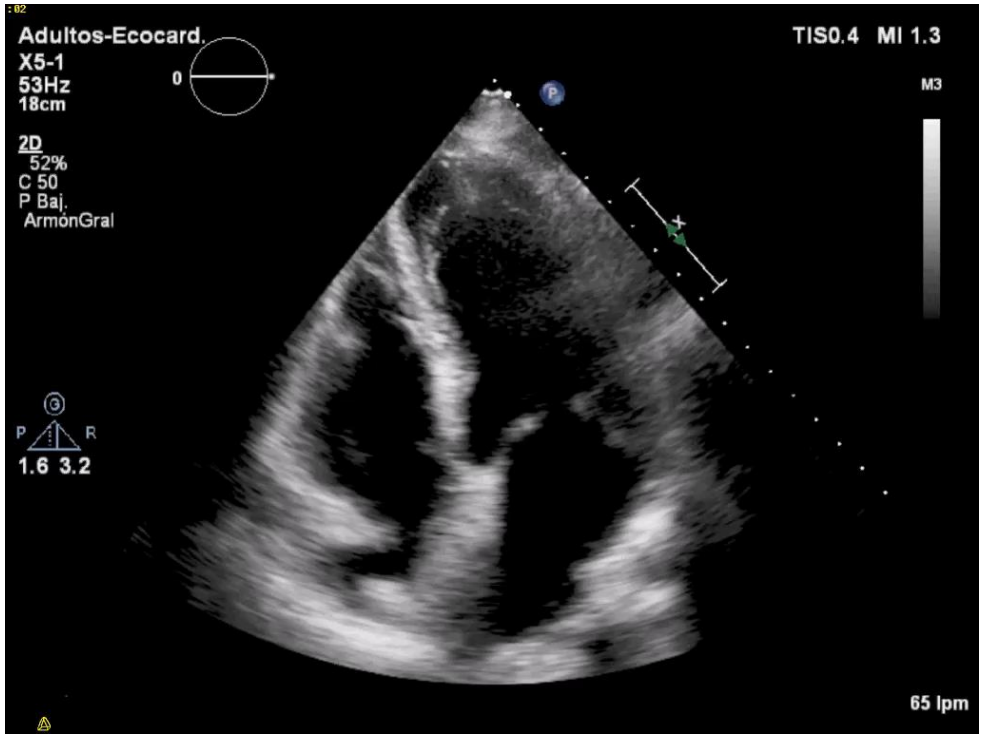
Barlow´s disease. MVP.

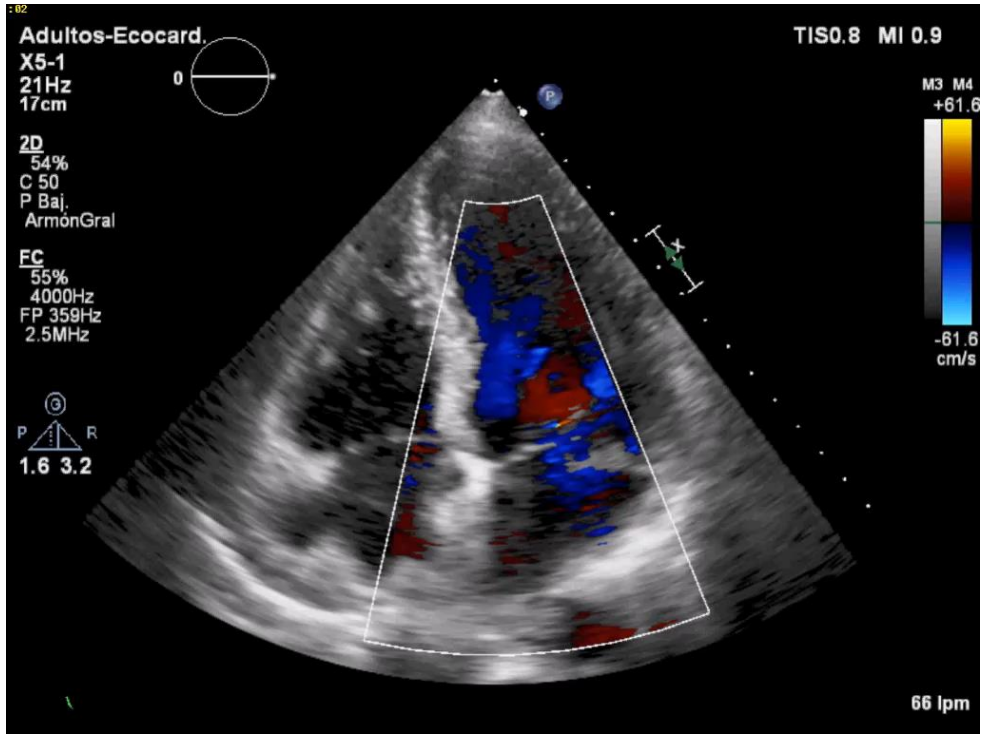
Asymptomatic severe MR.

	July 2014	January 2015	July 2015
LVEF Teich	76%	72%	
LVEF Simpson	70% →	68% →	???
LVEDV	155 ml	150 ml	
LVESV	45 ml	60 ml	
LA Volume	110 ml	114 ml	

MITRAL REGURGITATION

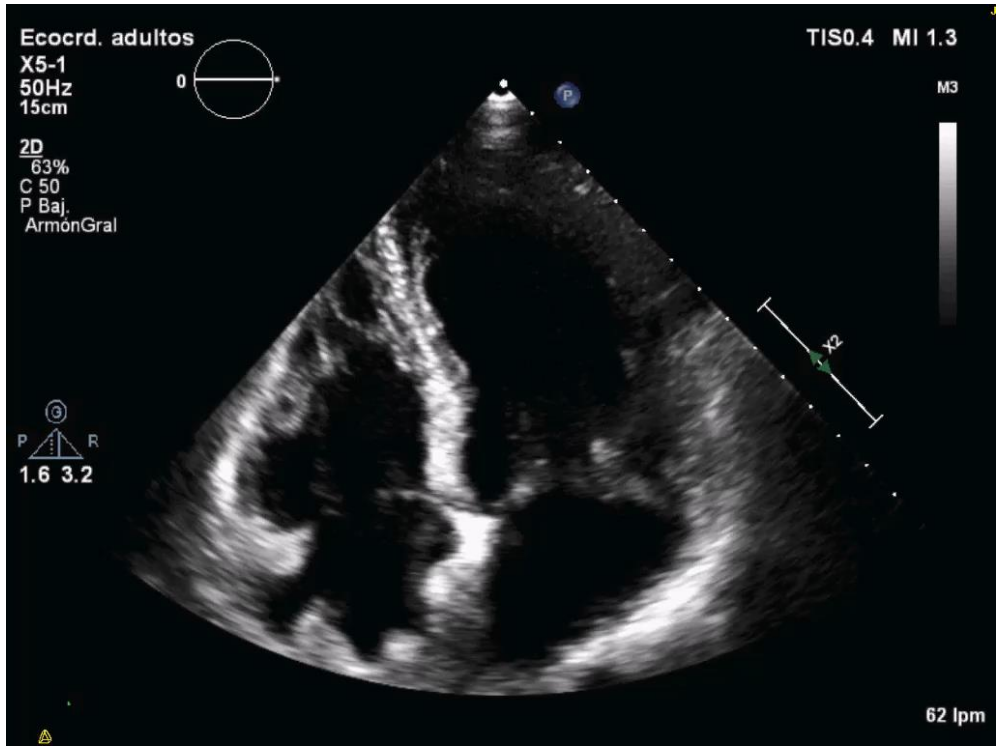
January 2015

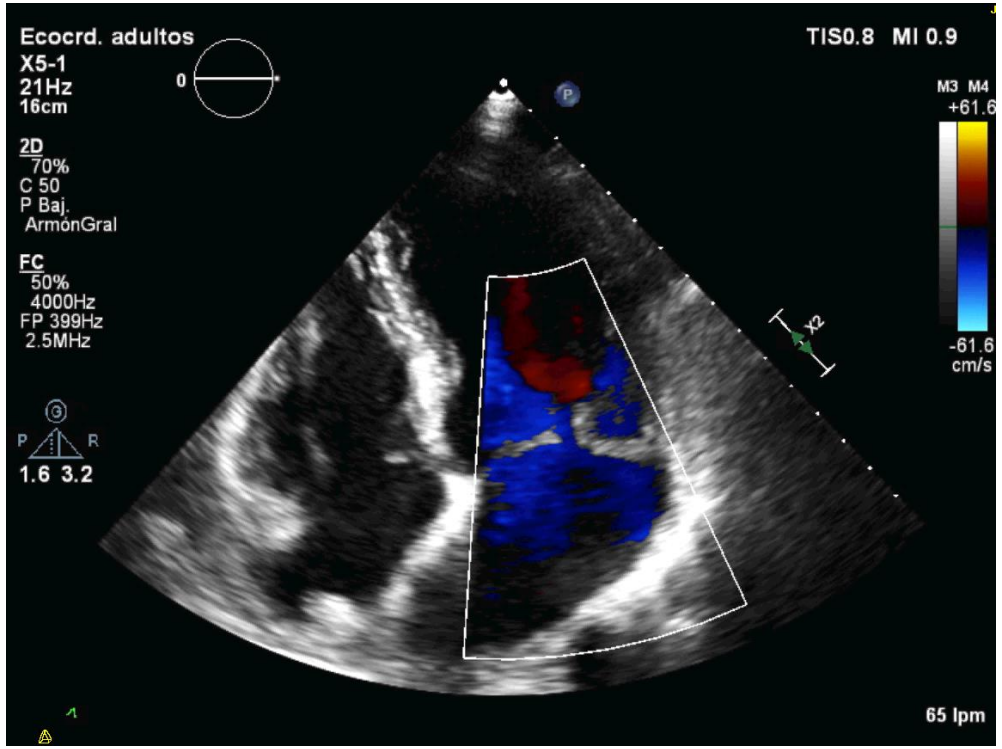




MITRAL REGURGITATION

July 2015

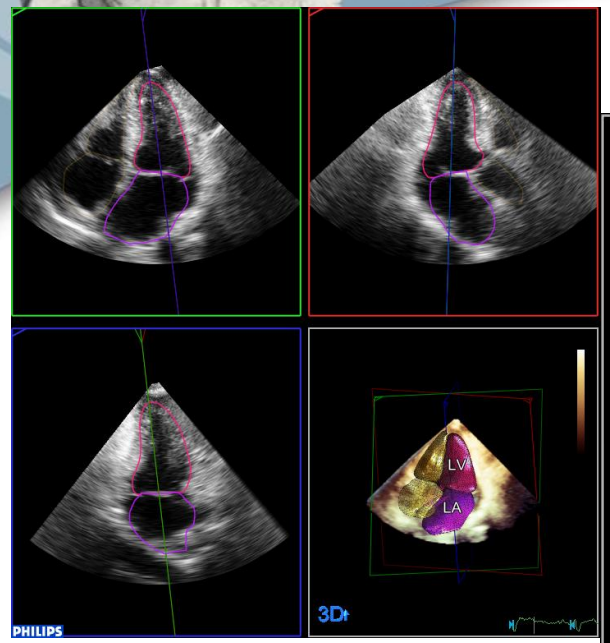


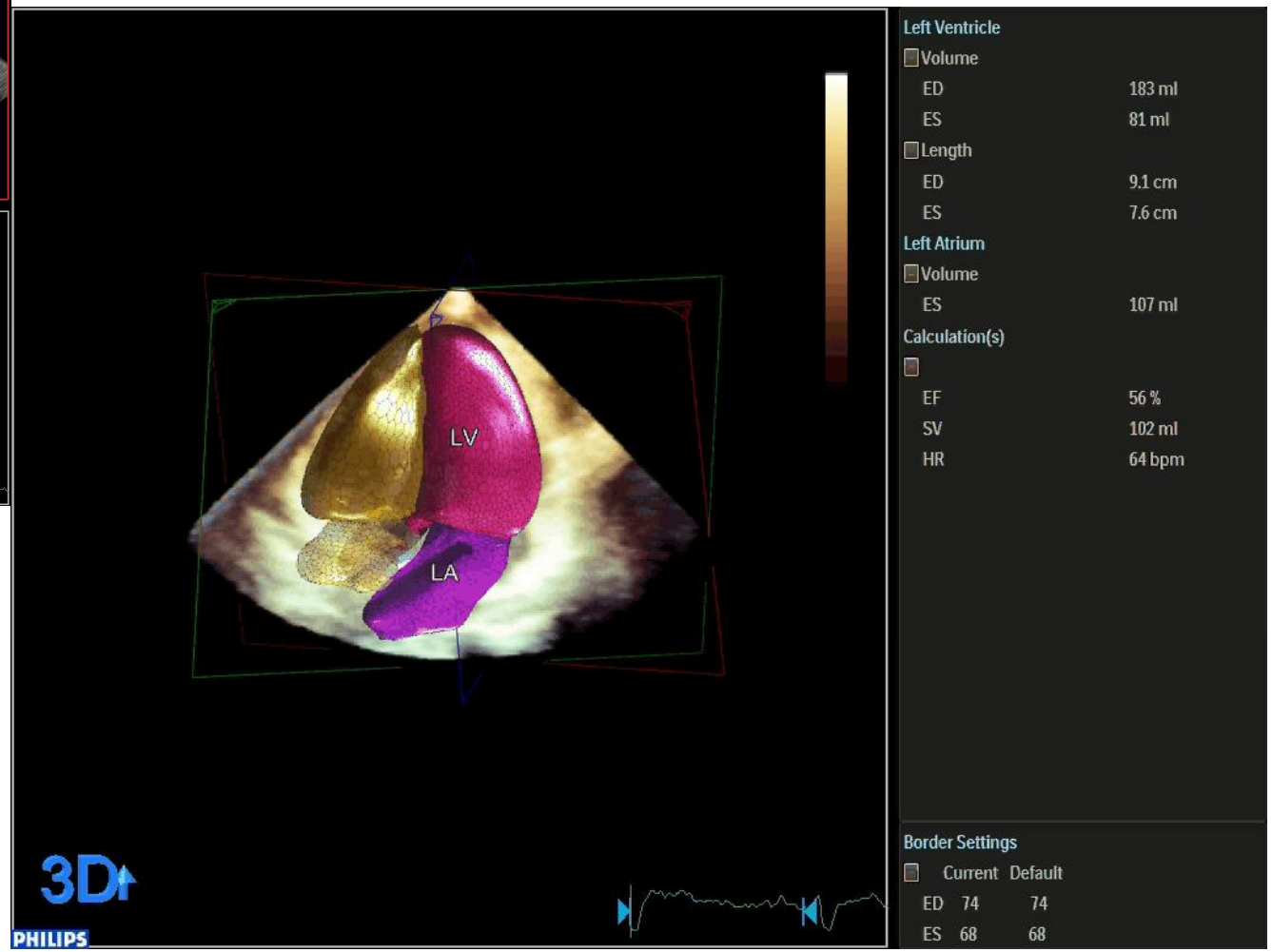


MITRAL REGURGITATION

	July 2014	January 2015
LVEF Teich	76%	72%
LVEF Simpson	70%	68%
LVEDV	155 ml	150 ml
LVESV	45 ml	60 ml
LA Volume	110 ml	114 ml

MITRAL REGURGITATION

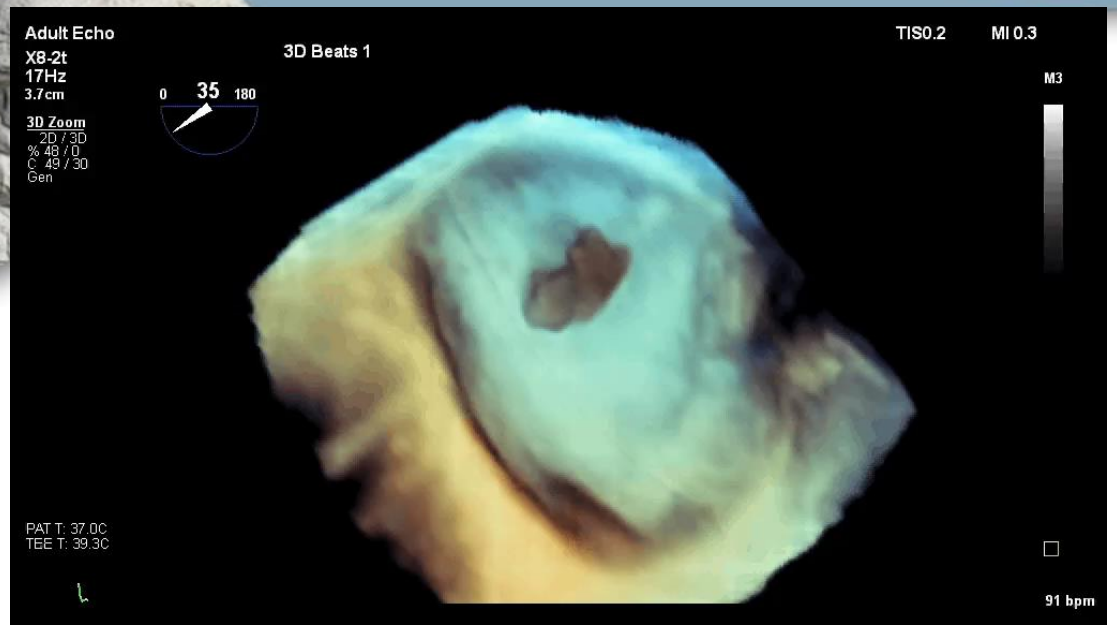


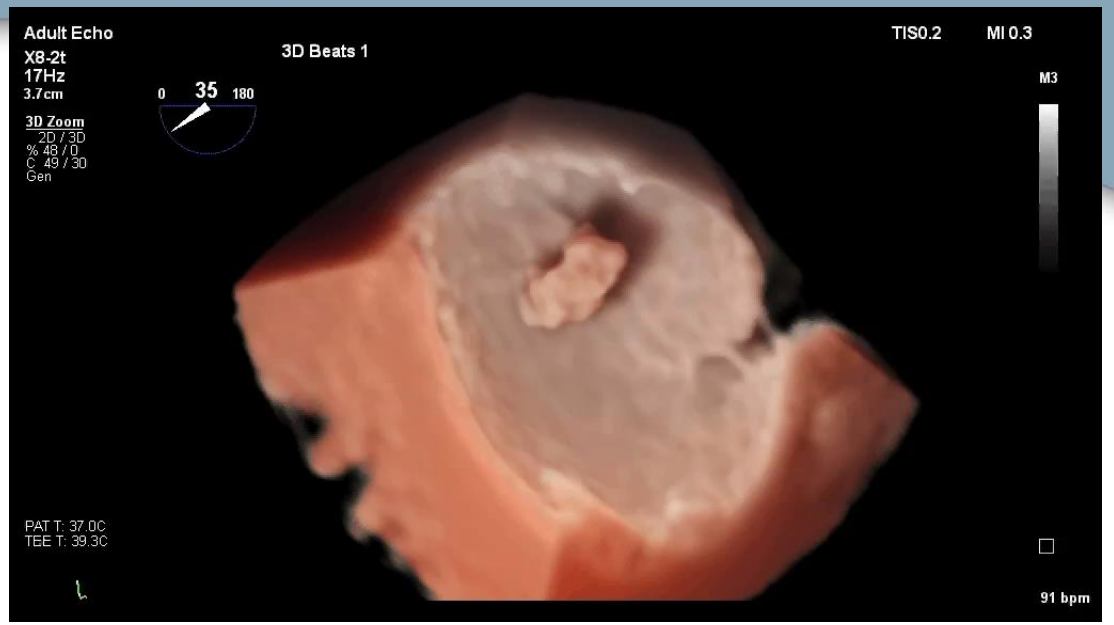


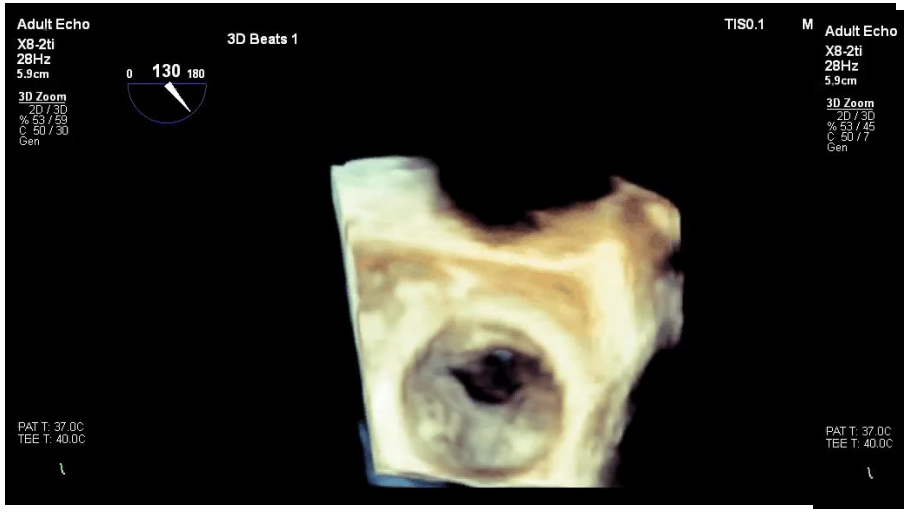
Left Ventricle
Volume
ED 183 ml
ES 81 ml
Length
ED 9.1 cm
ES 7.6 cm
Left Atrium
Volume
ES 107 ml
Calculation(s)
EF 56 %
SV 102 ml
HR 64 bpm

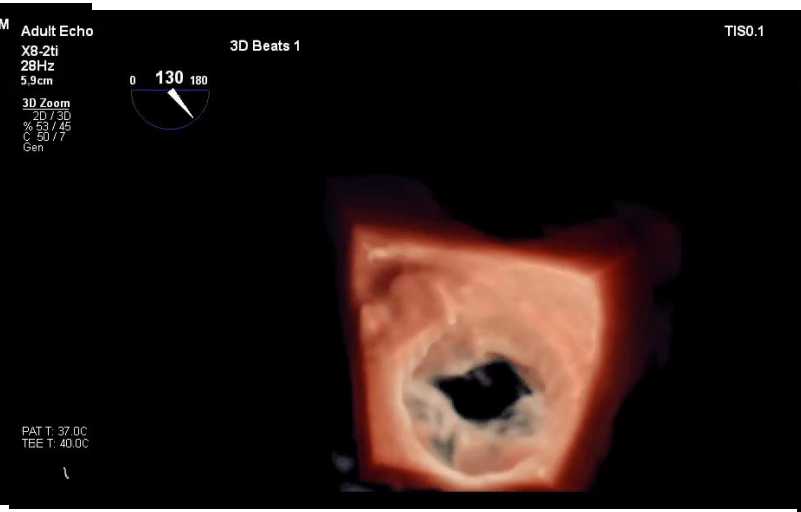
Border Settings
Current Default
ED 74 74
ES 68 68

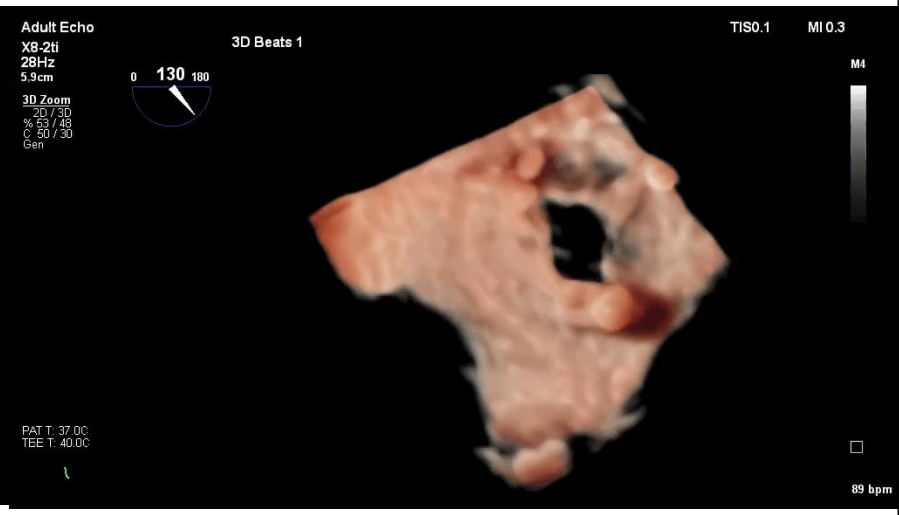
The near future ..

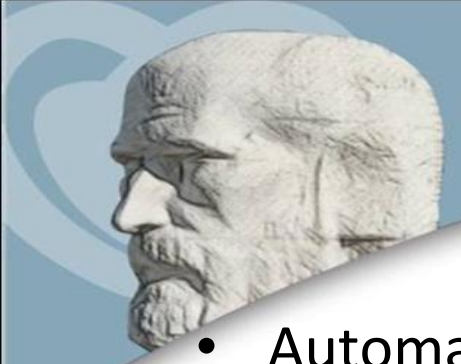

Adult Echo
X8-2t
17Hz
3.7cm
3D Zoom
2D / 3D
% 48 / 0
C 49 / 30
Gen
3D Beats 1
0 35 180
TIS0.2 MI 0.3
M3
PAT T: 37.0C
TEE T: 39.3C
91 bpm


Adult Echo
X8-2t
17Hz
3.7cm
3D Zoom
2D / 3D
% 48 / 0
C 49 / 30
Gen
3D Beats 1
0 35 180
TIS0.2 MI 0.3
M3
PAT T: 37.0C
TEE T: 39.3C
91 bpm


Adult Echo
X8-2ti
28Hz
5.9cm
3D Zoom
2D / 3D
% 53 / 69
C 50 / 30
Gen
3D Beats 1
0 130 180
TIS0.1 M
PAT T: 37.0C
TEE T: 40.0C

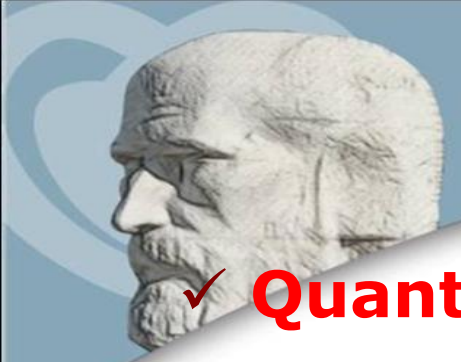

Adult Echo
X8-2ti
28Hz
5.9cm
3D Zoom
2D / 3D
% 53 / 45
C 50 / 7
Gen
3D Beats 1
0 130 180
TIS0.1
PAT T: 37.0C
TEE T: 40.0C


Adult Echo
X8-2ti
28Hz
5.9cm
3D Zoom
2D / 3D
% 53 / 48
C 50 / 30
Gen
3D Beats 1
0 130 180
TIS0.1 MI 0.3
M4
PAT T: 37.0C
TEE T: 40.0C
89 bpm



Conclusion

- Automated software is highly feasible and rapid, allowing the simultaneously measures of LA and LV volumes , LV SV and LVEF
- This software represent an accurate and robust alternative to conventional manual methodology and is more reproducible.
- Integration of 3DE quantification with standard measurement may implement pre-interventional screening in patients with valvular diseases (MR or AS) as well as post interventional follow up due to its lower inter and intra operator variability.



CONCLUSIONS

- ✓ **Quantification is a must.**
- ✓ **Importance in everyday clinical decision making**
- ✓ **Heart Model allows fast, easy, automatic and reproducible quantitation of LV and LA volumes and EF**
- ✓ **Measurements are not only comparable to manual but also CMR values.**
- ✓ **Promises to facilitate the integration of 3D-TTE based chamber quantification into clinical practice.**