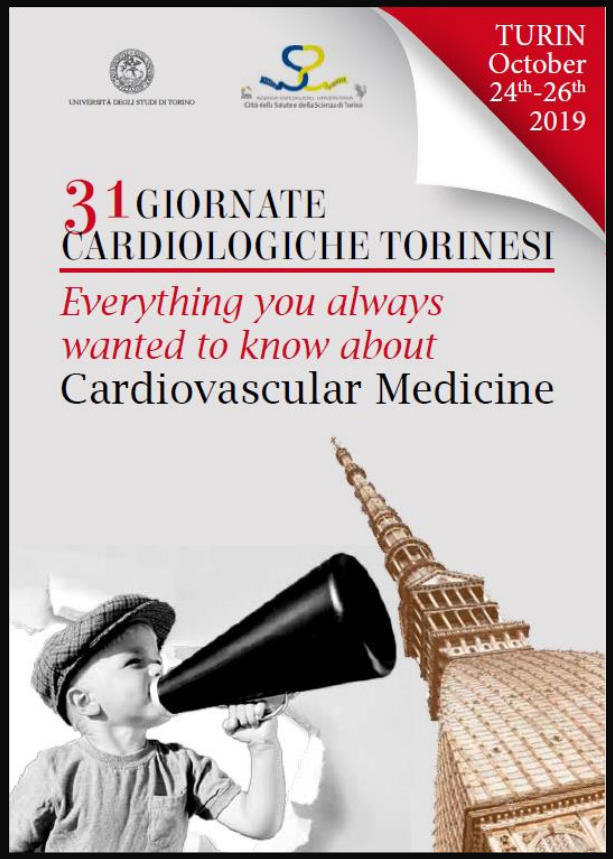
Università degli Studi di Foggia
S.C. Universitaria di Cardiologia
Cattedra di Cardiologia
Scuola di Specializzazione in Cardiologia
Dottorato di Ricerca in Cardiologia
Direttore : Prof. N.D. Brunetti



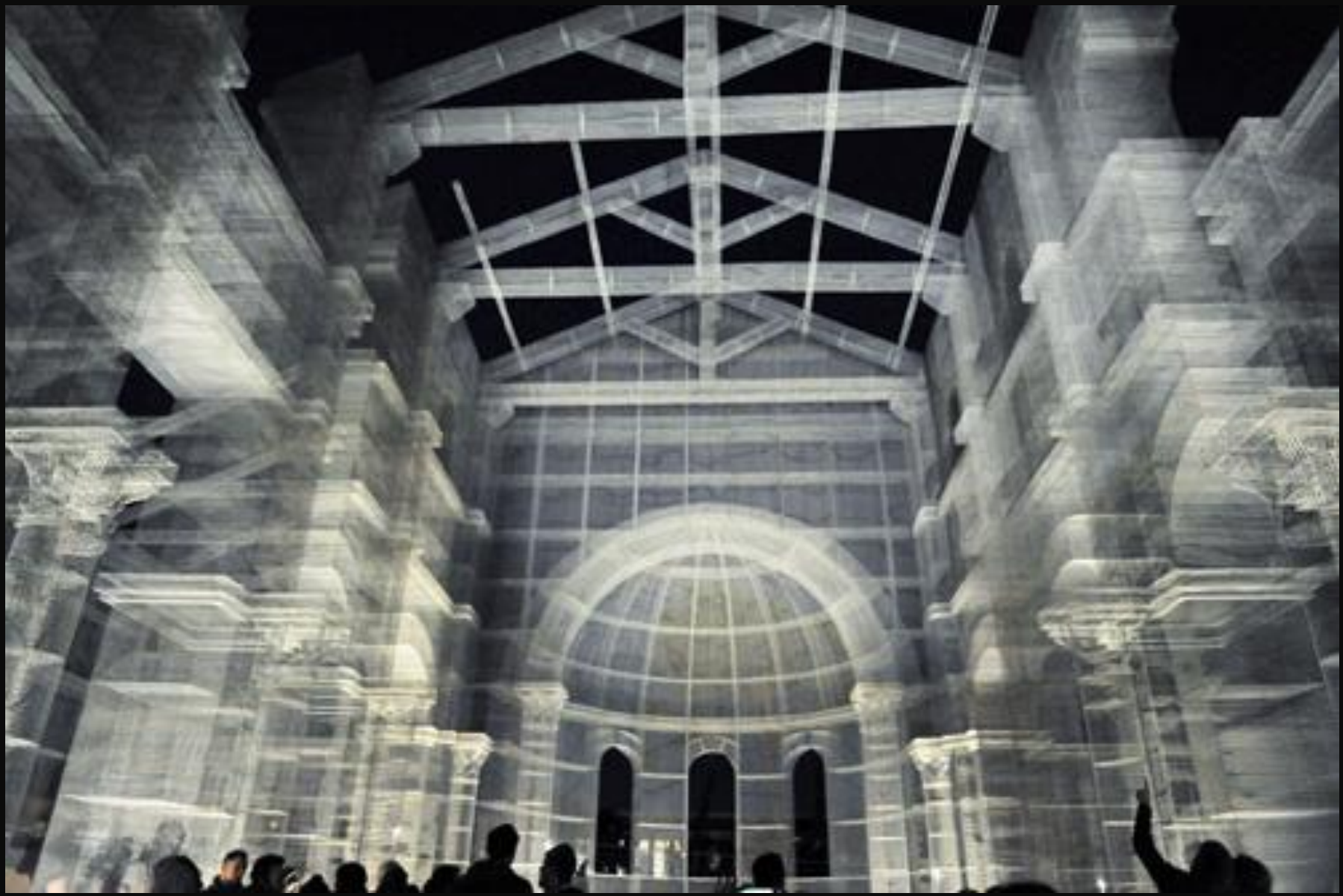
3D-Echocardiographic assestment of the right ventricle in the current era: application in clinical practice

Torino

24-26 Ottobre 2019

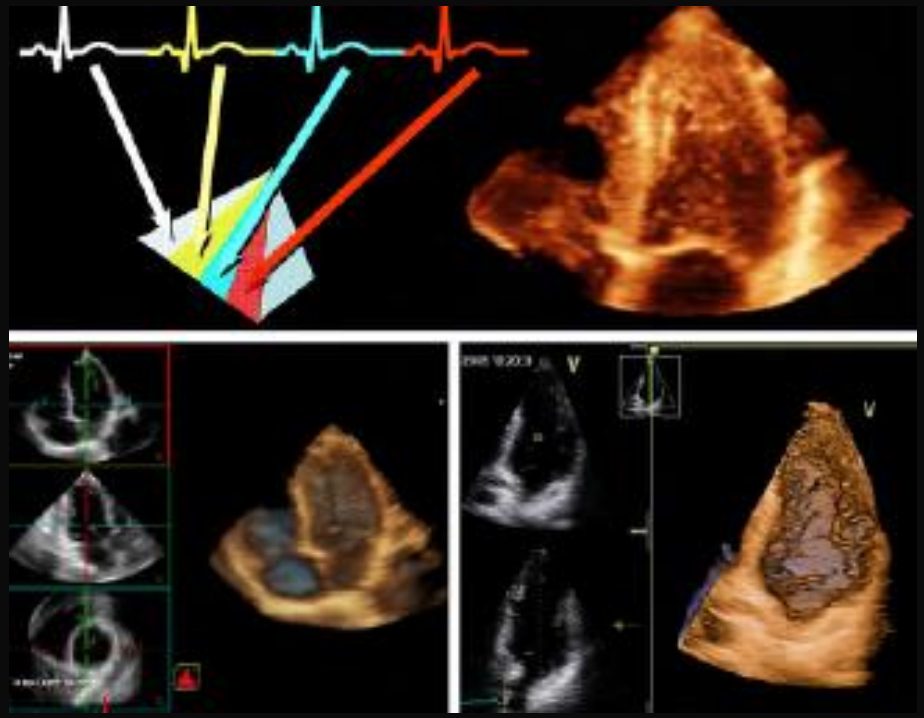
Vincenzo Manuppelli

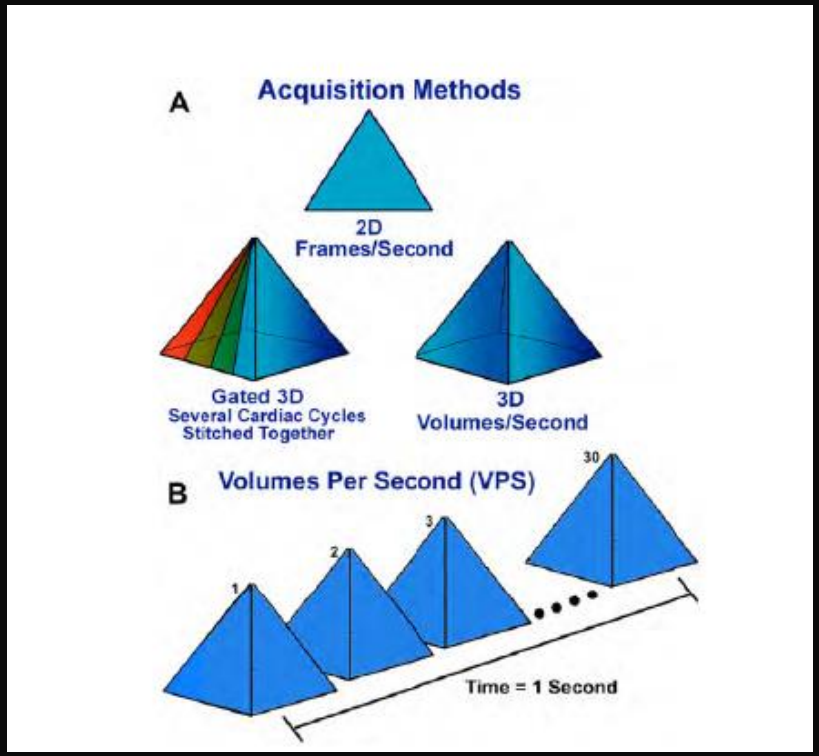

DIRETTA
9:54



“EAE/ASE Recommendations for Image Acquisitions and Display Using Three -Dimensional Echocardiography”

Roberto M. Lang , Jase 2012





Simultaneous multiplane mode

Real –Time 3D-Mode

Focused Wide sector –”Zoom”

Full Volume –gated Acquisition

Two plane rotate , multiplane

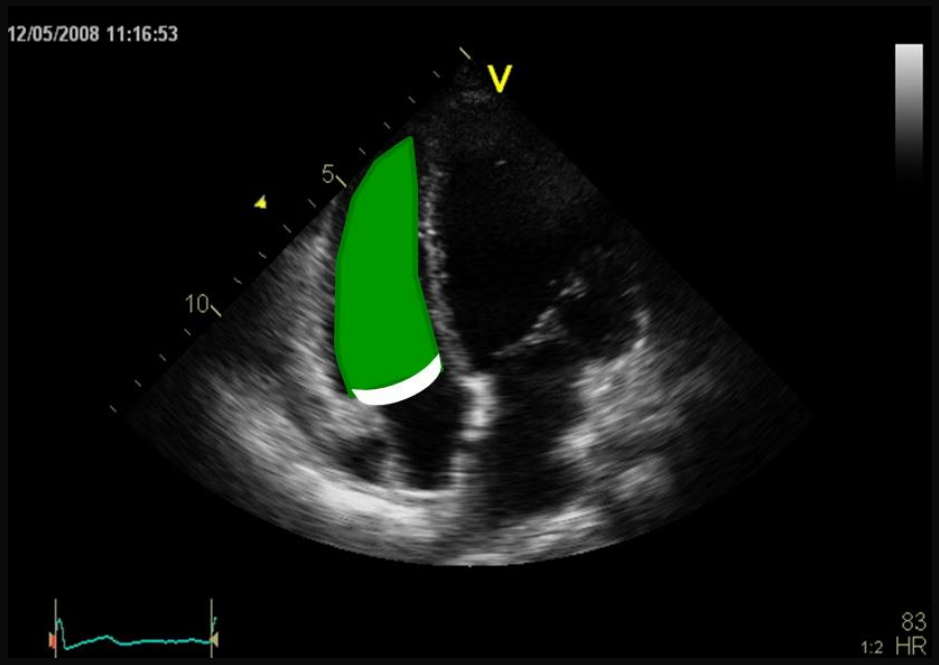
Insufficent to visualized the enirety, but superior spatial and temporal resolution

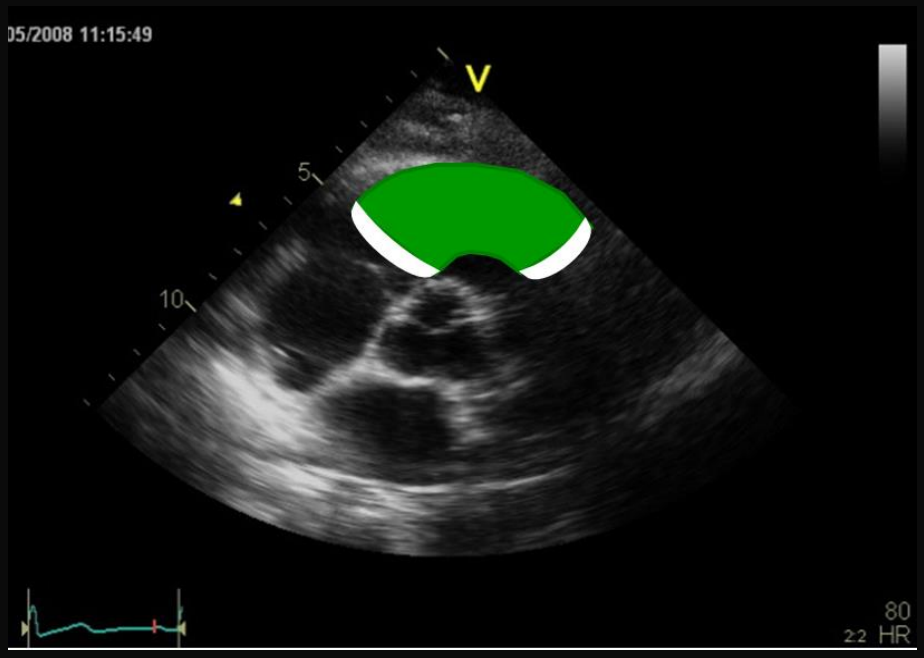
Detrimental decrease of spatial and temporal resolution, but focused wide sector

High temporal resolution

	Recommended for Clinical Practice	Promising Clinical Studies	Areas of Active Research	Unstudied
Left Ventricle Functional Assessment				
Volume	✓			
Shape			✓	
Ejection Fraction	✓			
Dyssynchrony			✓	
Mass		✓		
Right Ventricle Functional Assessment				
Volume		✓		
Shape				✓
Ejection Fraction		✓		
Left Atrial Assessment				
Volume			✓	
Right Atrial Assessment				
Volume				✓
Mitral Valve Assessment				
Anatomy	✓			
Stenosis	✓			
Regurgitation			✓	
Tricuspid Valve Assessment				
Anatomy				✓
Stenosis				✓
Regurgitation				✓
Pulmonic Valve Assessment				
Anatomy				✓
Stenosis				✓
Regurgitation				✓
Aortic Valve Assessment				
Anatomy		✓		
Stenosis		✓		
Regurgitation				✓
Infective Endocarditis				✓
Prosthetic Valves			✓	
Guidance of Transcatheter Procedures*	✓			

Da R. Lang , Jase 2012 , modificata





Inlet
Trabeculate apex
outlet

Minor wall tickness

Absence of real apex

High compliance

Reduce stiffness

Considerable sensivity

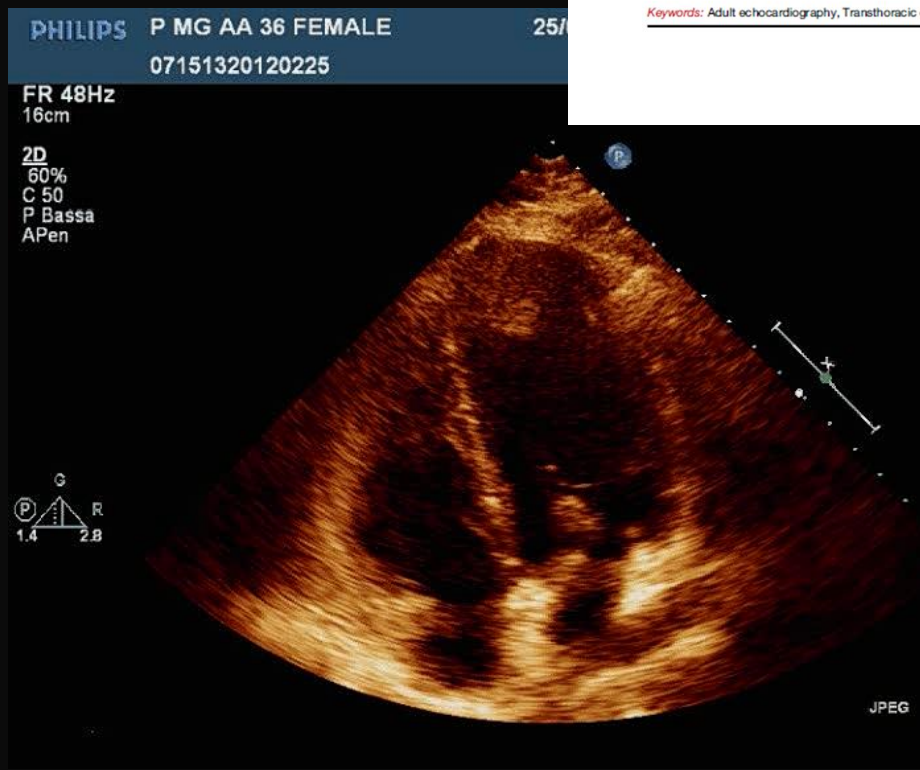
GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

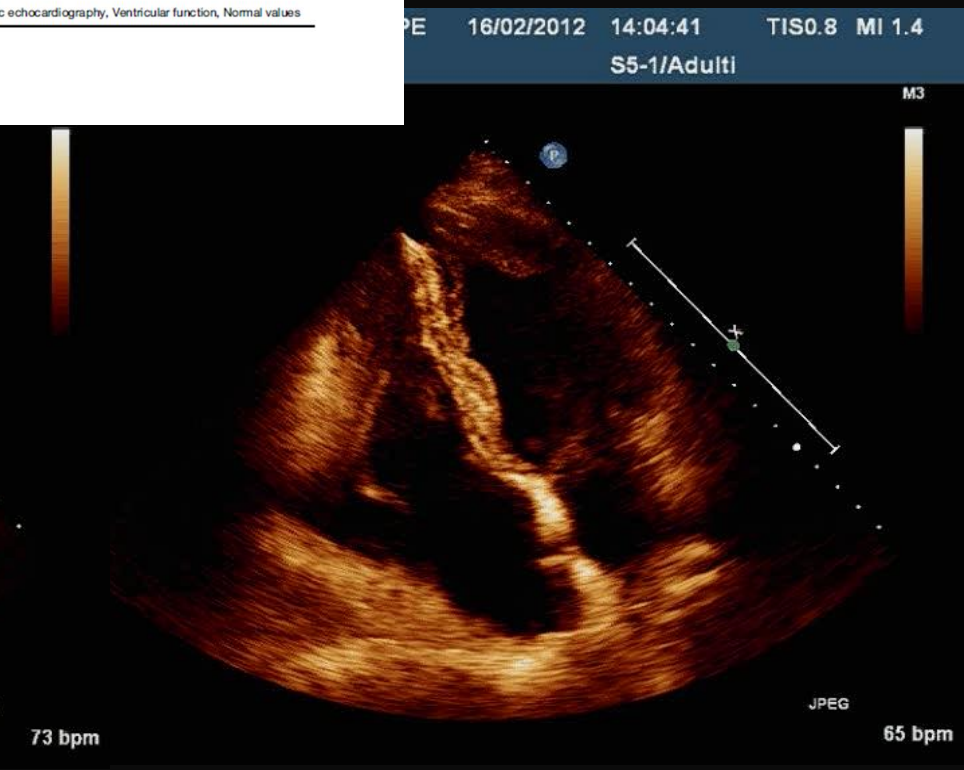
Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, FESC, Denisa Muraru, MD, PhD, Michael H. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, *Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Créteil, France; Uppsala, Sweden; San Francisco, California; Washington, District of Columbia; Leuven, Liège, and Ghent, Belgium; Boston, Massachusetts*

The rapid technological developments of the past decade and the changes in echocardiographic practice brought about by these developments have resulted in the need for updated recommendations to the previously published guidelines for cardiac chamber quantification, which was the goal of the joint writing group assembled by the American Society of Echocardiography and the European Association of Cardiovascular Imaging. This document provides updated normal values for all four cardiac chambers, including three-dimensional echocardiography and myocardial deformation, when possible, on the basis of considerably larger numbers of normal subjects, compiled from multiple databases. In addition, this document attempts to eliminate several minor discrepancies that existed between previously published guidelines. (J Am Soc Echocardiogr 2015;28:1-39.)

Keywords: Adult echocardiography, Transthoracic echocardiography, Ventricular function, Normal values

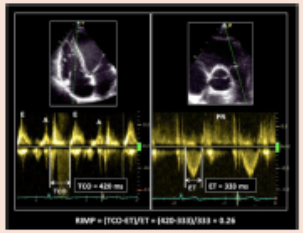
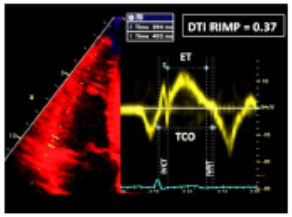
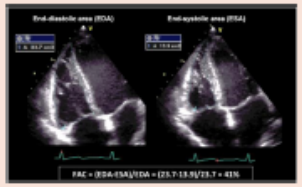
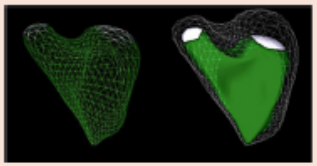


Apical 4 chamber



RV focused apical 4 chamber

Table 9 Recommendations for the echocardiographic assessment of RV function

Echocardiographic imaging	Recommended methods	Advantages	Limitations
RV global function Pulsed Doppler RIMP 	RIMP (Tei index) by pulsed Doppler: RIMP = (TCO − ET)/ET	• Prognostic value • Less affected by heart rate	• Requires matching for R-R intervals when measurements are performed on separate recordings • Unreliable when RA pressure is elevated
Tissue Doppler RIMP 	RIMP by tissue Doppler: RIMP = (IVRT + IVCT)/ET = (TCO − ET)/ET	• Less affected by heart rate • Single-beat recording with no need for R-R interval matching	• Unreliable when RA pressure is elevated
RV global systolic function FAC 	RV FAC in RV-focused apical four-chamber view: RV FAC (%) = 100 × (EDA − ESA)/EDA	• Established prognostic value • Reflects both longitudinal and radial components of RV contraction • Correlates with RV EF by CMR	• Neglects the contribution of RV outflow tract to overall systolic function • Only fair inter-observer reproducibility
EF 	Fractional RV volume change by 3D TTE: RV EF (%) = 100 × (EDV − ESV)/EDV	• Includes RV outflow tract contribution to overall function • Correlates with RV EF by CMR	• Dependent on adequate image quality • Load dependency • Requires offline analysis and experience • Prognostic value not established

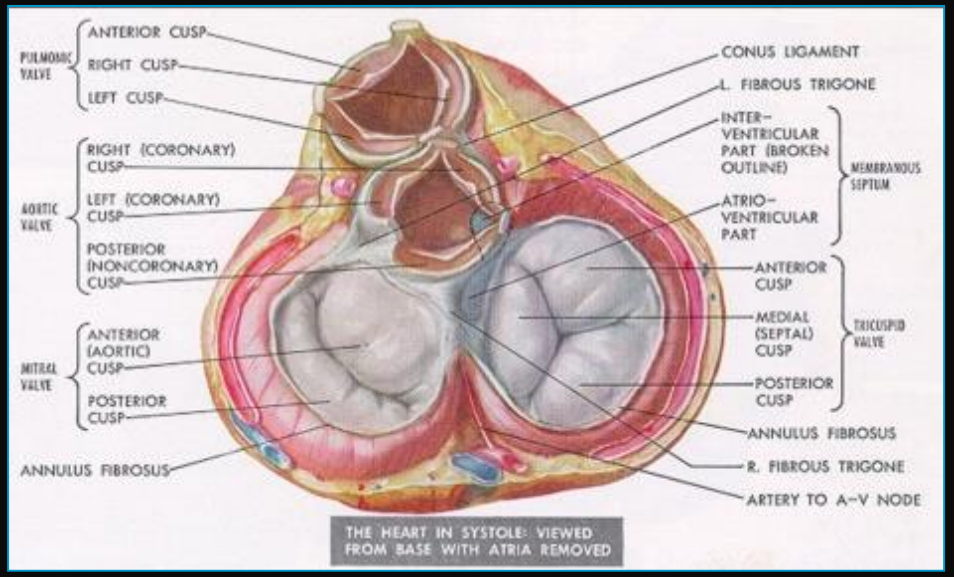
(Continued)

Lang R, JASE 2015

Valvular regurgitation among healty children:
PW-CW doppler study on 246 cases
Barretta G. et al.

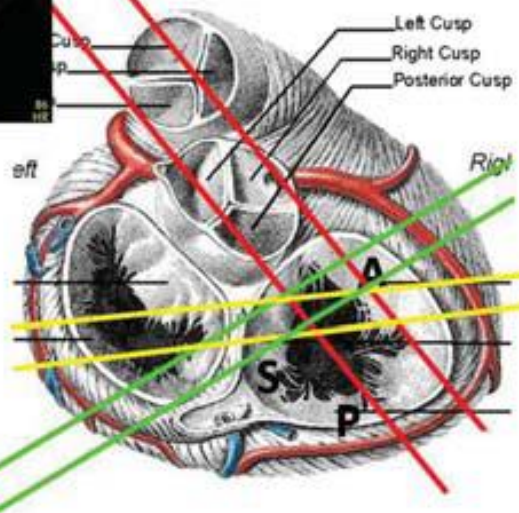
J Cardiovasc Ultrasound, IV: 4; 1985

- rigurgiti fisiologici tricuspidalici nel 68%
- rigurgiti fisiologici polmonari nel 72%
- rigurgiti fisiologici mitralici nel 49%
- mai rigurgiti fisiologici aortici

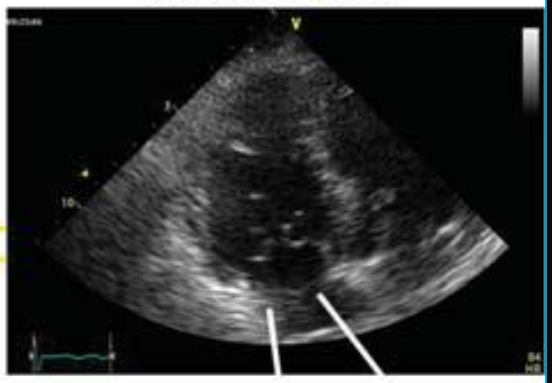


Parasternal SAX VIEW

Septal	0%	48%
Anterior	0%	52%
Posterior	92%	0%

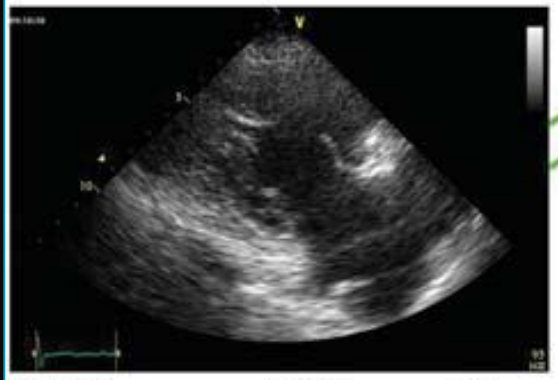


APICAL 4CH VIEW



Septal	0%	100%
Anterior	100%	0%
Posterior	0%	0%

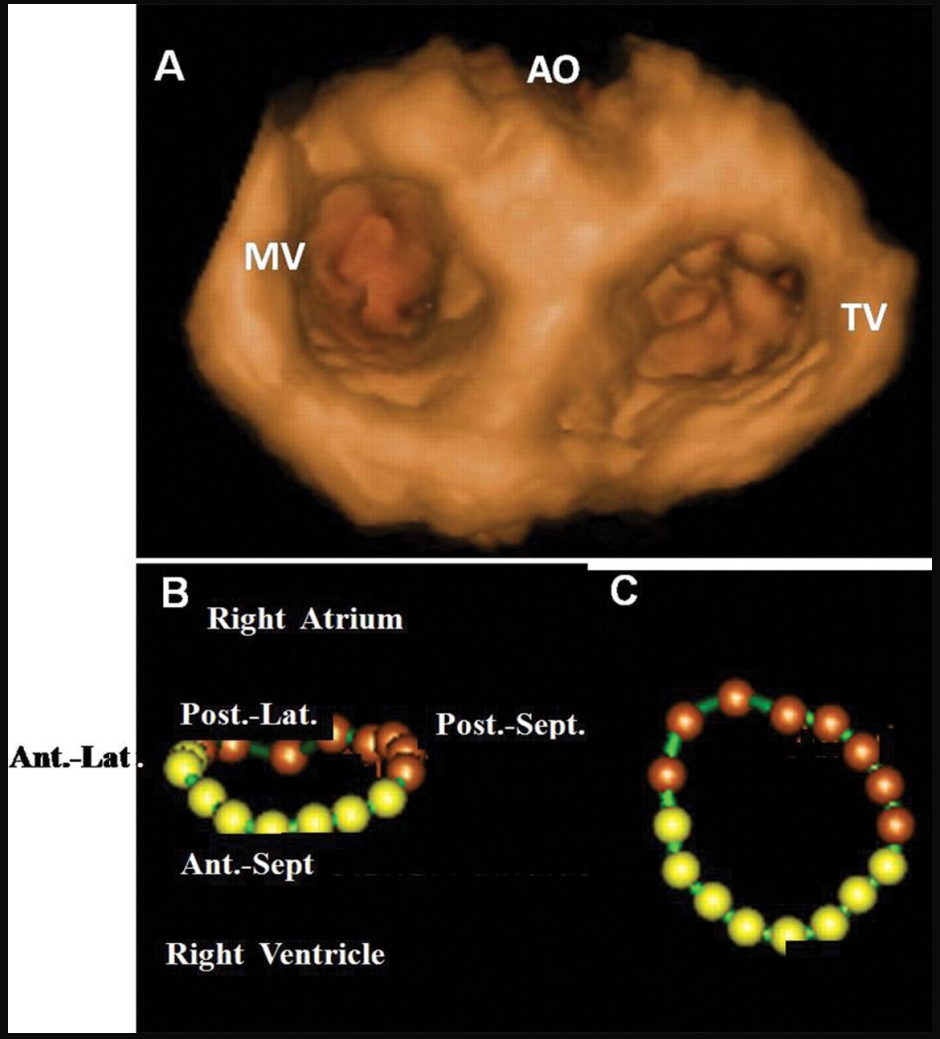
PARASTERNAL RV-Inflow



Septal	100%	0%
Anterior	0%	100%
Posterior	0%	0%

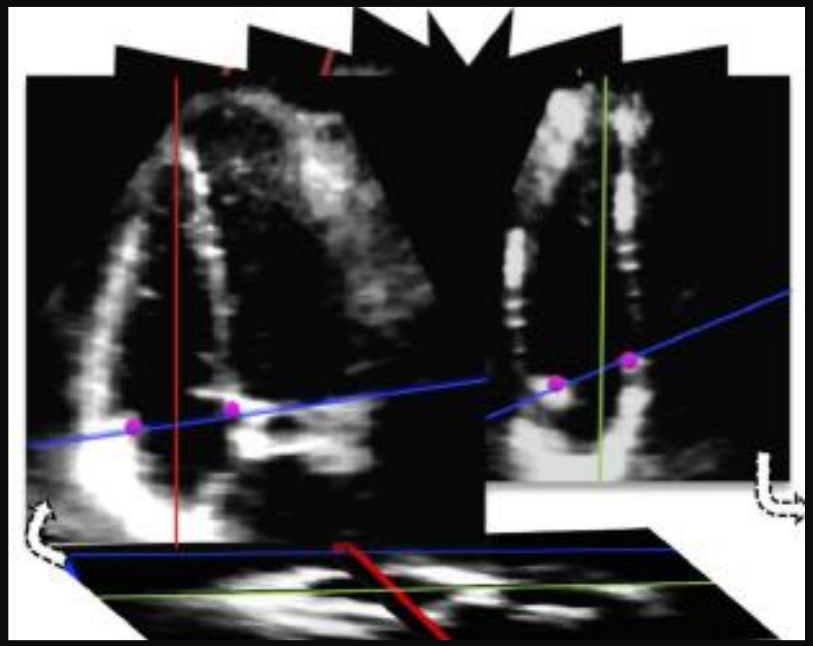
“ Evaluation of the tricuspid valve morfology and function by transtoracic real-time three-dimensional echocardiography ”

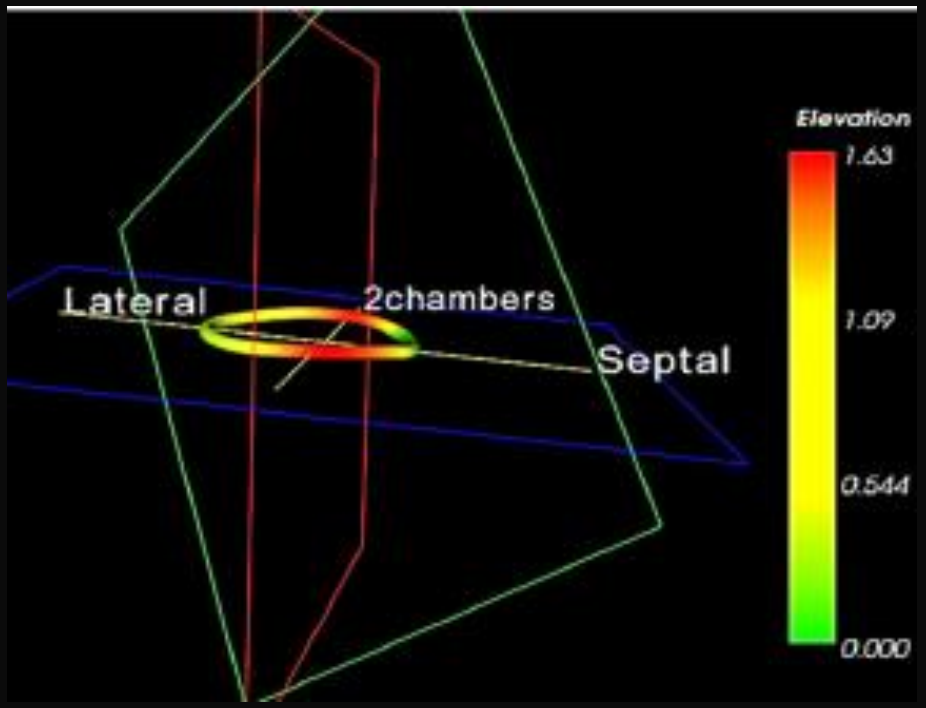
L. Badano et al European J of Echocardiography 2009



“Three dimensional echocardiography investigation of the mechanism of tricuspid anular dilatation”

Valentina Volpato et al, The International Journal of Cardiovascular Imaging 2019



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X7-2t/TEE
FR 34Hz
15cm
M4
Volume completo 0 180
3D 47%
3D 40dB
JPEG
Temp. PAZ.: 37.0C
Temp. TEE: 38.8C
89 bpm


PHILIPS
DR MA
16/02/2012
13:02:53
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MI 0.5
26/05/1978
13371220120216
X7-2t/TEE
FR 34Hz
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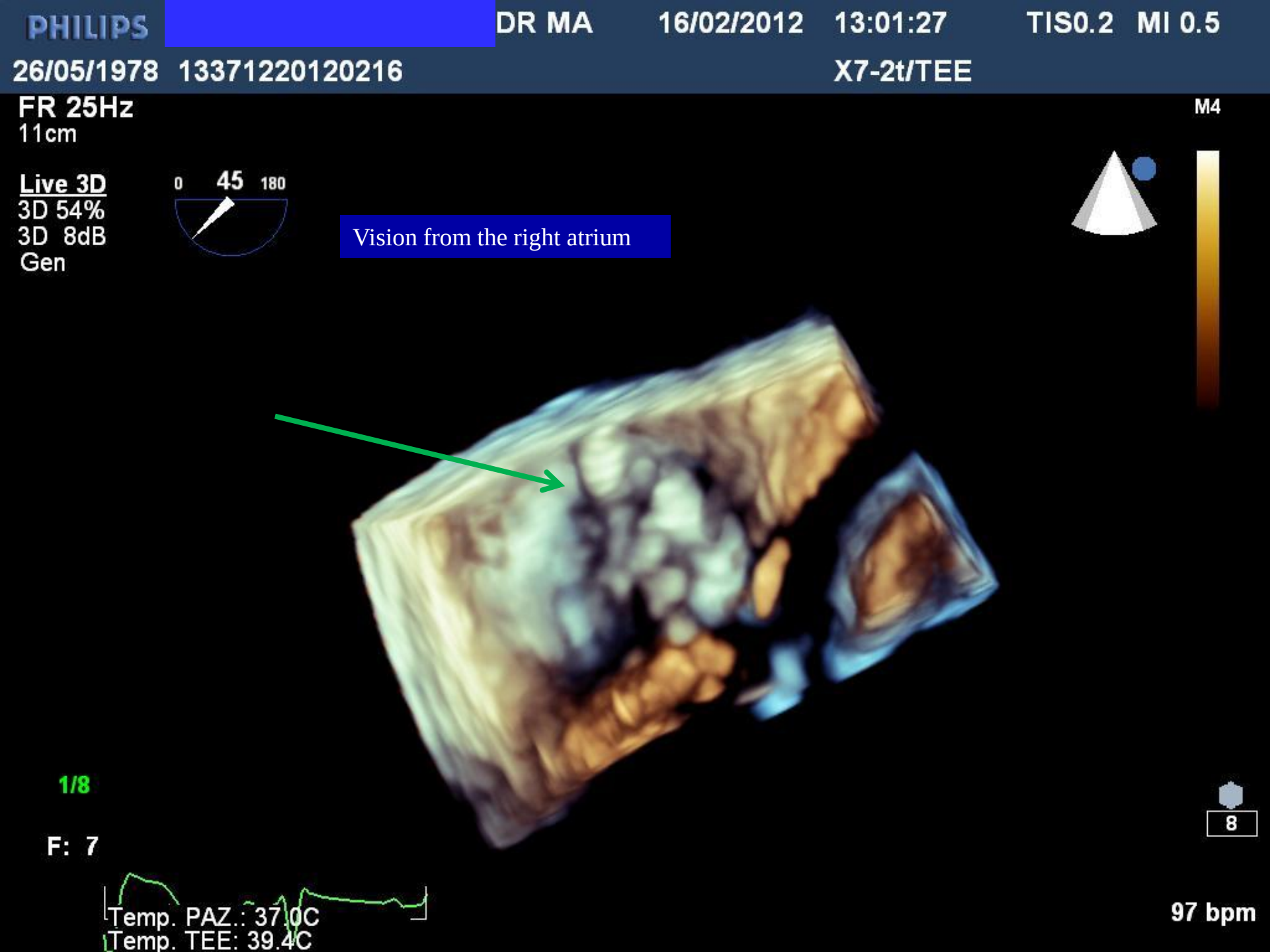
Temp. TEE: 38.8C
89 bpm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3D 54%
3D 8dB
Gen
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45
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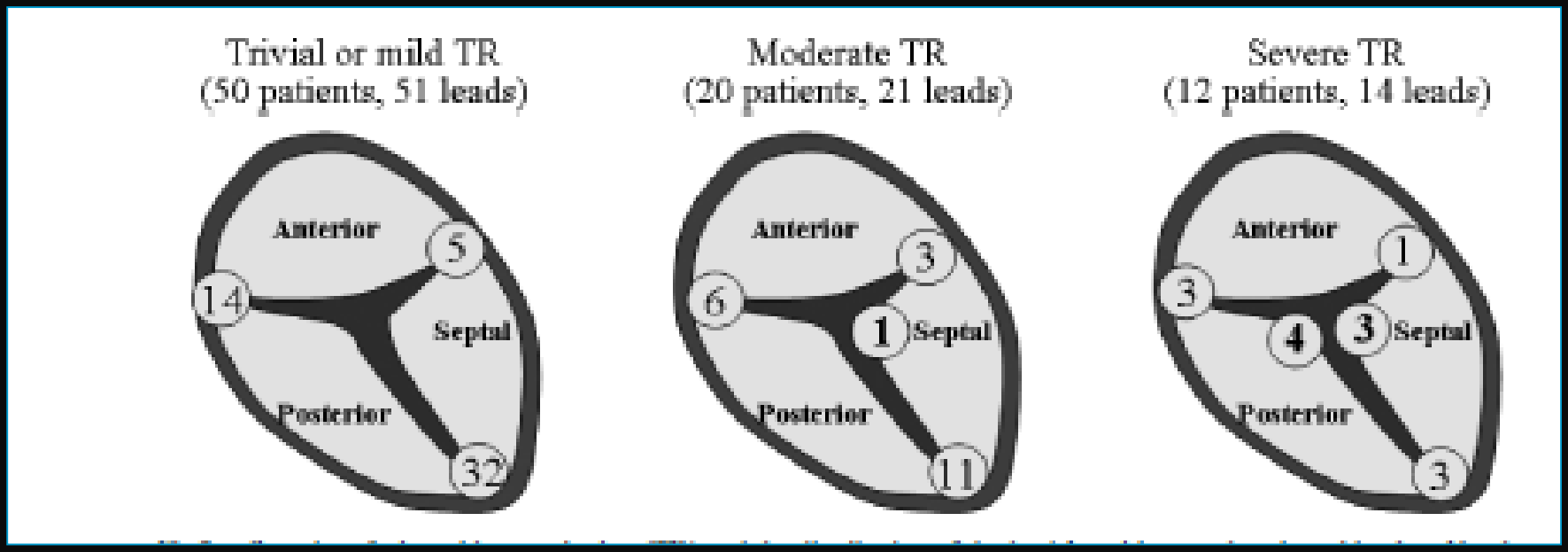
Vision from the right atrium
1/8
F: 7
8
Temp. PAZ.: 37.0C
Temp. TEE: 39.4C
97 bpm

“ Clinical Utility of 3-D-Dimensional Echocardiography in the Evaluation of Tricuspid Regurgitation caused by Pacemaker Leads”

Yoshihiro Se , Circ J 2008




PETPAT01031976
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Eco adulti
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53Hz
15cm
0 40 180
2D
68%
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Temp. TEE: 39.4C


PETPAT01031976
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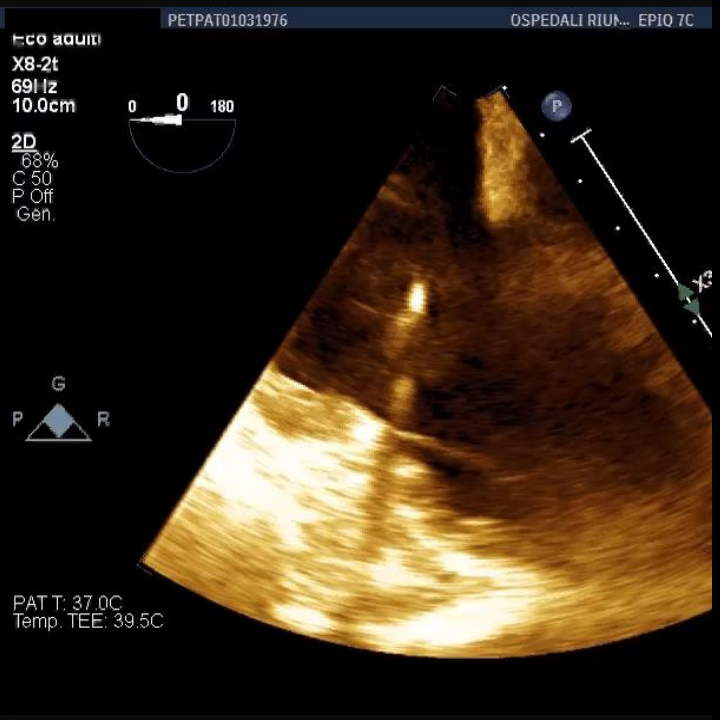
2D / 3D
% 68 / 45
C 50 / 30
Gen.
PAT T: 37.0C
Temp. TEE: 39.5C
8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C 50
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PAT T: 37.0C
Temp. TEE: 39.5C


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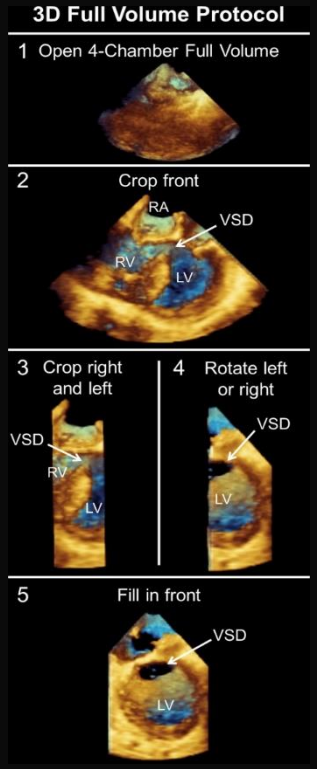
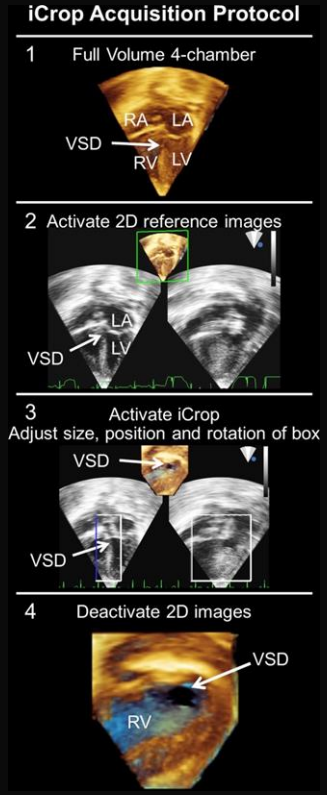
180
Zoom 3D
2D / 3D
% 68 / 45
C 50 / 30
Gen.
PAT T: 37.0C
Temp. TEE: 39.6C
74

"Three-Dimensional Echocardiographic En Face Views of Ventricular Septal Defects: Feasibility, Accuracy, Imaging Protocols and Reference Image Collection"

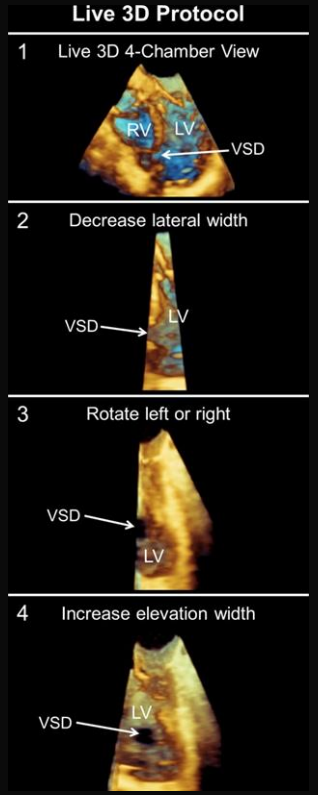
Waseem Cossor, MD, Vivian Wei Cui, MD, Jase 2015

87 % success rate





100% success rate



94 % success rate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56%
3dB
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VSN
Temp. PAZ.: 37.0C
Temp. TEE: 39.2C


PHILIPS
BG 49A TEE
11/11/2010
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TIS0.2
MI 0.5
02/04/1961
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X7-2t/
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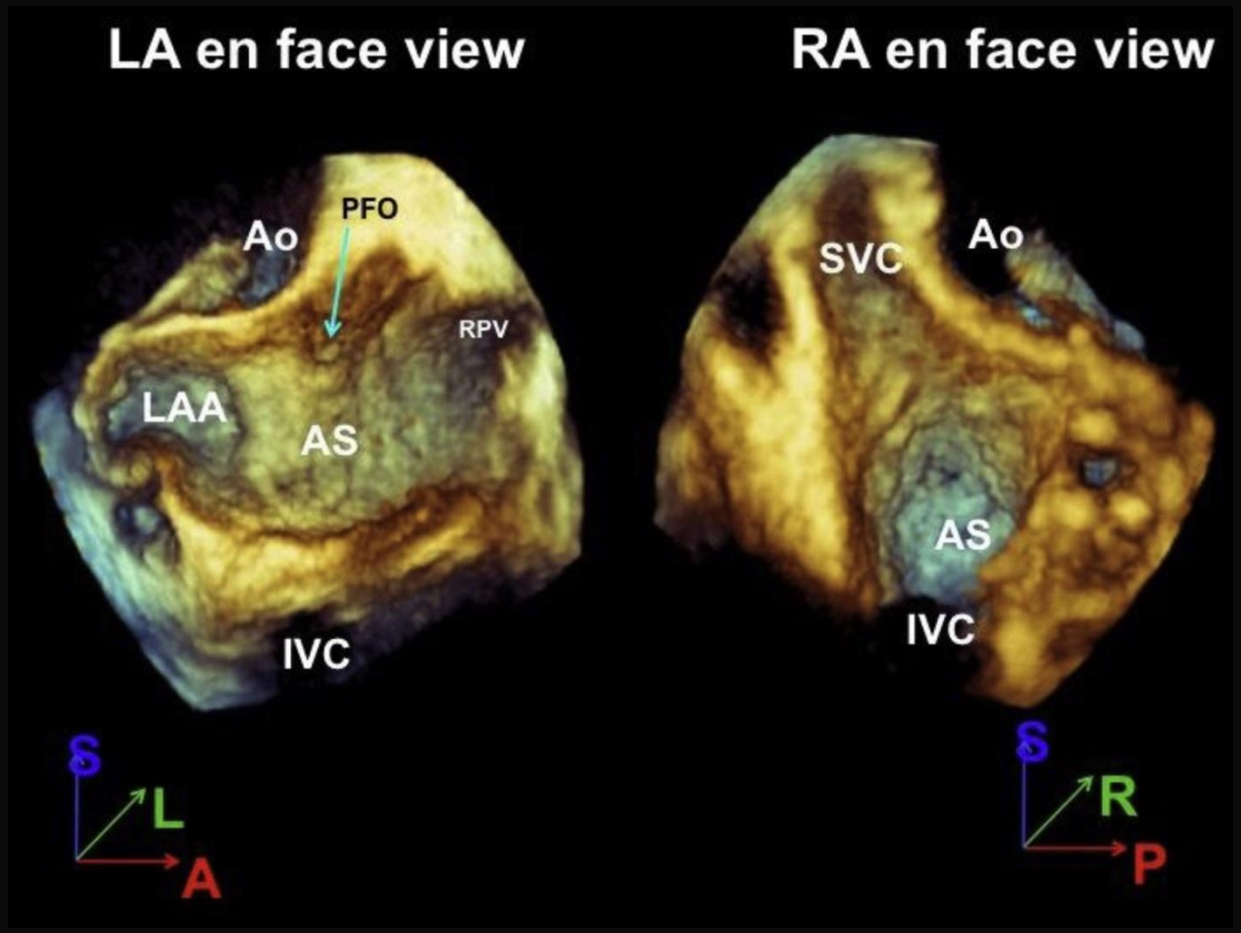
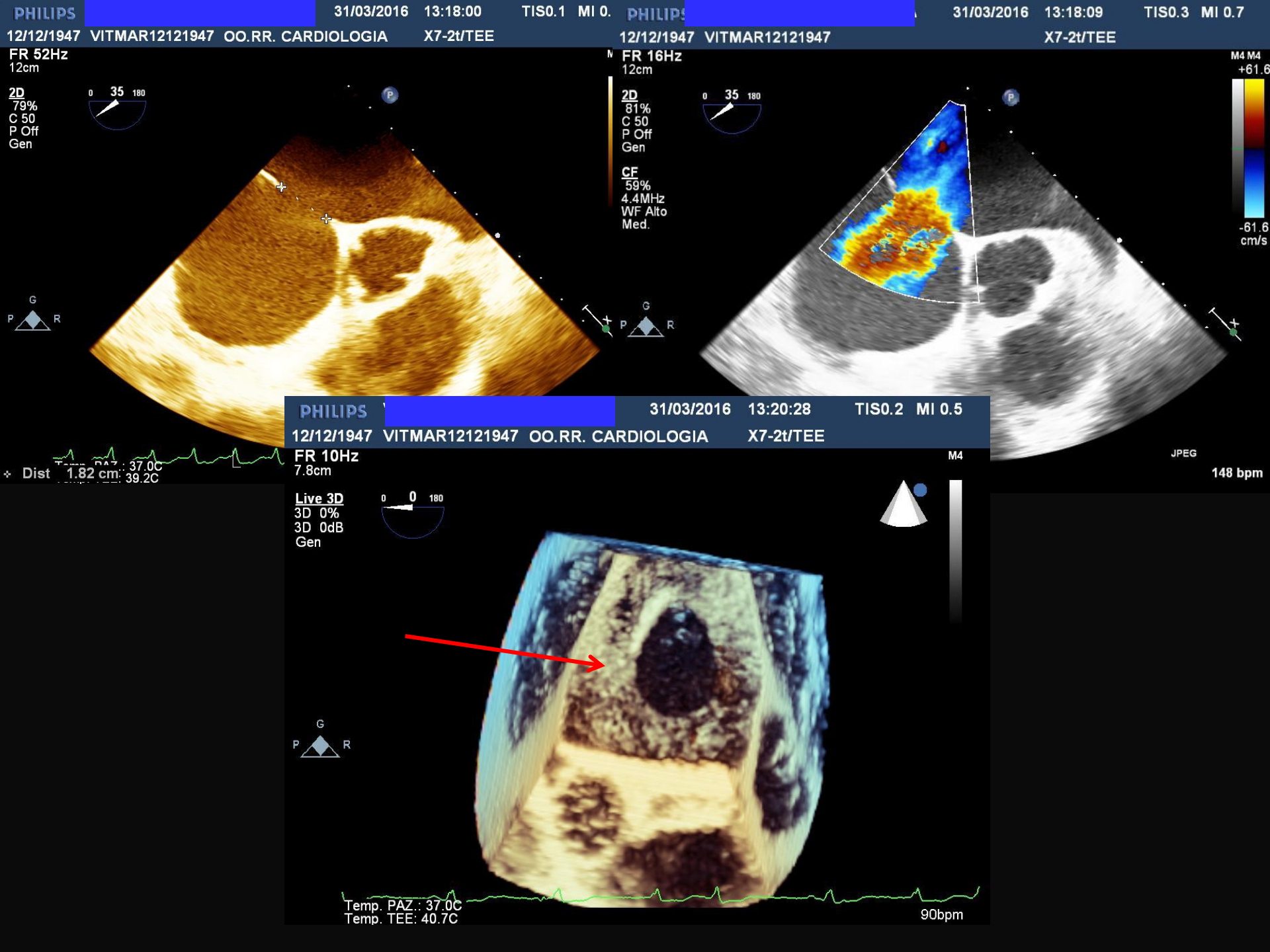
13cm
Live 3D
3D 30%
3D 43dB
Gen
0
20
180
M4
JPEG
Temp. PAZ.: 37.0C
Temp. TEE: 39.0C
92 bpm

“Guidelines for the Echocardiographic Assessment of Atrial Septal Defect and Patent Foramen Ovale: From the American Society of Echocardiography and Society for Cardiac Angiography and Interventions ”

Frank E. Silvestry, MD, FASE, , Jase, august 2015

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2D
79%
C 50
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Gen
PHILIPS
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12cm
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81%
C 50
P Off
Gen
CF
59%
4.4MHz
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Med.
M4 M4
+61.6
-61.6
cm/s
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Dist 1.82 cm
PHILIPS
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M4
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Gen
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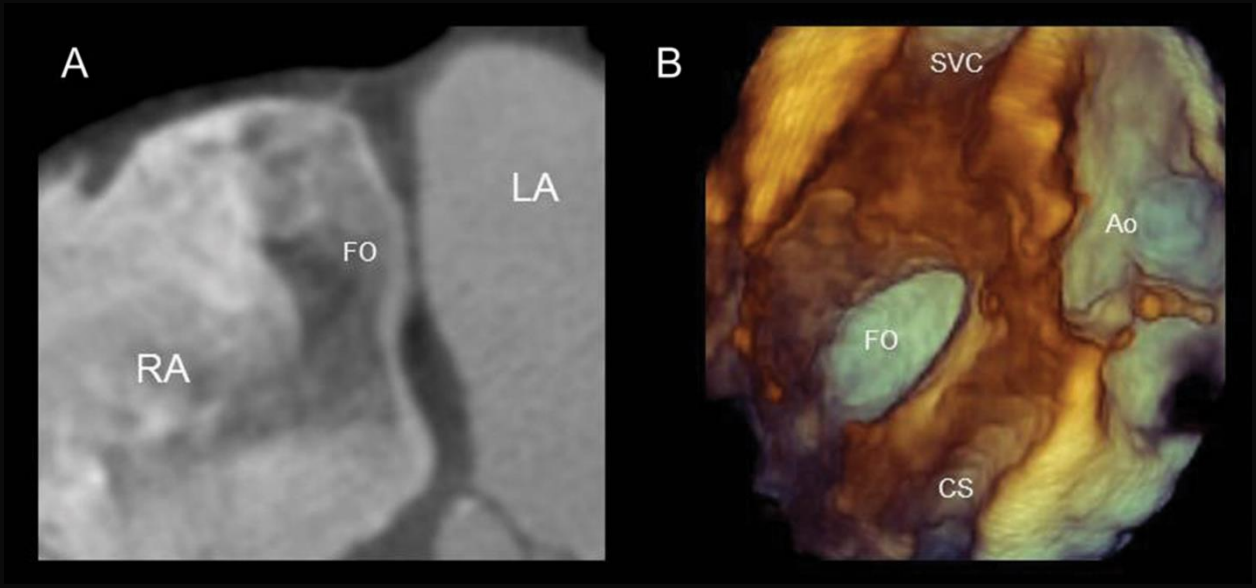
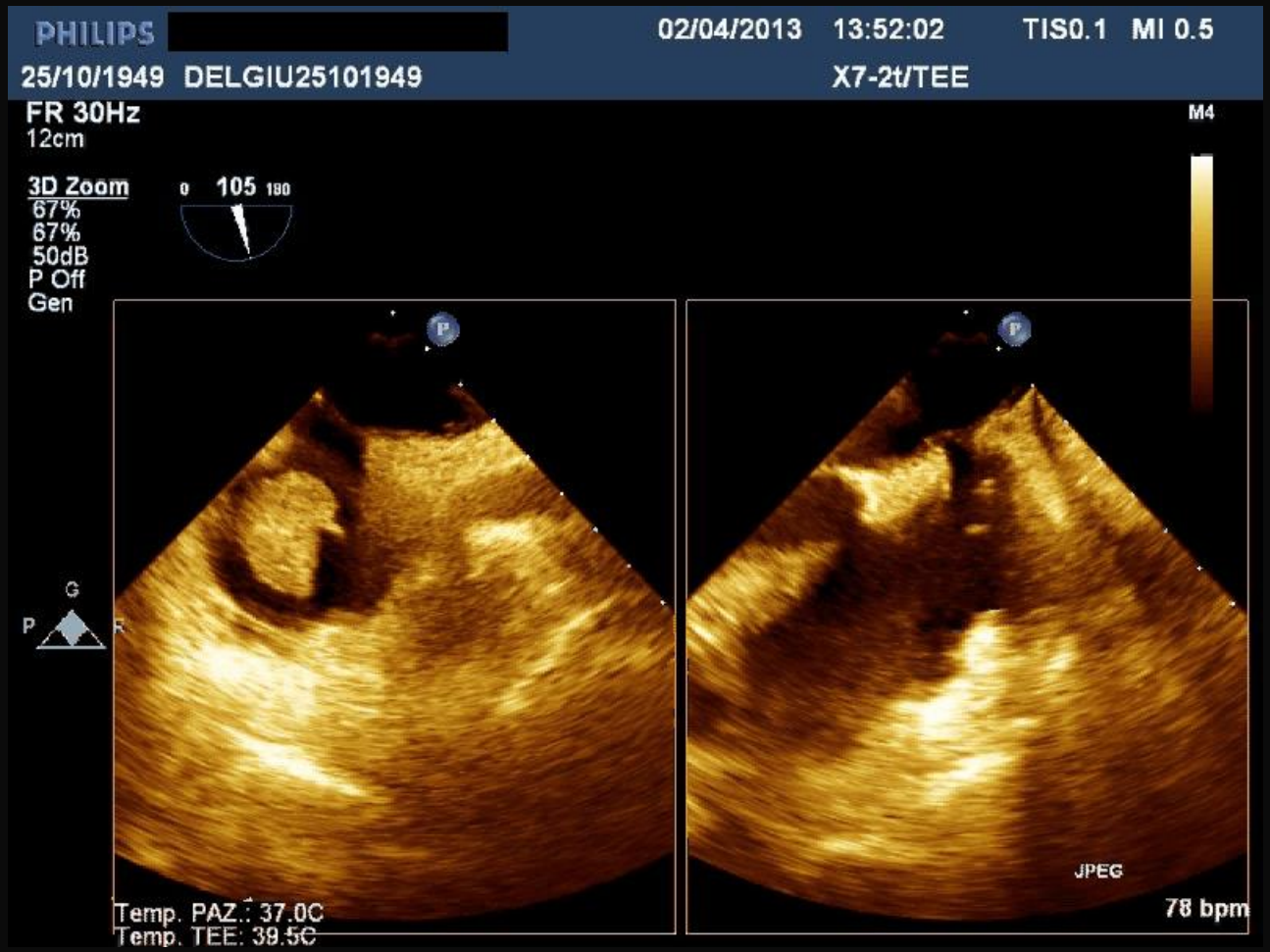
Temp. TEE: 40.7C
90bpm

“Imaging right atrial anatomy by computed tomography, magnetic resonance imaging , and three –dimensional transesophageal echocardiography; correlations with anatomic specimen “ ”

Francesco Faletra e t al ,European hearth journal 2013

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X7-2t/TEE
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67%
67%
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JPEG
78 bpm
Temp. PAZ.: 37.0C
Temp. TEE: 39.5C


PHILIPS
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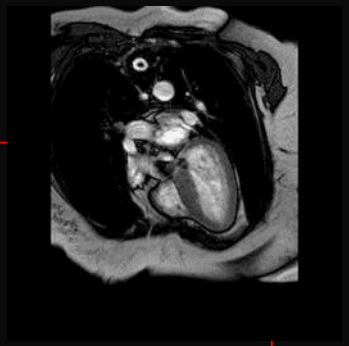
83 bpm



Limited availability

Exam duration

Duration of quantitative analysis

Contraindications (metal prostheses, CRF, contrast allergy, claustrophobia)

High cost

Volumes taken from multiple 2D sections

Poor visualization of the tricuspid ring

Superior ease of execution

Less duration analysis

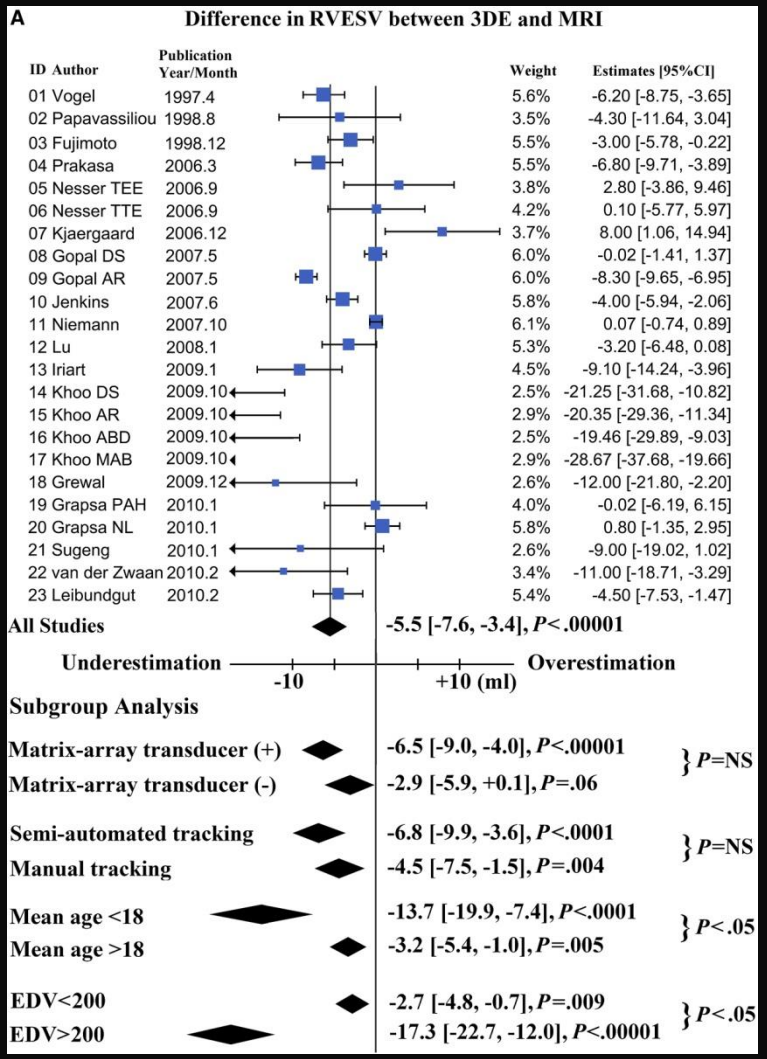
Low cost

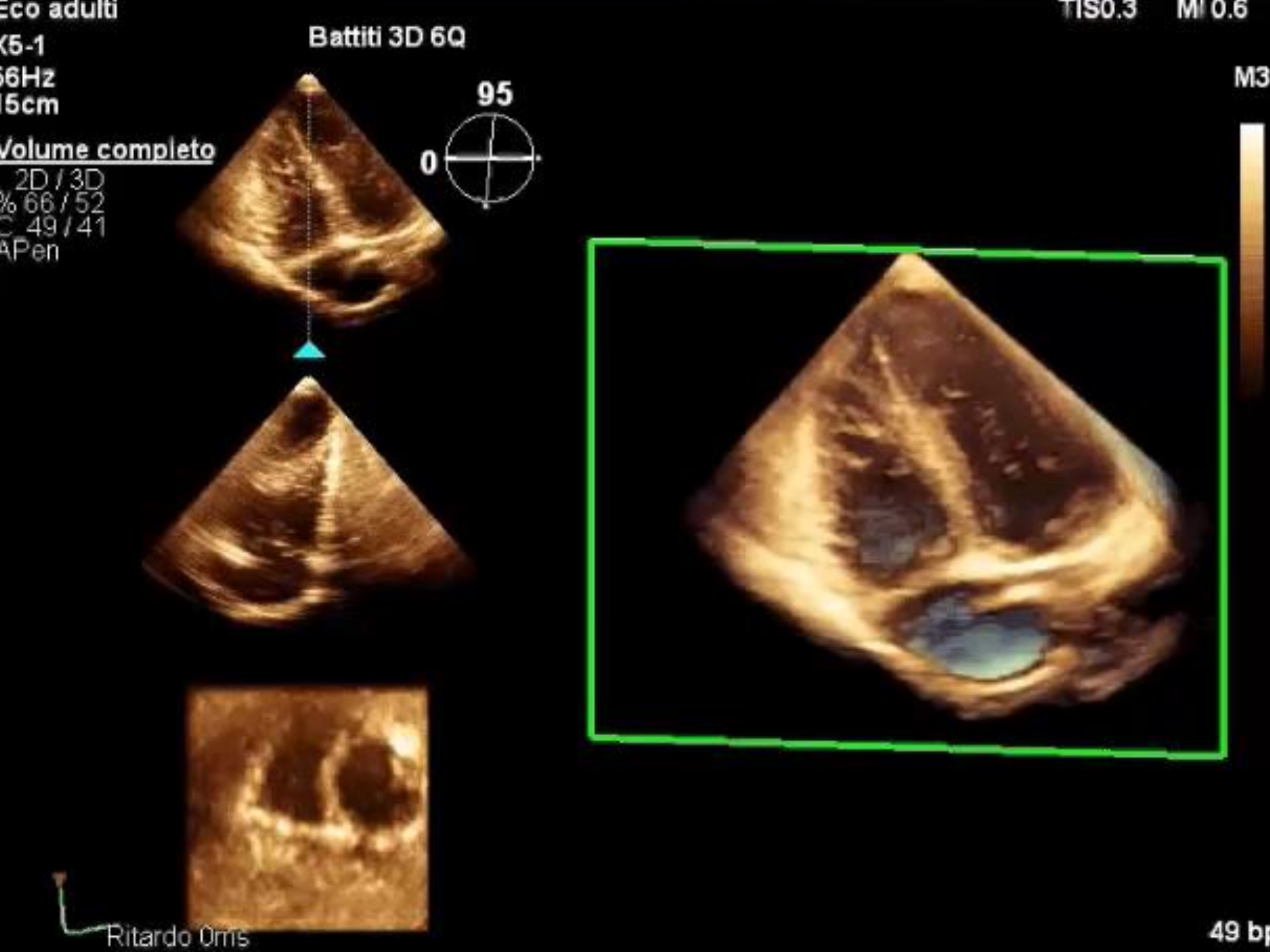
Absense of controindications

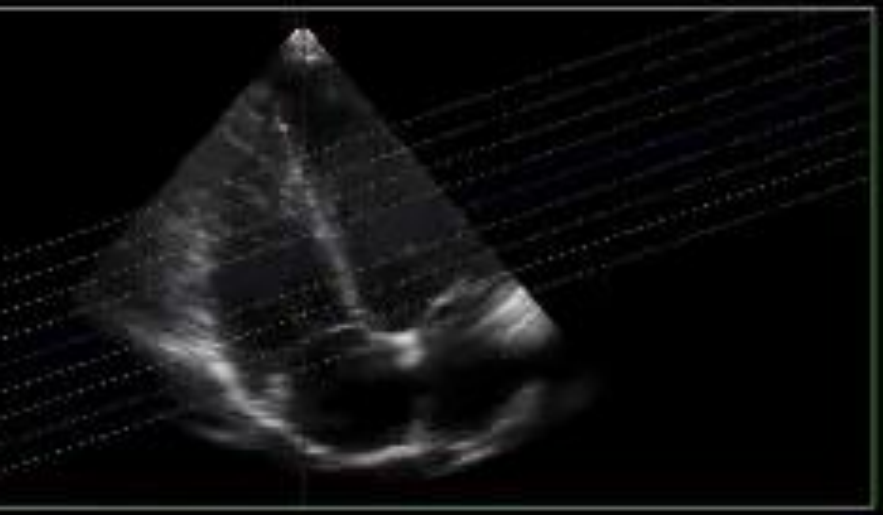
Volumes from voxels volumetric pyramid

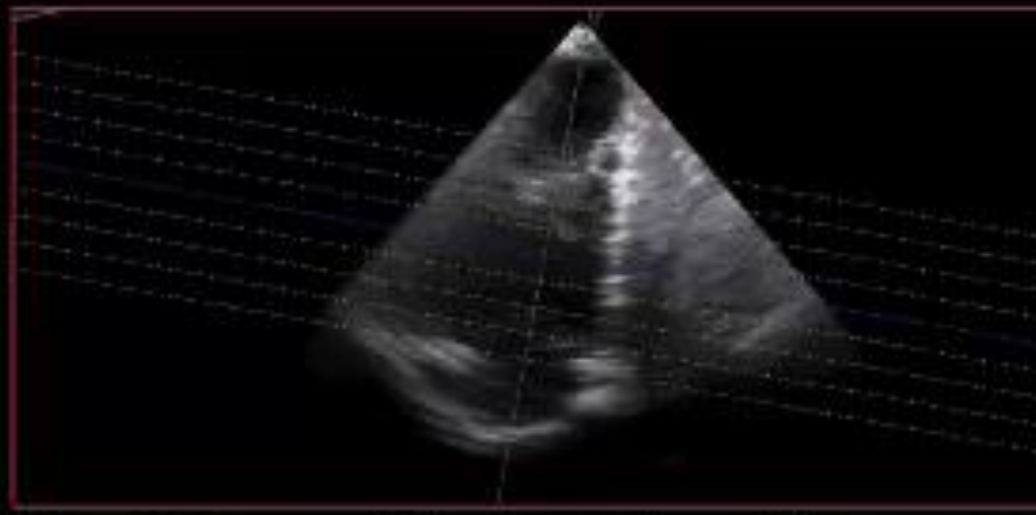
“Accuracy of Right Ventricular Volumes and Function Determined by Three-Dimensional Echocardiography in Comparison with Magnetic Resonance Imaging: A Meta-Analysis Study”

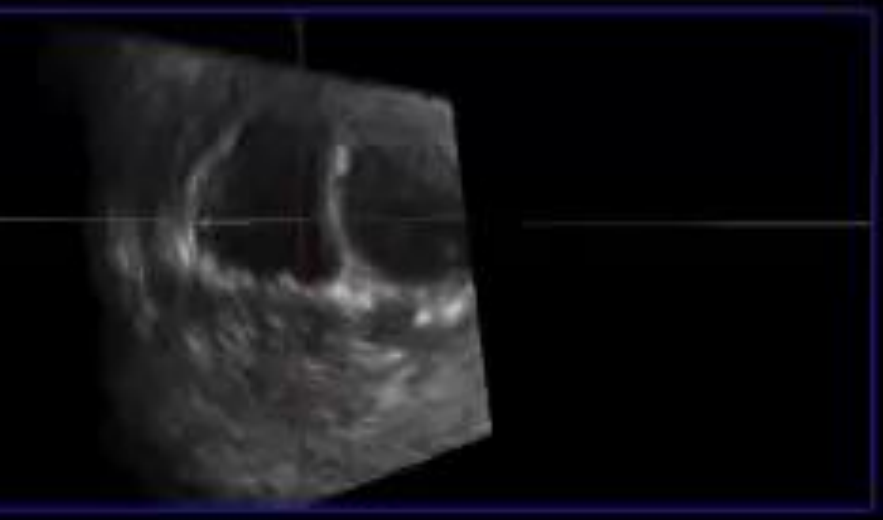
Yuichi J. Shimada, MD, JASE 2010

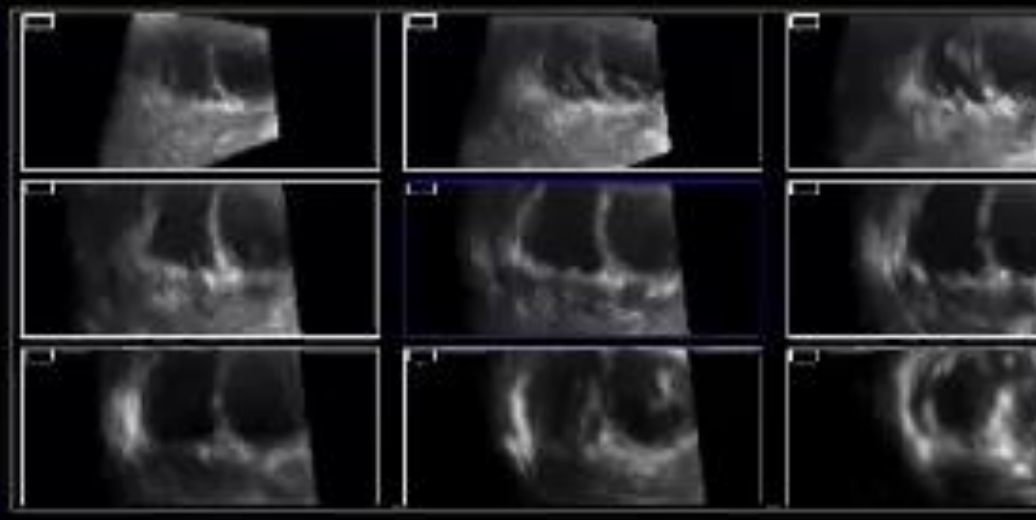



Eco adulti
X5-1
66Hz
15cm
Volume completo
2D / 3D
% 66 / 52
C 49 / 41
APen
Battiti 3D 6Q
95
0
TIS0.3
MI 0.6
M3
49 bp
Ritardo 0ms



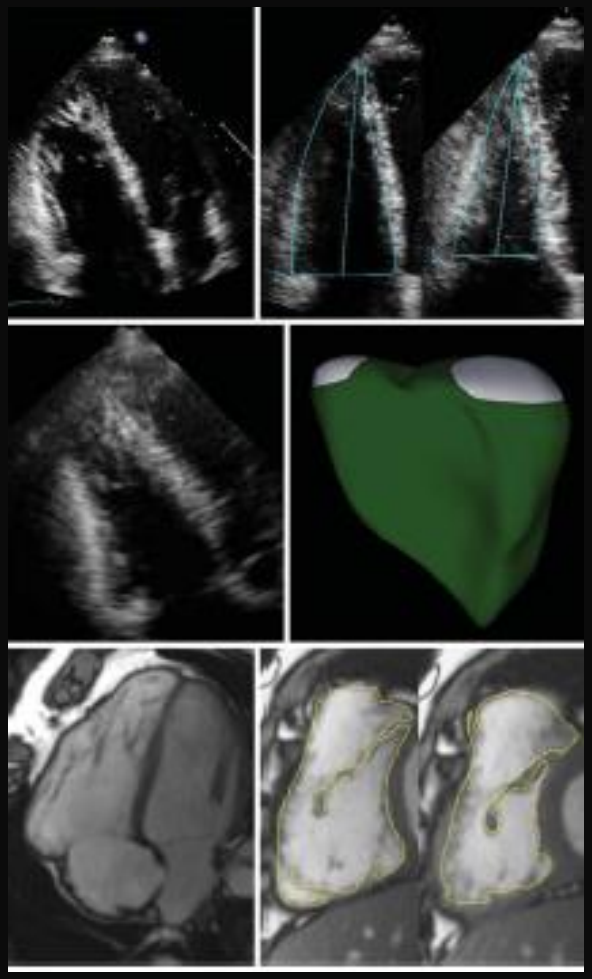






“ Right ventricular quantification in clinical practice:two dimensional vs three-dimensional echocardiography compared with cardiac magnetic resonance imaging”

Heleen B van der Zwaan European Journal of Echocardiography 2011



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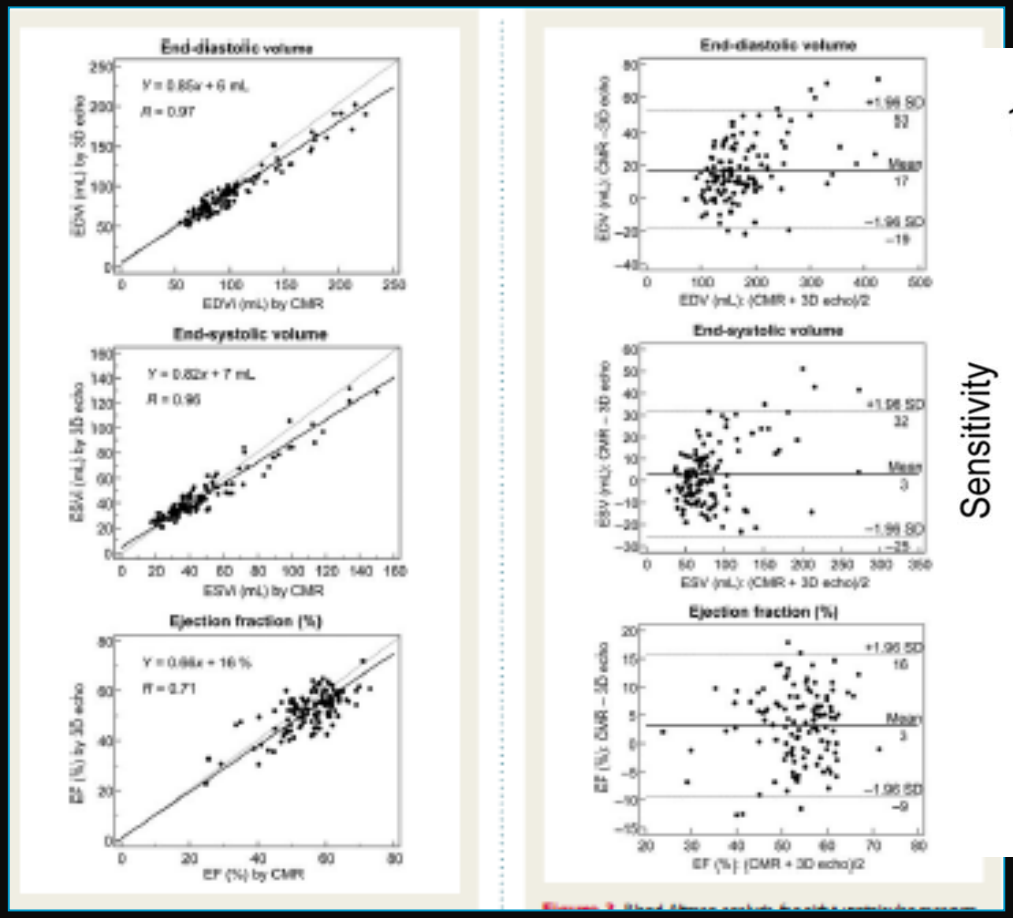
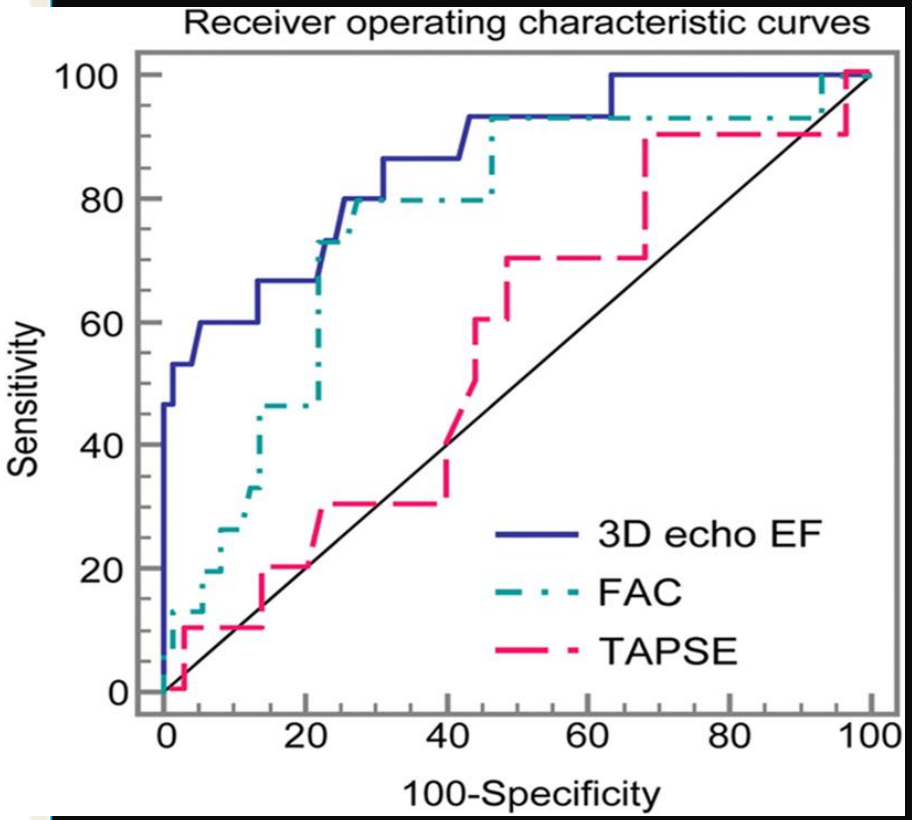
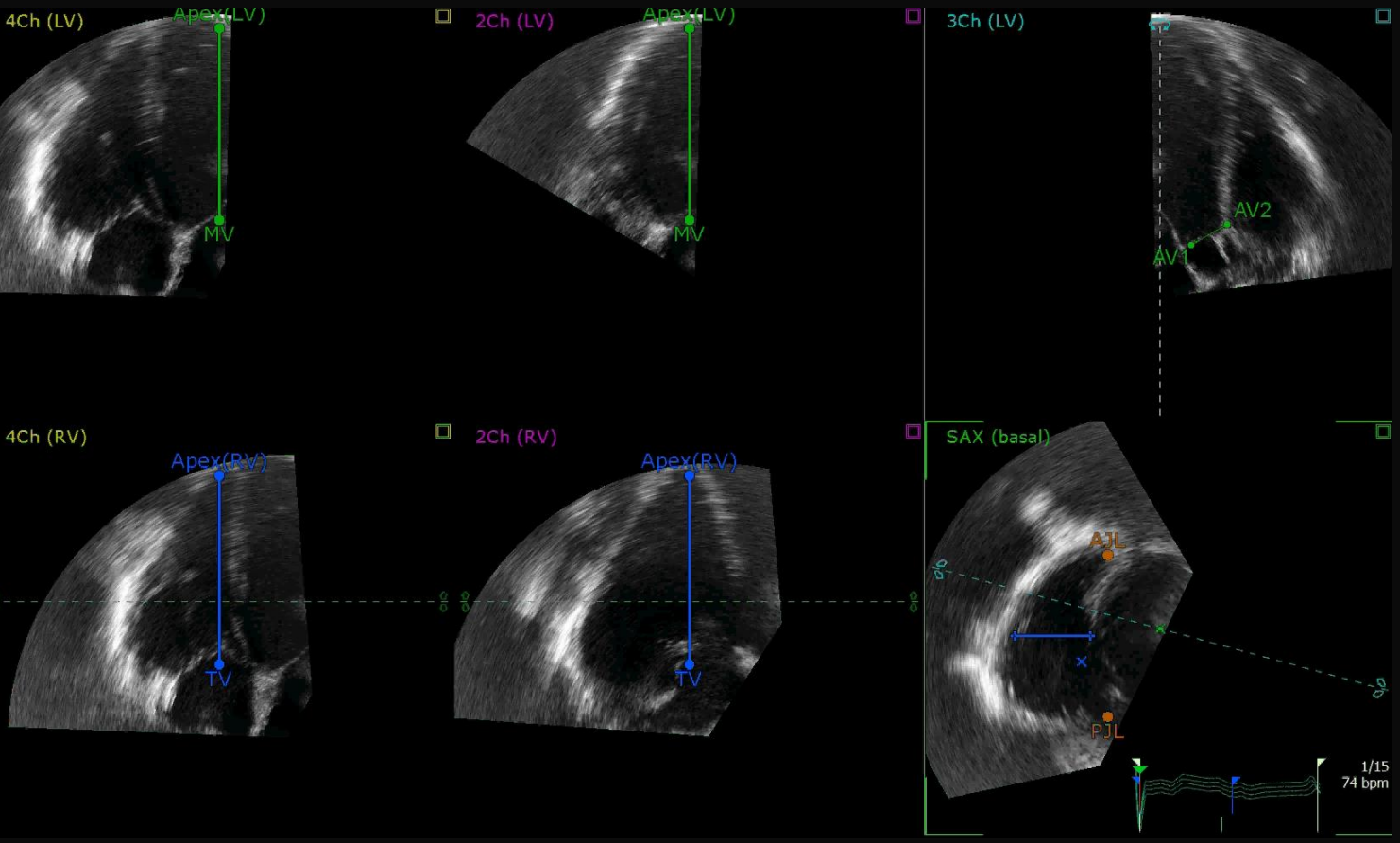
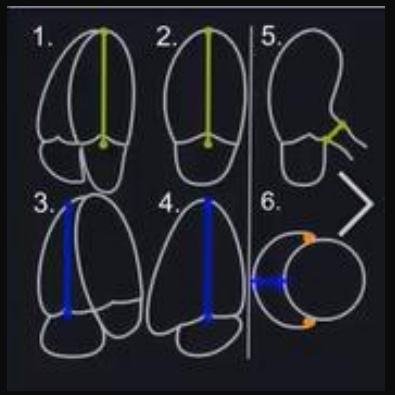




CMR RV disfunction :
EDVi > 129ml, ESVi>58ml,
EF<48%


4Ch (LV)
Apex(LV)
MV
2Ch (LV)
Apex(LV)
MV
3Ch (LV)
AV2
AV1
4Ch (RV)
Apex(RV)
TV
2Ch (RV)
Apex(RV)
TV
SAX (basal)
AJL
PJL
1/15
74 bpm


1.
2.
5.
3.
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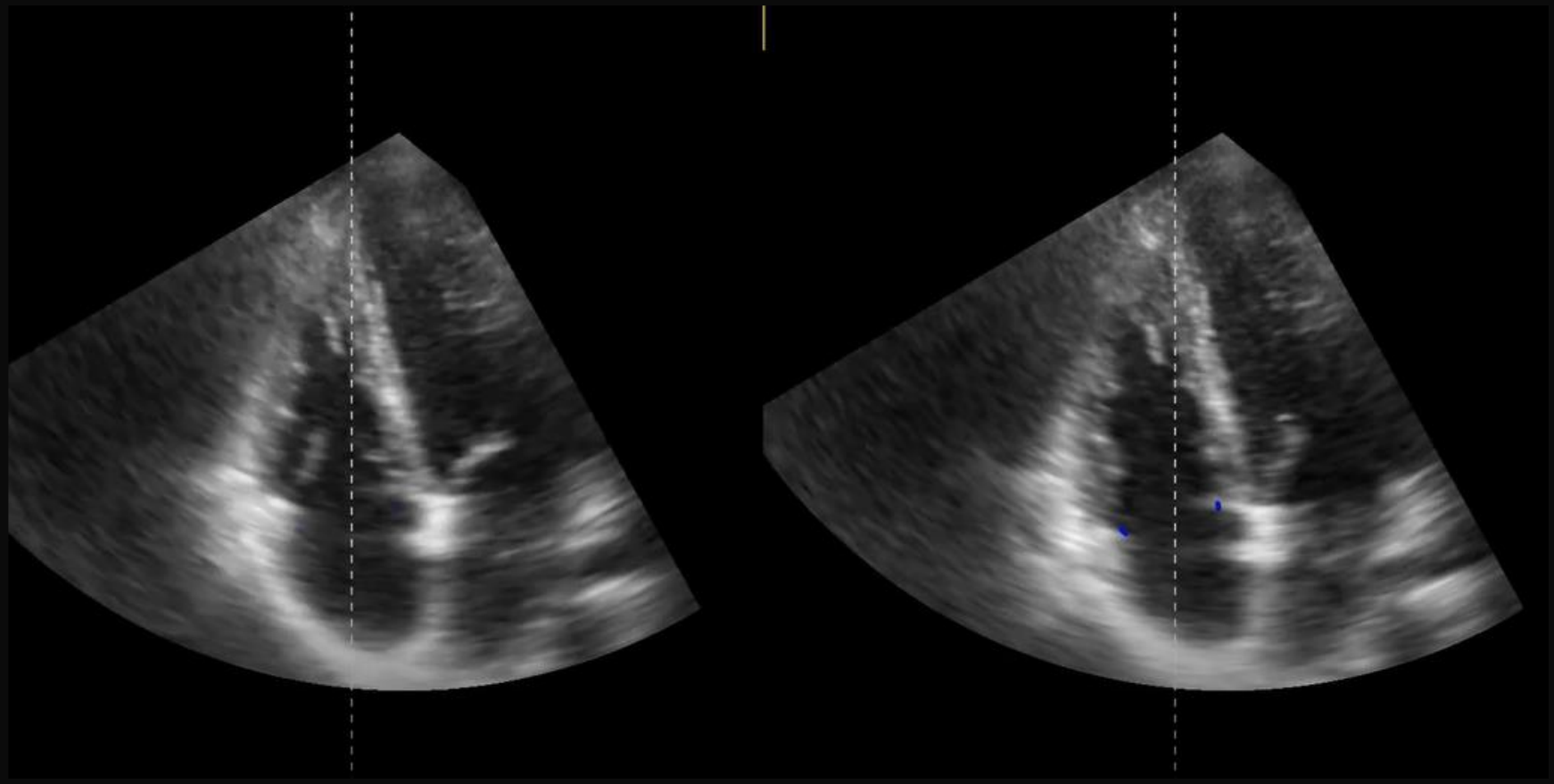
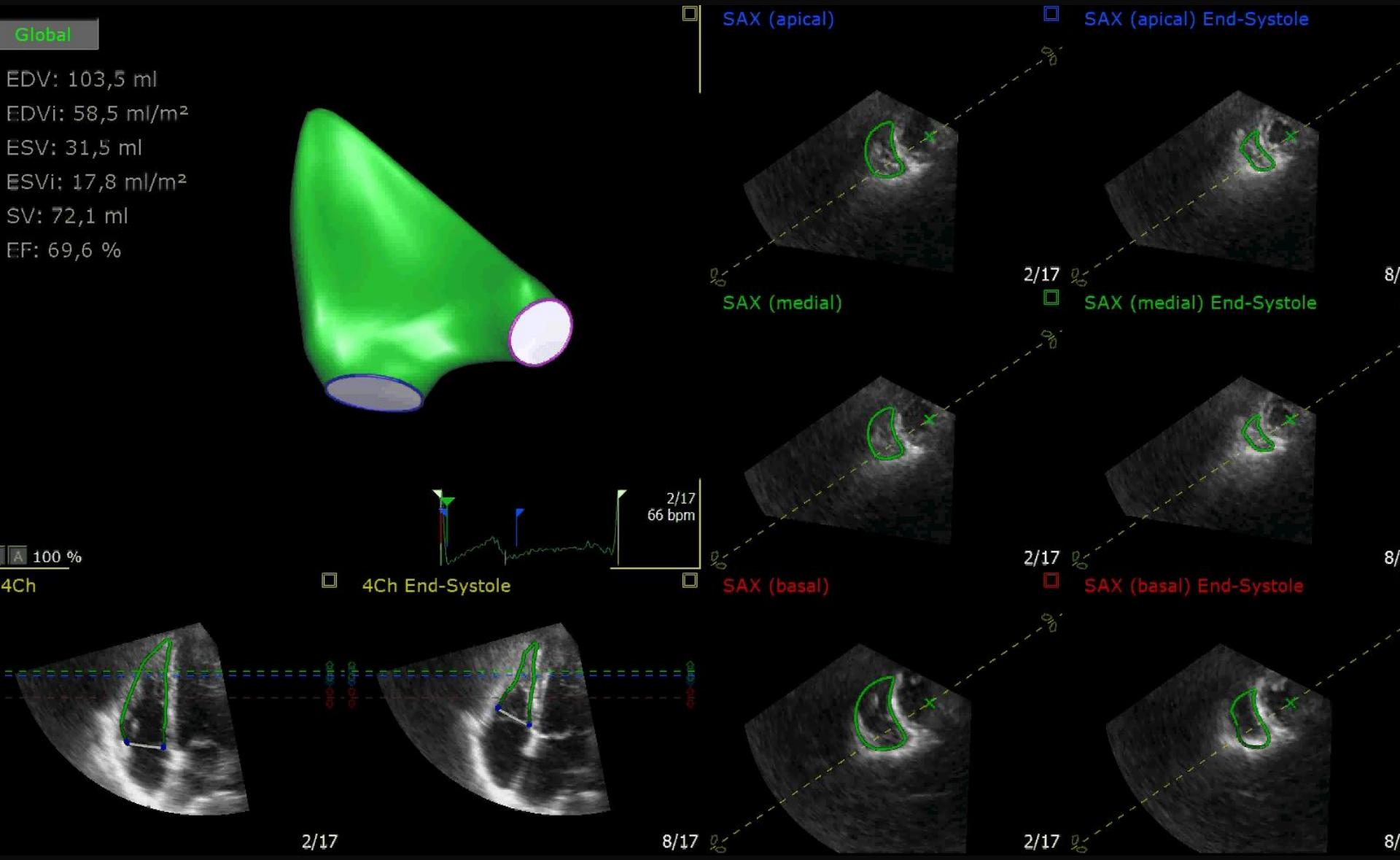
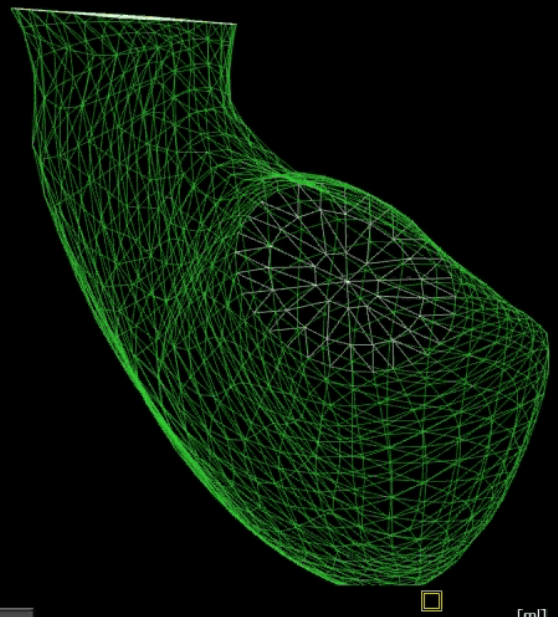
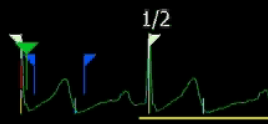
6.



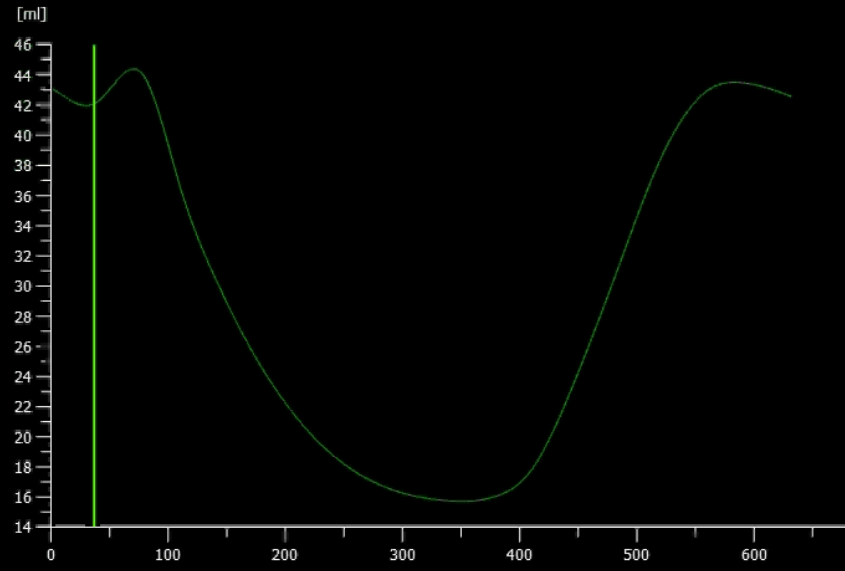

Global
EDV: 103,5 ml
EDVi: 58,5 ml/m²
ESV: 31,5 ml
ESVi: 17,8 ml/m²
SV: 72,1 ml
EF: 69,6 %
SAX (apical)
SAX (apical) End-Systole
2/17
SAX (medial)
SAX (medial) End-Systole
2/17
66 bpm
100 %
4Ch
4Ch End-Systole
SAX (basal)
SAX (basal) End-Systole
2/17
8/17
2/17
2/17



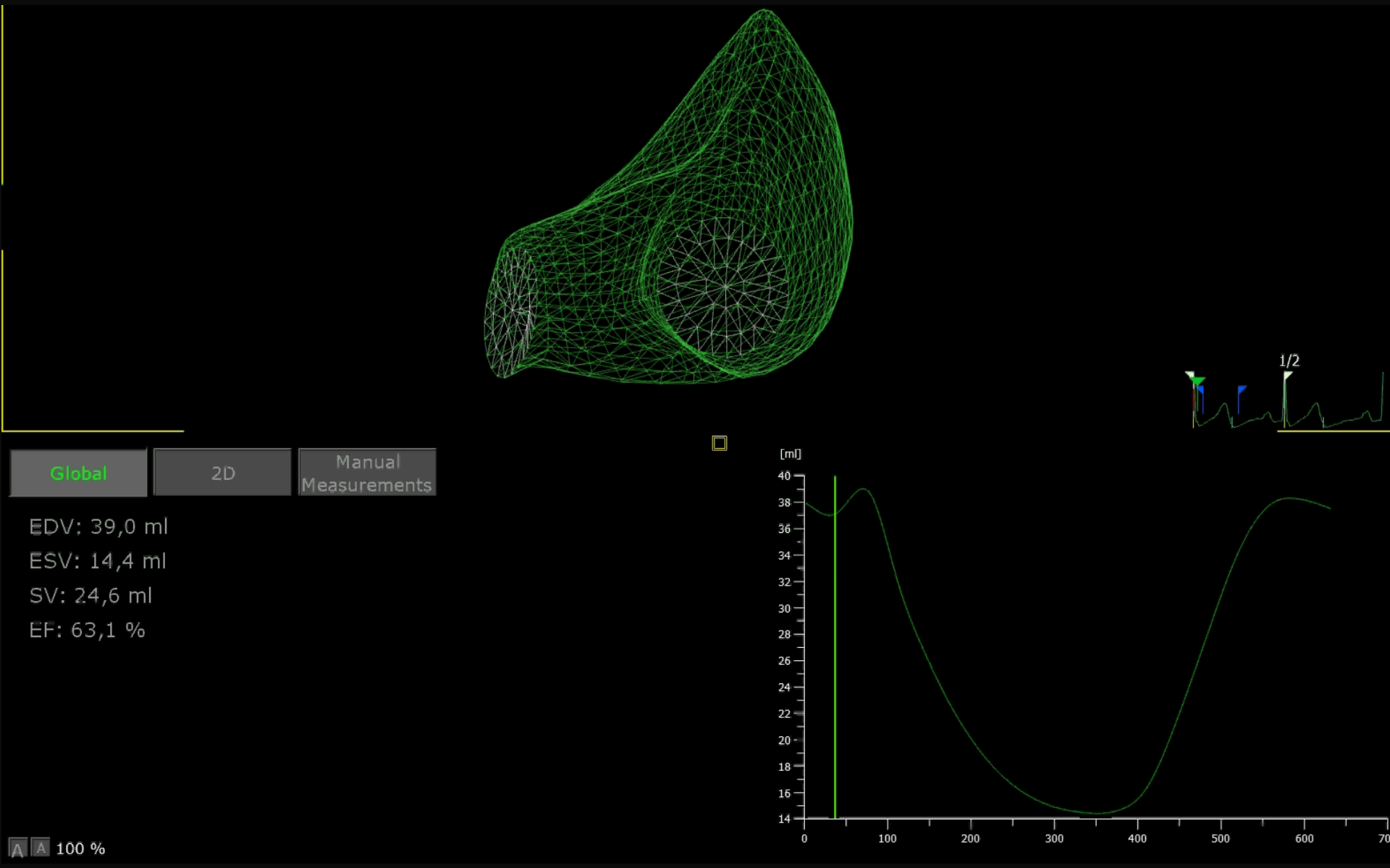


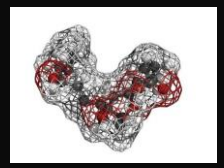
Global | 2D | Manual Measurements

EDV: 44,4 ml
ESV: 15,7 ml
SV: 28,7 ml
EF: 64,6 %



100 %


1/2
Global
2D
Manual Measurements
EDV: 39,0 ml
ESV: 14,4 ml
SV: 24,6 ml
EF: 63,1 %
[ml]
40
38
36
34
32
30
28
26
24
22
20
18
16
14
0
100
200
300
400
500
600
700
100 %




PHILIPS
06/06/2018 16:33:56 TIS0.6 MI 1.1
24/01/1949 MONVIN24011949 OO.RR. CARDIOLOGIA X3-1/Adulti
FR 75Hz
15cm
Exam (06/06/2016, 69 y)


PHILIPS
06/06/2018 16:34:04 TIS0.6 MI 1.1
24/01/1949 MONVIN24011949 X3-1/Adulti
FR 75Hz
15cm
Exam (06/06/2016, 69 y)


PHILIPS
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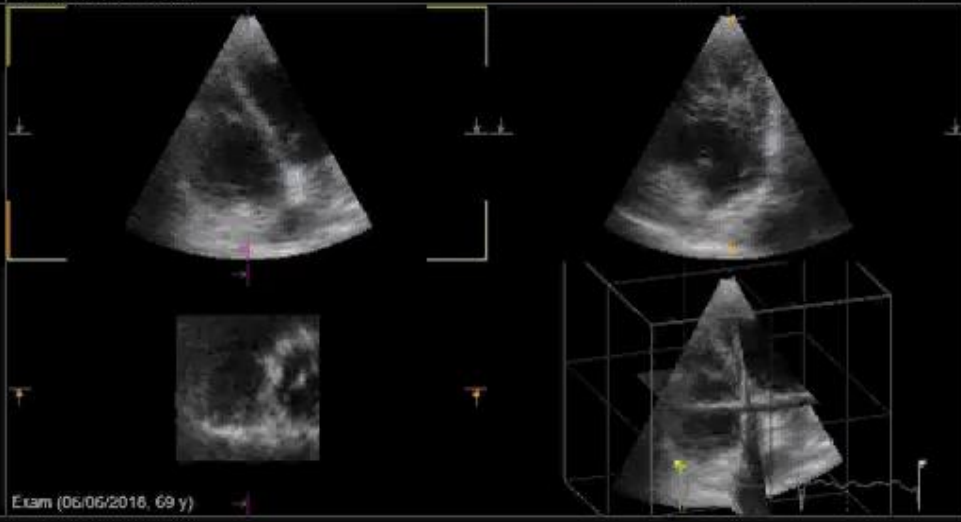
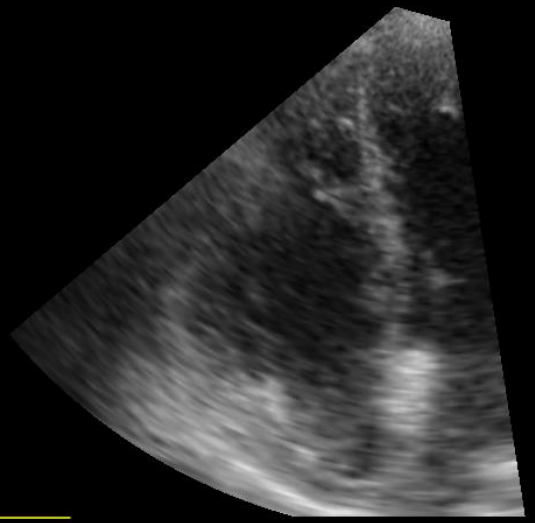
24/01/1949 MONVIN24011949 X3-1/Adulti
FR 49Hz
15cm
Exam (06/06/2016, 69 y)

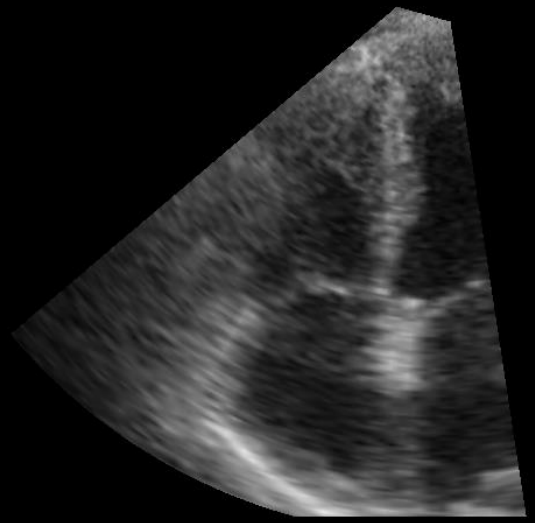

Exam (06/06/2016, 69 y)

4Ch End-Diastole



20/39

4Ch End-Systole



9/39

Global | 2D | Manual Measurements

RVDd base (RVD1): 28,5 mm
RVDd mid (RVD2): 28,1 mm
RVLd (RVD3): 58,1 mm
TAPSE: 11,0 mm
FAC: 37,8 %
RVLS (Septum): -9,8 %
RVLS (Freewall): -23,1 %

A A 100 %

Echocardiographic probability of pulmonary hypertension in symptomatic patients with a suspicion of pulmonary hypertension according with PTRV & additional signs

Peak tricuspid regurgitation velocity (m/s)	Presence of other echo "PH signs"	Echocardiographic probability of pulmonary hypertension
≤2.8 or not measurable	No	Low
≤2.8 or not measurable	Yes	Intermediate
2.9–3.4	No	
2.9–3.4	Yes	High
>3.4	Not required	

A: The ventricles	B: Pulmonary artery	C: Inferior vena cava and right atrium
Right ventricle/ left ventricle basal diameter ratio >1.0.	Right ventricular outlflow Doppler acceleration time <105 m/sec and/or midsystolic notching.	Inferior cava diameter >21 mm with decreased inspiratory collapse (<50 %with a sniff or <20 %with quiet inspiration).
Flattening of the interventricular septum (left ventricular eccentricity index >1.1 in systole and/or diastole).	Early diastolic pulmonary regurgitation velocity >2.2 m/sec.	Right atrial area (end-systole) >18 cm^2.
	PA diameter >25 mm..	

www.escardio.org

European Heart Journal 2016:37;67–119 -doi:10.1093/eurheartj/ehv317
European Respiratory Journal 2015 46: 903-975;

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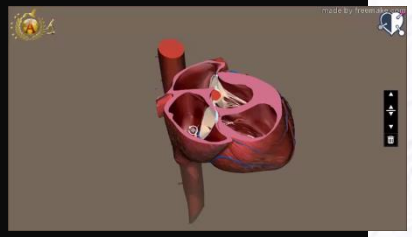
M.V. y 72 PAH , female



M.V. y 72 PAH , female

Efficacy of drug monotherapy, for PAH (Group 1)

Recommendations			Class - Level					
Measure/treatment			WHO-FC II		WHO-FC III		WHO-FC IV	
Calcium channel blockers			I	C	I	C	-	-
Endothelin receptor antagonists	Ambrisentan		I	A	I	A	IIb	C
	Bosentan		I	A	I	A	IIb	C
	Macitentan[d]		I	B	I	B	IIb	C
Phosphodiesterase type-5 inhibitors	Sildenafil		I	A	I	A	IIb	C
	Tadalafil		I	B	I	B	IIb	C
	Vardenafil*		IIb	B	IIb	B	IIb	C
Guanylate cyclase stimulators	Riociguat		I	B	I	B	IIb	C
Prostanoids	Epoprostenol	intravenous[d]	-	-	I	A	I	A
	Iloprost	Inhaled	-	-	I	B	IIb	C
		Intravenous*	-	-	IIa	C	IIb	C
	Treprostinil	subcutaneous	-	-	I	B	IIb	C
		Inhaled*	-	-	I	B	IIb	C
		Intravenous[e]	-	-	IIa	C	IIb	C
		Oral*	-	-	IIb	B	-	-
	Beraprost*		-	-	IIb	B	-	-
IP-receptor agonists	Selexipag (oral)*		I	B	I	B	-	-

[c]Only in responders to acute vasoreactivity tests: Class I for idiopathic PAH, heritable PAH and PAH due to drugs; Class IIa for APAH conditions. - [d]Time to clinical worsening as primary end-point in RCTs or drugs with demonstratedreduction in all-cause mortality. - [e]In patients not tolerating the subcutaneous form.
*This drug is not approved by the EMA at the time of publication of these guidelines.

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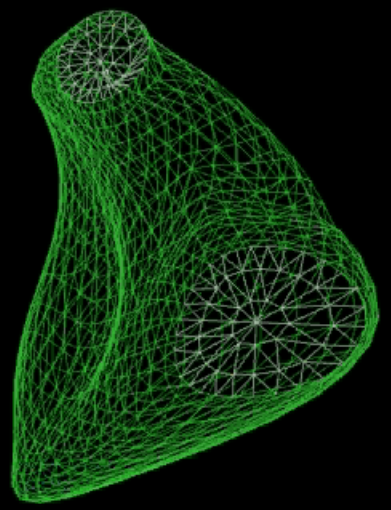
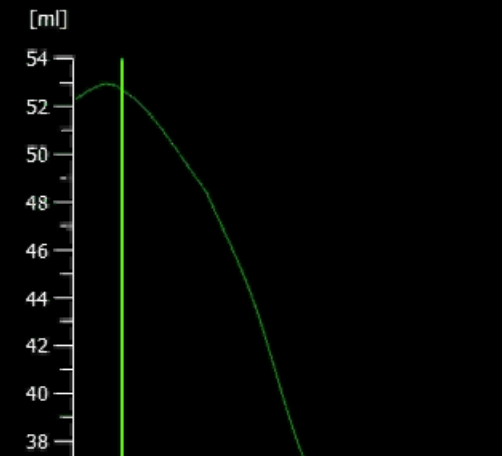
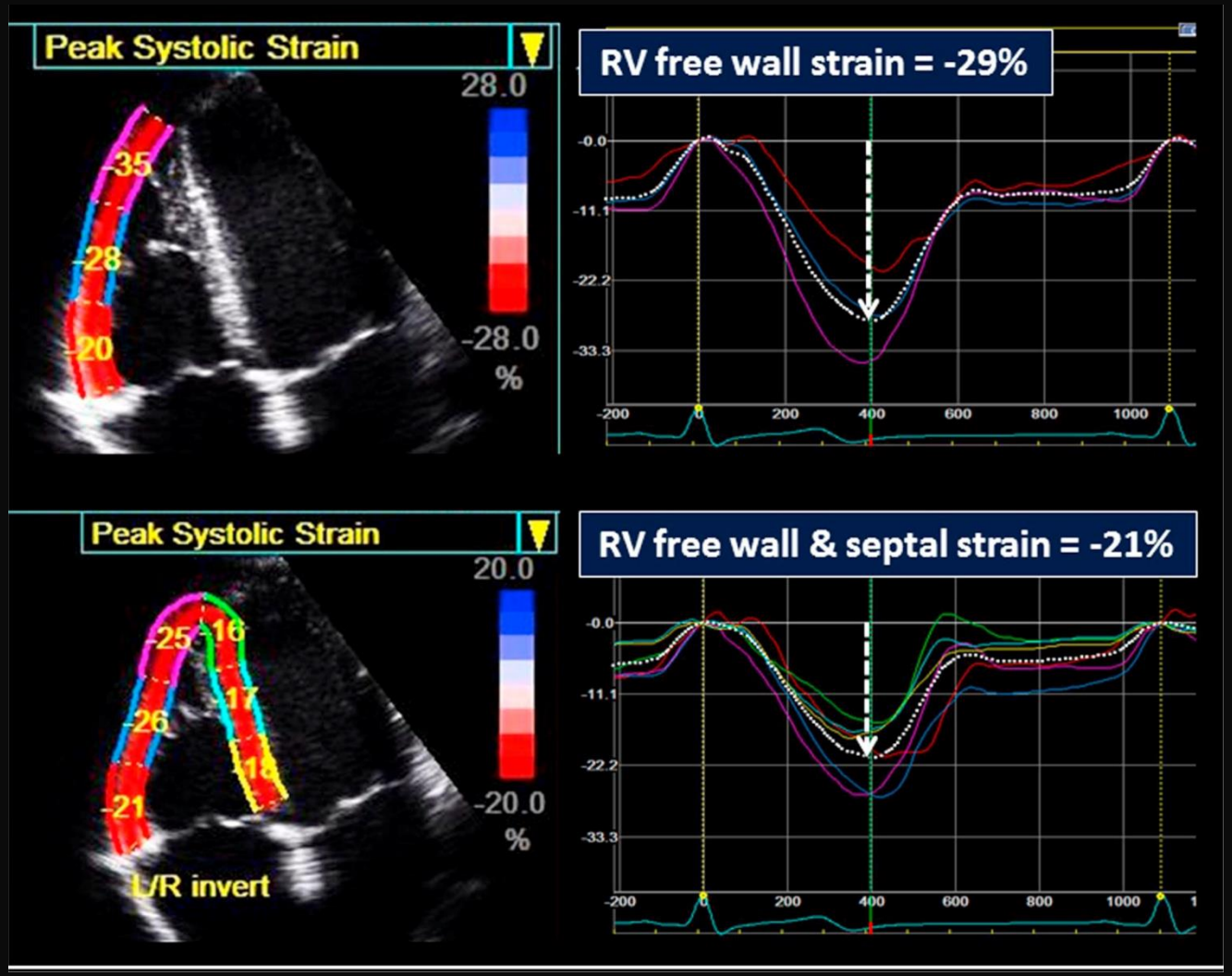


Global | 2D | Manual Measurements

EDV: 53,5 ml
ESV: 29,6 ml
SV: 23,9 ml
EF: 44,7 %

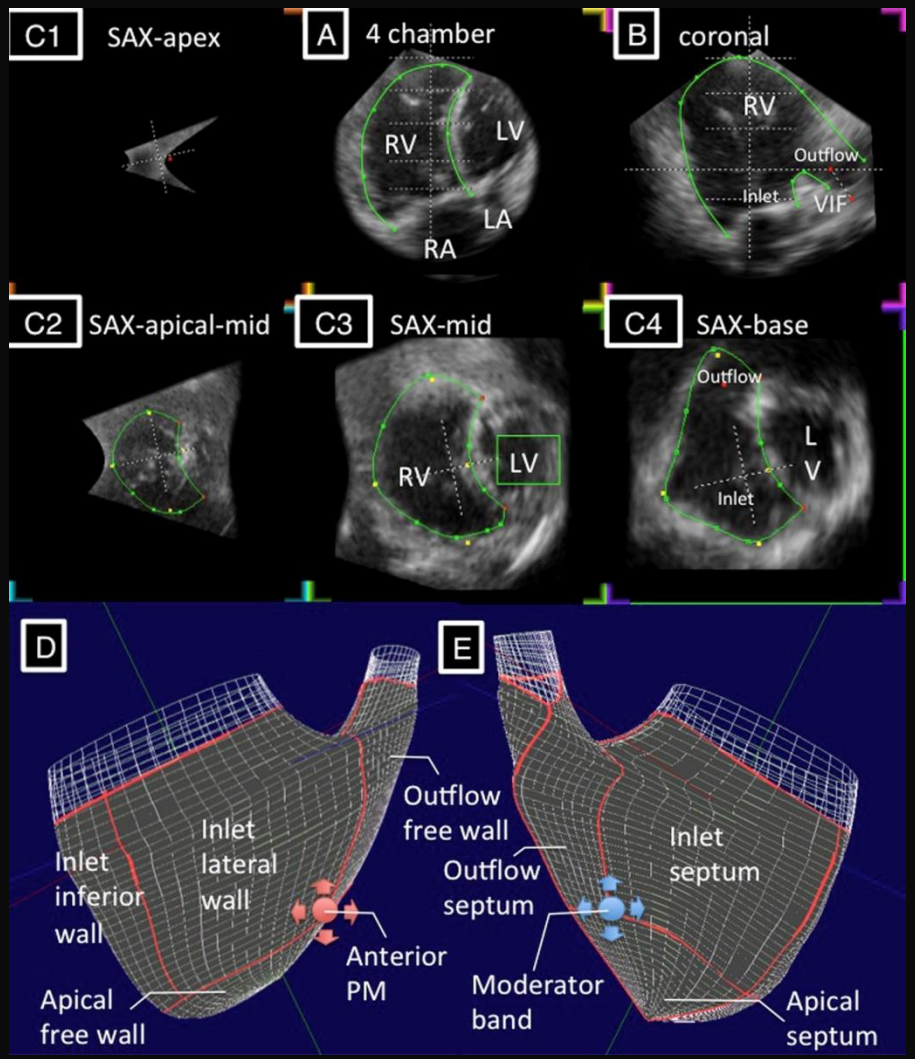




Lang R, JASE 2015

“Global and Regional Right Ventricular Function Assessed by Novel Three-Dimensional Speckle-Tracking Echocardiography ”

Tomoko Ishizu, MD, PhD, JAS , December 2017



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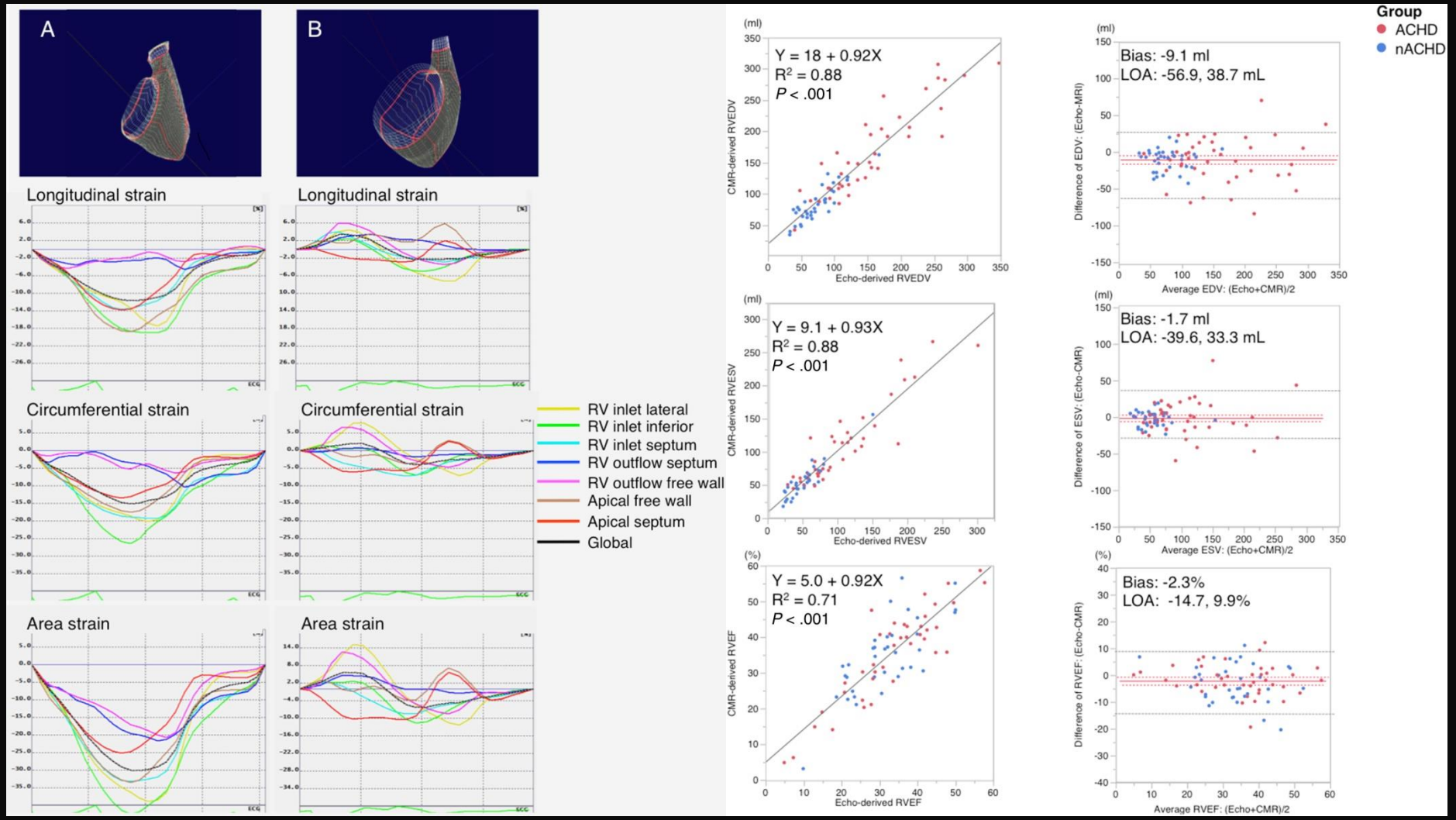
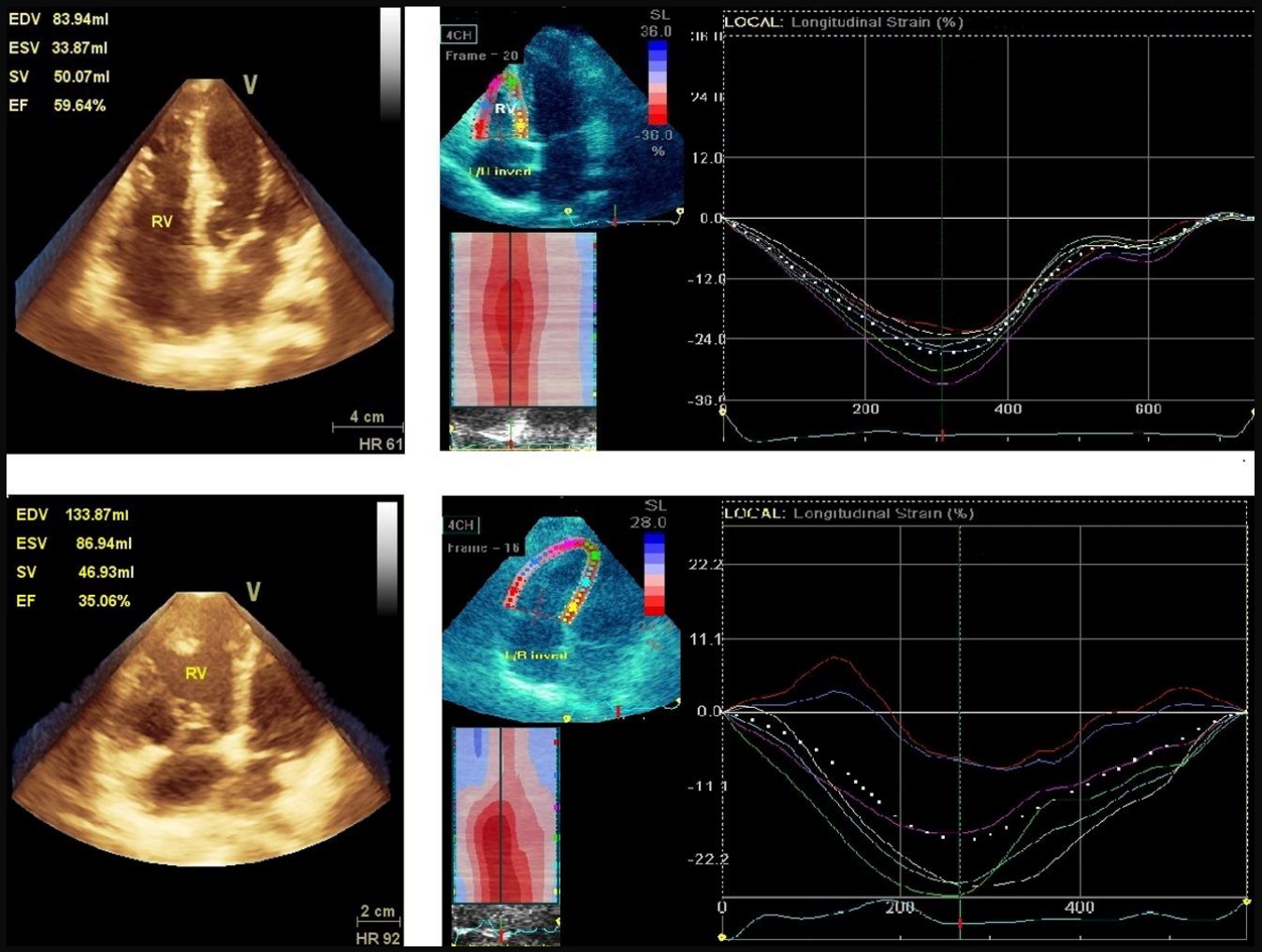


“Right Ventricular Function in Acute Pulmonary Embolism: A Combined Assessment by Three-Dimensional and Speckle-Tracking Echocardiography”

Antonio Vitarelli, MD, FACC, JASE , March 2014



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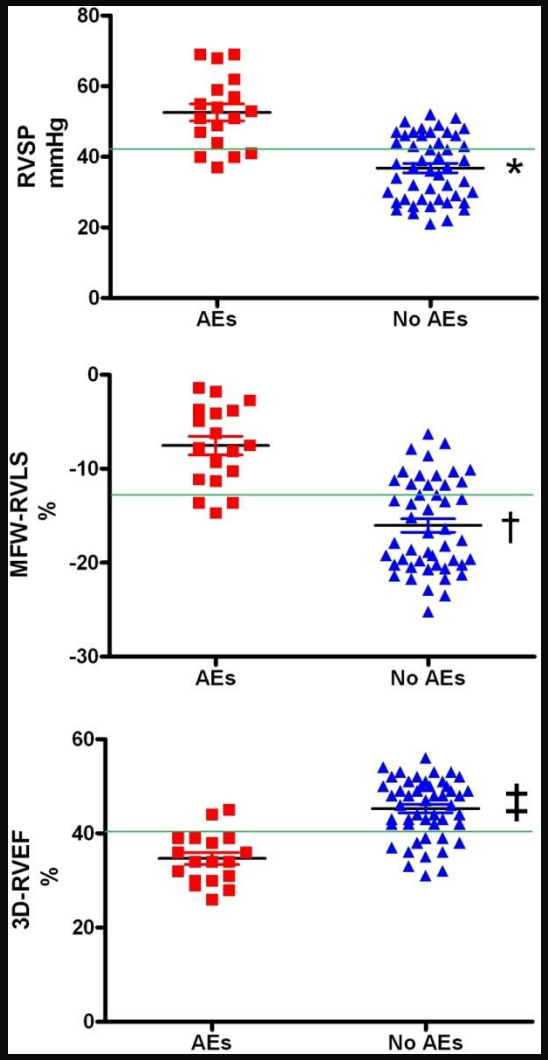


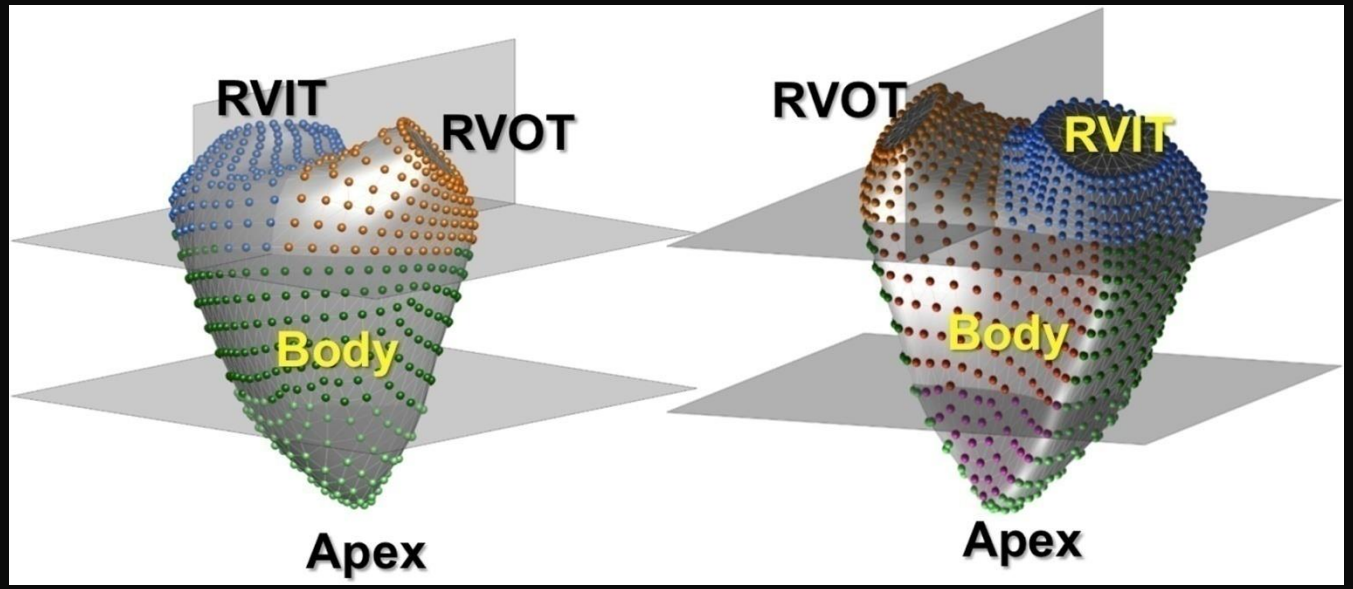
Table 2 Baseline echocardiographic parameters in patients with PE and controls

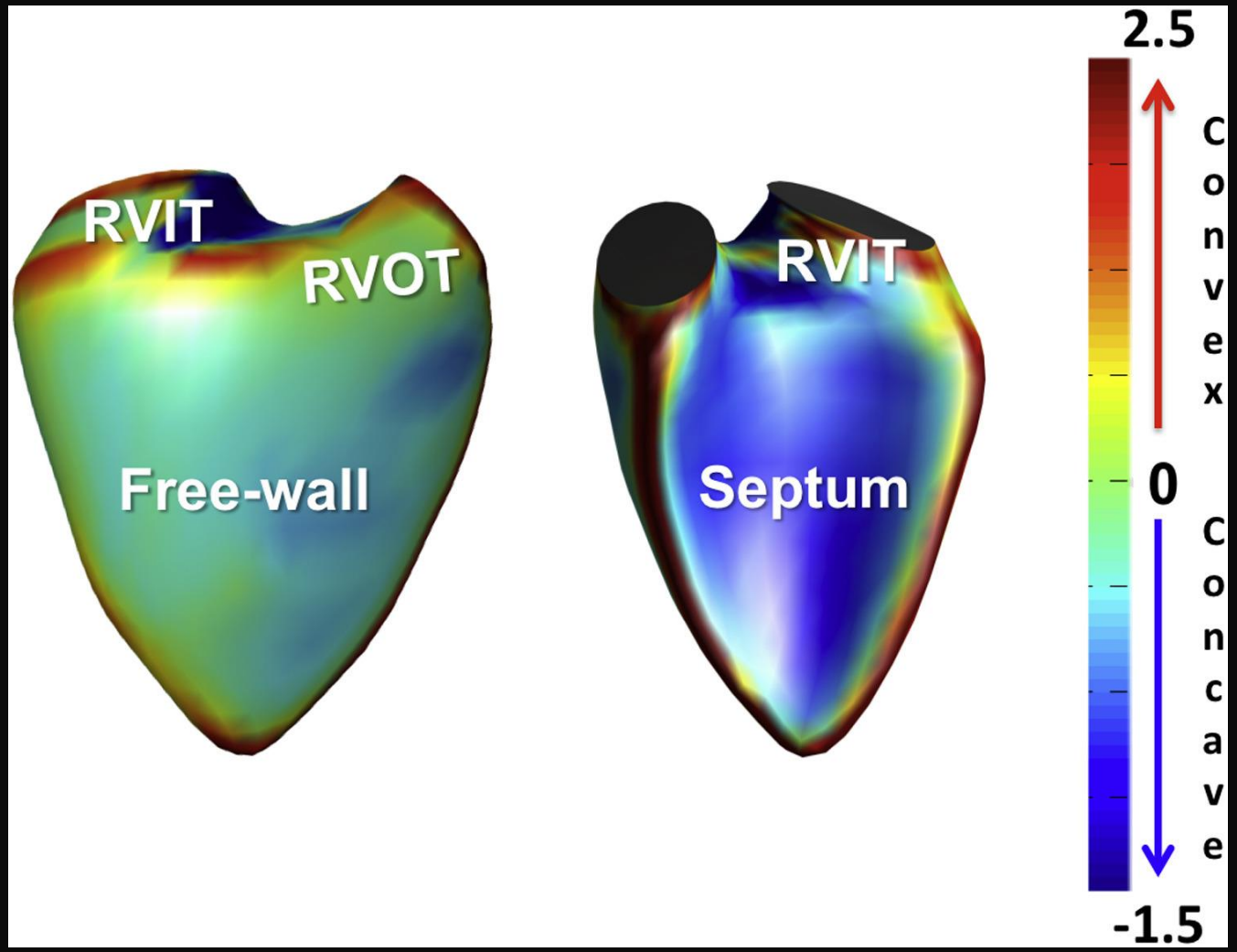
Variable	Patients with PE (n = 66)	Controls (n = 66)	P
RVEDA (cm^2)	30 ± 3	17 ± 5	.037
RVESA (cm^2)	20 ± 4	9 ± 4	.046
RVFAC (%)	32 ± 11	49 ± 13	.031
RV/LV ratio	1.23 ± 0.27	0.69 ± 0.16	.036
TAPSE (mm)	15 ± 4	23 ± 4	.024
RV MPI	0.56 ± 0.11	0.26 ± 0.06	.032
TV S_a (cm/sec)	7.2 ± 3.1	12.7 ± 2.5	.039
MS	35 (53%)	0	—
RVSP (mm Hg)	53 ± 14	23 ± 3	.011
PVR (Wood units)	3.9 ± 1.8	1.3 ± 0.5	.049
PAT (msec)	64.2 ± 11.7	126.2 ± 24.4	.032
3D RVEDV (mL)	197 ± 51	80 ± 16	.004
3D RVESV (mL)	119 ± 29	35 ± 7	.002
3D RVEF (%)	37 ± 8	56 ± 8	<.001
RV dyssynchrony (STE) (msec)	97 ± 34	24 ± 15	.041
Global RVLS (STE) (%)	−17.2 ± 4.5	−24.3 ± 3.8	.026
AFW RVLS (STE) (%)	−15.6 ± 5.8	−21.5 ± 4.3	.043
MFW RVLS (STE) (%)	−8.2 ± 6.6	−25.7 ± 4.2	<.001
BFW RVLS (STE) (%)	−19.1 ± 7.5	−26.5 ± 4.4	.019

“Morphologic Analysis of the Normal Right Ventricle Using Three-Dimensional Echocardiography–Derived Curvature Indices ”

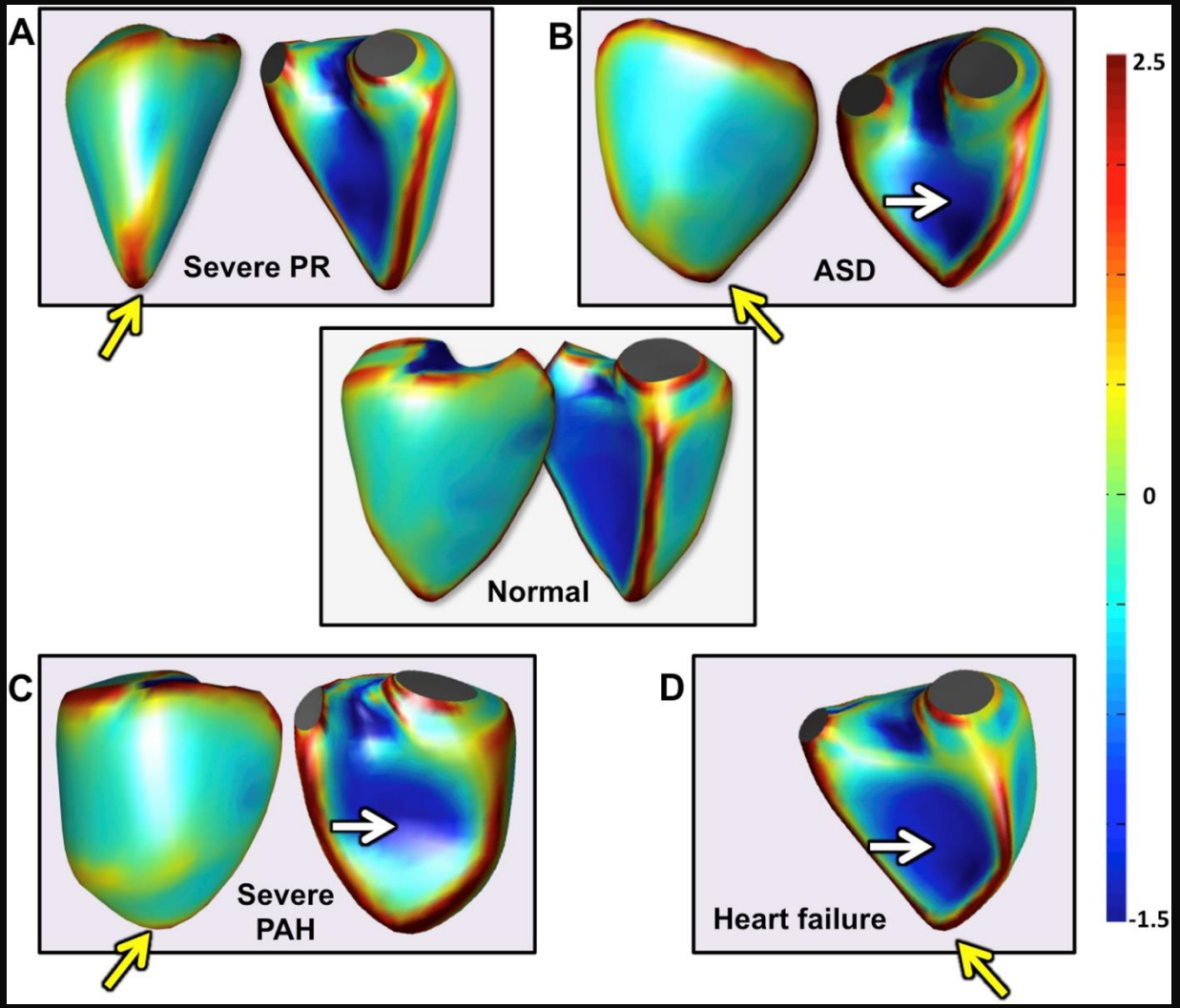
Karima Addetia, MD, Francesco Maffessanti, PhD, Denisa Muraru, MD, PhD, Amita Singh, MD, Elena Surkova, MD, Victor Mor-Avi, PhD, Luigi P. Badano, MD, PhD, Roberto M. Lang, MD

Journal of the American Society of Echocardiography
Volume 31, Issue 5, Pages 614-623 (May 2018)
DOI: 10.1016/j.echo.2017.12.009





Karima Addetia MD, JASE May 2018



Karima Addetia MD, JASE May 2018


Grazie !!!

Università degli Studi di Foggia
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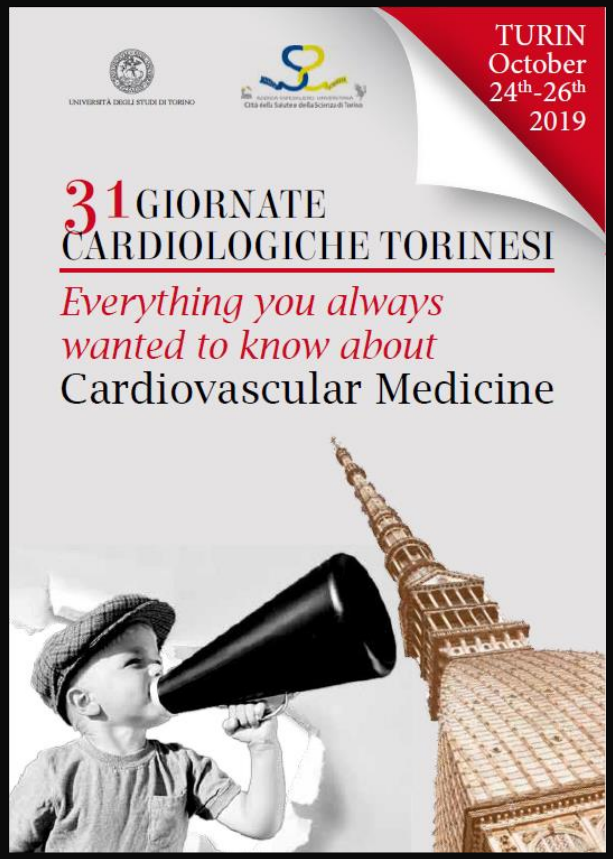
Scuola di Specializzazione in Cardiologia
Dottorato di Ricerca in Cardiologia
Direttore : Prof. N.D. Brunetti



3D-Echocardiographic assestment of the right ventricle in the current era: application in clinical practice

Torino

24-26 Ottobre 2019

Vincenzo Manuppelli