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Added value of 3D Echocardiography in chamber quantitation

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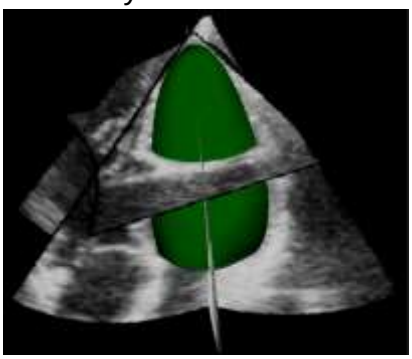
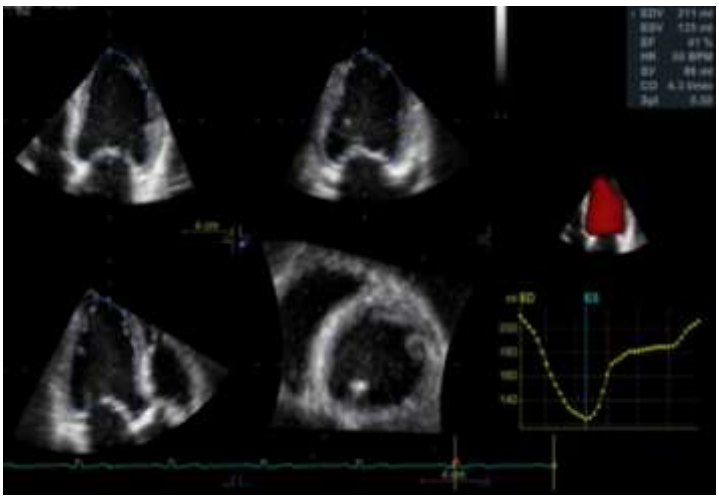
Why 3D Echocardiography Makes the Difference?

- No geometric assumptions about chamber's shape/morphology
- Allows to ***measure***, not ***calculate*** using mathematical formulas
- Volumetric analysis is not affected by foreshortening or off-axis views

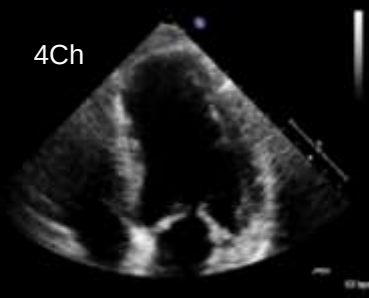
LEFT VENTRICLE

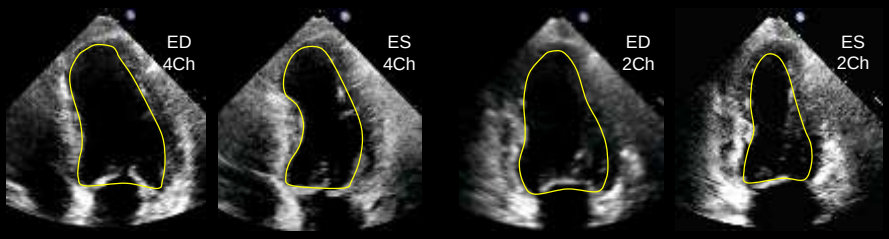
- 3DE provides more accurate and reproducible assessment of LV volumes and EF than 2DE
- Closely correlates to CMR





CASE #1 LV systolic function?

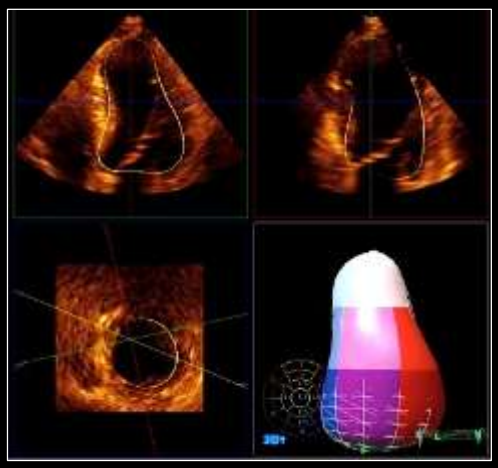




2D Simpson:

- EDV 112 ml
- ESV 55 ml
- EF 51%

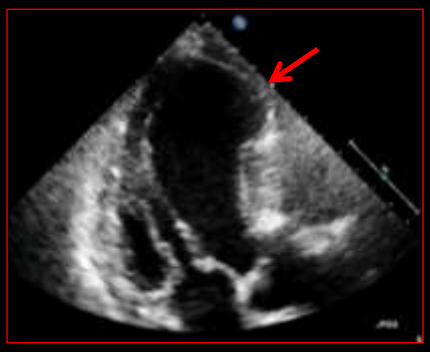
CASE #1 LV systolic function?



Courtesy of Prof. L. Badano

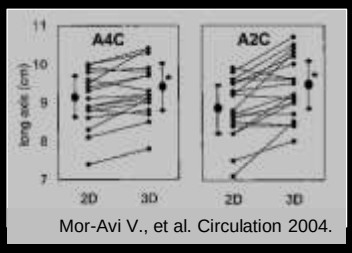
3D:

- EDV 126 ml
- ESV 70 ml
- EF 44%

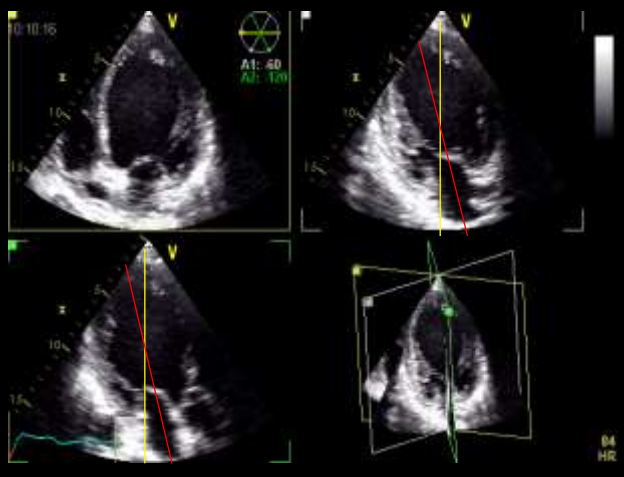


- 3DE takes into account contribution of all LV walls in the ejection fraction

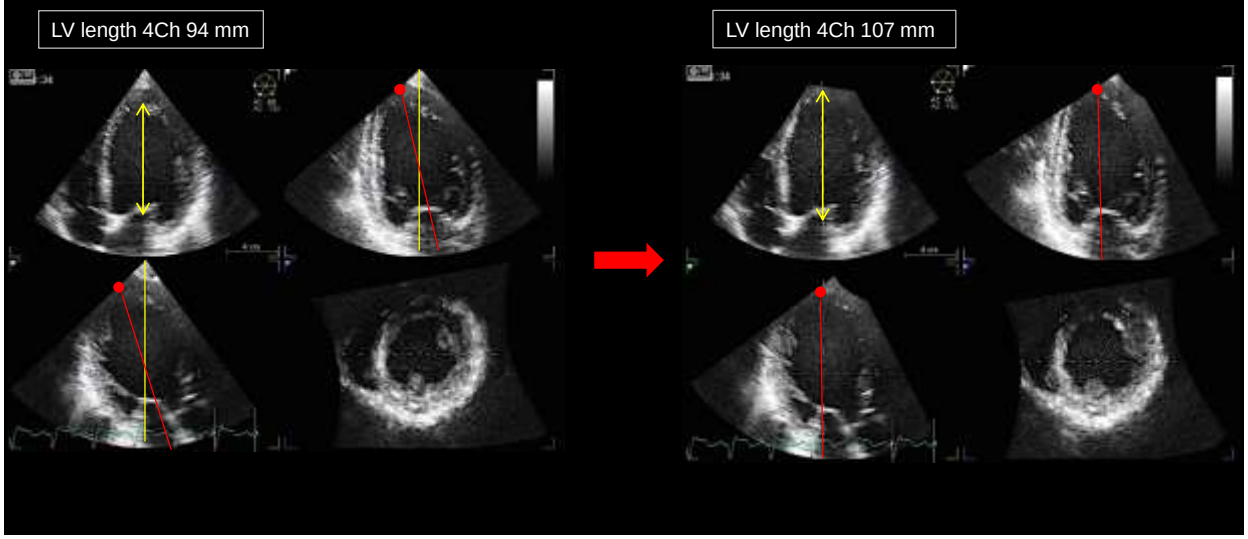
• Avoiding LV foreshortening



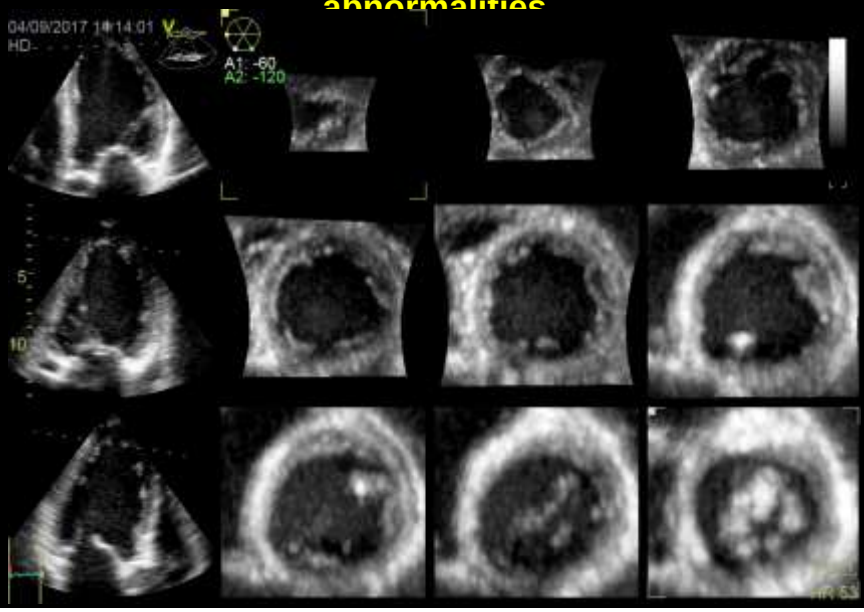
Mor-Avi V., et al. Circulation 2004.



- **Avoiding LV foreshortening**



- **Assessment of LV regional wall motion abnormalities**



Added value of 3DE in LV quantification

Advantages	• Comprehensive quantitation of LV volumes, EF, sphericity, and assessment of RWMAs from a single full-volume dataset • No geometric assumptions about LV shape • Re-aligning planes on 3D data sets eliminates foreshortening
Established clinical indications	• Measurement of LV volumes • Calculation of LV EF
Who benefits most	• Patients with extensive wall motion abnormalities • Patients with abnormal LV shape

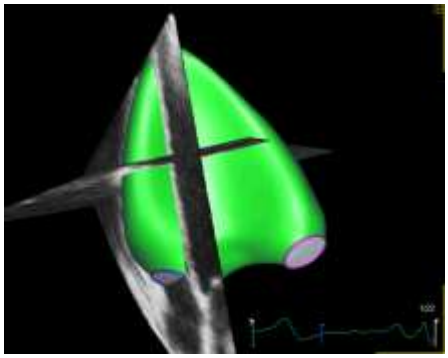
Recommendation. LV size should be routinely assessed on 2DE by calculating volumes using the biplane method of disks summation technique. In laboratories with experience in 3DE, 3D measurement and reporting of LV volumes is recommended when feasible depending on image quality. When reporting LV

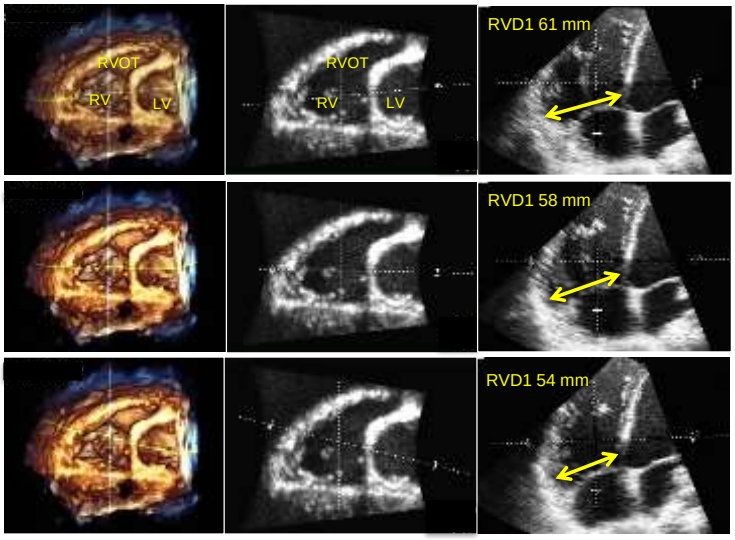
Use method-specific reference values!

Abnormality threshold	2DE	3DE
LV EDVi (ml/m^2)		
men	>74	**>79**
women	>61	**>71**
LV ESVi (ml/m^2)		
men	>31	**>32**
women	>24	**>28**
LV EF (%)		
men	<52	<52
women	<54	<54

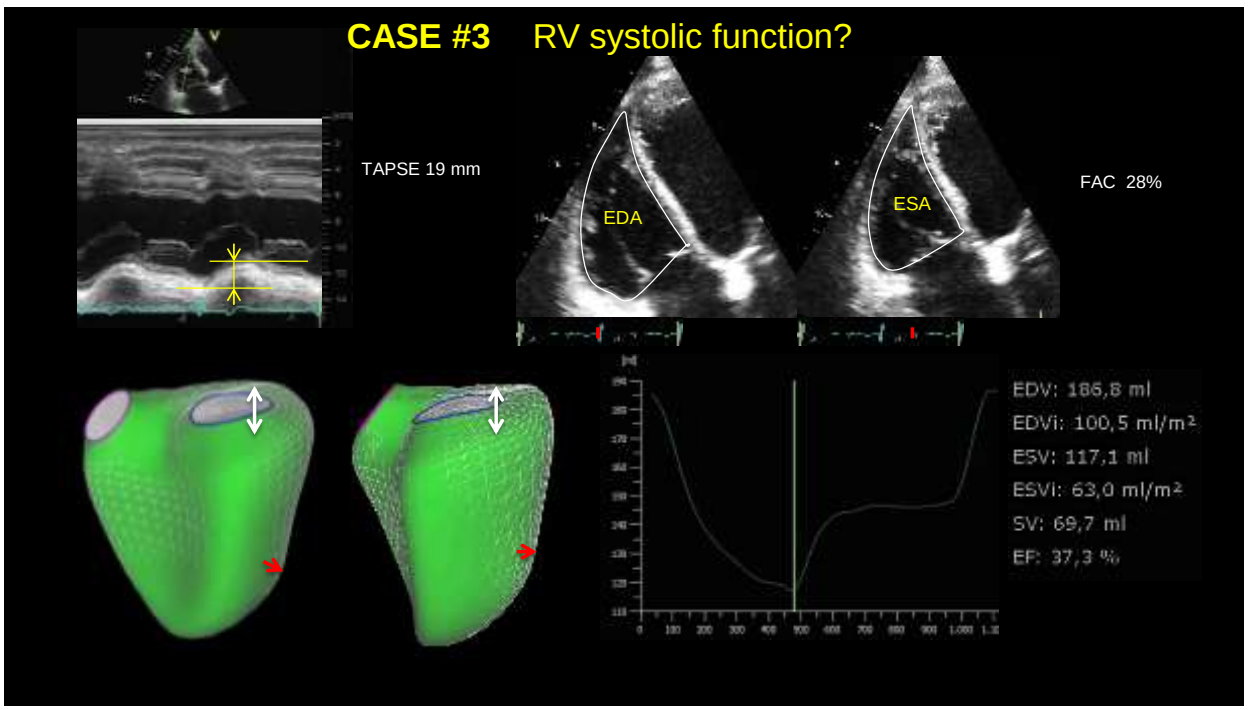
Lang RM, et al.
Recommendations for cardiac chamber quantification
EHJ Cardiovasc Imaging. 2015

RIGHT VENTRICLE

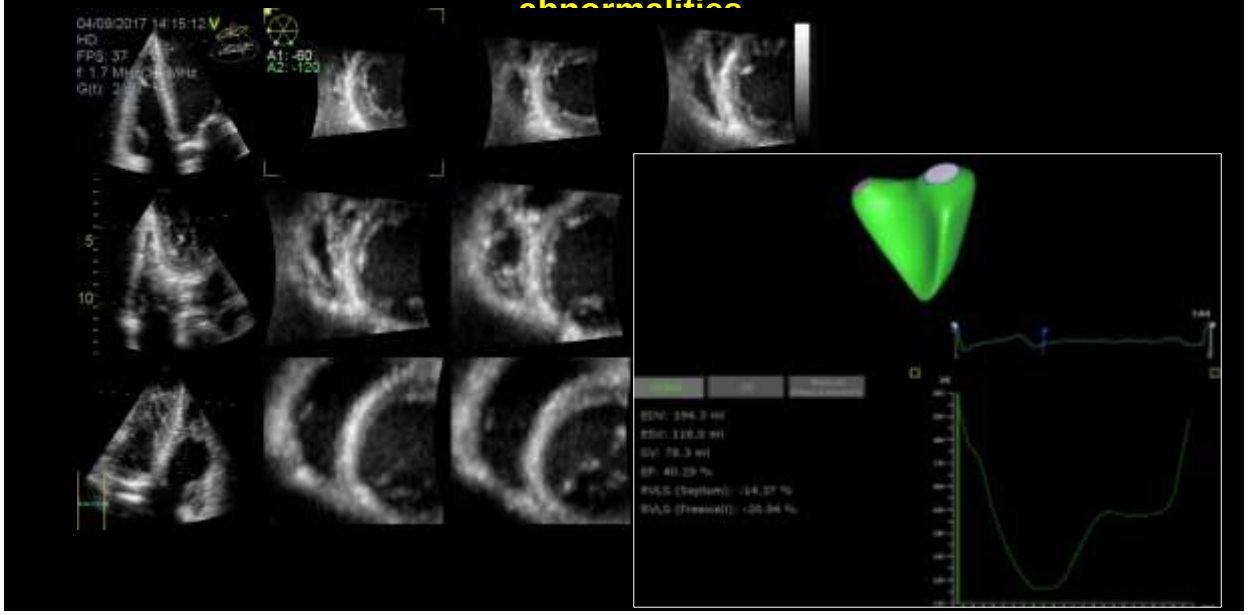




Surkova E, et al.
The use of multimodality imaging to assess right ventricular size and function
Int Journal of Cardiol, 2016



- **Assessment of RV regional wall motion abnormalities**



Added value of 3DE in RV quantification

Advantages	• The ONLY echocardiographic technique permitting quantitation of RV volumes and EF • Incorporates all three components of the RV in a single data set • No geometrical assumptions about RV shape
Established clinical indications	• Measurement of RV volumes • Calculation of RV EF
Who benefits most	• All patients' categories where RV information is clinically/prognostically important (PH, CHD, MI, RV pathology/failure)

Recommendations. RV size should be routinely assessed by conventional 2DE using multiple acoustic windows, and the report should include both qualitative and quantitative parameters. In laboratories with experience in 3DE, when knowledge of RV volumes may be clinically important, 3D measurement of RV volumes is recommended. Although normal 3D echocardiographic values of RV

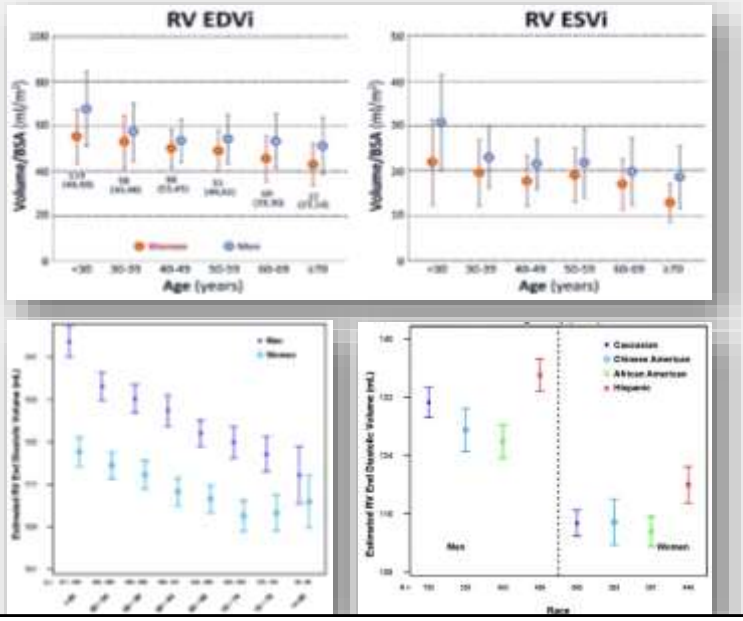
Reference values depend on age, gender and race!

507 healthy volunteers

Maffessanti F, et al. Circulation CV Img 2013

441 healthy volunteers

Kawut SM, et al. Circulation 2011



Reference values

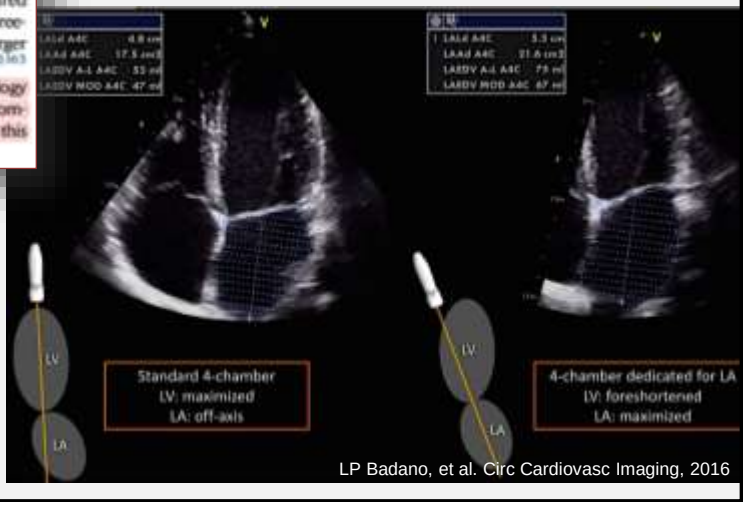
Abnormality threshold	3DE
RV EDVi (ml/m²)	
men	>87
women	>74
RV ESVi (ml/m²)	
men	>44
women	>36
RV EF (%)	<45

Lang RM, et al.
Recommendations for cardiac chamber quantification. EHJ Cardiovasc Imaging, 2015

LEFT and RIGHT ATRIA

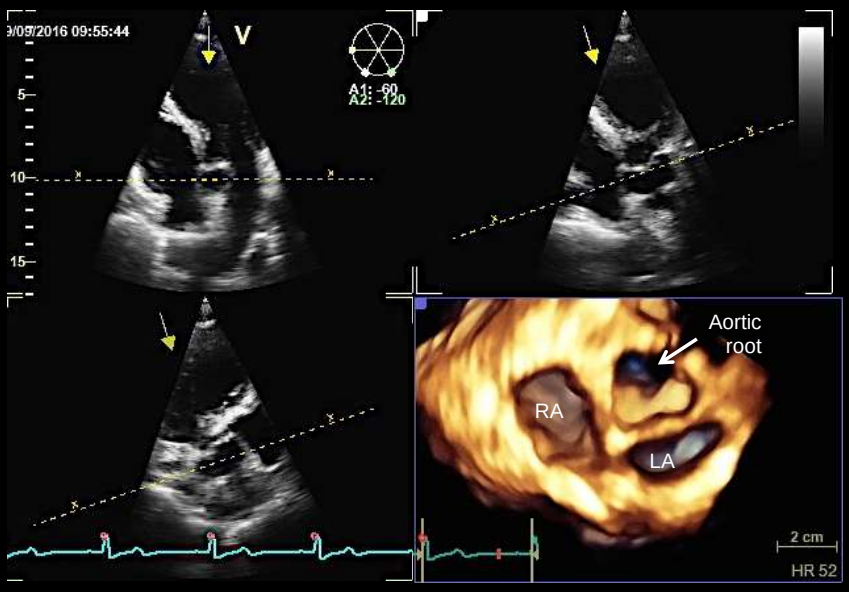
Three-dimensional echocardiography holds promise for assessing LA volume and correlates with cardiac computed tomography[157,158] and magnetic resonance imaging.[159,160] Compared with 2D assessment of LA volume, 3DE is more accurate compared with CMR[159,162] and has superior prognostic ability.[161,162] Three-dimensional echocardiographic LA volumes are typically larger than 2D echocardiographic volumes in most studies.[160,163] Despite these advantages, the lack of a standardized methodology and limited normative data[164] prevent this committee from recommending the use of 3D echocardiographic normal values at this time.

- Biplane method of discs
- Biplane area-length method



LP Badano, et al. Circ Cardiovasc Imaging, 2016

CASE #3 LA size?



Added value of 3DE in quantification of atria

Advantages	• Comprehensive quantitation of maximum, minimum and preA volumes and function from a single dataset • No geometric assumptions about atria shape • Re-aligning planes on 3D data sets eliminates foreshortening
Potential clinical indications	• Measurement of maximum, minimum and preA volumes • Calculation of phasic emptying volumes
Who benefits most	• Patients with non-standard shape of the atria • Patients with difference in 4Ch/2Ch atria length >5 mm

Use method-specific reference values!

276 healthy volunteers

200 healthy volunteers

Table 3. Comparison of Left Atrial Volumes and Function Indices Obtained Using 3DE and 2DE

	3DE		2DE			
	median (p25; p75)	LN	median (p25; p75)	LN	*P*Value*	Δ% (95% CI)
Vmax, mL/m²	32 (28; 36)	43	24 (21; 28)	35	<0.001	26.7 (23.6 to 29.8)
VpreA, mL/m²	18 (14; 21)	31	14 (12; 18)	25	<0.001	21.7 (17.3 to 26.2)
Vmin, mL/m²	10 (8; 12)	18	8 (6; 10)	14	<0.001	29.9 (24.5 to 35.4)
Total EV, mL/m²	21 (18; 24)	13	16 (14; 18)	10	<0.001	26.4 (23.3 to 29.6)
Passive EV, mL/m²	14 (11; 16)	7	10 (7; 12)	4	<0.001	35.9 (31.2 to 40.7)
Active EV, mL/m²	7 (5; 9)	3	7 (5; 8)	3	0.64	9.4 (3.6 to 15.3)
Total EF, %	67 (63; 71)	53	67 (62; 74)	48	0.03	−0.3 (−2.3 to 1.6)
Passive EF, %	44 (38; 49)	24	41 (32; 48)	19	<0.001	9.9 (5.5 to 14.3)
Active EF, %	41 (35; 48)	21	46 (39; 53)	24	0.09	−12.2 (−16.2 to 8.3)

***Badano LP, et al**. Circ Cardiovasc Imaging, 2016*

Table 4 Comparison between 3DE and 2DE parameters of RA size and function

	3DE	2DE	*P*-value	Limit 3D	Limit 2D
V_{max} (mL)	52 ± 15	41 ± 14	<0.0001	78*	69*
V_{min} (mL)	19 ± 8	17 ± 7	<0.0001	36†	33†
V_{preA} (mL)	28 ± 10	27 ± 11	<0.0001	49‡	49‡
Total SV (mL)	33 ± 10	24 ± 9	<0.0001	17§	11§
Passive SV (mL)	24 ± 9	14 ± 7	<0.0001	10§	4§
True SV (mL)	9 ± 4	10 ± 5	0.017	4§	3§
TotEF (%)	63 ± 9	58 ± 9	<0.0001	49§	42§
PassEF (%)	46 ± 11	34 ± 12	<0.0001	24§	14§
True EF (%)	31 ± 8	35 ± 11	<0.0001	18§	17§

***Peluso D, et al**. EHJ Cardiovasc Imaging, 2013*

TAKE-HOME MESSAGES

3D Echocardiography:

- Enables actual 3D acquisition and anatomically guided direct measurements
- Avoids calculations that imply geometrical assumptions
- Validated against CMR
- Reference values are now available for all cardiac chambers
- Has unlimited repeatability
- Cost-effective and safe

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THANK YOU FOR YOUR ATTENTION