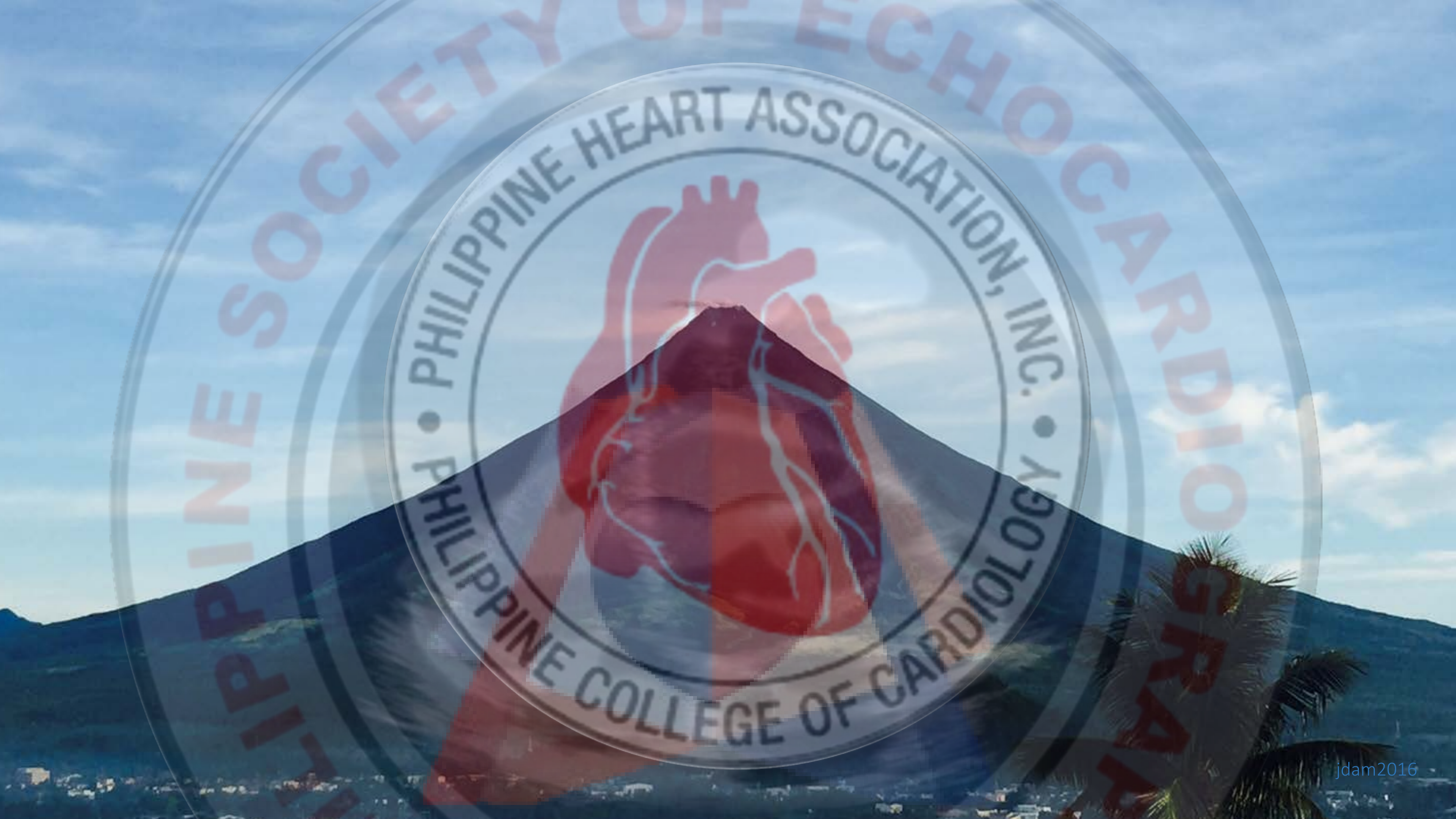
MAYON VOLCANO: FAST FACTS

Type of Volcano: Stratovolcano
Elevation: 2.46 km
Base Diameter: 20 km
Base Circumference: 62.8 km
Area: 314.1 km^2

Reference: http://www.phivolcs.dost.gov.ph/html/update_VMEPD/Volcano/VolcanoList/mayon.htm

jdam2016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ASE
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Sizing up the situation:
Cardiac Chamber Quantification using Echocardiography

Jose Donato A. Magno, MD
Philippine Society of Echocardiography

Session Outline

- Understanding the importance of correct chamber quantification techniques
- Knowing which aspects to quantify: chamber dimensions, parameters of function*
- Mastering the technique of quantification:** image optimization, basic strategies, tips and pitfalls

**Will not include RV assessment (separate session)*
***2015 ASE/EACI Recommendations*

Session Roadmap

Technical Tips

Key Insight

Main Reference

European Heart Journal – Cardiovascular Imaging (2015) **16**, 233–271
doi:10.1093/ehjci/jev014

POSITION PAPER

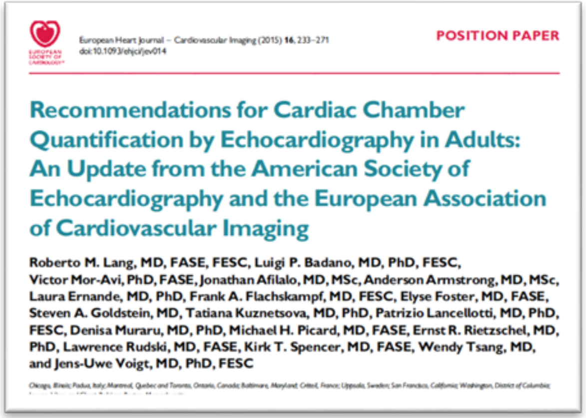
Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

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

Main Reference: why update?

- Rapid flux of technological and methodological advances
- Clamor for “normative values”
- Existence of discrepancies between previous guidelines
- Need for general guidance across centers in the world



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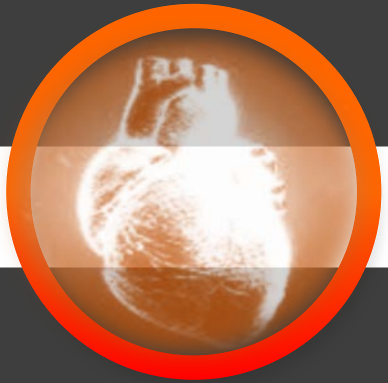
Importance of Chamber Quantification



Why measure?

- Measurements reduce doubt about size conclusions.
- Measurements can be compared objectively.
- Measurements transcend language barriers.

Why measure properly?

- Incorrect measurements lead to incorrect assumptions and conclusions
- Echo reports can greatly affect the end-users' (physician, sonographer, laboratory, patient, community) decisions and behavior
- Harmonized and accurate techniques minimize variability and allow for comparison

Why measure chambers properly?

- Cardiac size is “important” to the lay
- Heart function is crucial to the physician
- Cardiomegaly may be the first clue to pathology
- Chamber size and function reflect hemodynamics and overall cardiac physiology
- Chamber dimensions on echo usually serve as reference standard for basic non-invasive imaging tests (e.g. electrocardiogram, chest radiograph)

Clinical implications of abnormal dimensions

- Left ventricular mass (LVM) can independently predict adverse cardiovascular events and premature death.[1-3]
- LA size is a powerful prognosticator independent of left ventricular systolic dysfunction during stress echo[4] and in patients with preserved ejection fraction[5]
- LV ejection fraction is a powerful predictor of mortality among patients with LV systolic dysfunction.

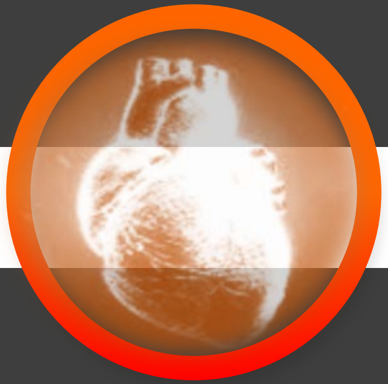
1. Koren MJ et al. Ann Intern Med 1991;114:345-52.
2. Drazner MHet al. J Am Coll Cardiol 2004;43:2207-15.
3. Verma A et al. JACC Cardiovasc Imaging 2008;1:582- 91.
4. Bangalore S et al. J Am Coll Cardiol. 2007 Sep 25;50(13):1254-62.
5. Patel DA, et al. Mayo Clinic Proceedings. 2011;86(8):730-737.

Key Insight

"The quantification of chamber size and function is the cornerstone of cardiac imaging." -- ASE/EACI 2015


Where did my patient go???
STORZ
OXYGEN

Items to measure on echocardiography



What to quantify

- Chamber dimensions
- Global systolic function
- Regional function

- Left ventricle
- Right ventricle
- Atria
- Aortic territory
- Vena cava

What to quantify

LEFT VENTRICLE

- Cavity size: LVEDD, LVEDD indexed to BSA
- Wall thickness: IVSD, PWD, RWT
- Mass: LVM, LVMI
- Volumes: LVEDV, LVESV
- Systolic function: LVEF (biplane Simpson’s)

What to quantify

LEFT ATRIUM

- Length: LA $length_{4C}$, LA $length_{2C}$
- Area: LA $area_{4C}$, LA $area_{2C}$
- Volume: LAV, LAV indexed to BSA

What to quantify

AORTIC ROOT (diamters)

- LV outflow tract (LVOT)
- AV annulus
- Sinus of Valsalva (SOV)
- Sinotubular junction (STJ)
- Prox. Ascending aorta

The debate: thresholds for severity

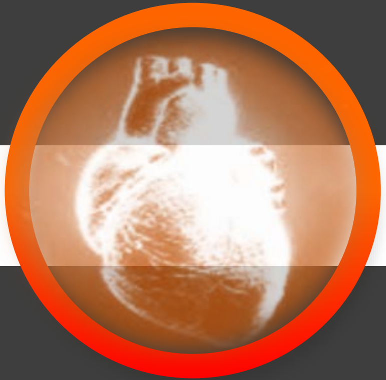
- Partition values for severity of abnormality
- Normative data on classification of severity
- Standard cut-offs

The resolution

- Experience-based partition values only for: LVEF and LA volume

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Correct quantification techniques



General guidelines

- All measurements should be performed on more than 1 cardiac cycle (to account for interbeat variability)
  - e.g. average of 3 beats for sinus, and at least 5 beats for AF
  - However, the use of representative bets is acceptable in the clinical setting
- The same range of normal values generally apply for TTE and TEE, but certain views are more optimal in selected scenarios
- Range of normal values are provided for LV size, function and mass as well as LA volume,
- For other parameters, measurements exceeding +- 1.96 SDs should be classified as abnormal.

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

General guidelines

- Get basic clinical profile to come up with a pre-test analysis.
- Accurately measure the patient's height and weight, and compute the body surface area.
- Check the patient's rhythm and ensure a good ECG tracing.

Left ventricle: Size

Internal linear dimensions

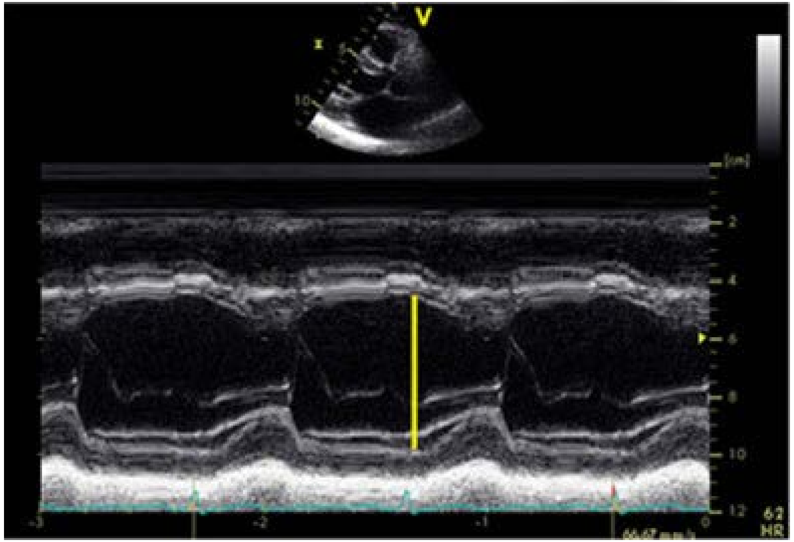
- Linear dimensions are used to provide geometric conclusions about the left ventricle

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle: Size

Internal linear dimensions

- Two methods: M-mode approach and direct 2D measurement
- M-mode approach has high temporal resolution but is prone to tangentiality issues

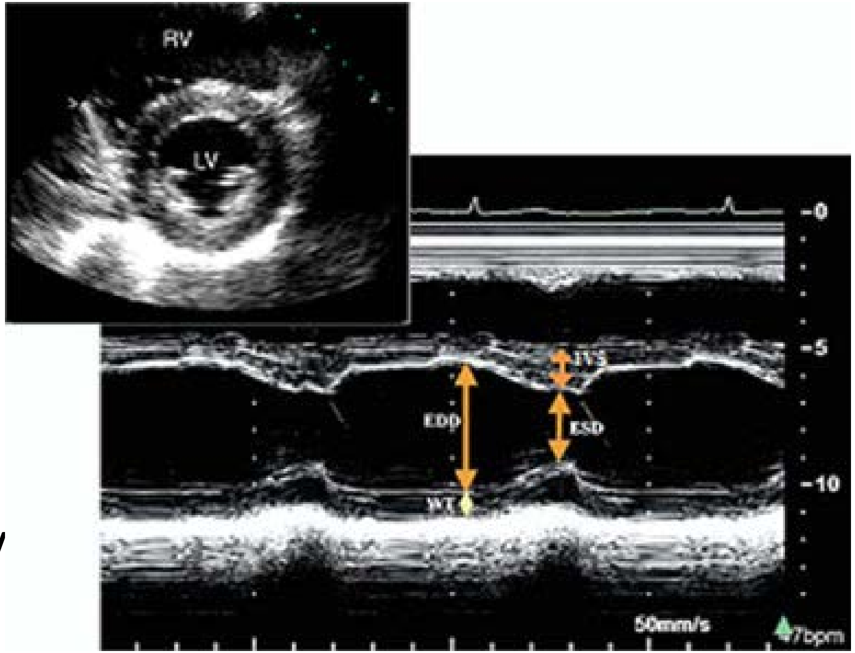


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle: Size

Internal linear dimensions

- M-mode measurements guided by targeted SAX or PLAX view
- Simple for screening large populations
- Beam orientation may be off-axis
- Inaccurate in abnormal LV geometry

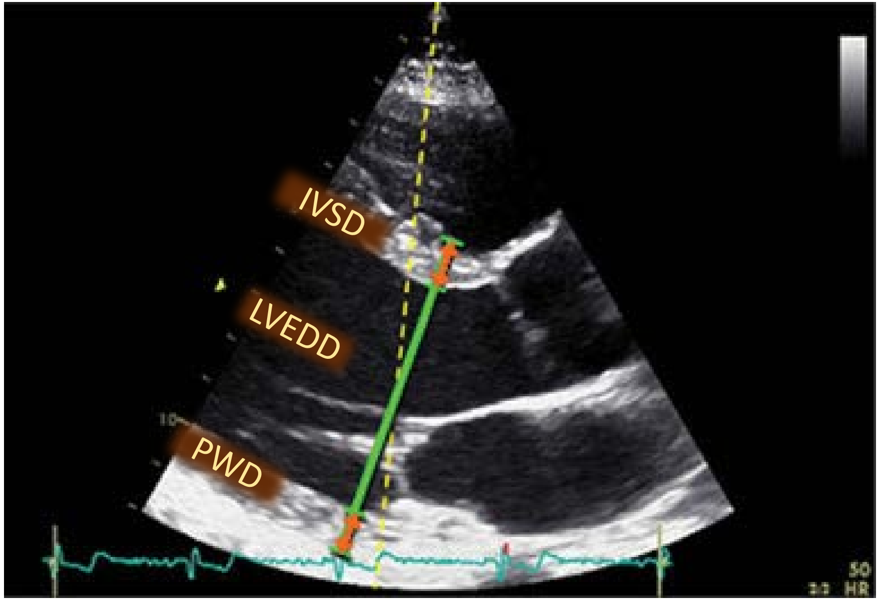


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Internal linear dimensions

- get good 2D PLAX view
- measure LVEDD at end-diastole, when MV leaflets are fully open
- draw caliper perpendicular to long axis of LV, at level of MV leaflet tips
- locate landmarks properly: endocardium-cavity interface



LV internal dimensions: directly measure on 2D PLAX

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

LV mass

- Perform all measurements at end-diastole
- 3 methods
  - Linear or Cube method
  - 2D truncated ellipsoid
  - 3D based formula

Cube formula

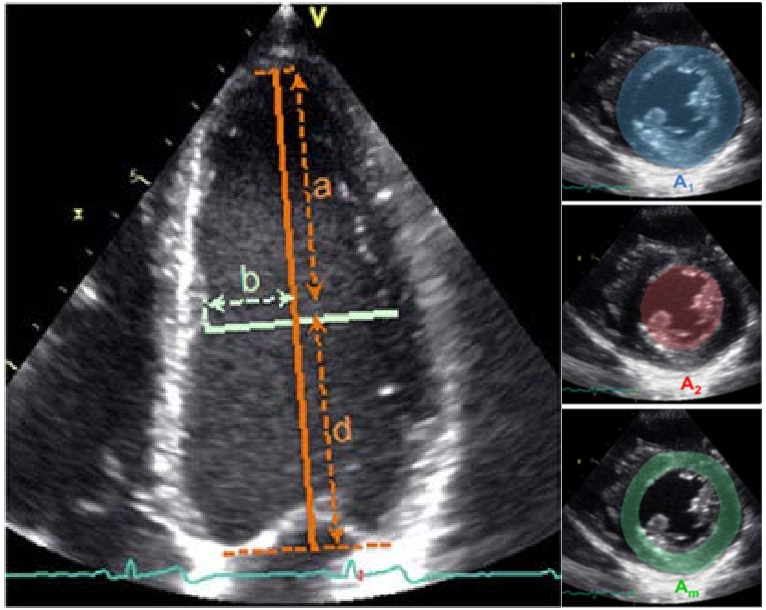
$$\text{LV mass} = 0.8 \cdot 1.04 \cdot [(\text{IVS} + \text{LVID} + \text{PWT})^3 - \text{LVID}^3] + 0.6\ \text{g}$$

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

LV mass

- Perform all measurements at end-diastole
- 3 methods
    - Linear or Cube method
    - 2D truncated ellipsoid
    - 3D based formula



- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

LV mass

- Perform all measurements at end-diastole
- 3 methods
  - Linear or Cube method
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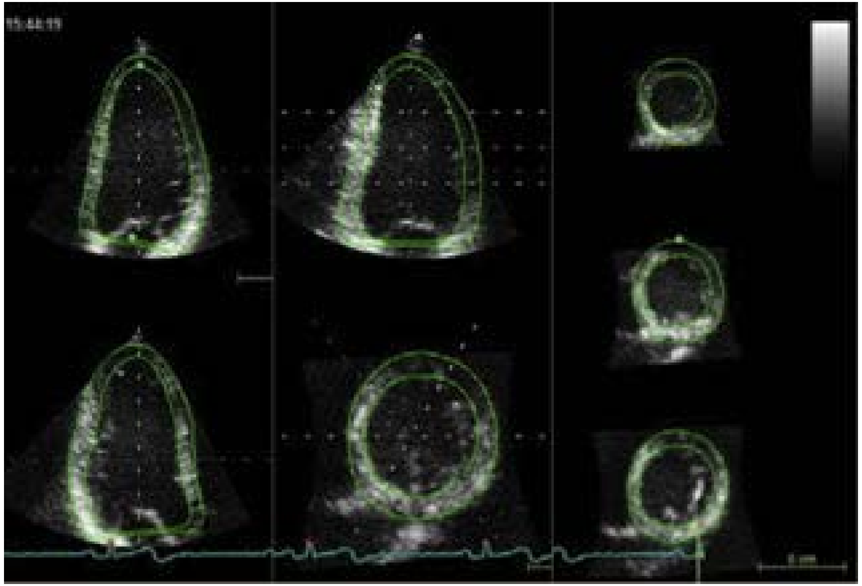


LV mass: 2D-guided, or 3D ideally

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

LV mass index

- Reference values

Normal ranges for LV mass indices

	Women	Men
Linear method		
LV mass (g)	67–162	88–224
LV mass/BSA (g/m^2)	***43–95***	***49–115***
Relative wall thickness (cm)	0.22–0.42	0.24–0.42
Septal thickness (cm)	***0.6–0.9***	***0.6–1.0***
Posterior wall thickness (cm)	***0.6–0.9***	***0.6–1.0***
2D method		
LV mass (g)	66–150	96–200
LV mass/BSA (g/m^2)	***44–88***	***50–102***

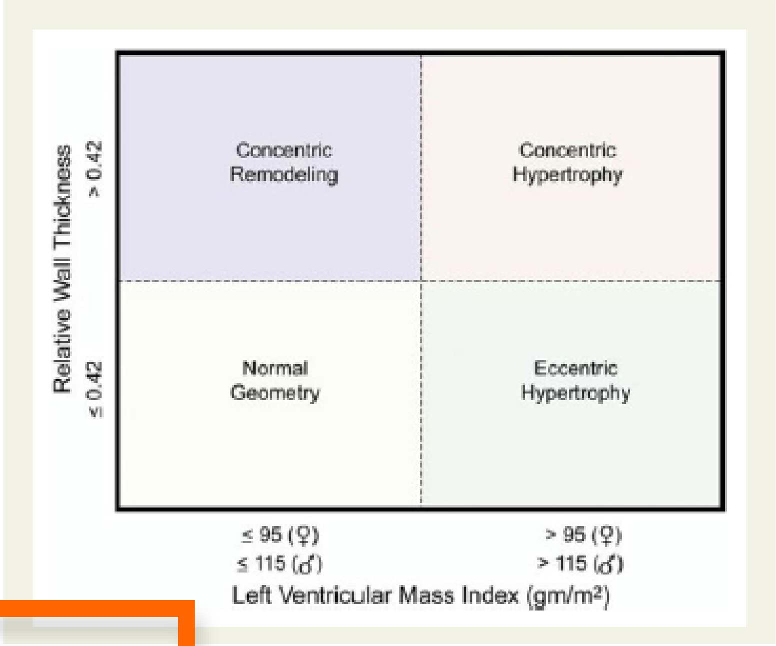
Bold italic values: recommended and best validated.

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

LV geometrical conclusions

- Based on:
    - LVMI
    - RWT
    - sex



LV geometry conclusion is important

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Key Insight

LV linear dimensions provide information regarding geometrical conclusions.

Sample Computations

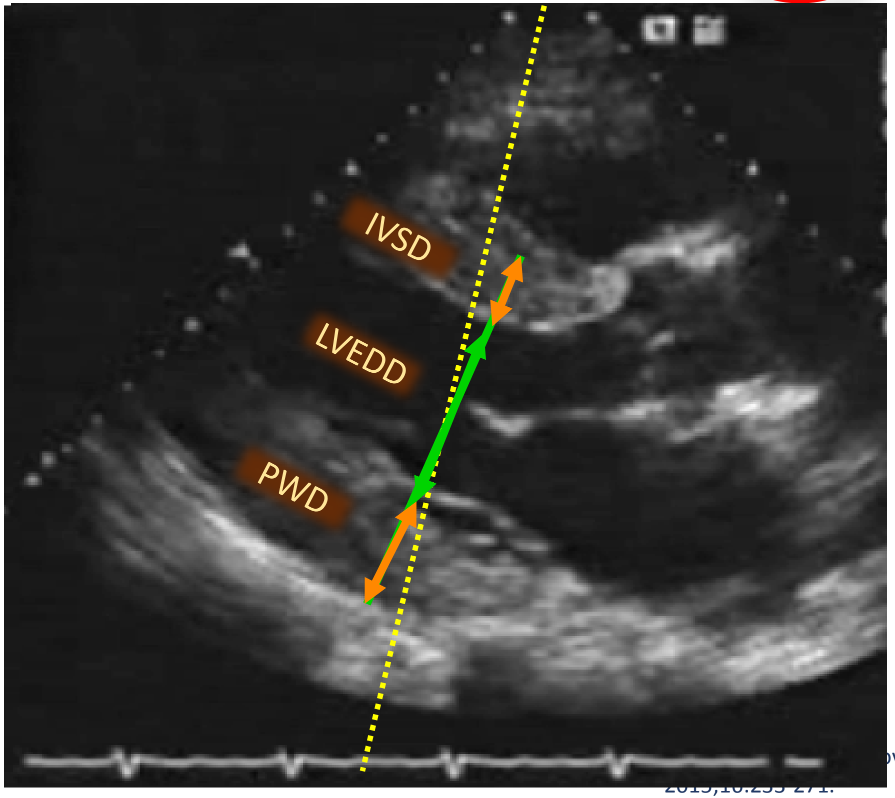
Clinical scenario

- 45 male
- Hypertensive
- Non-adherent to meds
- Height: 1.5 m
- Weight: 60 kg
- BSA: 1.58 m^2

Sample Computations

LV dimensions

- LVEDD: 4.0 cm
- IVSD : 1.3 cm
- PWD : 1.6 cm



vasc Imaging

Sample Computations

LV dimensions

- LVEDD indexed to BSA

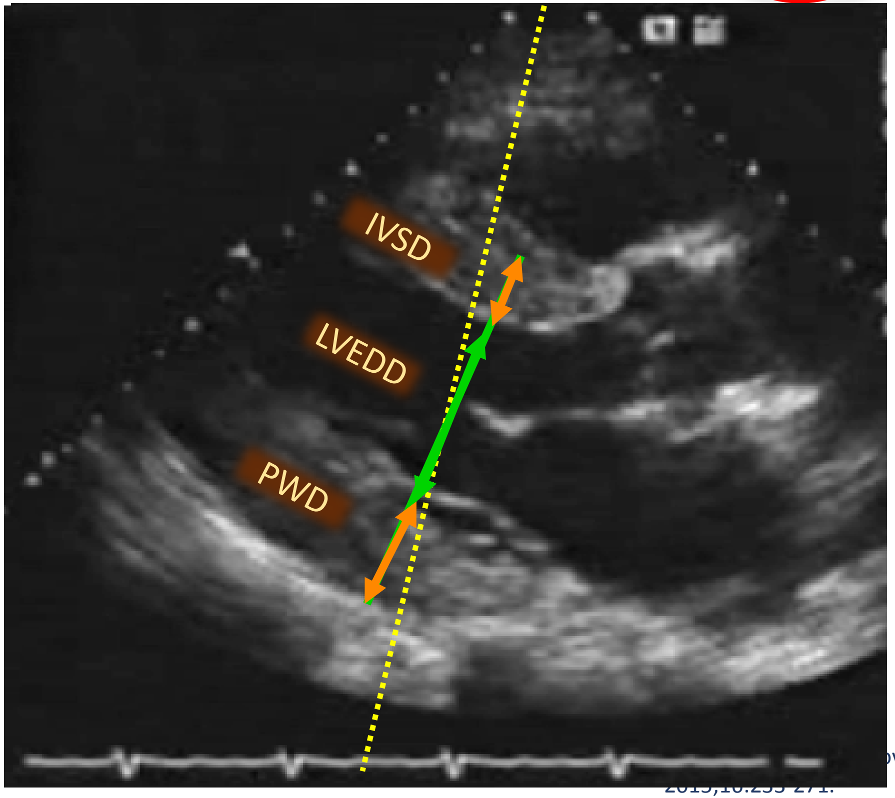
  = 4.0 cm / 1.58 m2

  = 2.5 cm/m²

- RWT

  = (1.6 x 2) / 4.0

  = 0.80



vasc Imaging 2015;16:233-271.

Sample Computations

LV dimensions

- LV mass

  $= 0.8 \times 1.04\ [\ (IVSD + LVEDD + PWD)^3 - LVEDD^3\ ] + 0.6\ g$

  $= 0.8 \times 1.04\ [\ (1.3 + 4.0 + 1.6)^3 - 4.0^3\ ] + 0.6\ g$

  = 221 g

- LV mass index

  = LV mass / BSA

  $= 221\ g / 1.58\ m^2$

  $= 140\ g/m^2$

Patient data

- LVEDD: 4.0 cm
- IVSD : 1.3 cm
- PWD : 1.6 cm

Cube formula

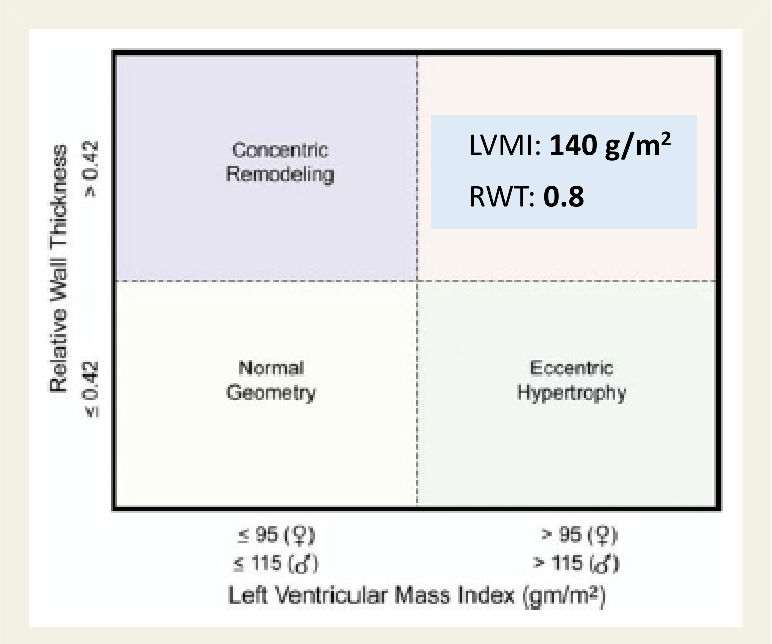
$$LV\ mass = 0.8 \cdot 1.04 \cdot [(IVS + LVID + PWT)^3 - LVID^3] + 0.6\ g$$

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Sample Computations

LV geometrical conclusions

- Patient data:
  - 45 male
  - LVEDD : **4.0 cm (N)**
  - $LVEDD_{BSA}$: **2.5 cm/m2 (N)**
  - LVMI : **140 g/m²**
  - RWT : **0.8**



Concentric LV hypertrophy

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Volumes

- Volumes are used for EF calculation

$$EF = (EDV - ESV)/EDV.$$

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Volumes

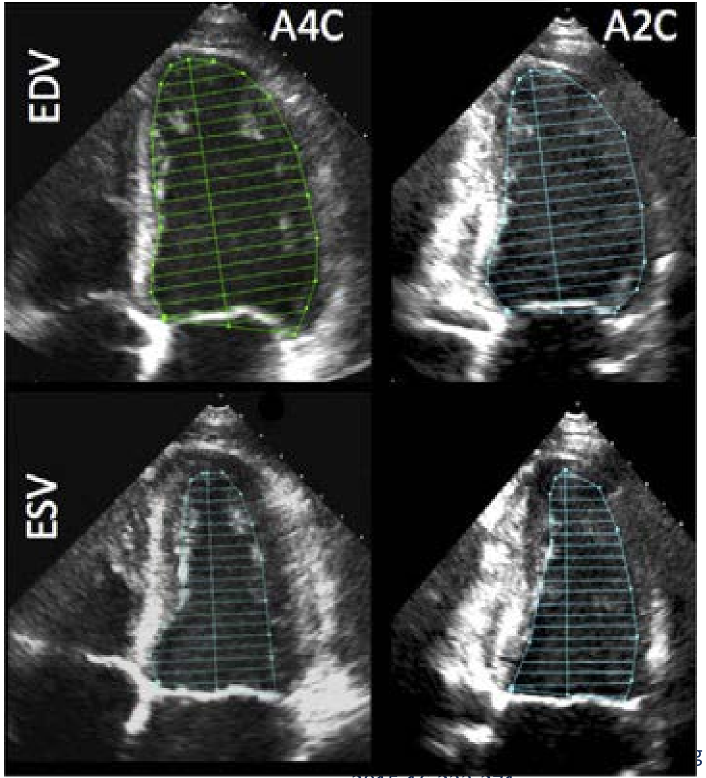
- Two methods: using 2DE or 3DE
- Linear derivations based on geometric assumptions may be inaccurate
- Teichholz and Quinones methods are no longer recommended for clinical use

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Volumes: Biplane disk summation

- Corrects for shape distortions
- Apex frequently foreshortened

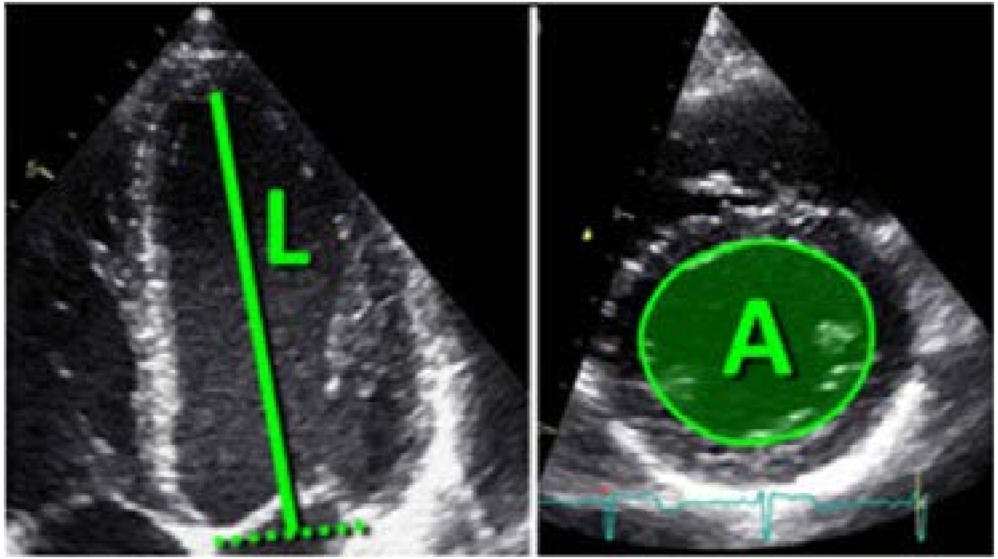


2015;16:233-271.

Left ventricle Size

Volumes: Area-length

- Partial correction for shape distortion
- Heavily based on geometrical assumptions

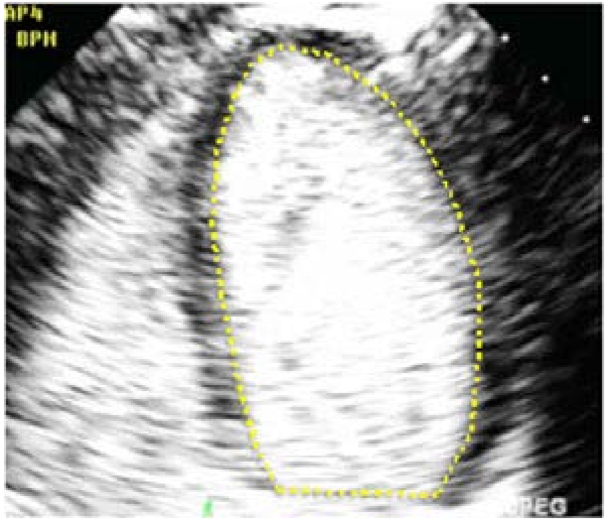


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Volumes: Endocardial enhancement

- Useful for suboptimal windows
- Acoustic shadowing in LV basal segments with excess contrast

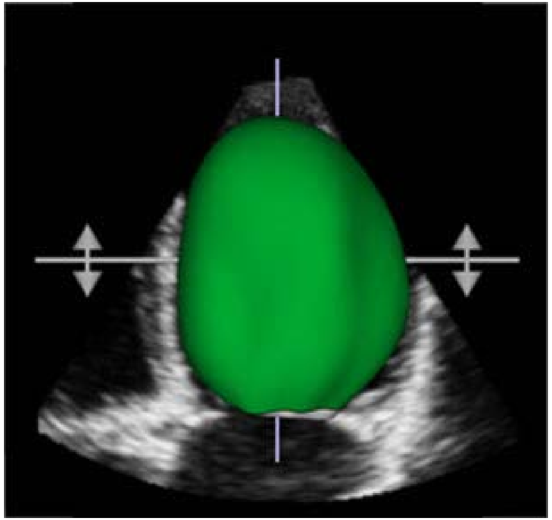


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle Size

Volumes: 3D data sets

- No geometrical assumption
- Unaffected by foreshortening
- More accurate and reproducible
- Lower temporal resolution
- Image quality dependent



- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

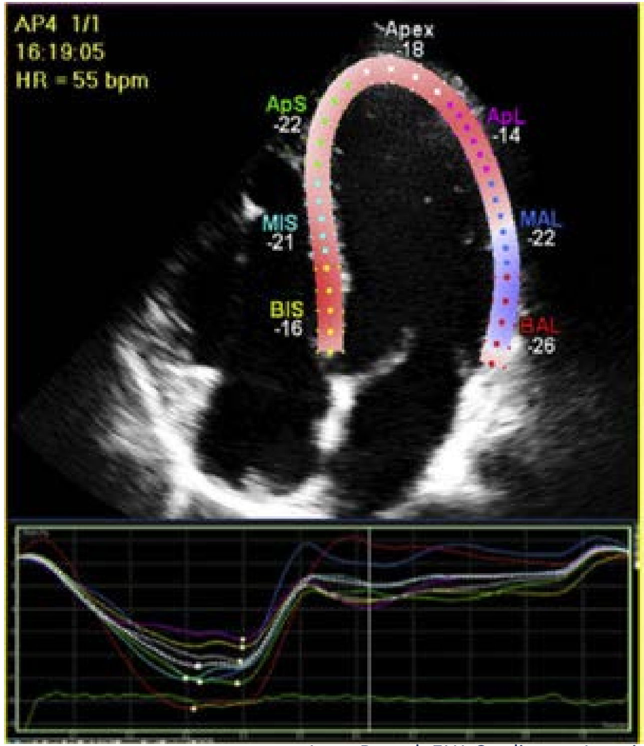
Left ventricle: Global systolic function

Global longitudinal strain

- Angle and vendor independent
- with established prognostic value

$$GLS(\%) = (MLs - MLd)/MLd,$$

where ML is myocardial length at end-systole (MLs) and end-diastole (MLd).



- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle: Global systolic function

2DE-derived LVEF

- Severity classification
- Adjusted for sex

LV systolic function: 2DE-derived LVEF (biplane Simpson's formula) or 3D-derived, if applicable

	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal
Male				
	52–72	41–51	30–40	<30
	16–34	35–41	42–48	>48
Female				
	54–74	41–53	30–40	<30
	16–34	35–41	42–48	>48

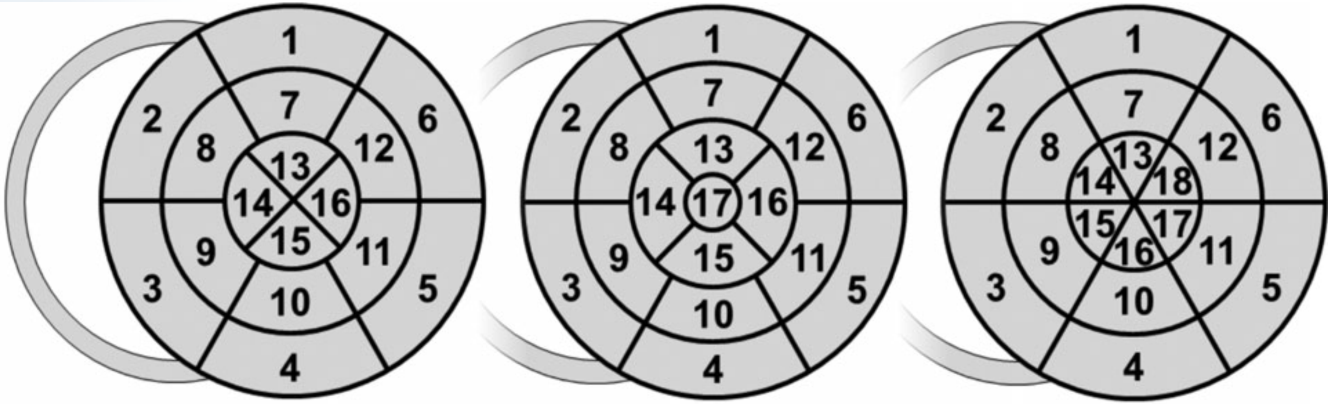
- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Key Insight

LV volumes are used to indicate systolic function via the ejection fraction .

Left ventricle: Regional function

LV segmentation



all models

1. basal anterior
2. basal anteroseptal
3. basal inferoseptal
4. basal inferior
5. basal inferolateral
6. basal anterolateral
7. mid anterior
8. mid anteroseptal
9. mid inferoseptal
10. mid inferior
11. mid inferolateral
12. mid anterolateral

16 and 17 segment model

13. apical anterior
14. apical septal
15. apical inferior
16. apical lateral

17 segment model only

17. apex

18 segment model only

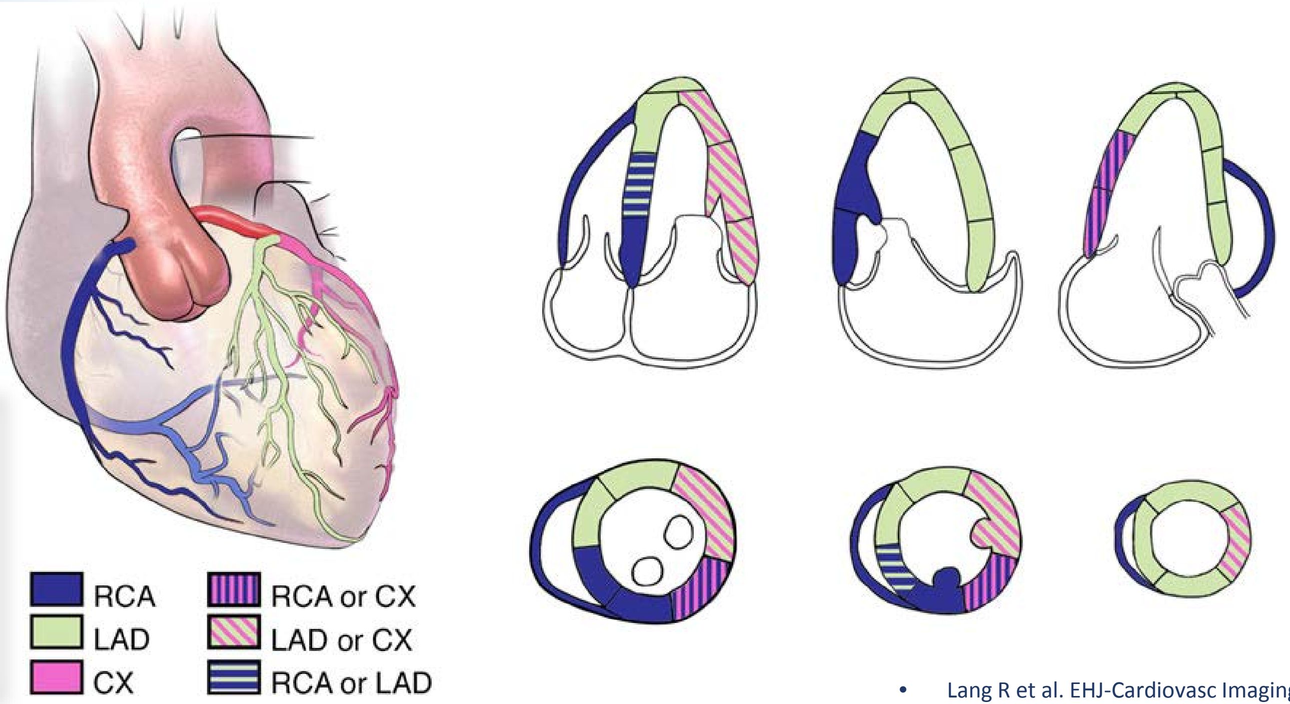
13. apical anterior
14. apical anteroseptal
15. apical inferoseptal
16. apical inferior
17. apical inferolateral
18. apical anterolateral

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left ventricle: Regional function

Correlation

Keep perfusion territories in mind when regional wall motion



- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Key Insight

When numbers do not fit, re-assess and correlate with visual estimation and clinical data.

Left atrial dimensions

LA functions

- Contractile pump
- Reservoir
- Conduit

Echo uses of LA size

- Diastolic function
- LV function
- Intracardiac pressure
- Valve lesions

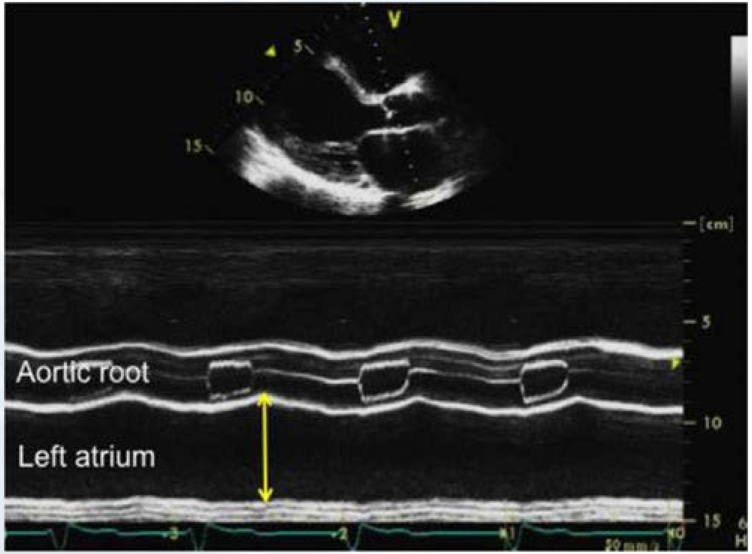
TTE is preferred approach

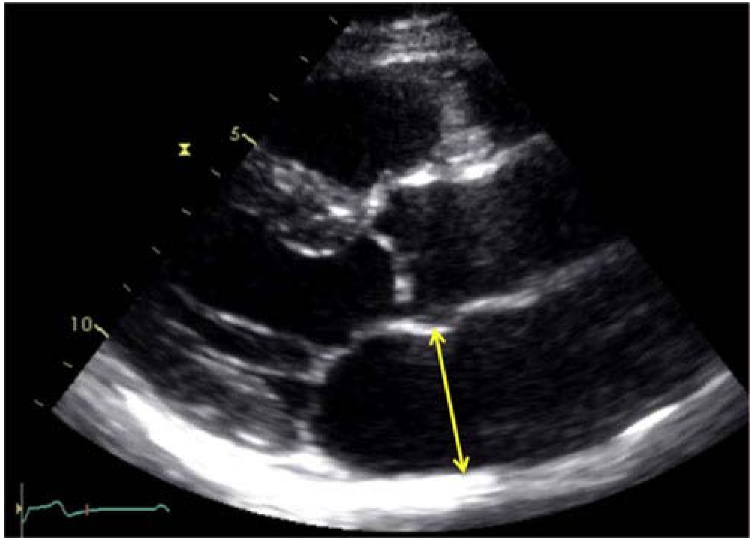
- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left atrial dimensions

Correlation

- S



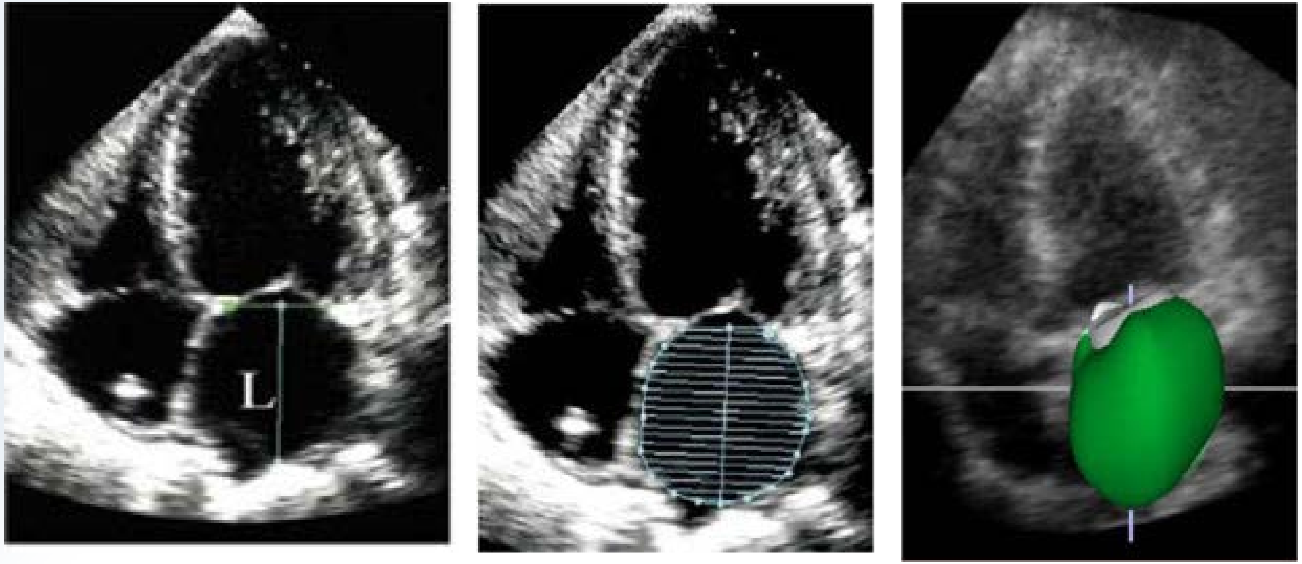


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left atrial dimensions

LA volumetric measurement

- Area-length
- Disc summation
- 3D volumes

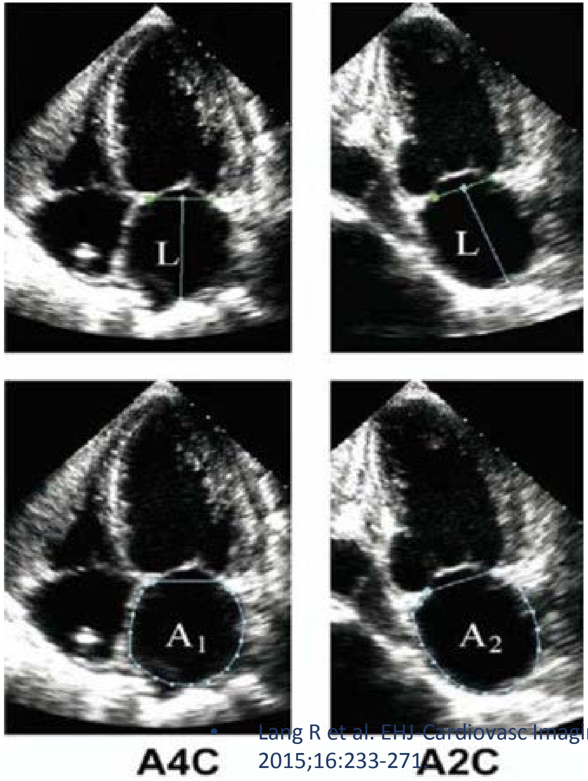


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left atrial dimensions

Biplane area length method

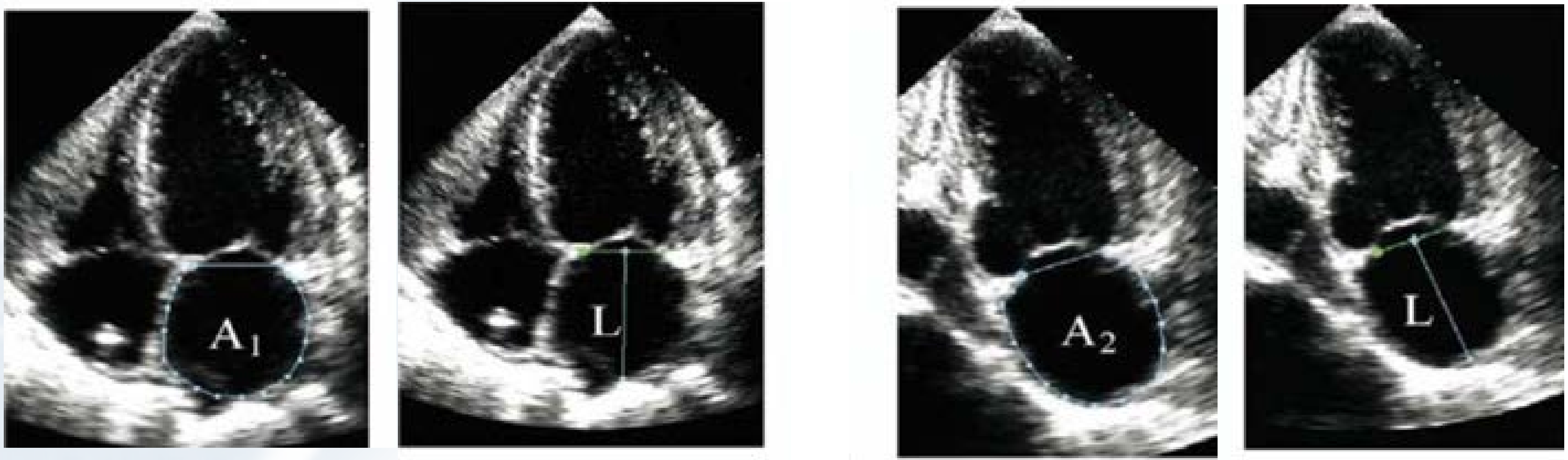
- Enables accurate assessment of the asymmetric remodeling of the left atrium
- More robust predictor of cardiovascular events than linear or area measurements



Lang R et al. EHJ Cardiovasc Imaging 2015;16:233-271

Left atrial dimensions

Biplane area length method



LA volume index: biplane area-length is preferred

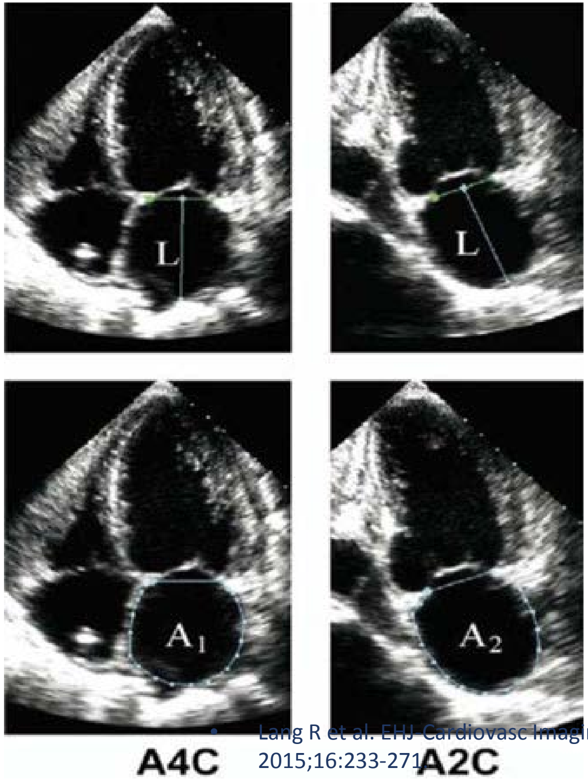
- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Left atrial dimensions

LA volume index

- 2006 cut-off: 28 ml/m^2
- **2015 cut-off: 34 ml/m^2**
- much more studies to back up new cut-off

Volume index is the preferred measure of LA size



Lang R et al. EHJ Cardiovasc Imaging 2015;16:233-271

Key Insight

Take equally great care in measuring the LA size, since this will have several echo and clinical implications.

Right atrial dimensions

RA size measurement

- Less research and fewer clinical outcomes
- Apical 4 chamber view is preferred
- Diameters and volumes

• Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Right atrial dimensions

RA size measurement

- Less research and fewer clinical outcomes
- Apical 4 chamber view is preferred
- Diameters and volumes

Normal RA size obtained from 2D echocardiographic studies

	Women	Men
RA minor axis dimension (cm/m^2)	1.9 ± 0.3	1.9 ± 0.3
RA major axis dimension (cm/m^2)	2.5 ± 0.3	2.4 ± 0.3
2D echocardiographic RA volume (mL/m^2)	21 ± 6	25 ± 7

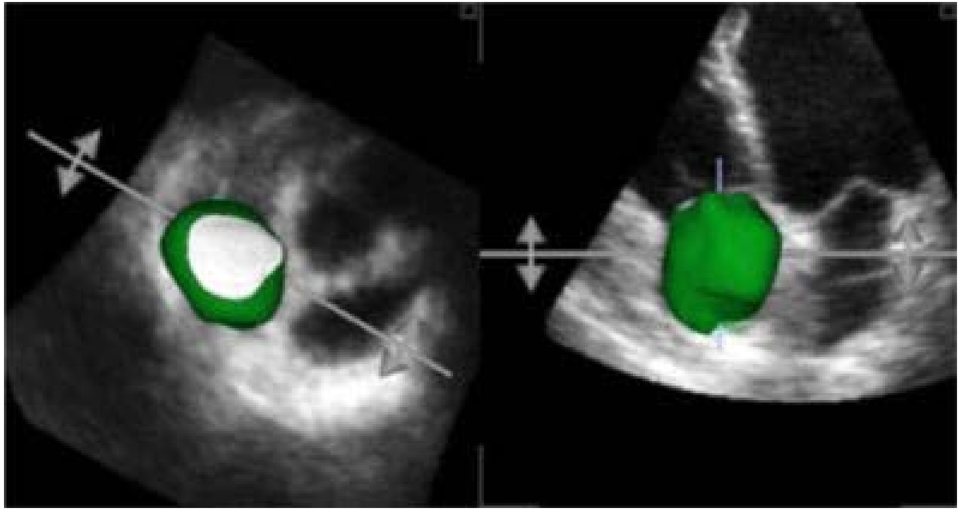
Data are expressed as mean ± SD.

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Right atrial dimensions

RA size measurement

- RA volume
- Calculated using single-plane area-length or disk summation techniques
- normal ranges
  - 25+7 mL/m^2 in men
  - 21+6 mL/m^2 in women



RA size: recommended parameter is RA volume

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Aortic territory

General rules

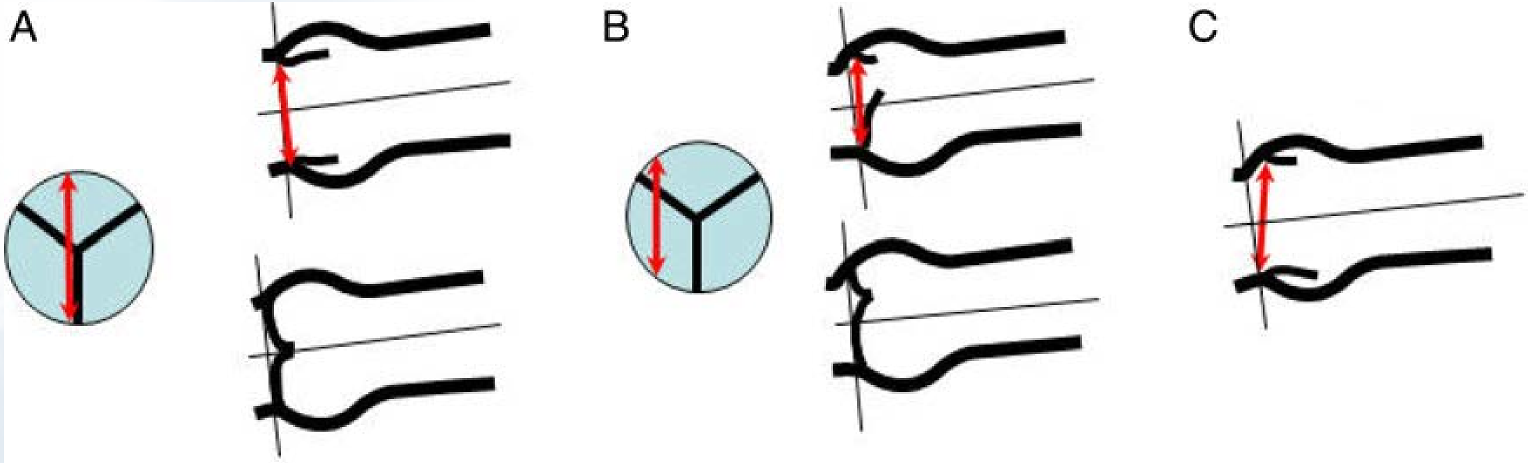
- Get good long-axis view with a central AV coaptation point
- calcium protuberances should be considered as part of the lumen, not of the aortic wall, and therefore excluded from the diameter measurement
- AV annulus: Inner edge to inner edge technique
- Other parts: leading edge to leading edge

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Aortic root dimensions

Correlation

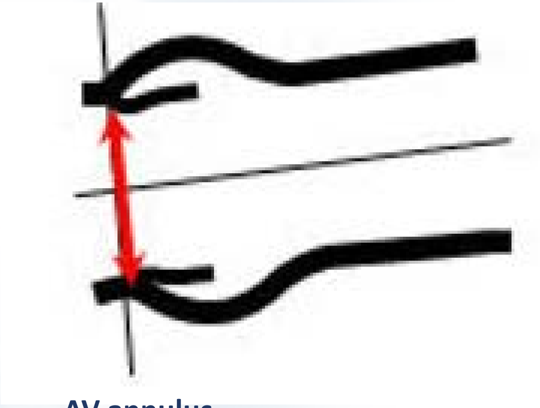
- Annulus
- root

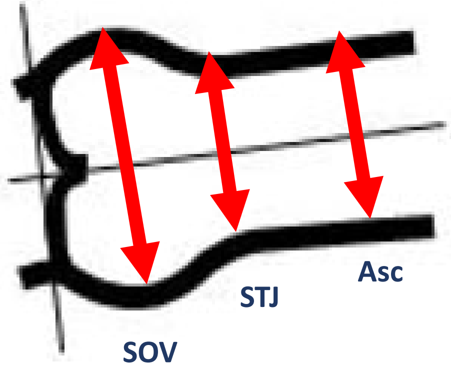


- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Aortic root dimensions

Proper measurement

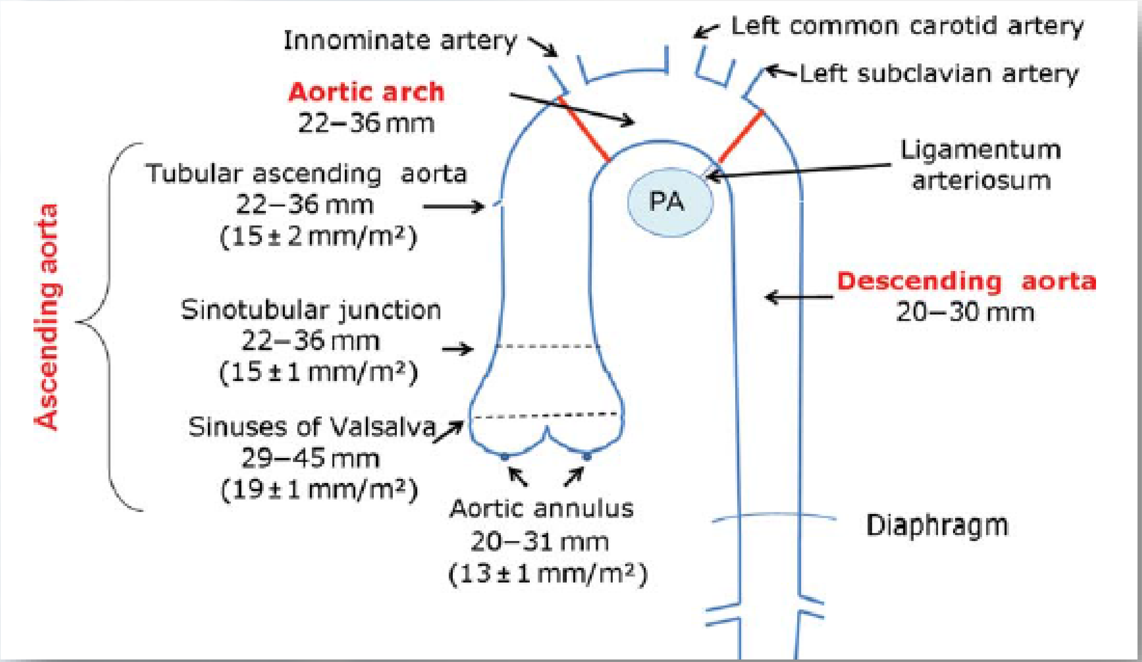




AV annulus: Inner edge technique; the rest: leading edge technique

- Lang R et al. EHJ-Cardiovasc Imaging 2015;16:233-271.

Aortic root dimensions



- Feigenbaum H, Armstrong WF, Ryan T, eds. Feigenbaum’s Echocardiography. 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2005. p673; Ascending aorta values from Erbel et al

Key Insight

Optimize the view before taking aortic measurements.

Recap of Session Outline

- Understanding the importance of correct chamber quantification techniques
- Knowing which aspects to quantify: chamber dimensions, parameters of function
- Mastering the technique of quantification: image optimization, basic strategies, tips and pitfalls


THANH THUY

Questions

- Sigmoid septum: how to address?
- HCM: how to report?
- When EF values differ: how to decide?
- When numbers and visual estimate contradict
- LV mass: when LVMI is increased, LVEDD and RWT are normal: how to conclude?
- RWT: double PWD or average IVSD and PWD?