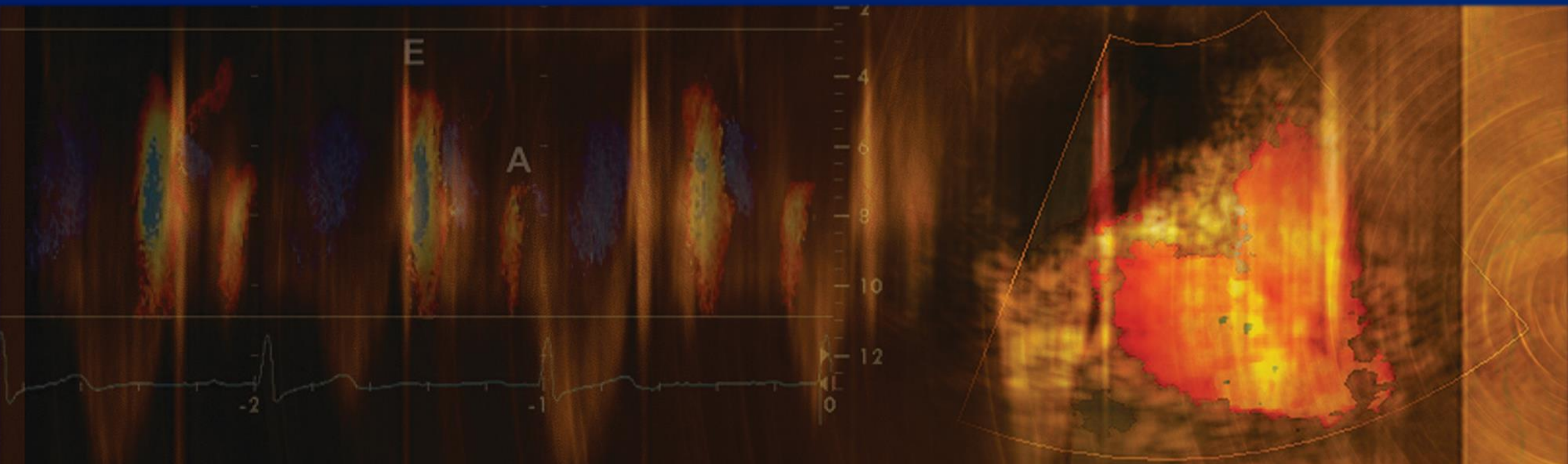
Chamber Quantification and Evaluation of Systolic Function



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Professor of Medicine
ACC Latin America
June, 2017

Disclosures

- No relevant financial disclosures

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Overview

- Assessment of LV size
- Assessment of LV function
- Assessment of LV mass and geometry

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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*

J Am Soc Echocardiogr 2015;28:1-39

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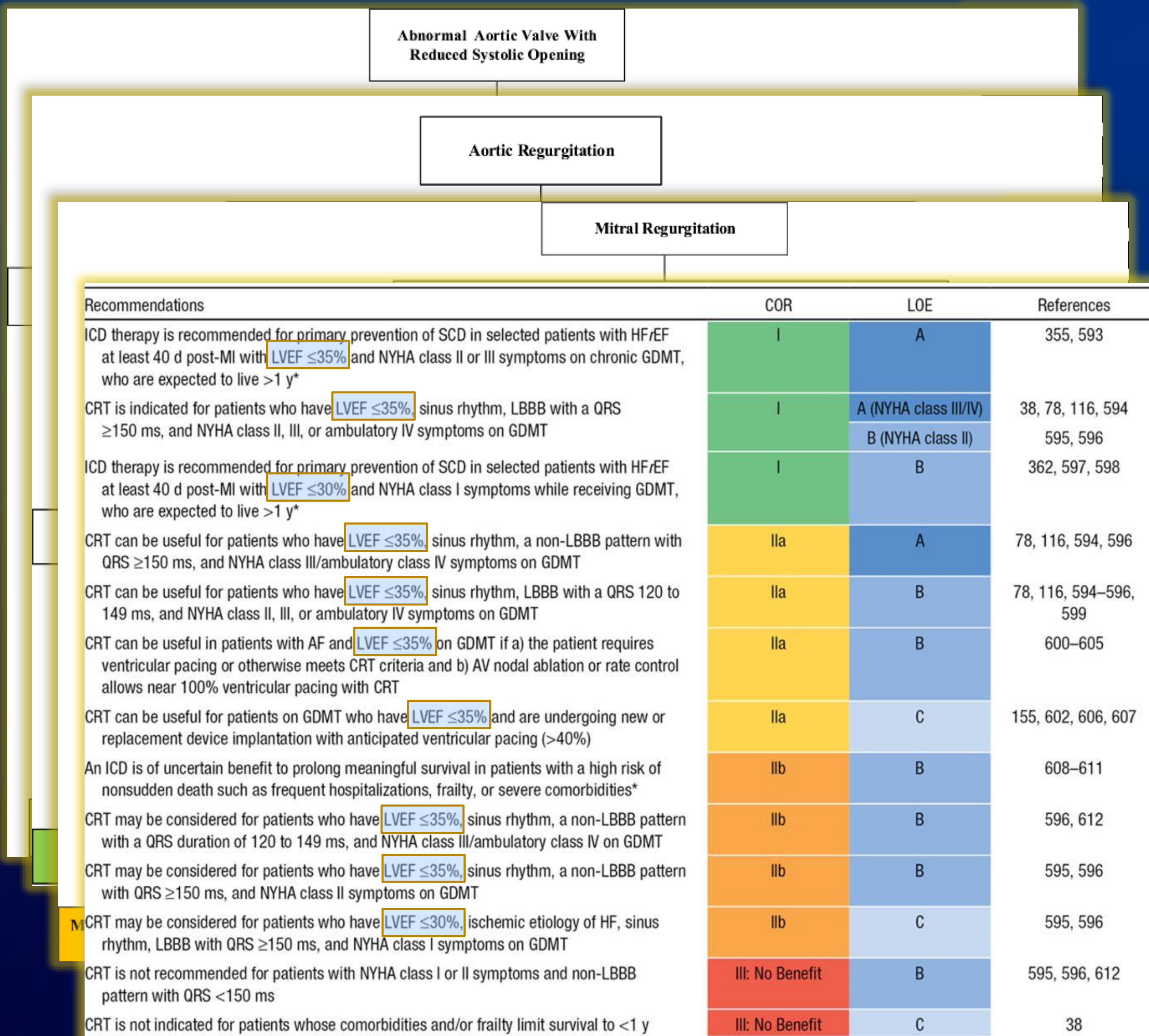


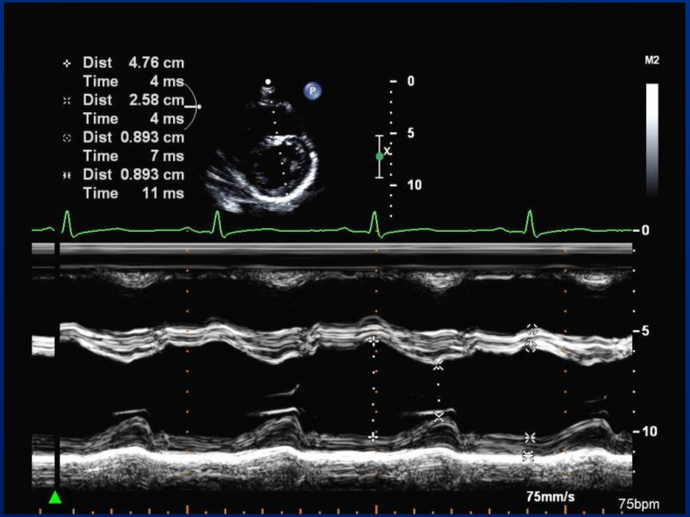
Recommendations	COR	LOE	References
ICD therapy is recommended for primary prevention of SCD in selected patients with HF*r*EF at least 40 d post-MI with LVEF ≤35% and NYHA class II or III symptoms on chronic GDMT, who are expected to live >1 y*	I	A	355, 593
CRT is indicated for patients who have LVEF ≤35%, sinus rhythm, LBBB with a QRS ≥150 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT	I	A (NYHA class III/IV)	38, 78, 116, 594
		B (NYHA class II)	595, 596
ICD therapy is recommended for primary prevention of SCD in selected patients with HF*r*EF at least 40 d post-MI with LVEF ≤30% and NYHA class I symptoms while receiving GDMT, who are expected to live >1 y*	I	B	362, 597, 598
CRT can be useful for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with QRS ≥150 ms, and NYHA class III/ambulatory class IV symptoms on GDMT	IIa	A	78, 116, 594, 596
CRT can be useful for patients who have LVEF ≤35%, sinus rhythm, LBBB with a QRS 120 to 149 ms, and NYHA class II, III, or ambulatory IV symptoms on GDMT	IIa	B	78, 116, 594–596, 599
CRT can be useful in patients with AF and LVEF ≤35% on GDMT if a) the patient requires ventricular pacing or otherwise meets CRT criteria and b) AV nodal ablation or rate control allows near 100% ventricular pacing with CRT	IIa	B	600–605
CRT can be useful for patients on GDMT who have LVEF ≤35% and are undergoing new or replacement device implantation with anticipated ventricular pacing (>40%)	IIa	C	155, 602, 606, 607
An ICD is of uncertain benefit to prolong meaningful survival in patients with a high risk of nonsudden death such as frequent hospitalizations, frailty, or severe comorbidities*	IIb	B	608–611
CRT may be considered for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with a QRS duration of 120 to 149 ms, and NYHA class III/ambulatory class IV on GDMT	IIb	B	596, 612
CRT may be considered for patients who have LVEF ≤35%, sinus rhythm, a non-LBBB pattern with QRS ≥150 ms, and NYHA class II symptoms on GDMT	IIb	B	595, 596
CRT may be considered for patients who have LVEF ≤30%, ischemic etiology of HF, sinus rhythm, LBBB with QRS ≥150 ms, and NYHA class I symptoms on GDMT	IIb	C	595, 596
CRT is not recommended for patients with NYHA class I or II symptoms and non-LBBB pattern with QRS <150 ms	III: No Benefit	B	595, 596, 612
CRT is not indicated for patients whose comorbidities and/or frailty limit survival to <1 y	III: No Benefit	C	38

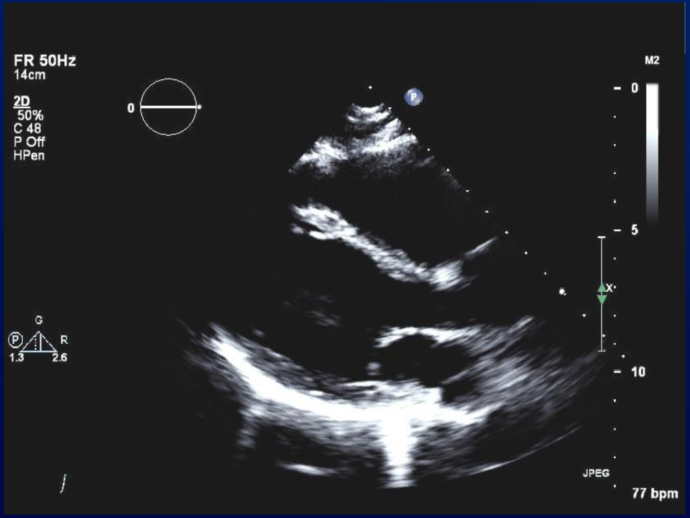
Nishimura RA et al. J Am Coll Cardiol. 2014;63(22):e57-e185.
Yancy CW et al. J Am Coll Cardiol. 2013;62(16):e147-e239.

Assessment of LV Size

LV Dimensions

- Measure in PLAX view.
- Measure at or immediately below mitral valve leaflet tips.
- 2D images are preferred to avoid oblique sections of the ventricle
- Representative of LV size only in normally shaped ventricles





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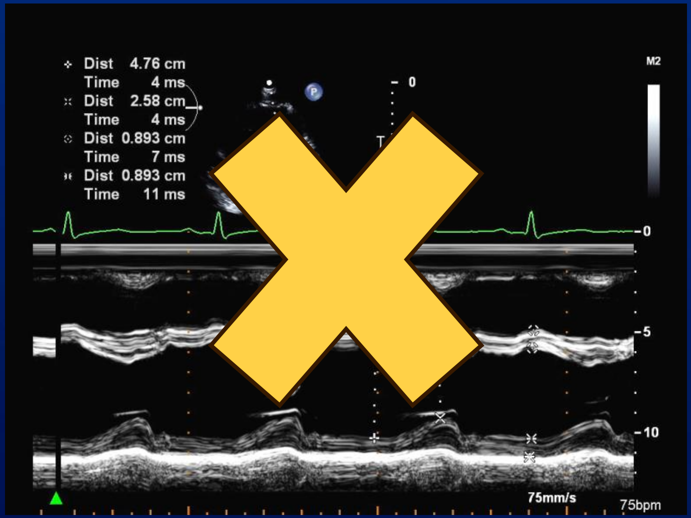
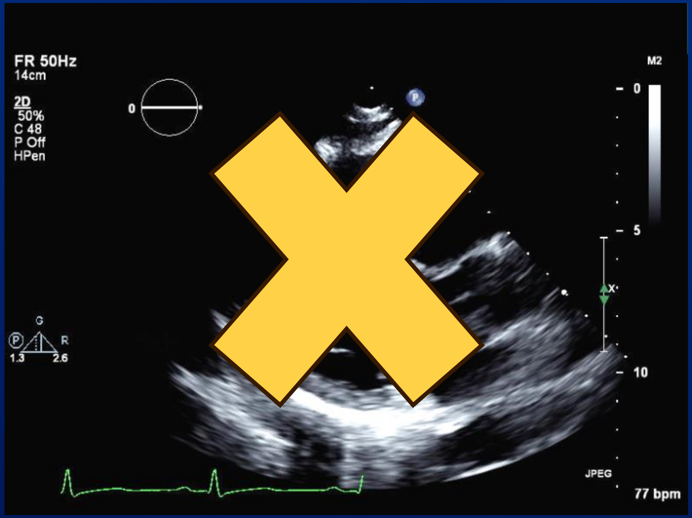
LV Volumes





- Calculation of LV volumes from linear dimensions is **no longer recommended.**
- May be inaccurate due to assumption of a fixed geometric LV shape which does not apply in a variety of pathologies.

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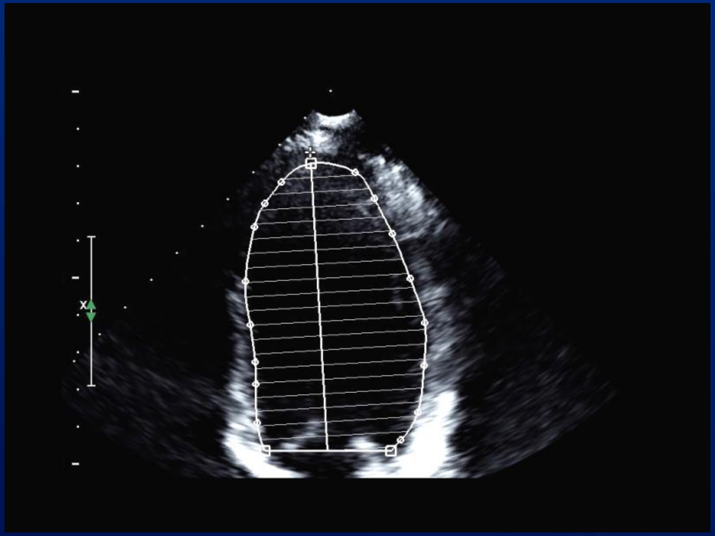
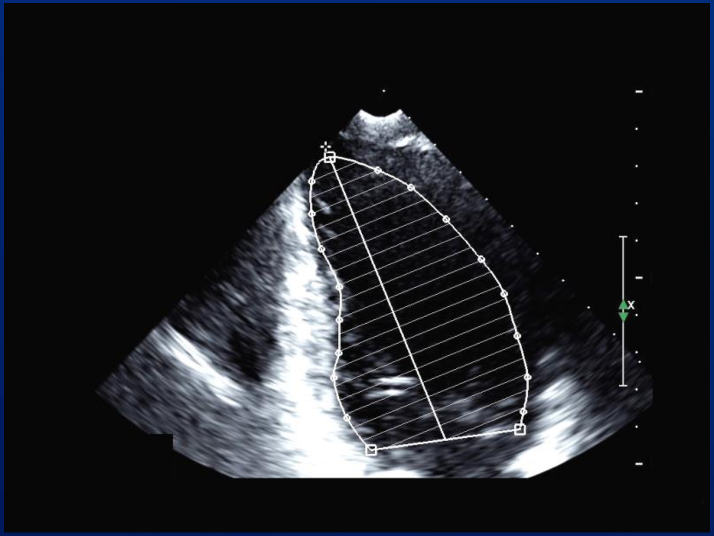
LV Volumes





- Should routinely be assessed by using the biplane method of disks summation technique.
- Should be measured from apical 4- and 2-chamber views.
- Avoiding foreshortening and aim to maximize LV areas

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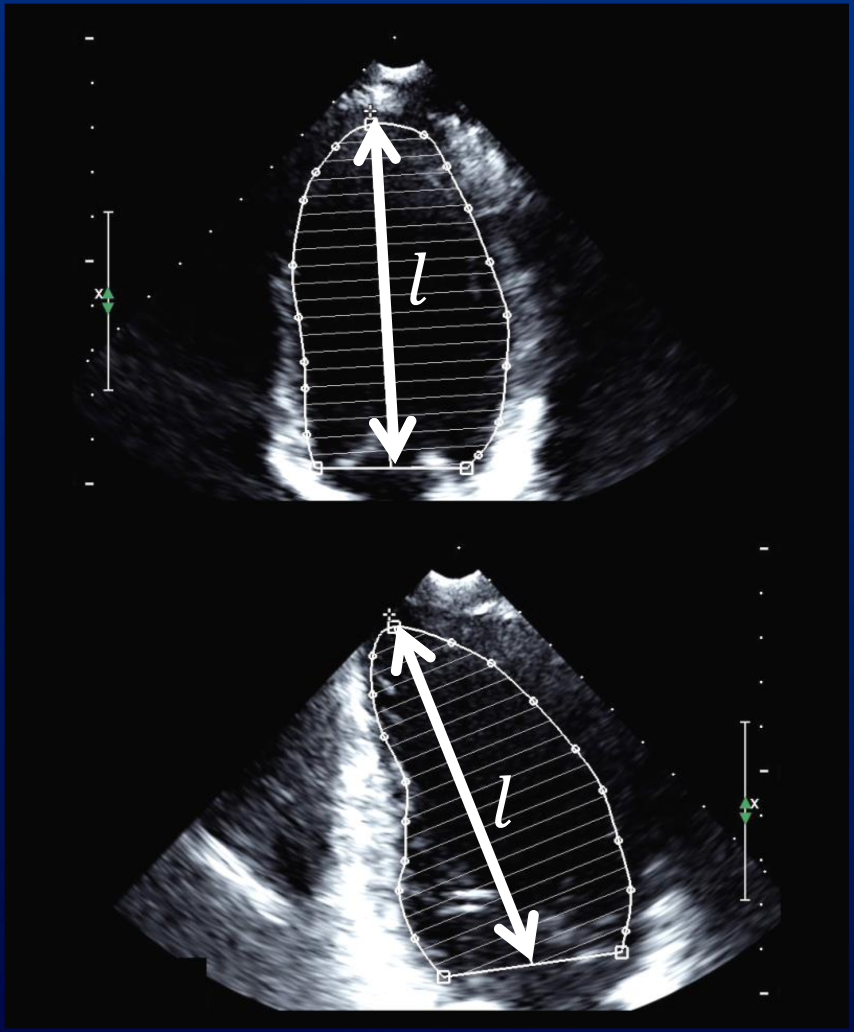
Tips

- Avoiding foreshortening
- LV lengths should be comparable between views
- Exclude trabeculations and papillary muscle



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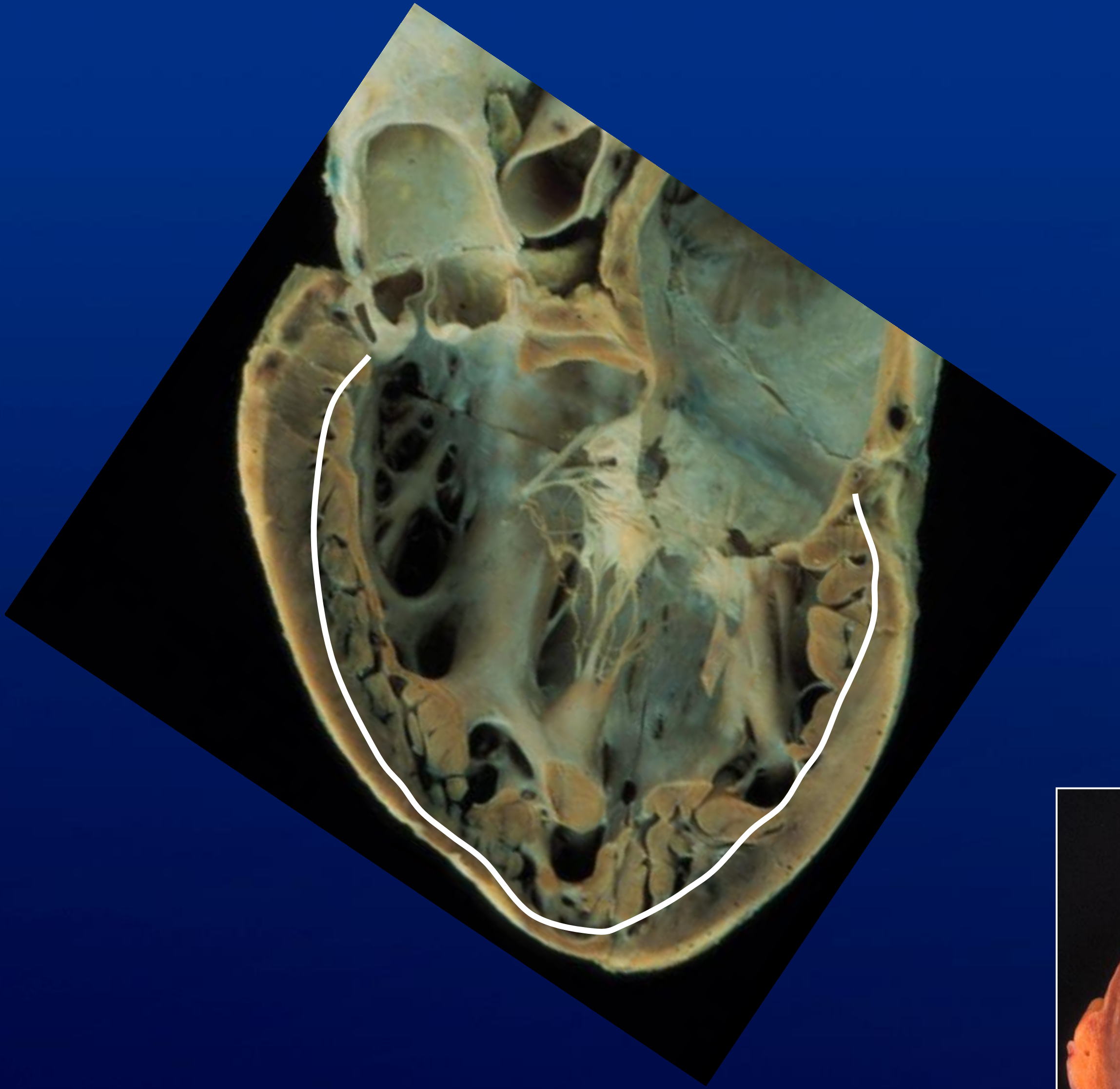

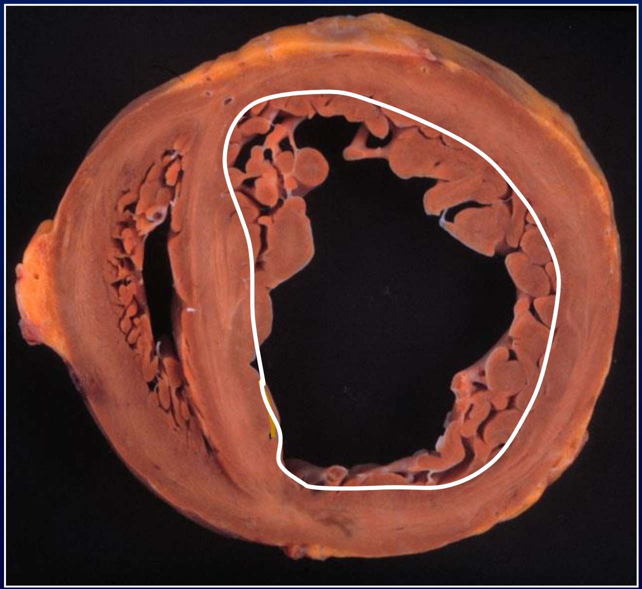

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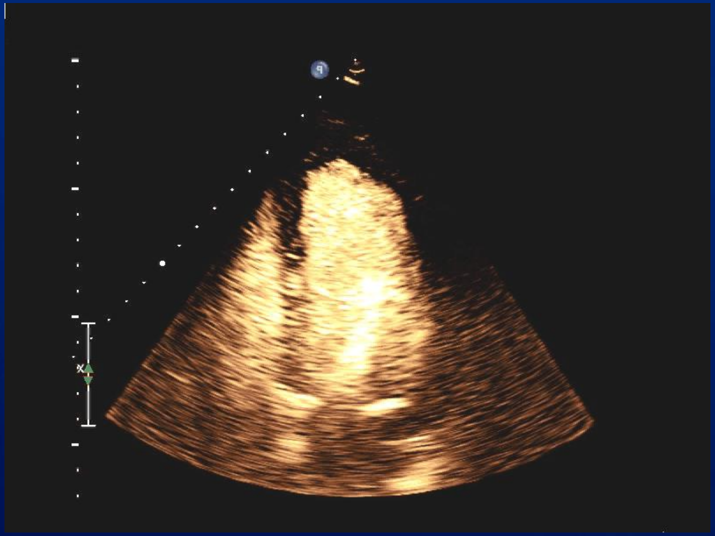
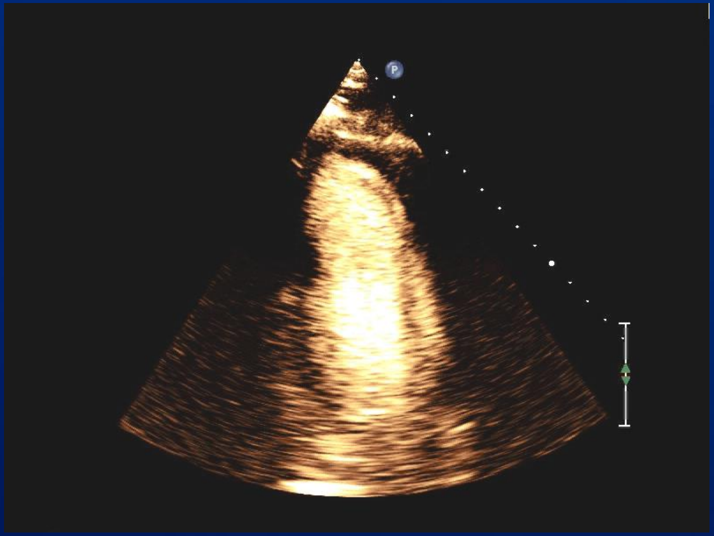
Contrast Echocardiography





- Should be used when two or more contiguous LV segments are poorly visualized in apical views.
- Contrast-enhanced images may provide larger volumes than unenhanced images.

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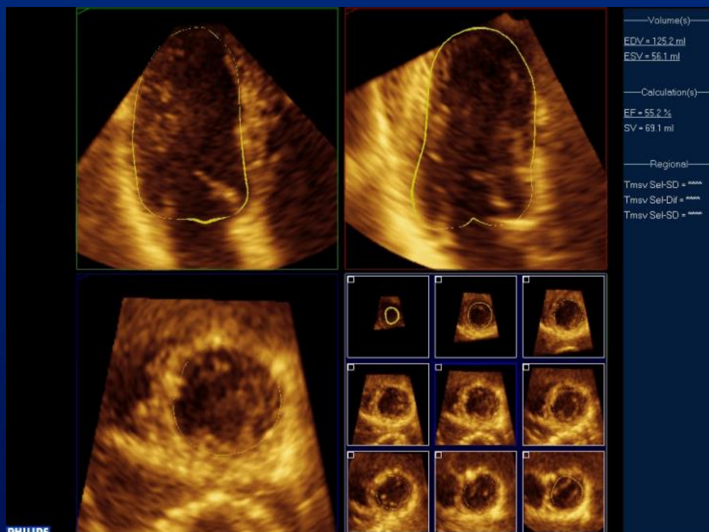
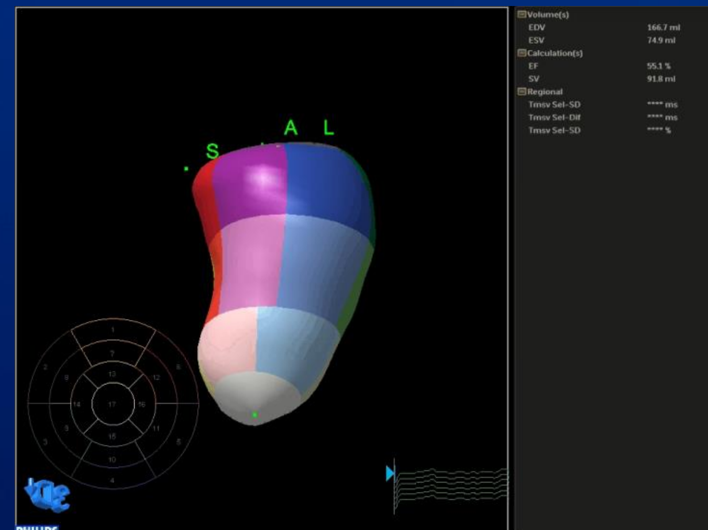
3D Echocardiography





- More accurate and reproducible
- No geometrical assumptions
- 3D LV volume measurement is recommended when feasible depending on image quality.

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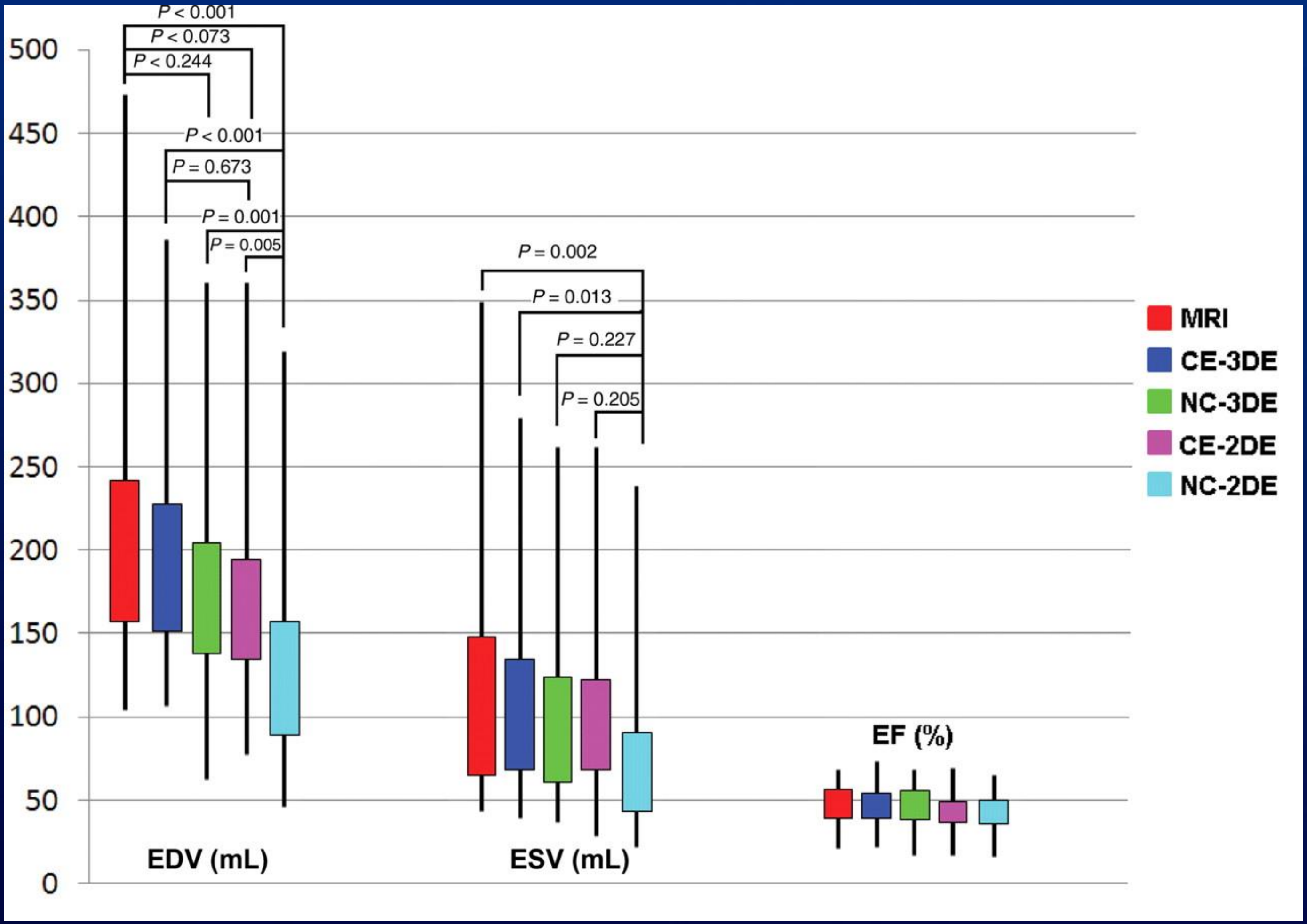
Assessment of LV Volumes by Echo

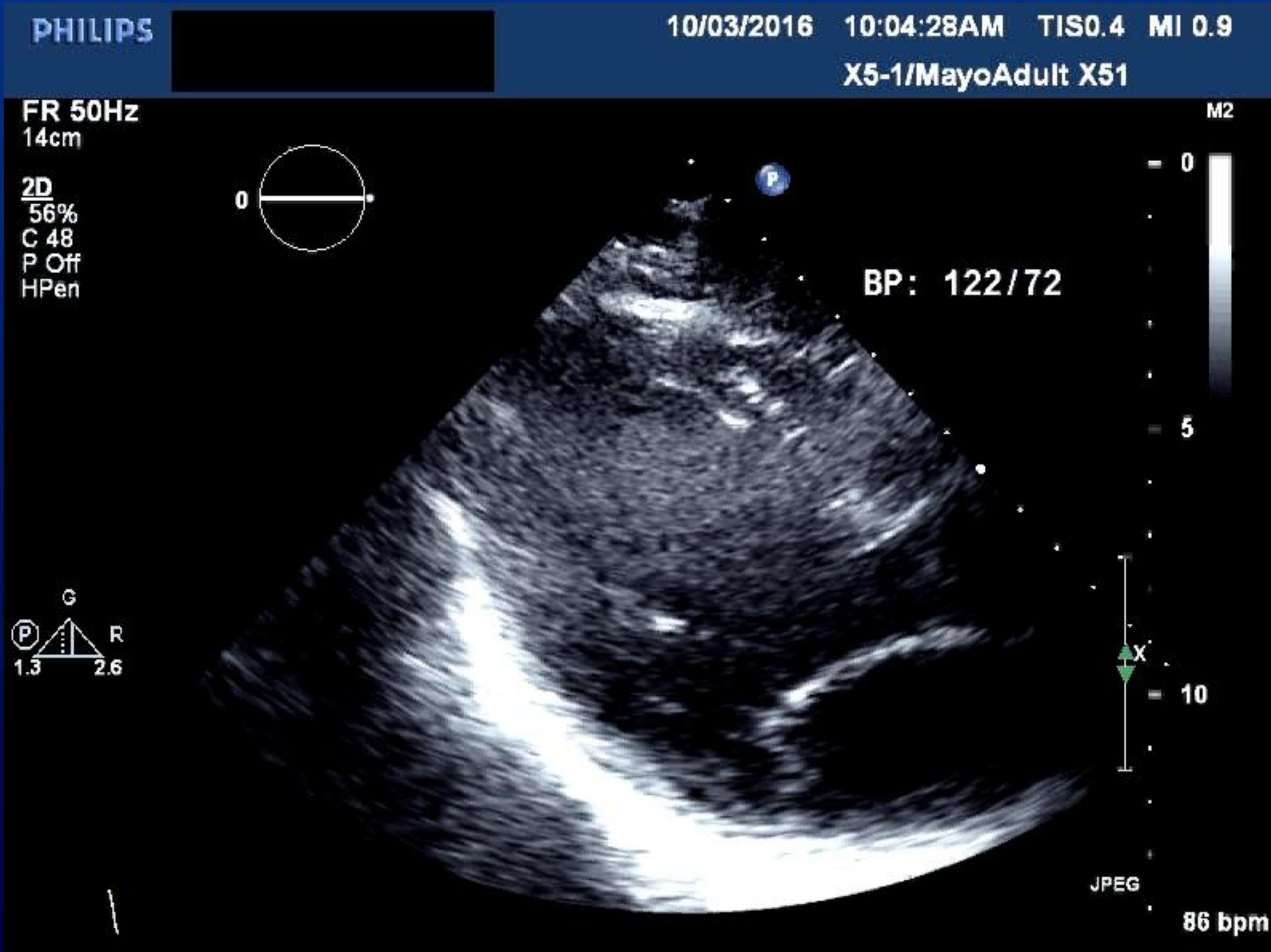


Jenkins C et al. Left ventricular volume measurement with echocardiography: a comparison of left ventricular opacification, three-dimensional echocardiography, or both with magnetic resonance imaging. Eur Heart J. 2009;30:98-106.

Interpretation of LV size

	Male				Female			
	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal
LV dimension								
LV diastolic diameter (cm)	4.2–5.8	5.9–6.3	6.4–6.8	>6.8	3.8–5.2	5.3–5.6	5.7–6.1	>6.1
LV diastolic diameter/BSA (cm/m^2)	2.2–3.0	3.1–3.3	3.4–3.6	>3.6	2.3–3.1	3.2–3.4	3.5–3.7	>3.7
LV systolic diameter (cm)	2.5–4.0	4.1–4.3	4.4–4.5	>4.5	2.2–3.5	3.6–3.8	3.9–4.1	>4.1
LV systolic diameter/BSA (cm/m^2)	1.3–2.1	2.2–2.3	2.4–2.5	>2.5	1.3–2.1	2.2–2.3	2.4–2.6	>2.6
LV volume								
LV diastolic volume (mL)	62–150	151–174	175–200	>200	46–106	107–120	121–130	>130
LV diastolic volume/BSA (mL/m^2)	34–74	75–89	90–100	>100	29–61	62–70	71–80	>80
LV systolic volume (mL)	21–61	62–73	74–85	>85	14–42	43–55	56–67	>67
LV systolic volume/BSA (mL/m^2)	11–31	32–38	39–45	>45	8–24	25–32	33–40	>40

Lang RM et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr 2015;28:1-39.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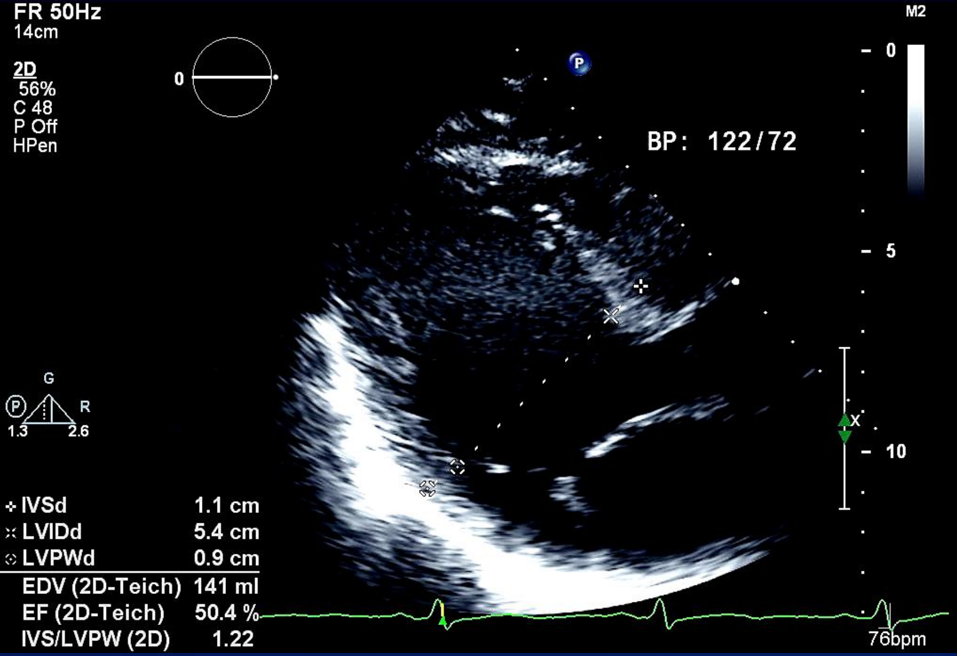
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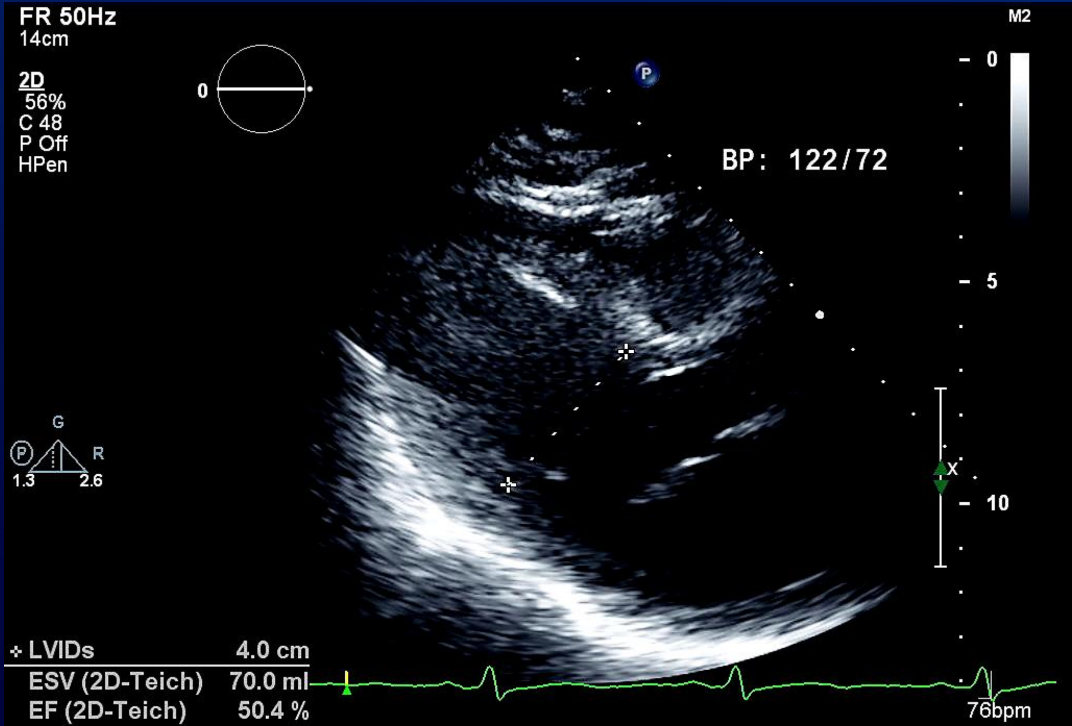
EF (2D-Teich) 50.4 %
IVS/LVPW (2D) 1.22
76bpm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EF (2D-Teich) 50.4 %
76bpm

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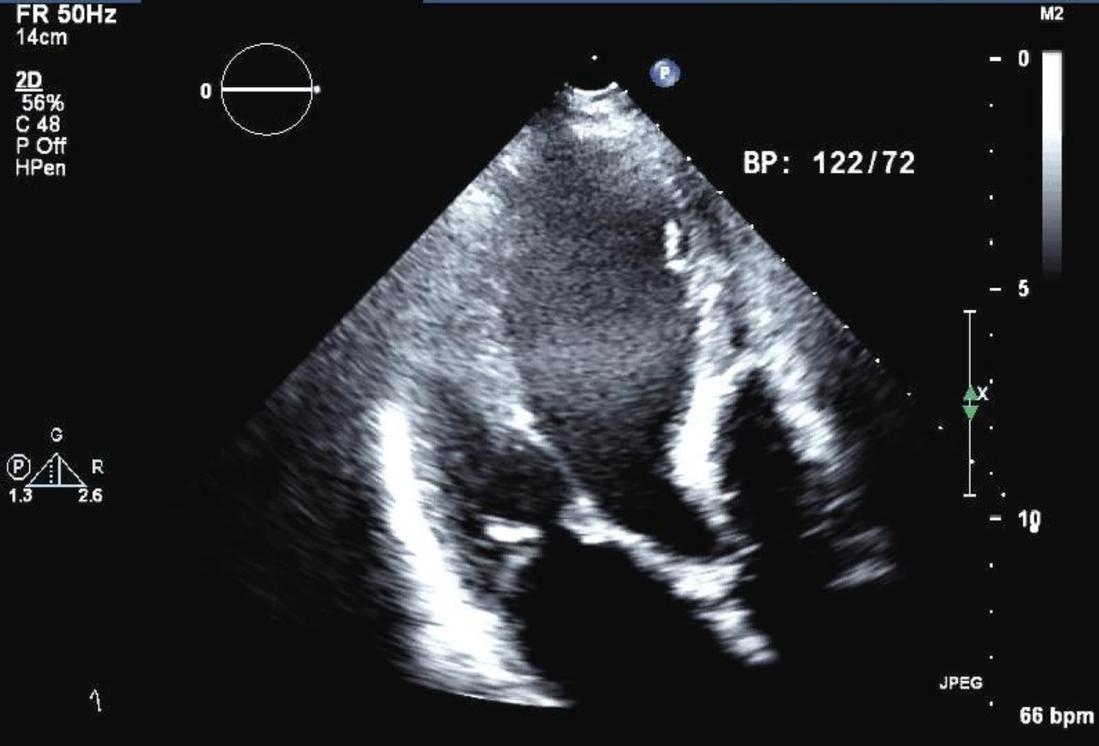
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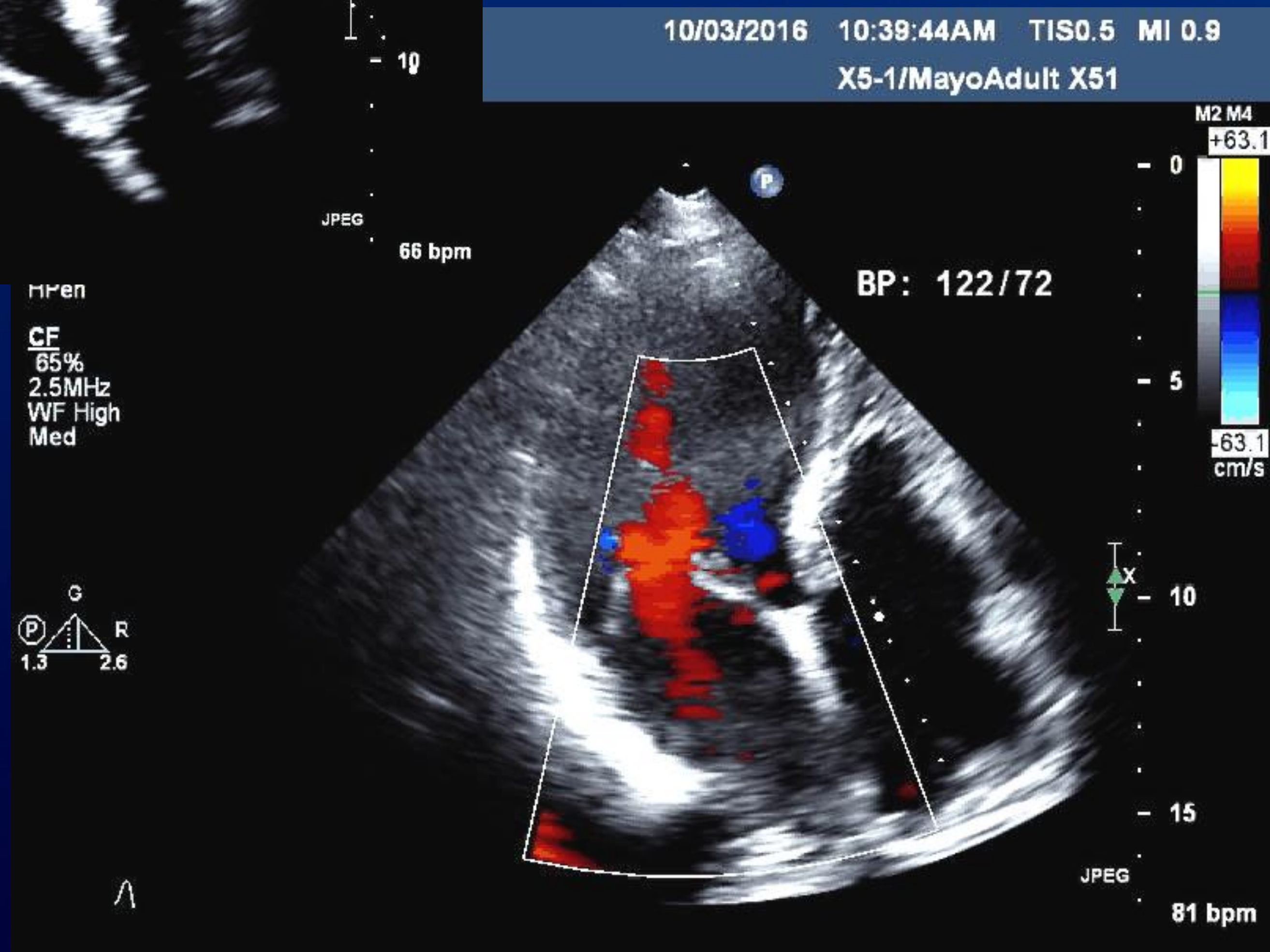
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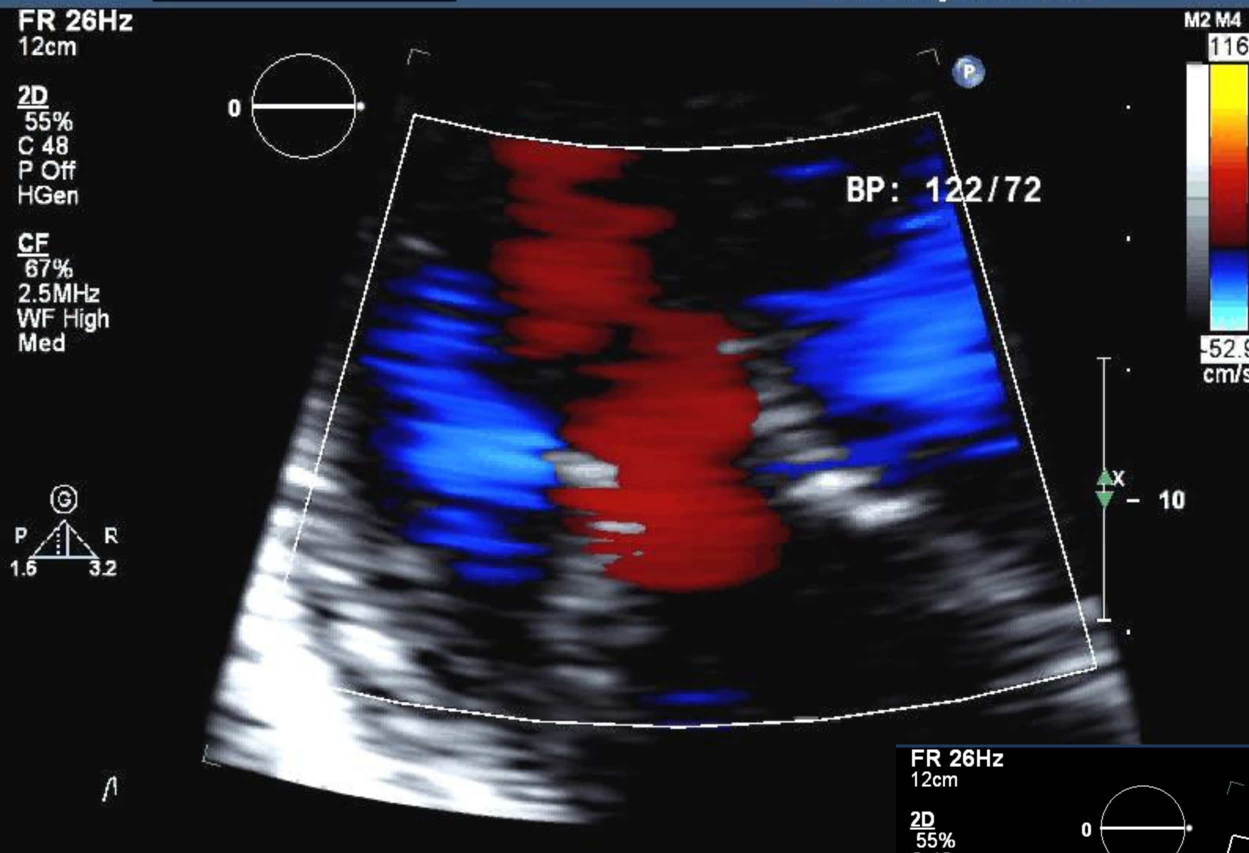
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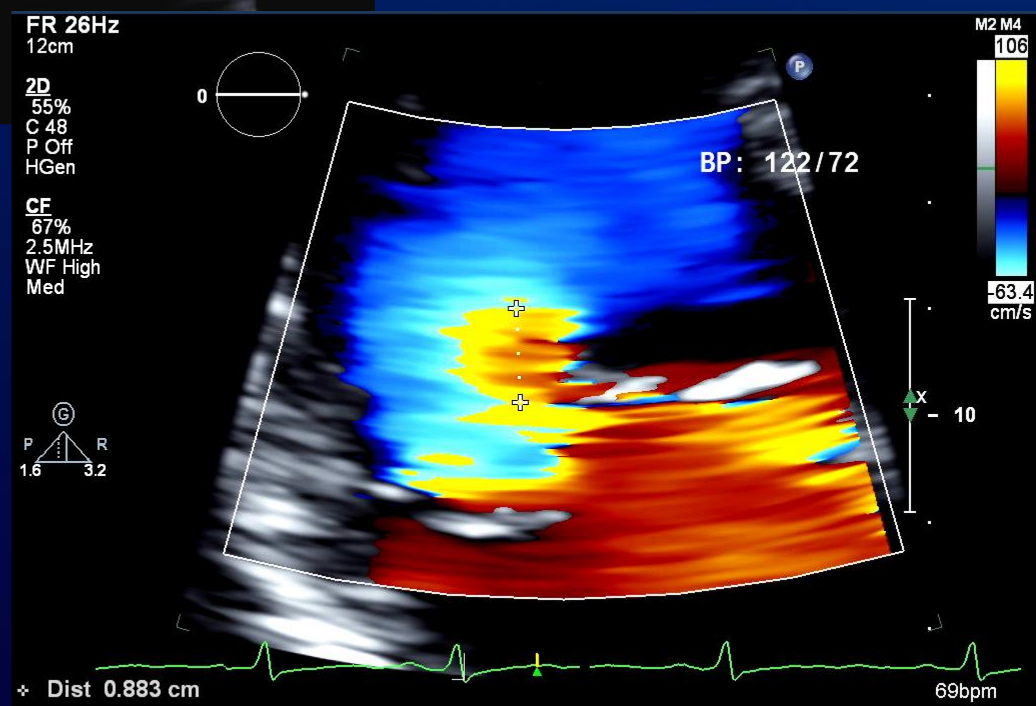
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1.6
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Dist 0.883 cm
69bpm

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	Male				Female			
	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal
LV dimension								
LV diastolic diameter (cm)	4.2–5.8	5.9–6.3	6.4–6.8	>6.8	3.8–5.2	5.3–5.6	5.7–6.1	>6.1
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LV systolic diameter (cm)	2.5–4.0	4.1–4.3	4.4–4.5	>4.5	2.2–3.5	3.6–3.8	3.9–4.1	>4.1
LV systolic diameter/BSA (cm/m^2)	1.3–2.1	2.2–2.3	2.4–2.5	>2.5	1.3–2.1	2.2–2.3	2.4–2.6	>2.6
LV volume								
LV diastolic volume (mL)	62–150	151–174	175–200	>200	46–106	107–120	121–130	>130
LV diastolic volume/BSA (mL/m^2)	34–74	75–89	90–100	>100	29–61	62–70	71–80	>80
LV systolic volume (mL)	21–61	62–73	74–85	>85	14–42	43–55	56–67	>67
LV systolic volume/BSA (mL/m^2)	11–31	32–38	39–45	>45	8–24	25–32	33–40	>40

Rvol MR 105 cc/beat
2D LVEDD 54 mm
2D LVESD 40 mm
Volumetric LVEF 54%
LA index 75 cc/m2
Biplane LV EDD Vol 225 cc
Biplane LV EDD Vol/index 137 cc/m2

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Assessment of LV Function

Methods

- Fractional Shortening
- Ejection Fraction
- Stroke Volume
- Global Longitudinal Strain
- Regional Wall Motion Analysis

LVEF: Modified Quinones Method

$$LVEF_{calc} = \frac{LVEDD^2 - LVESD^2}{LVEDD^2}$$

$EF = LVEF_{calc} + [(1 – LV$ … $)]$

Not ASE Recommended

Where ap… (%ΔL) is :

- *1… …rmal*
- *5 Hypokinetic*
- *0 Akinetic*
- *-5 Dyskinetic*
- *-10 Aneurysmal*

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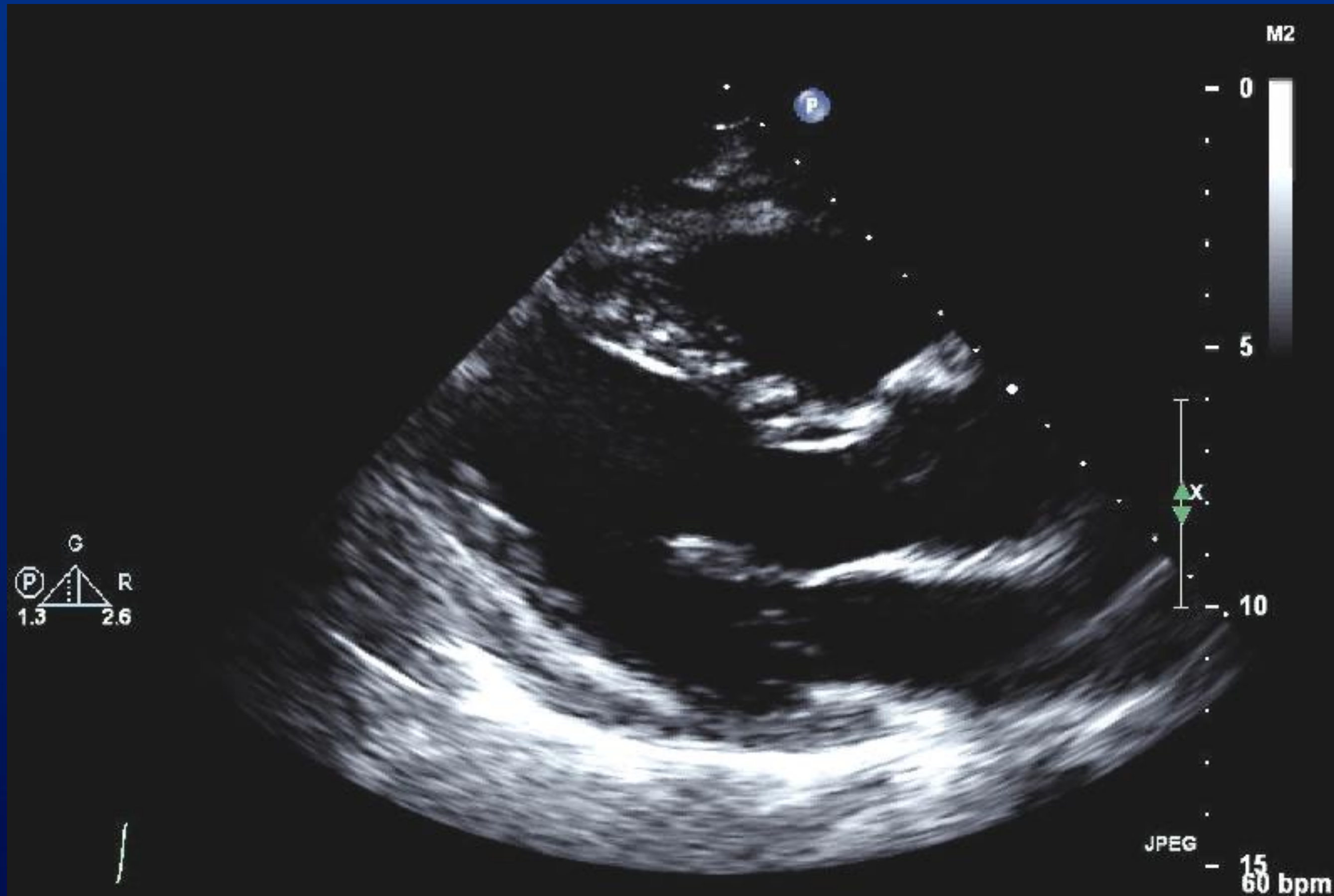
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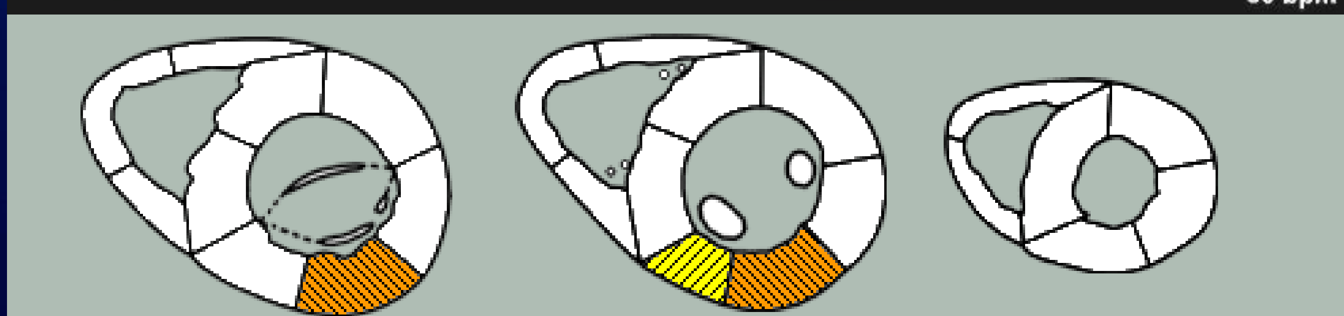
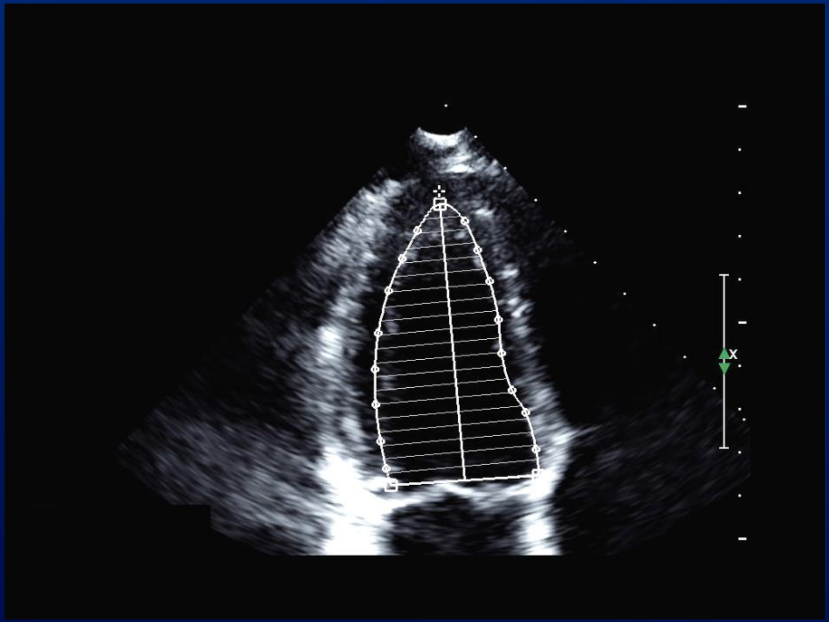
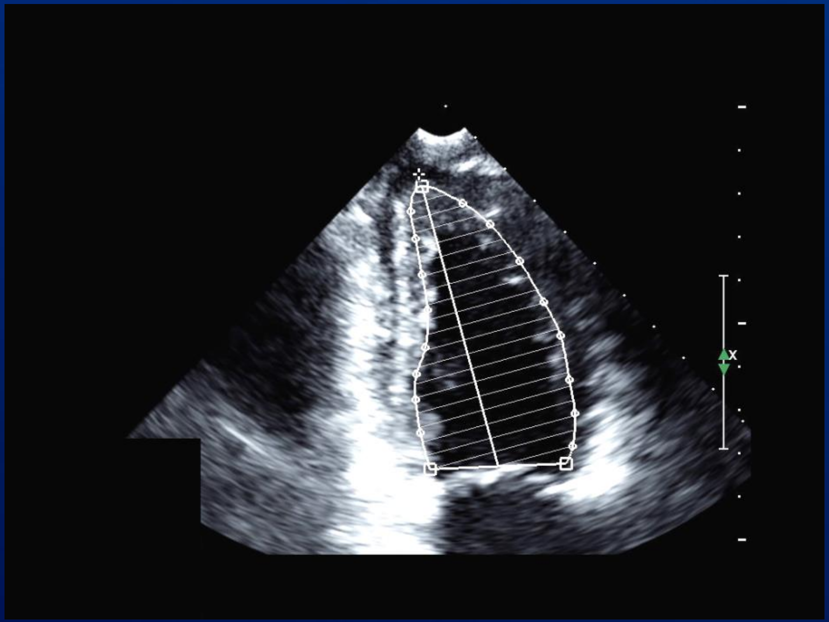


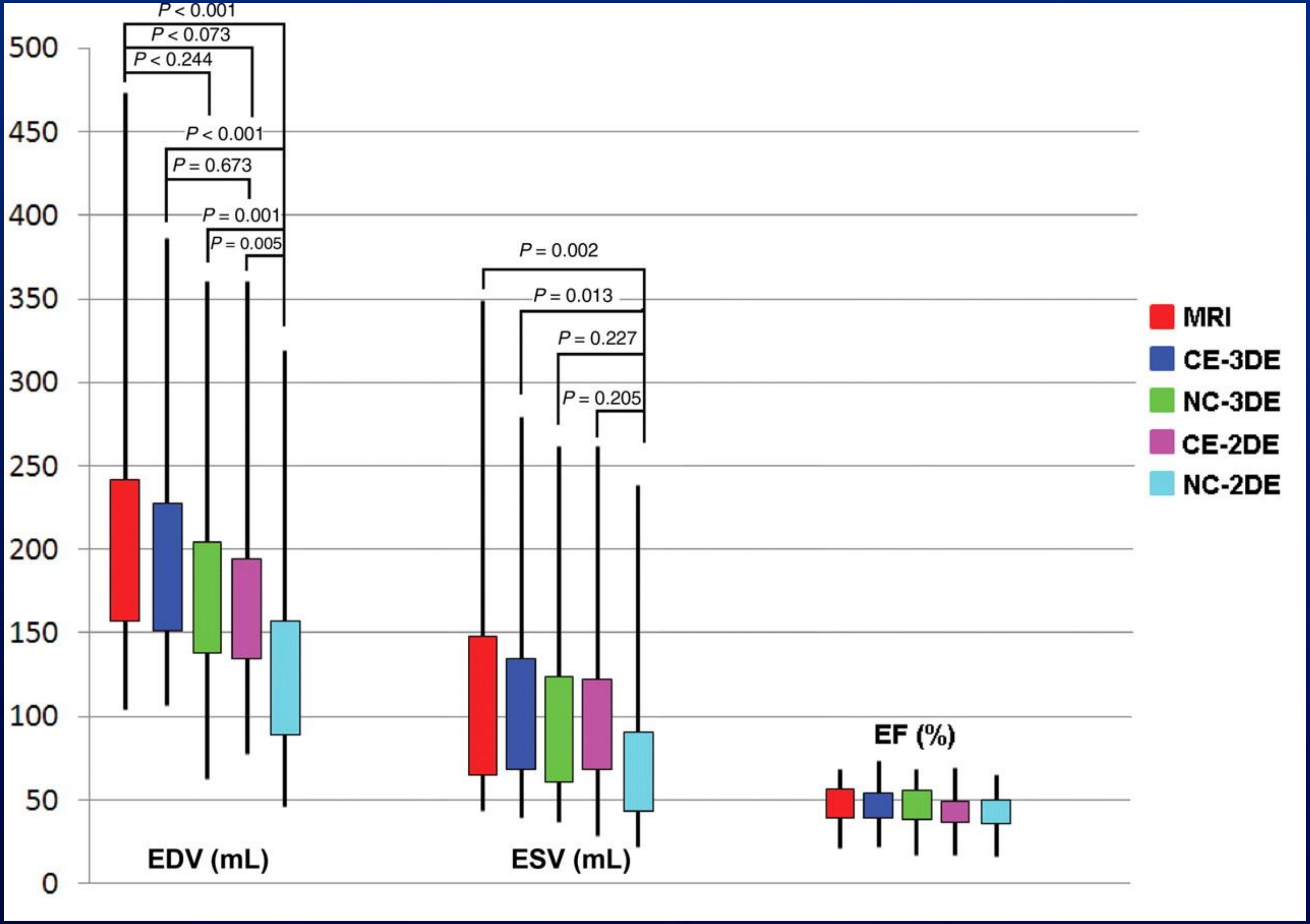
LVEF: Modified Simpson's Biplane





$$LVEF = \frac{LVEDV - LVESV}{LVEDV} \times 100$$

Assessment of LV Volumes by Echo



Jenkins C et al. Left ventricular volume measurement with echocardiography: a comparison of left ventricular opacification, three-dimensional echocardiography, or both with magnetic resonance imaging. Eur Heart J. 2009;30:98-106.

LV Ejection Fraction

	Male	Female
Normal	52 – 72 %	54 – 74 %
Mildly Abnormal	41 – 51 %	41 – 51 %
Moderately Abnormal	30 – 40 %	30 – 40 %
Severely Abnormal	< 30 %	< 30 %

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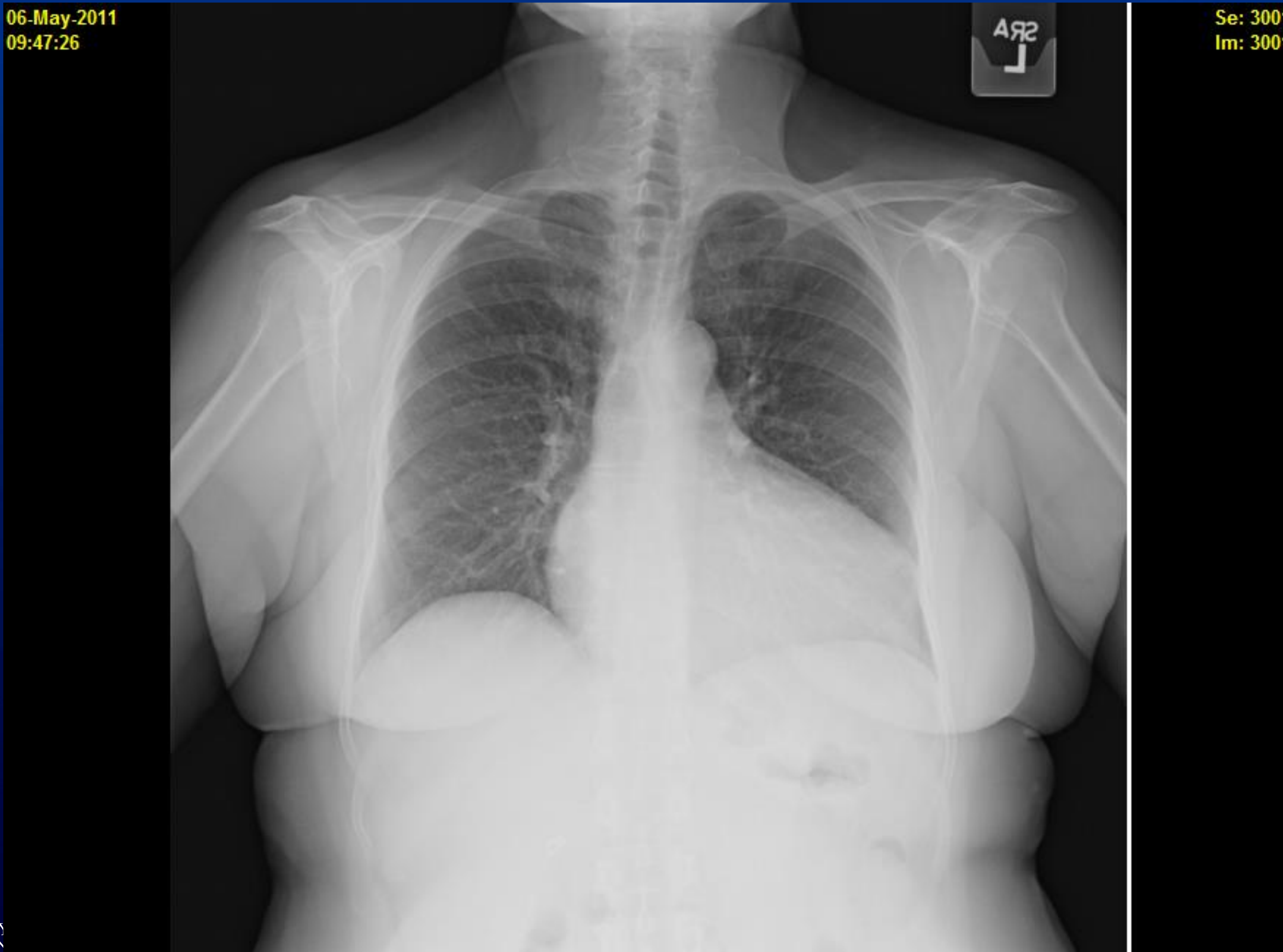
Assessment of LV Mass and Geometry

Question

- 64 year old white female presents with a 16 year history of hypertension, she initially was managed with diuretics alone but has been managed with two drug therapy with ACE inhibitor and diuretics for the last 7 years.

Question

- She describes NYHA class II DOE, no orthopnea or PND. Denies chest pain or other cardiac symptoms.
- Exam
  - 165cm 82 Kg
  - BP 137/81 HR 67
  - Lungs Clear
  - CV soft S1 paradoxically split S2, 1/6 holosystolic blowing murmur at apex
  - No Edema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Question

- Echocardiogram demonstrates enlarged left ventricle with global hypokinesis, LVEF 23%, Moderate mitral regurgitation
  - LVEDD 79mm LVESD 74 mm
  - Septal wall 9 mm Posterior wall 9 mm
  - LV Mass 121 gm/m2

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Question

- Which best describes the remodeling of the left ventricle

1. Concentric remodelling
2. Normal geometry
3. Concentric hypertrophy
4. Eccentric hypertrophy

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Interpretation of LV Mass

	Male				Female			
	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal
LV mass by linear method								
Septal wall thickness (cm)	0.6–1.0	1.1–1.3	1.4–1.6	>1.6	0.6–0.9	1.0–1.2	1.3–1.5	>1.5
Posterior wall thickness (cm)	0.6–1.0	1.1–1.3	1.4–1.6	>1.6	0.6–0.9	1.0–1.2	1.3–1.5	>1.5
LV mass (g)	88–224	225–258	259–292	>292	67–162	163–186	187–210	>210
LV mass/BSA (g/m^2)	49–115	116–131	132–148	>148	43–95	96–108	109–121	>121
LV mass by 2D method								
LV mass (g)	96–200	201–227	228–254	>254	66–150	151–171	172–193	>193
LV mass/BSA (g/m^2)	50–102	103–116	117–130	>130	44–88	89–100	101–112	>112

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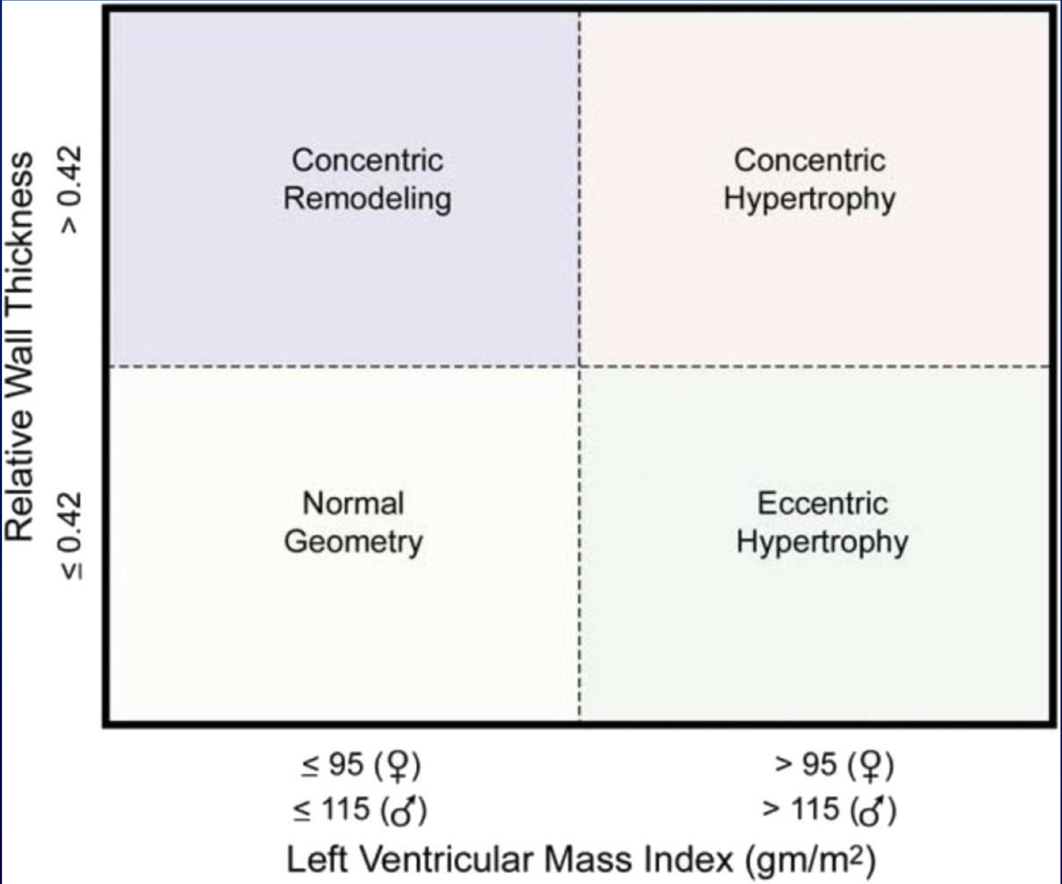
Classification of LV Geometry



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Relative Wall Thickness

Relative Wall Thickness (RWT)		
> 0.42	Concentric Remodeling	Concentric Hypertrophy
≤ 0.42	Normal Geometry	Eccentric Hypertrophy
	≤ 95 (♀) ≤ 115 (♂)	> 95 (♀) > 115 (♂)

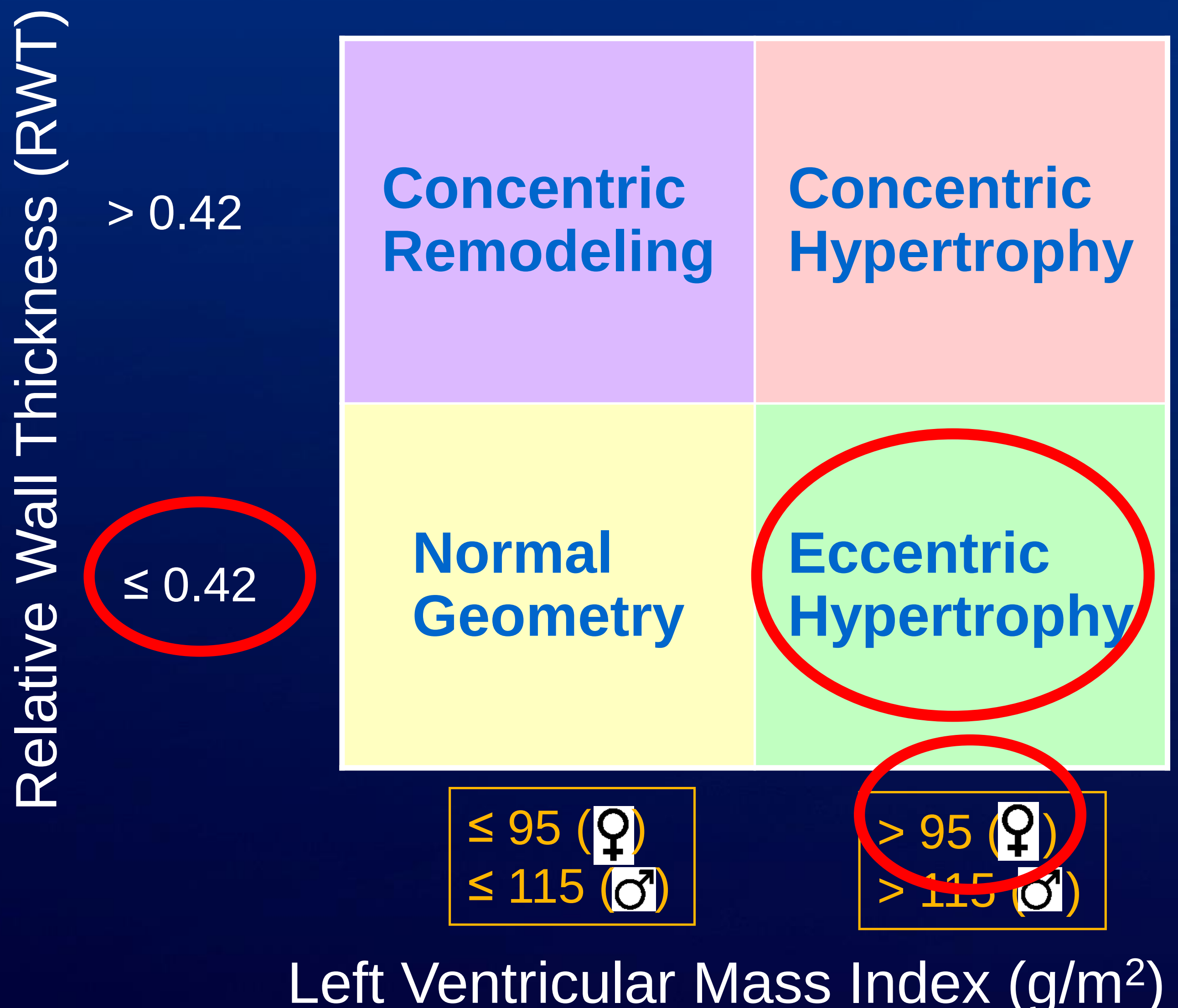
Left Ventricular Mass Index (g/m^2)

$$RWT = \frac{2 \times PWT_d}{LVID_d}$$

Question

- Calculate relative wall thickness (RWT)
  - $RWT = \dfrac{2 \times PWT_d}{LVID_d}$
  - $RWT = \dfrac{2 \times 9}{79}$
  - RWT = 0.22
- Plot on 2 by 2 table

Relative Wall Thickness



Question

- Which best describes the remodeling of the left ventricle

1. Concentric remodelling
2. Normal geometry
3. Concentric hypertrophy
4. Eccentric hypertrophy

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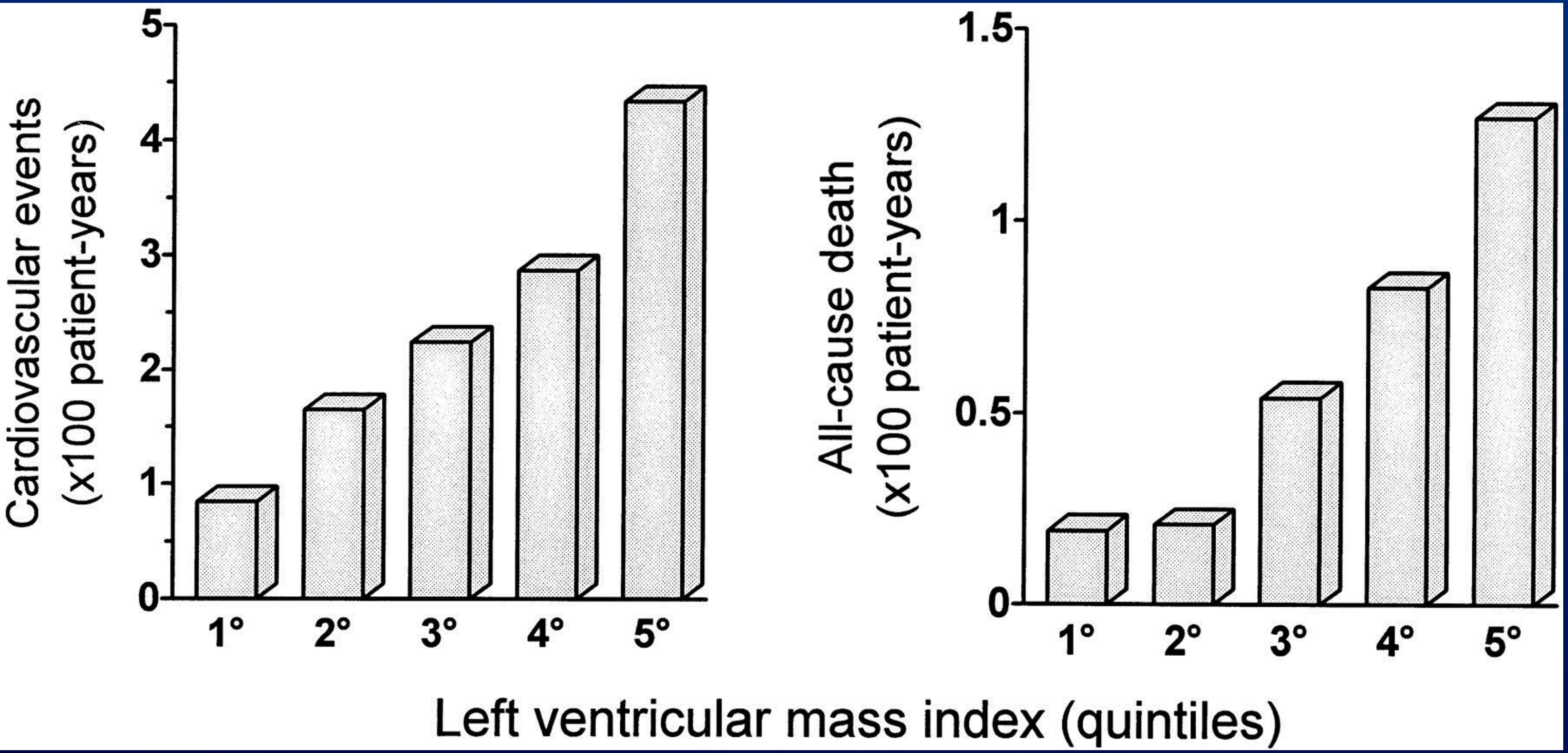
LV Mass: A Marker of Prognosis



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Comprehensive characterisation of hypertensive heart disease left ventricular phenotypes

Jonathan C L Rodrigues,[1,2] Antonio Matteo Amadu,[1,3] Amardeep Ghosh Dastidar,[1,4] Gergley V Szantho,[1,5] Stephen M Lyen,[1,6] Cattleya Godsave,[7] Laura E K Ratcliffe,[8] Amy E Burchell,[4,8] Emma C Hart,[2,8] Mark C K Hamilton,[6] Angus K Nightingale,[4,8] Julian F R Paton,[2,8] Nathan E Manghat,[1,6] Chiara Bucciarelli-Ducci[1,4]

Heart 2016;**102**:1671–1679.

Conclusions Myocardial interstitial fibrosis varies across hypertensive LV phenotypes with functional consequences. Eccentric LVH has the most fibrosis and systolic impairment. Concentric remodelling is only associated with abnormal aortic function. Understanding these differences may help tailor future antihypertensive treatments.

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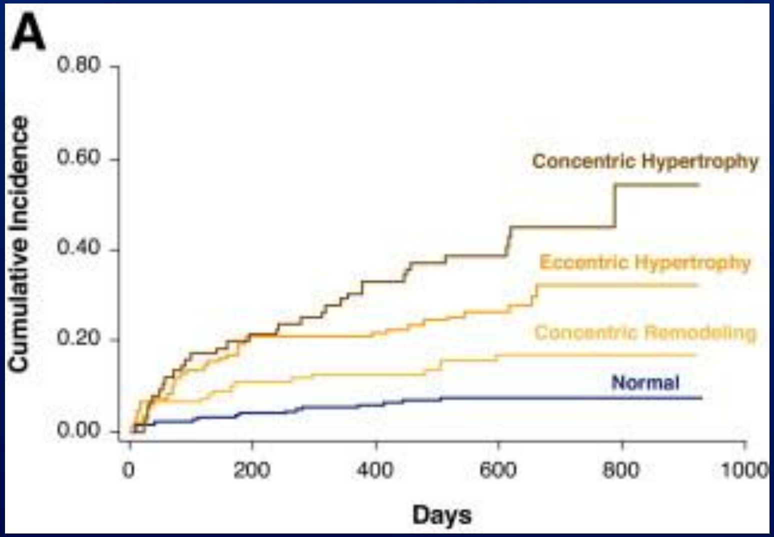
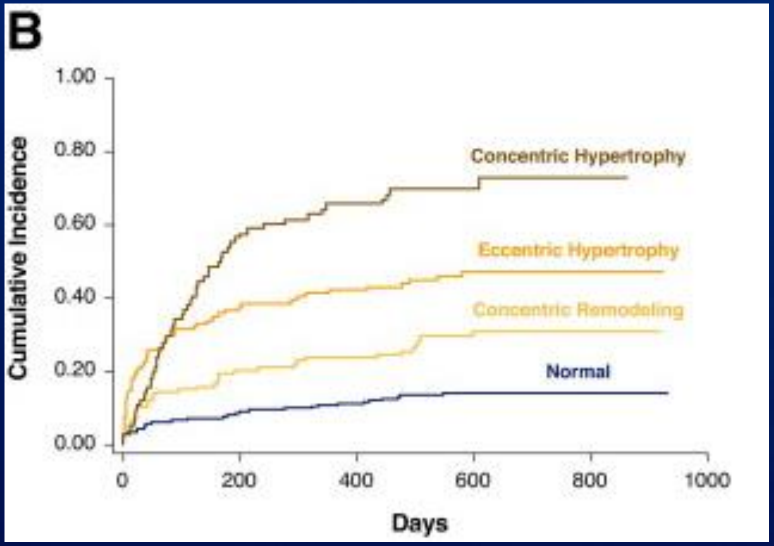
LV Geometry: Clinical Implications

All Cause Mortality



Cardiovascular Events



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Questions & Discussion

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