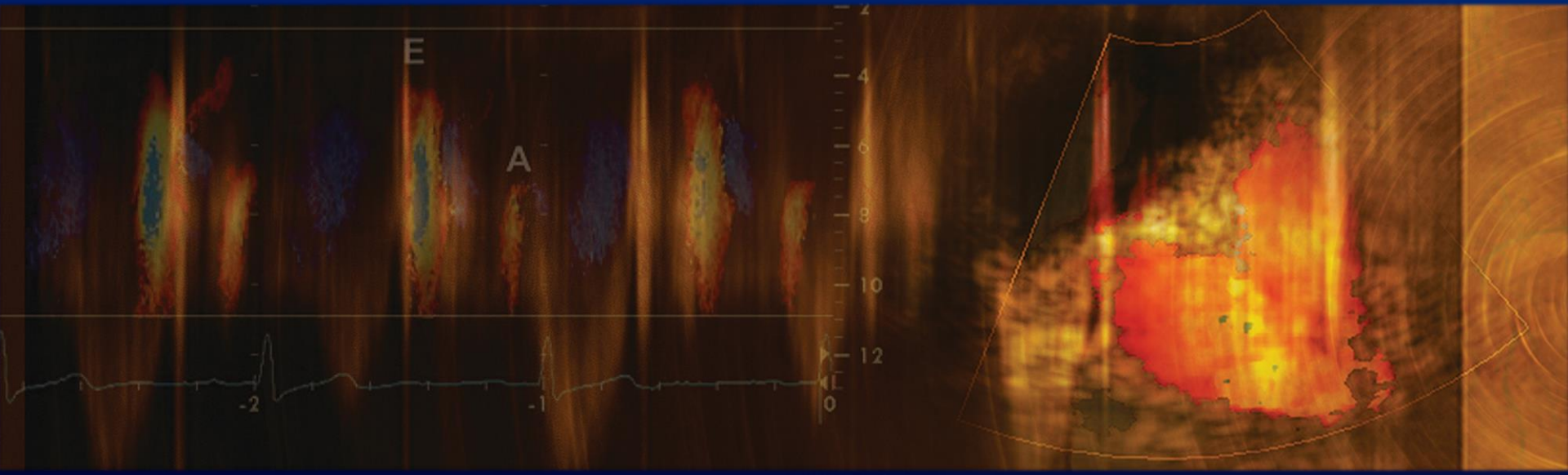
Chamber Quantification and Evaluation of Systolic Function



Hector I. Michelena, FACC, FASE
Associate Professor of Medicine
ACC Latin America
October, 2016

 |

Disclosures

- No relevant financial disclosures

MAYO CLINIC

Overview

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

MAYO CLINIC

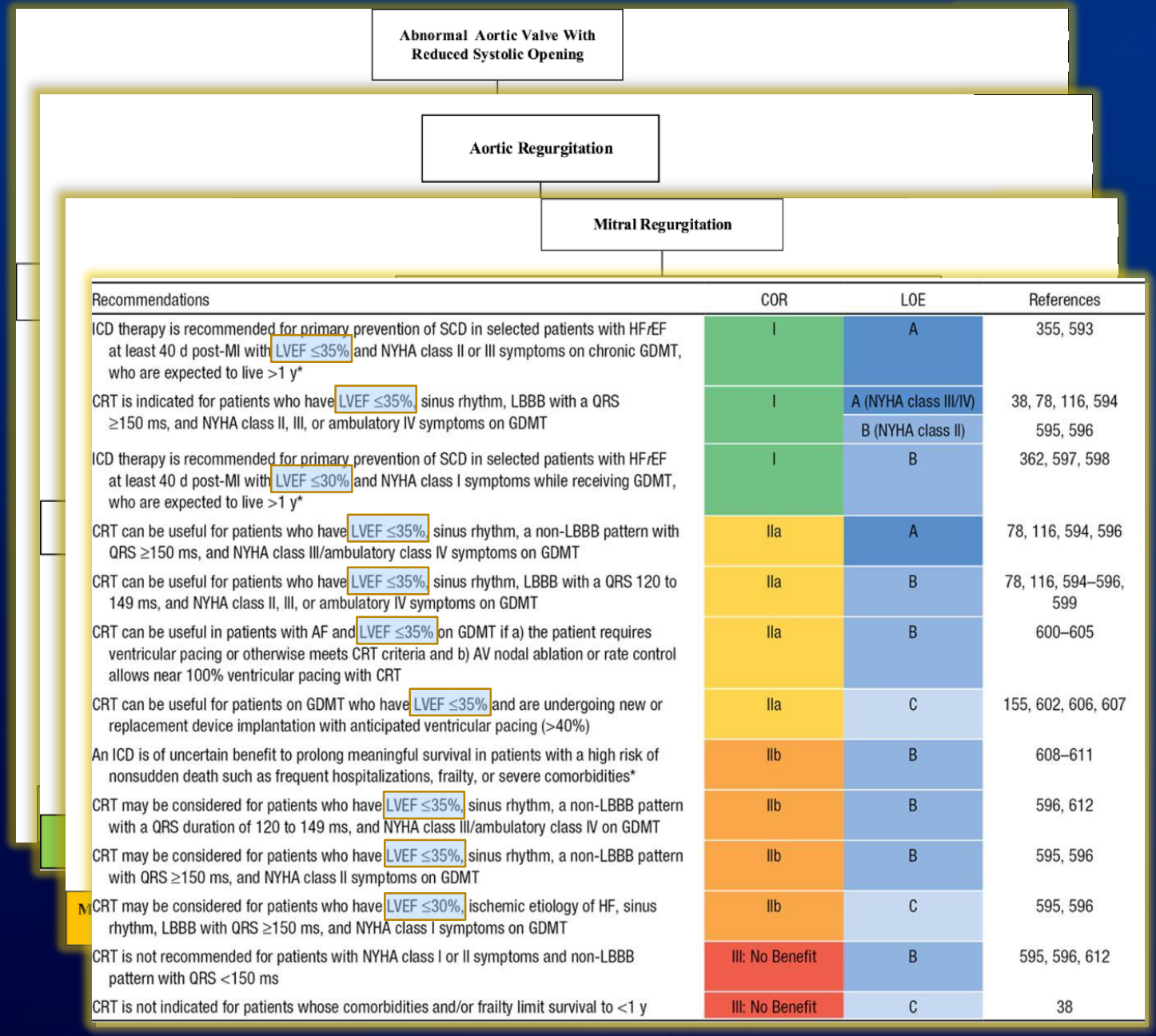
GUIDELINES AND STANDARDS

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

MAYO CLINIC



Recommendations	COR	LOE	References
ICD therapy is recommended for primary prevention of SCD in selected patients with HFrEF 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) B (NYHA class II)	38, 78, 116, 594 595, 596
ICD therapy is recommended for primary prevention of SCD in selected patients with HFrEF 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

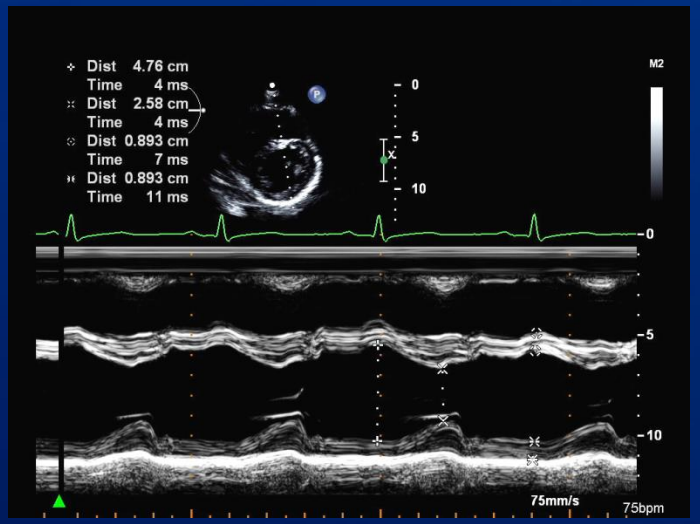
Nishimura RA et al. J Am Coll Cardiol. 2014;63(22):e57-e185.
Yancy CW et al. J Am Coll Cardiol. 2013;62(16):e147-e239.

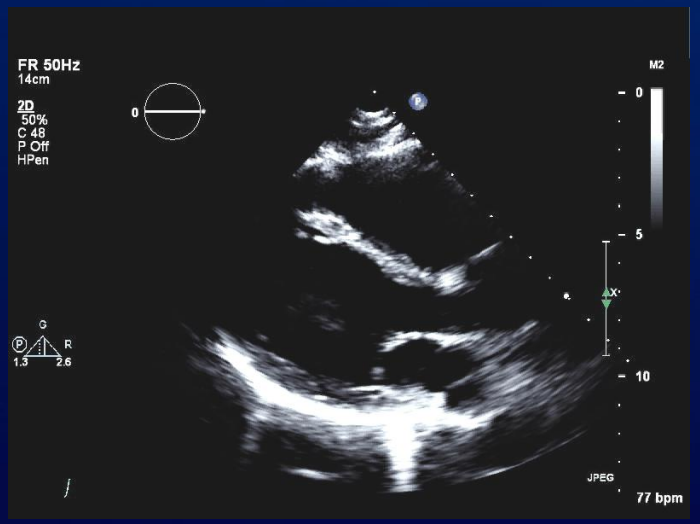
Assessment of LV Size

MAYO CLINIC

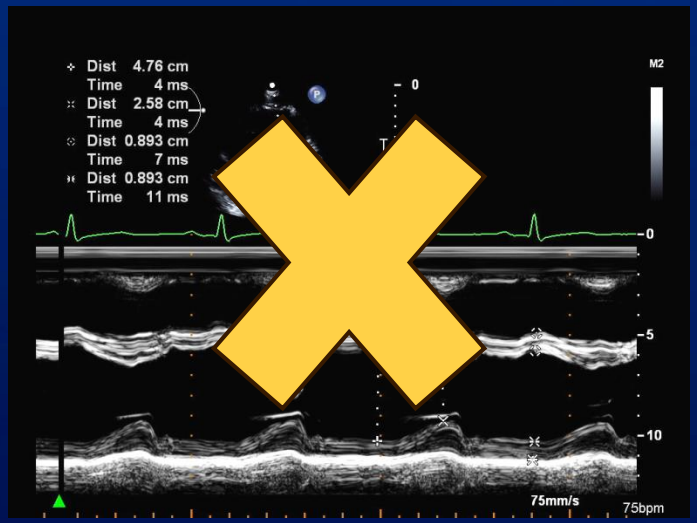
LV Dimensions

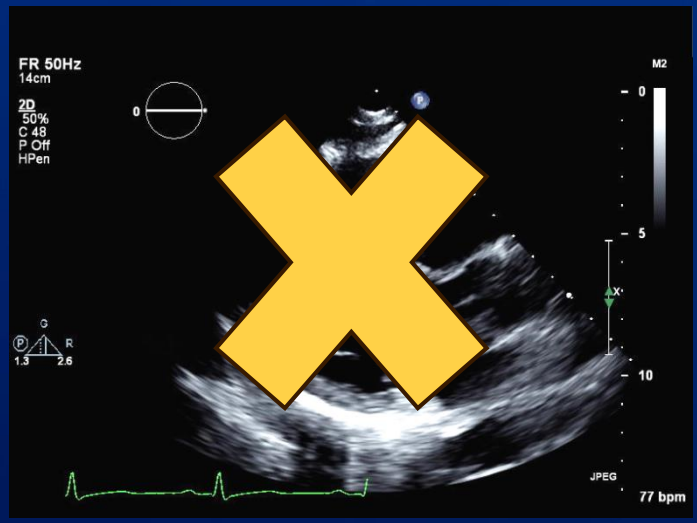
- Measure in PLAX view.
- Measure at or immediately below mitral valve leaflet tips.
- 2D images are preferred to avoid oblique sections of the ventricle
- Representative of LV size only in normally shaped ventricles





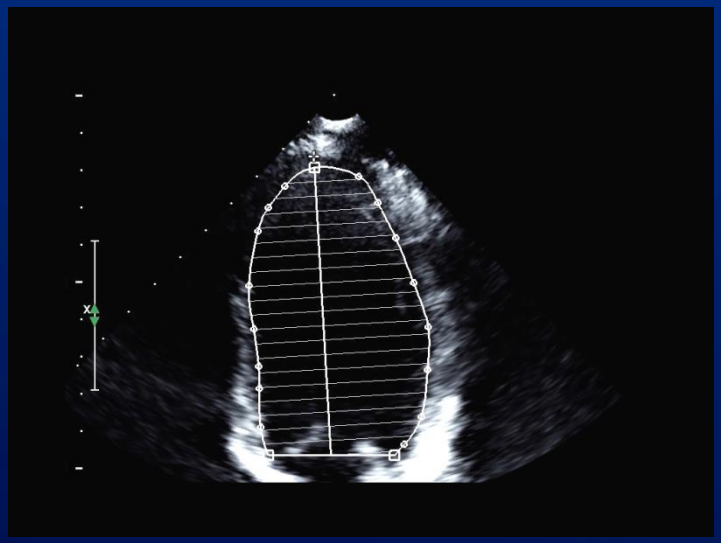
LV Volumes

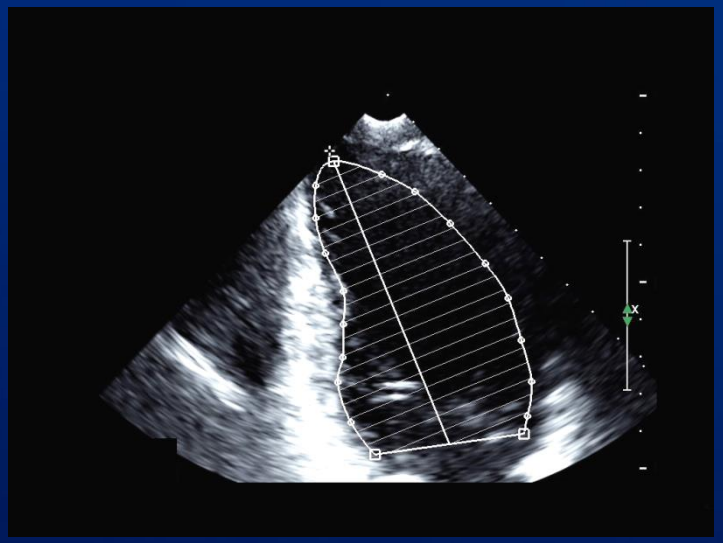




- Calculation of LV volumes from linear dimensions is **no longer recommended.**
- May be inaccurate due to assumption of a fixed geometric LV shape which does not apply in a variety of pathologies.

LV Volumes



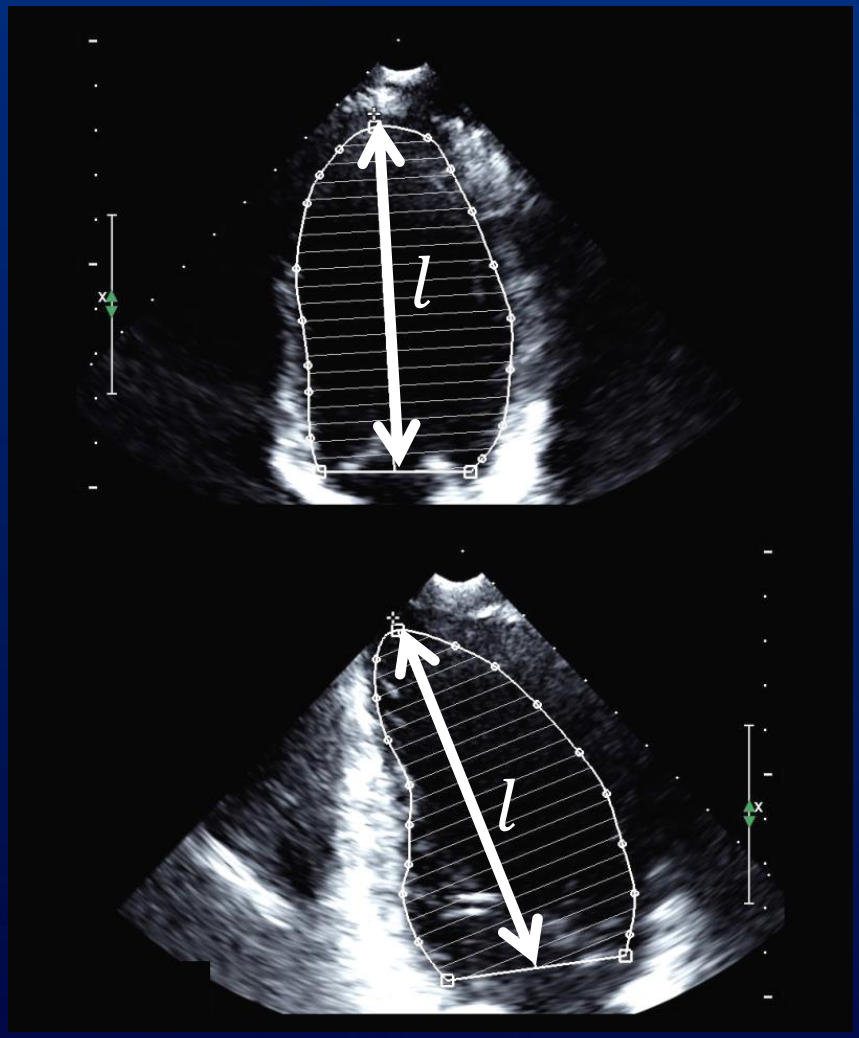


- Should routinely be assessed by using the biplane method of disks summation technique.
- Should be measured from apical 4- and 2-chamber views.
- Avoiding foreshortening and aim to maximize LV areas

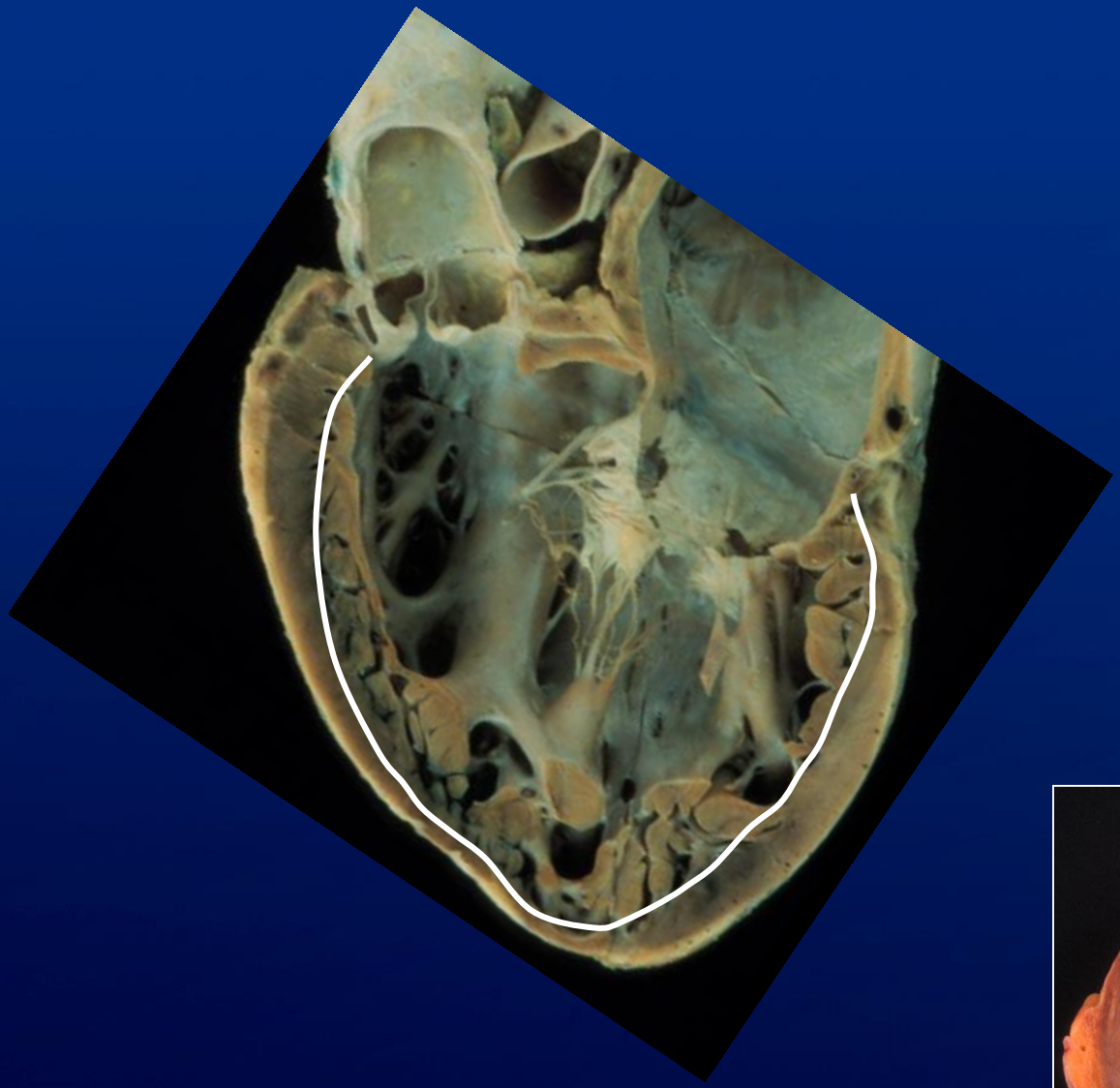
MAYO CLINIC

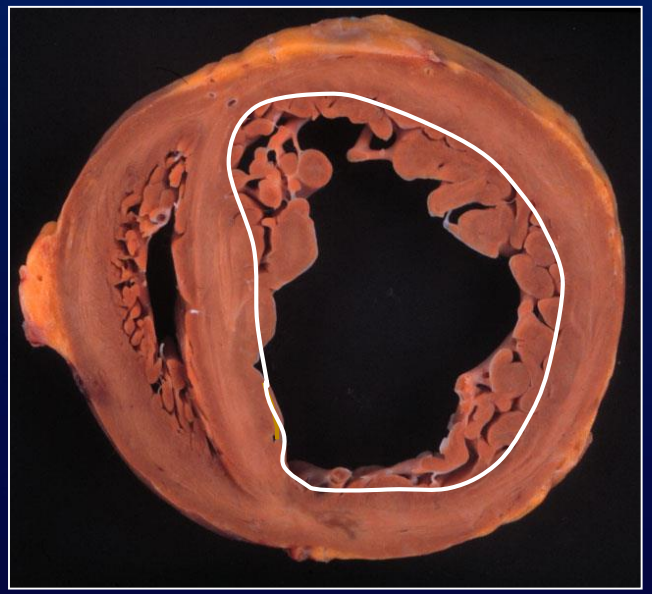
Tips

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



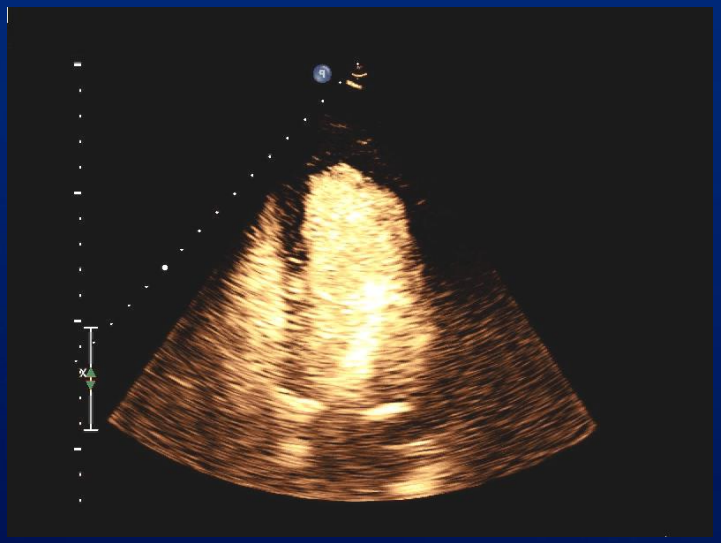
MAYO CLINIC

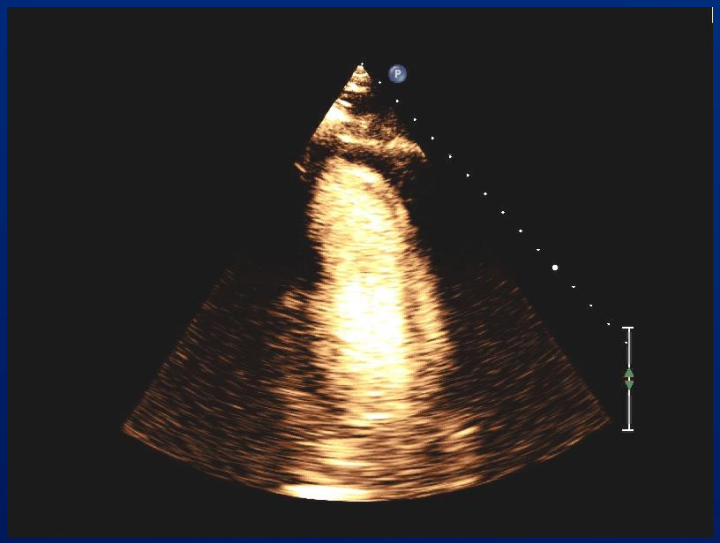




MAYO CLINIC

Contrast Echocardiography

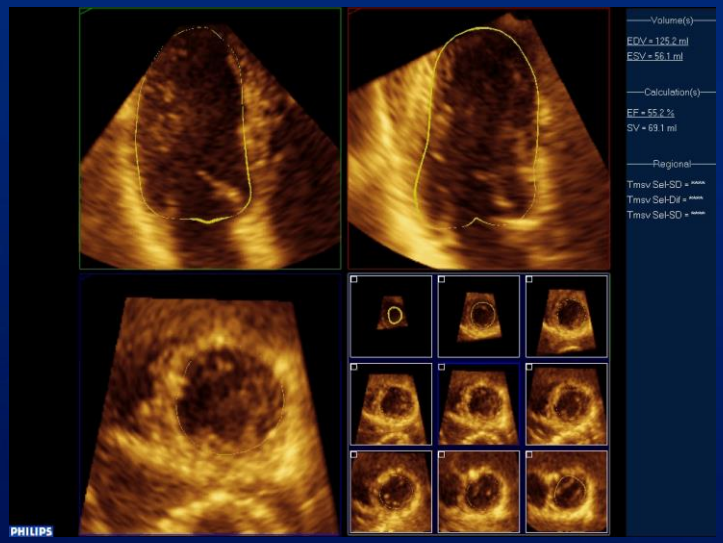


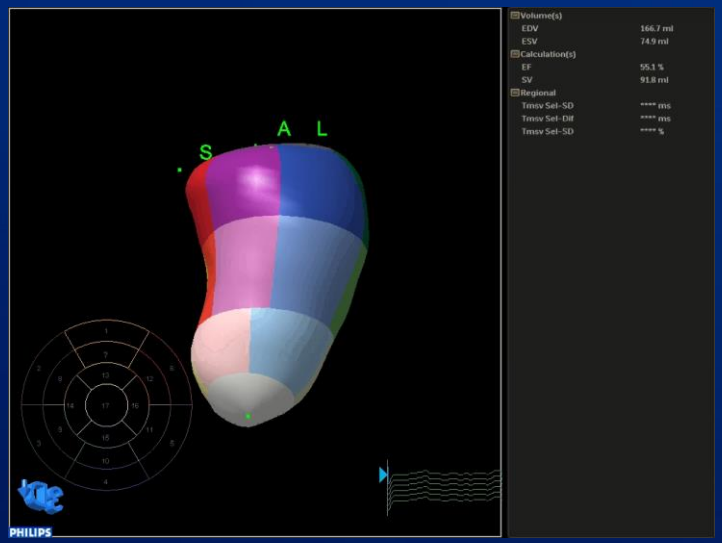


- Should be used when two or more contiguous LV segments are poorly visualized in apical views.
- Contrast-enhanced images may provide larger volumes than unenhanced images.

MAYO CLINIC

3D Echocardiography

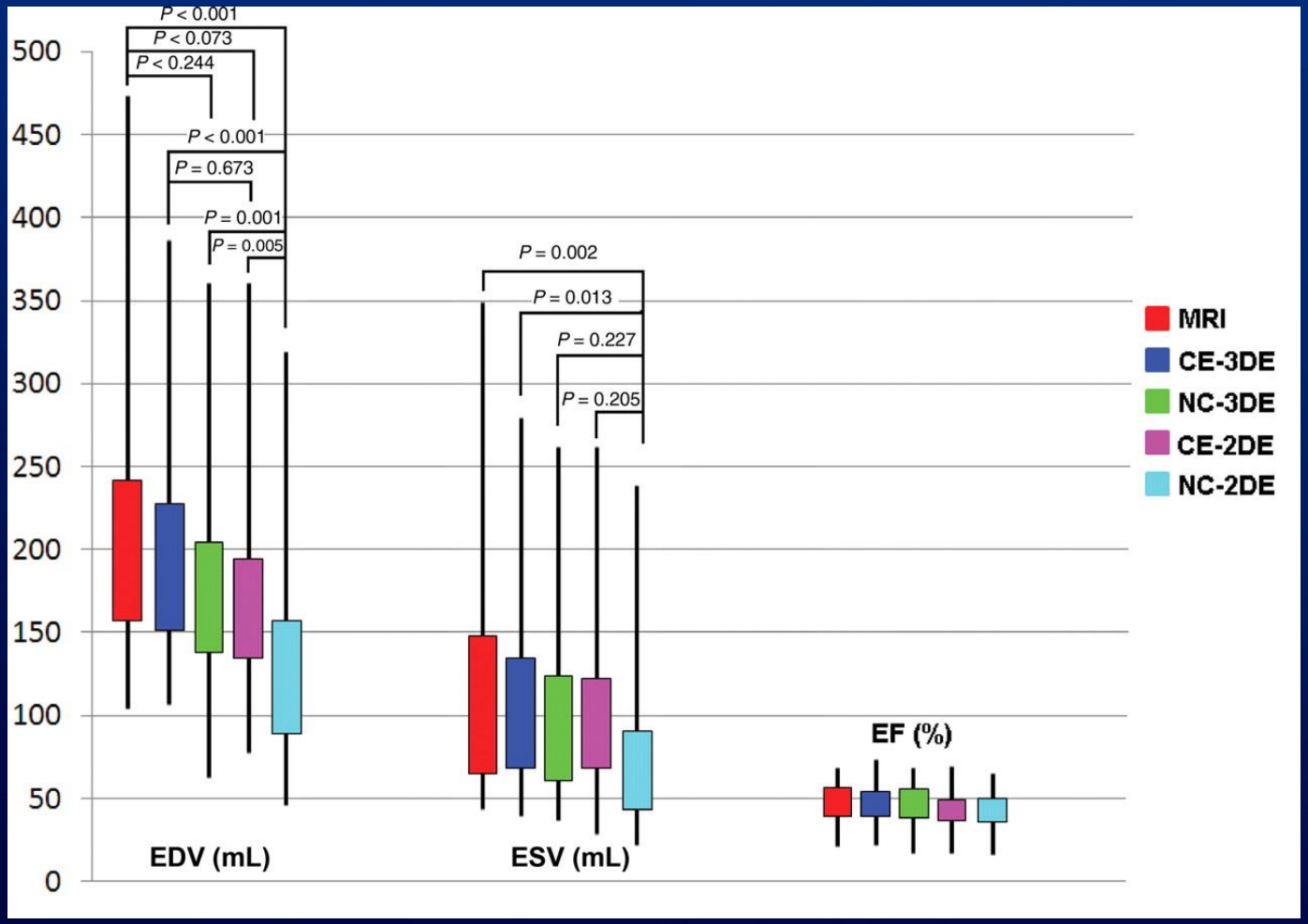




- More accurate and reproducible
- No geometrical assumptions
- 3D LV volume measurement is recommended when feasible depending on image quality.

MAYO CLINIC

Assessment of LV Volumes by Echo



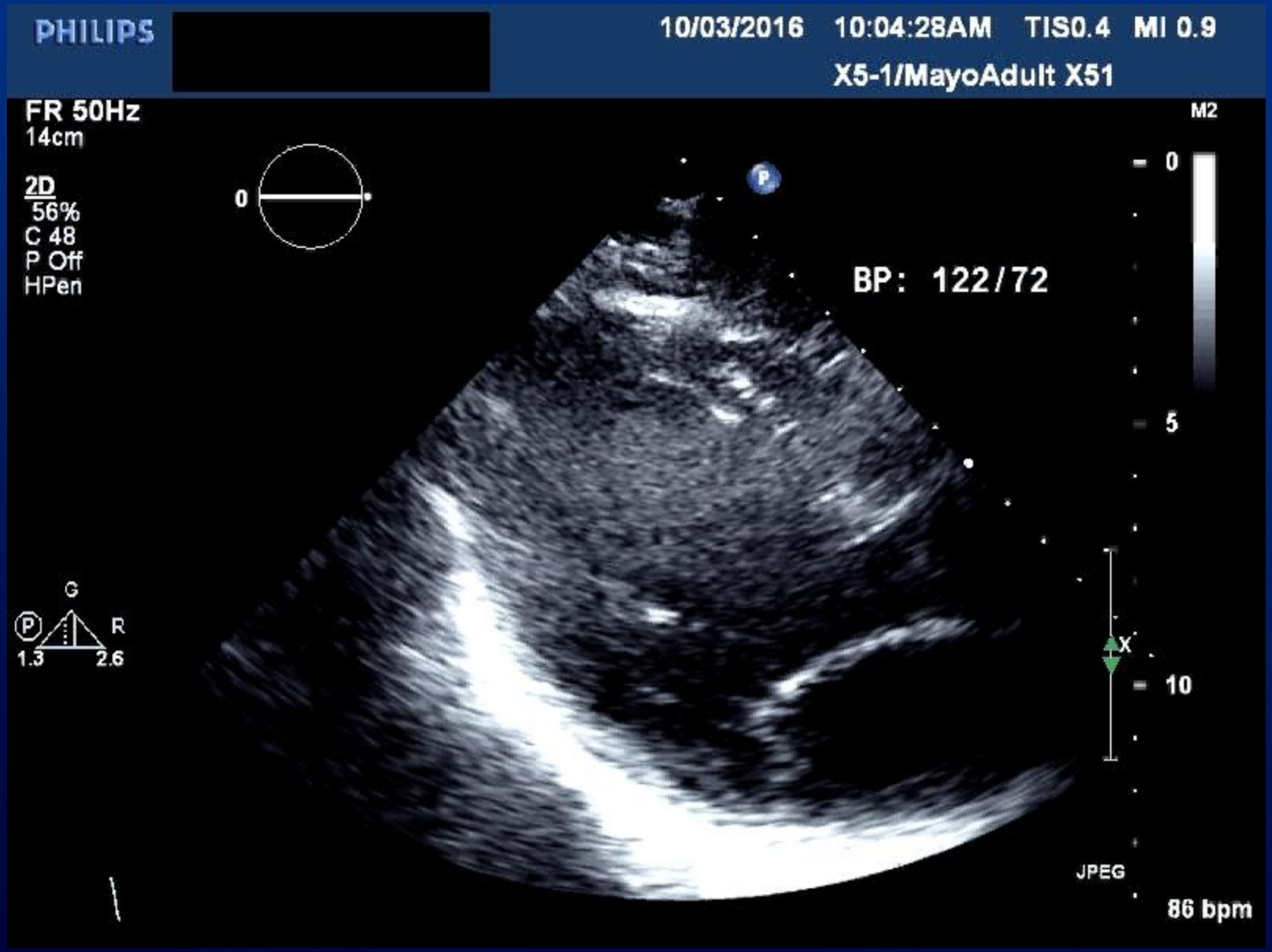
Jenkins C et al. Left ventricular volume measurement with echocardiography: a comparison of left ventricular opacification, three-dimensional echocardiography, or both with magnetic resonance imaging. Eur Heart J. 2009;30:98-106.

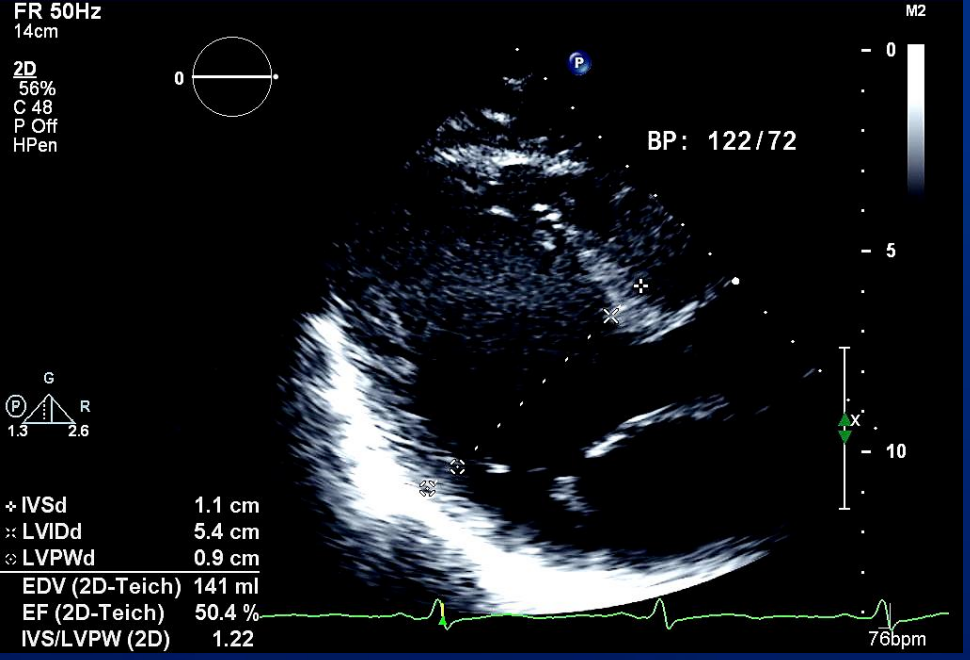
Interpretation of LV size

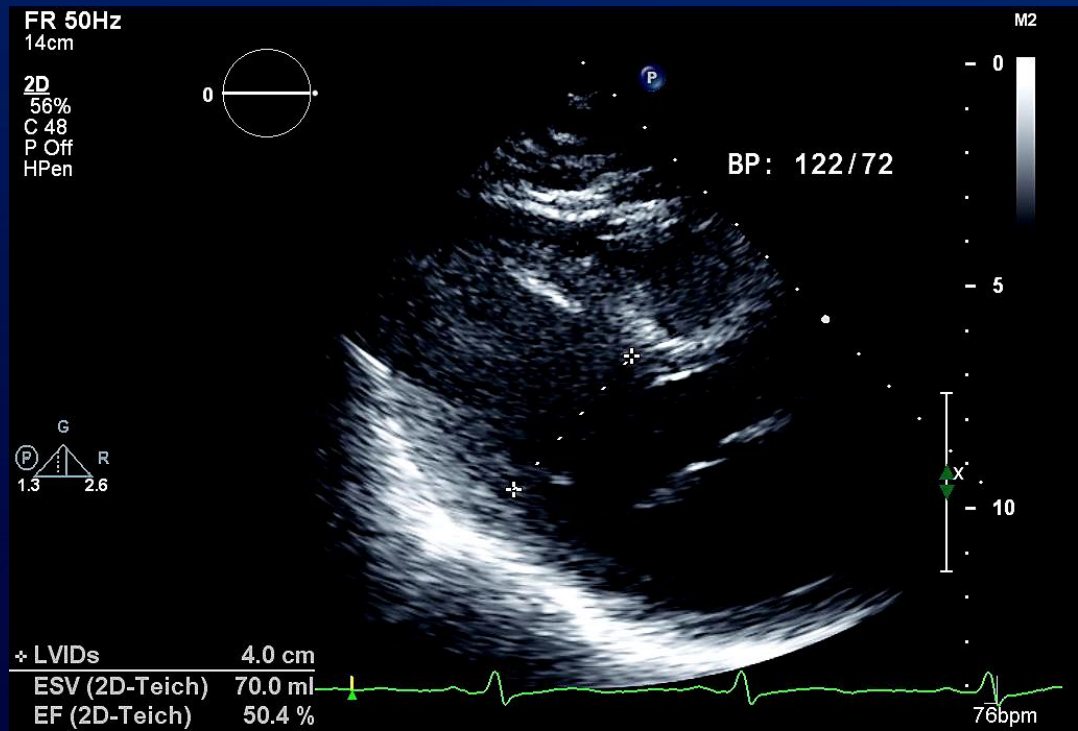
	Male				Female			
	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal	Normal range	Mildly abnormal	Moderately abnormal	Severely abnormal
LV dimension								
LV diastolic diameter (cm)	4.2–5.8	5.9–6.3	6.4–6.8	>6.8	3.8–5.2	5.3–5.6	5.7–6.1	>6.1
LV diastolic diameter/BSA (cm/m^2)	2.2–3.0	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

MAYO CLINIC

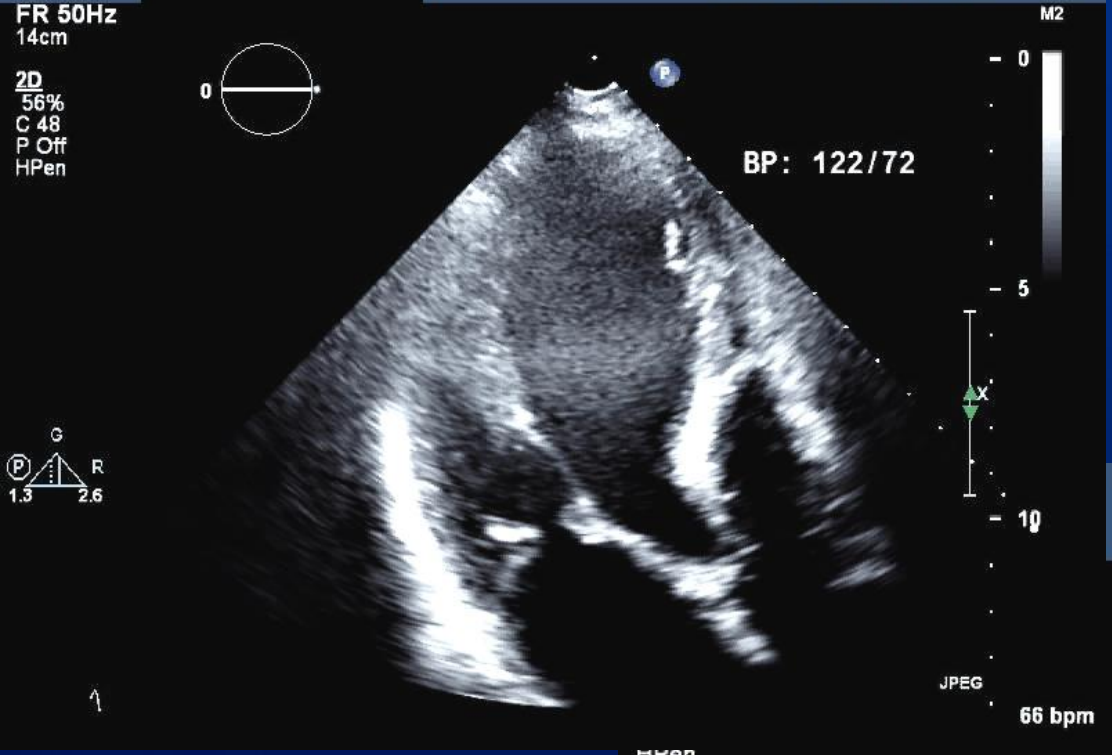
Lang RM et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr 2015;28:1-39.

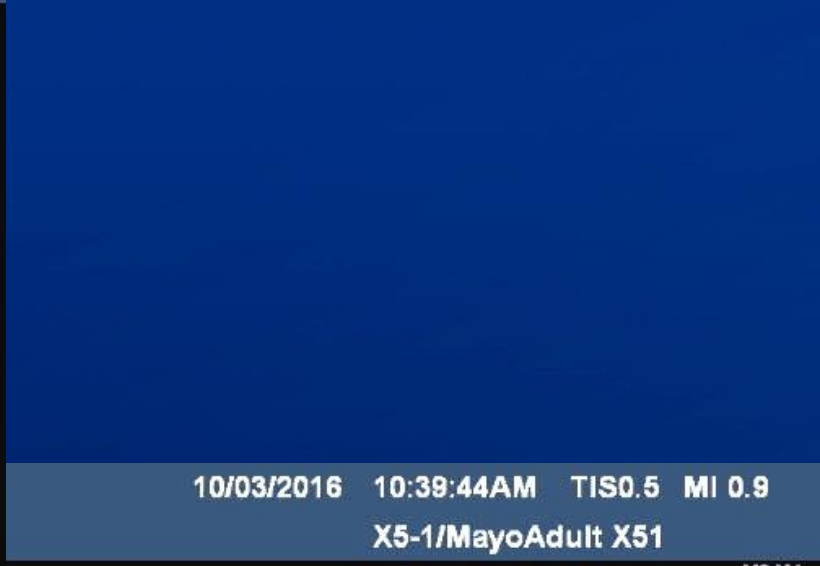

PHILIPS
[redacted]
10/03/2016 10:04:28AM TIS0.4 MI 0.9
X5-1/MayoAdult X51
FR 50Hz
14cm
2D
56%
C 48
P Off
HPen
0
M2
0
5
10
BP: 122/72
G
P
R
1.3
2.6
X
JPEG
86 bpm

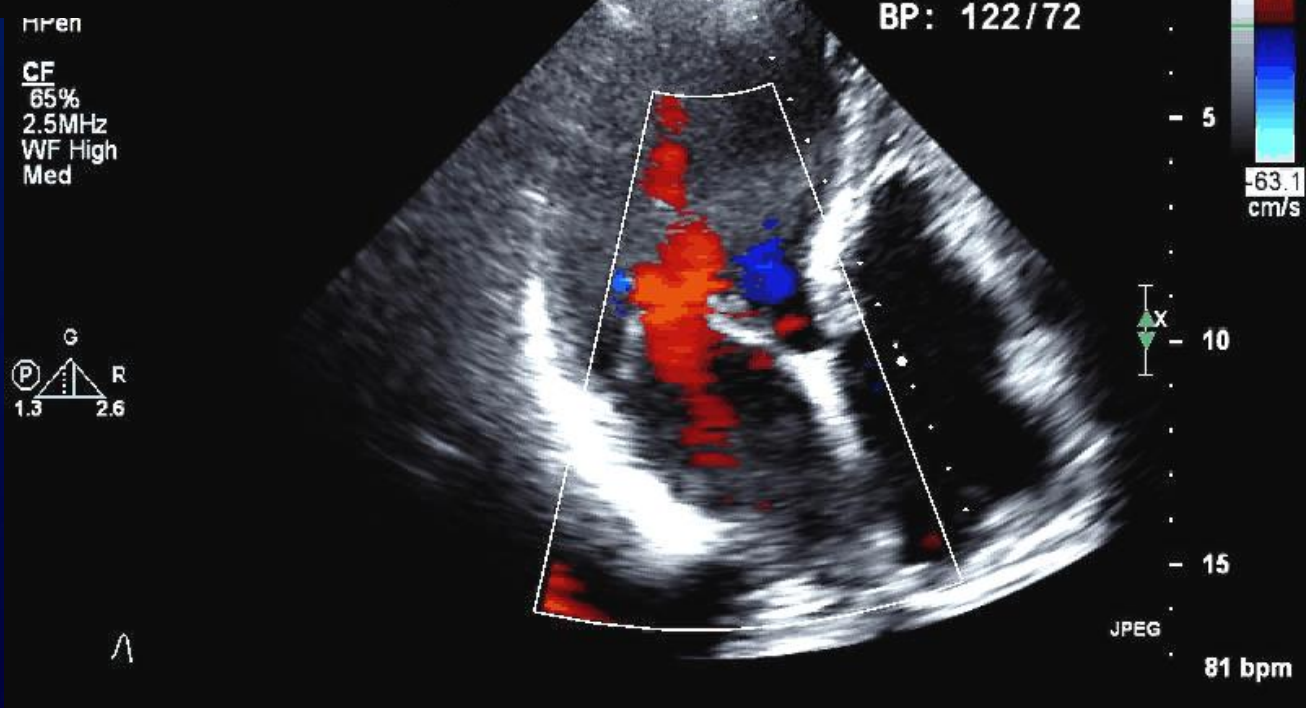

FR 50Hz
14cm
2D
56%
C 48
P Off
HPen
M2
BP: 122/72
0
5
10
G
R
1.3
2.6
IVSd 1.1 cm
LVIDd 5.4 cm
LVPWd 0.9 cm
EDV (2D-Teich) 141 ml
EF (2D-Teich) 50.4 %
IVS/LVPW (2D) 1.22
76bpm


FR 50Hz
14cm
2D
56%
C 48
P Off
HPen
M2
BP: 122/72
0
5
10
G
R
1.3
2.6
LVIDs 4.0 cm
ESV (2D-Teich) 70.0 ml
EF (2D-Teich) 50.4 %
76bpm

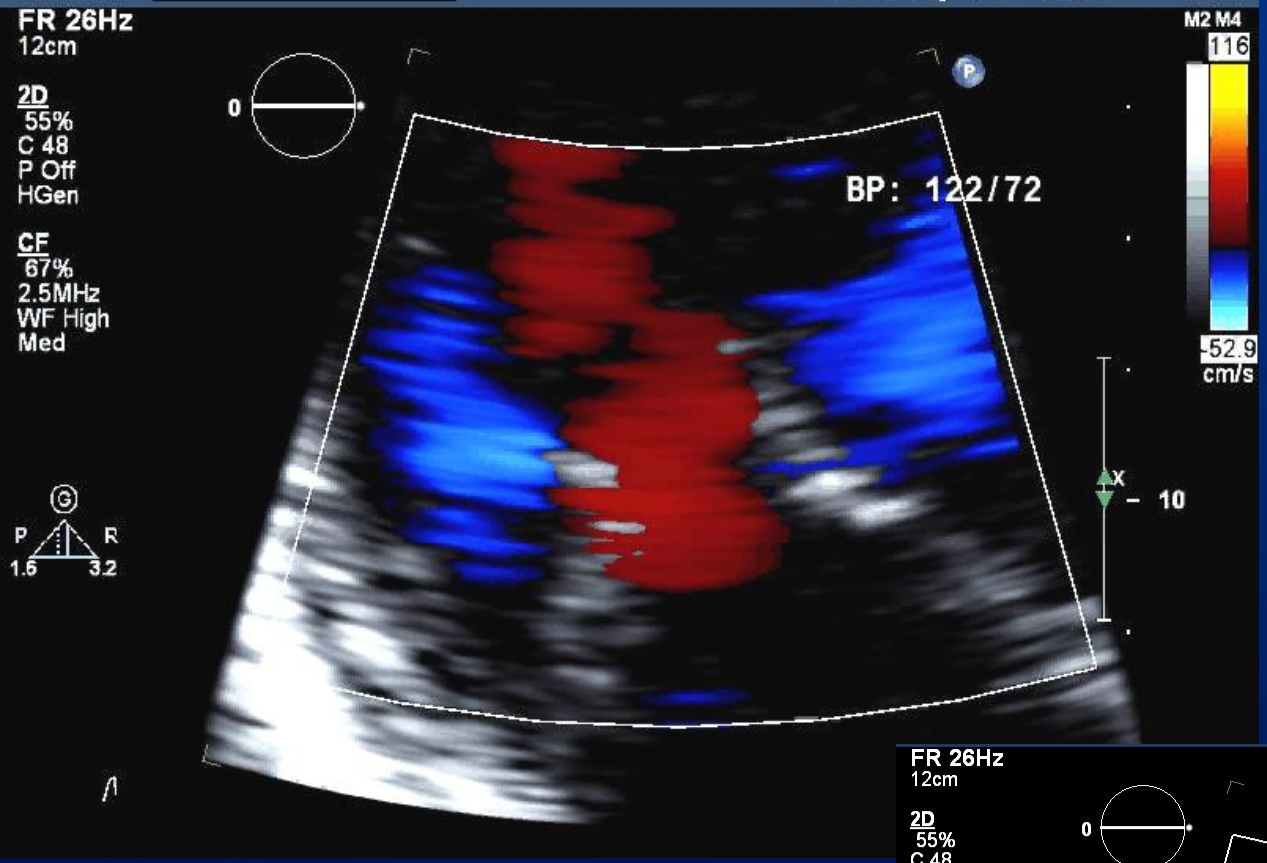
MAYO CLINIC

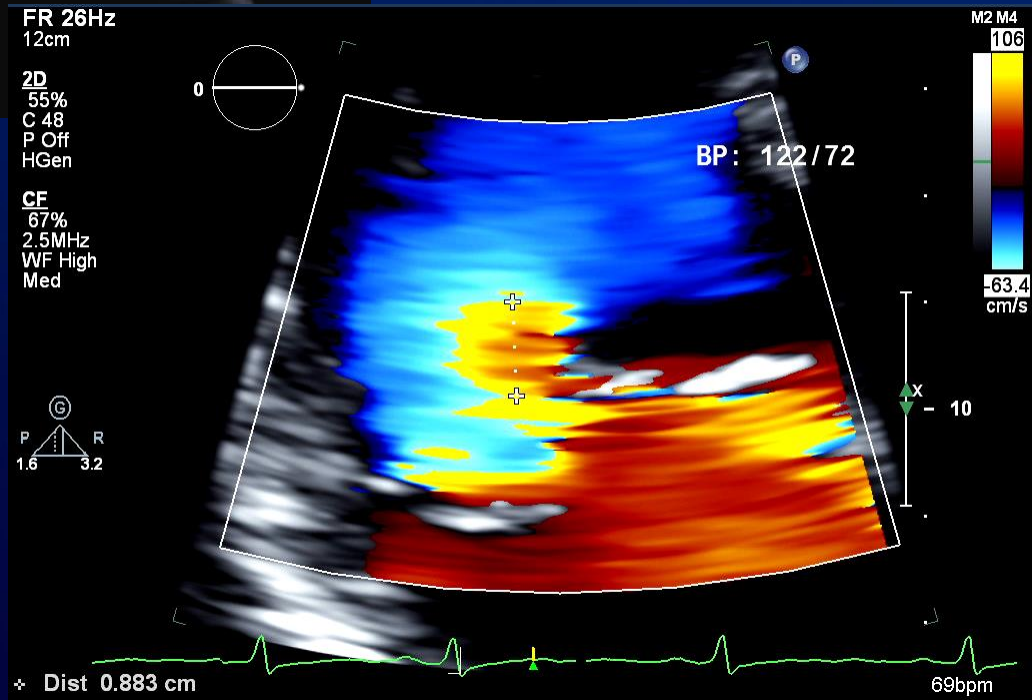

FR 50Hz
14cm
2D
56%
C 48
P Off
HPen
M2
BP: 122/72
JPEG
66 bpm


10/03/2016 10:39:44AM TIS0.5 MI 0.9
X5-1/MayoAdult X51


HPen
CF
65%
2.5MHz
WF High
Med
M2 M4
+63.1
-63.1
cm/s
BP: 122/72
JPEG
81 bpm

MAYO CLINIC


FR 26Hz
12cm
2D
55%
C 48
P Off
HGen
CF
67%
2.5MHz
WF High
Med
BP: 122/72
M2 M4
116
-52.9
cm/s
10
P
R
1.6
3.2


FR 26Hz
12cm
2D
55%
C 48
P Off
HGen
CF
67%
2.5MHz
WF High
Med
BP: 122/72
M2 M4
106
-63.4
cm/s
10
P
R
1.6
3.2
Dist 0.883 cm
69bpm

MAYO CLINIC

	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

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

MAYO CLINIC

Assessment of LV Function

MAYO CLINIC

Methods

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

MAYO CLINIC

LVEF: Modified Quinones Method

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

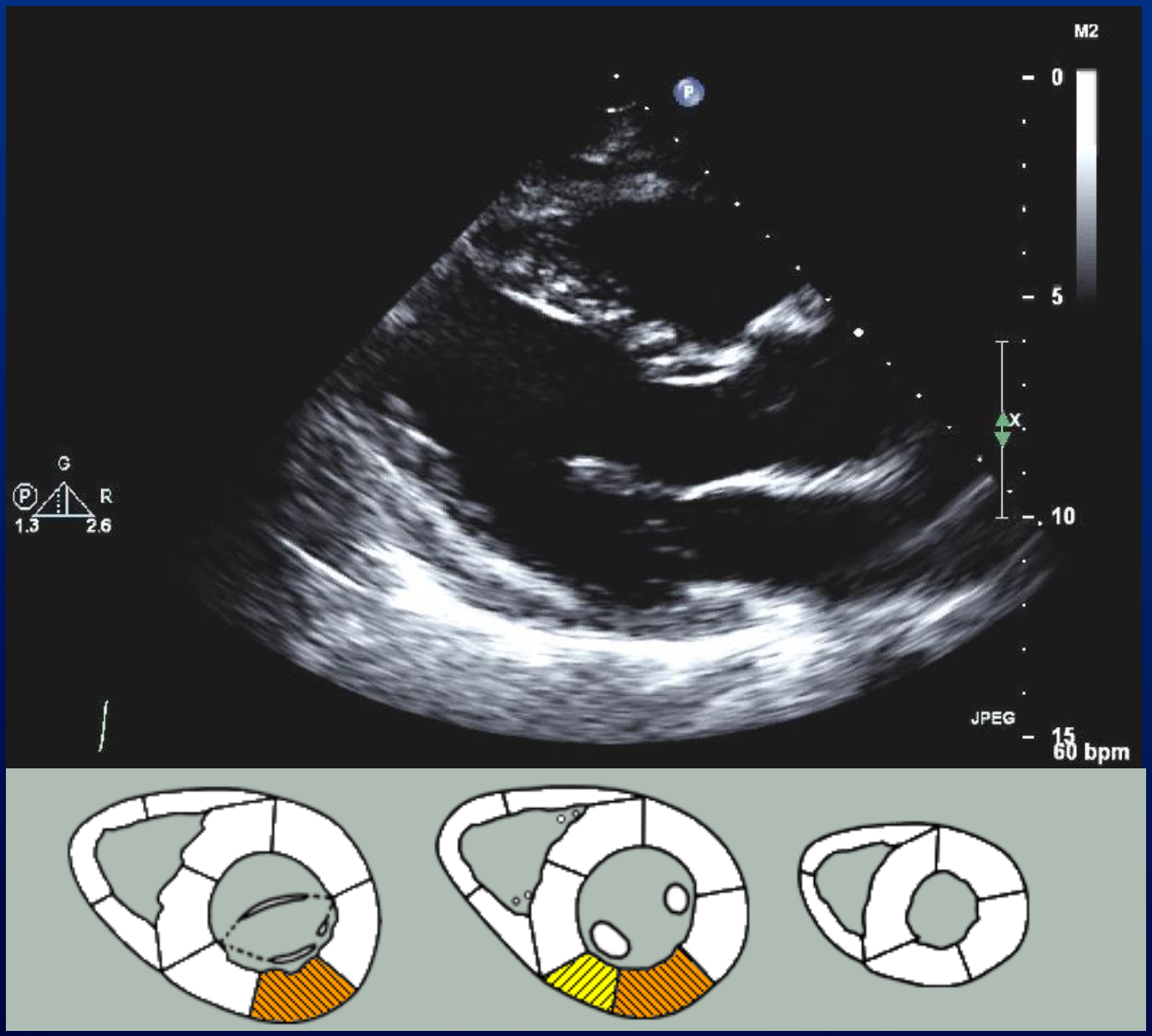
$$EF = LVEF_{calc} + [(1 - LVE$$

Where ap (%ΔL) is :

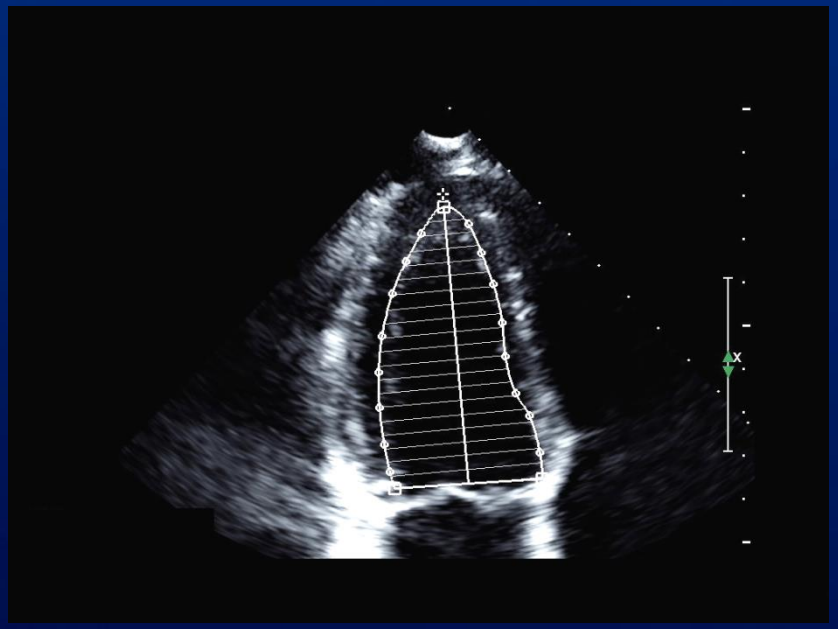
- 1 mal
- 5 Hypokinetic
- 0 Akinetic
- -5 Dyskinetic
- -10 Aneurysmal

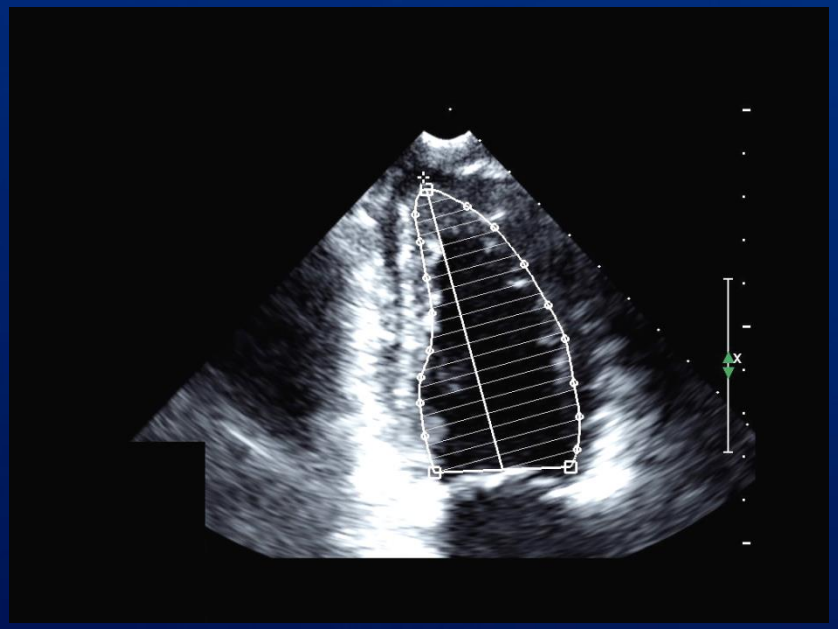
Not ASE Recommended

MAYO CLINIC



LVEF: Modified Simpson's Biplane

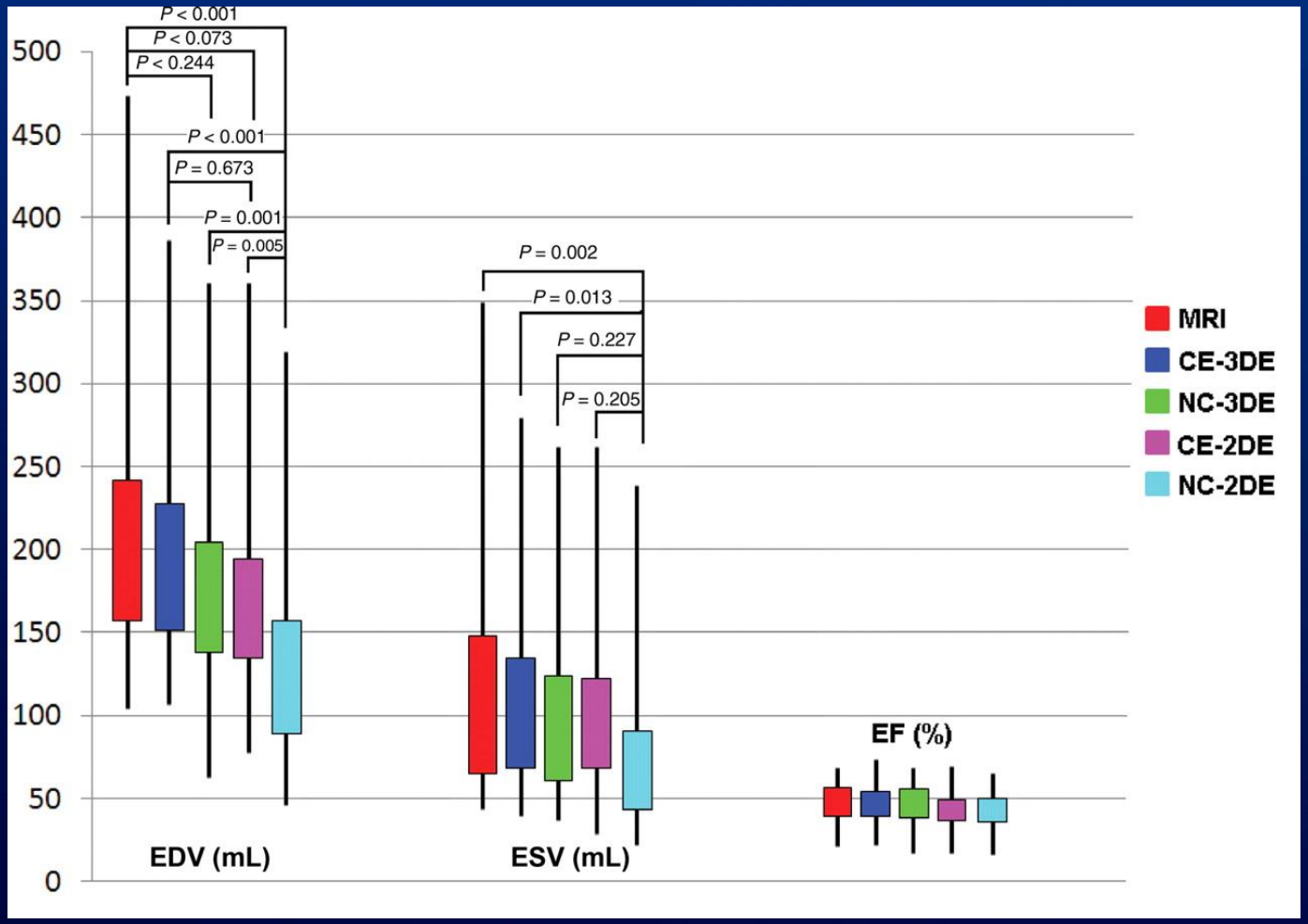




$$LVEF = \frac{LVEDV - LVESV}{LVEDV} \times 100$$

MAYO CLINIC

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 %

MAYO CLINIC

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.

Assessment of LV Mass and Geometry

MAYO CLINIC

Question

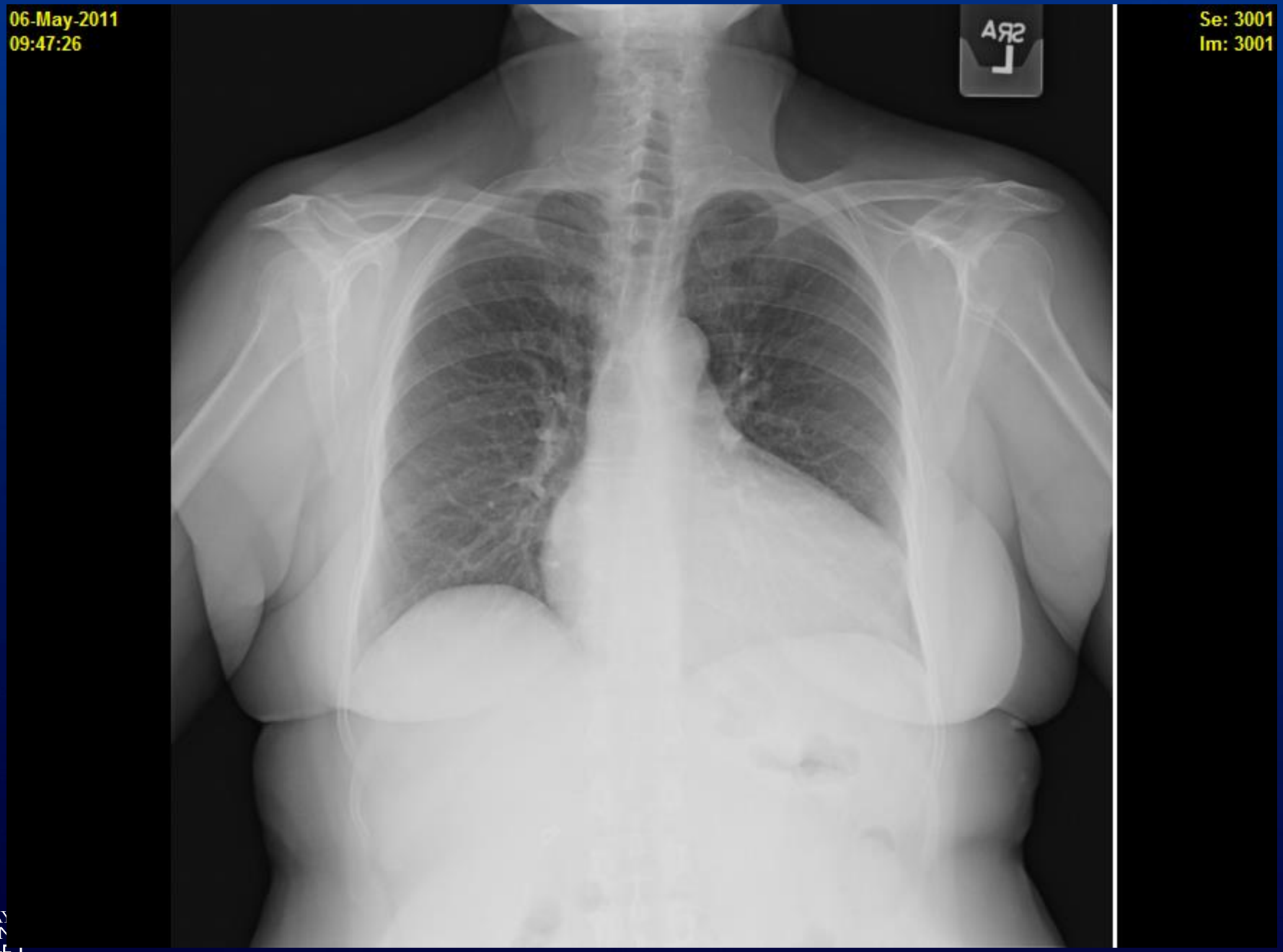
- 64 year old white female presents with a 16 year history of hypertension, she initially was managed with diuretics alone but has been managed with two drug therapy with ACE inhibitor and diuretics for the last 7 years.

MAYO CLINIC

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

MAYO CLINIC


06-May-2011
09:47:26
Se: 3001
Im: 3001
SRA
L

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

MAYO CLINIC

Question

- Which best describes the remodeling of the left ventricle

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

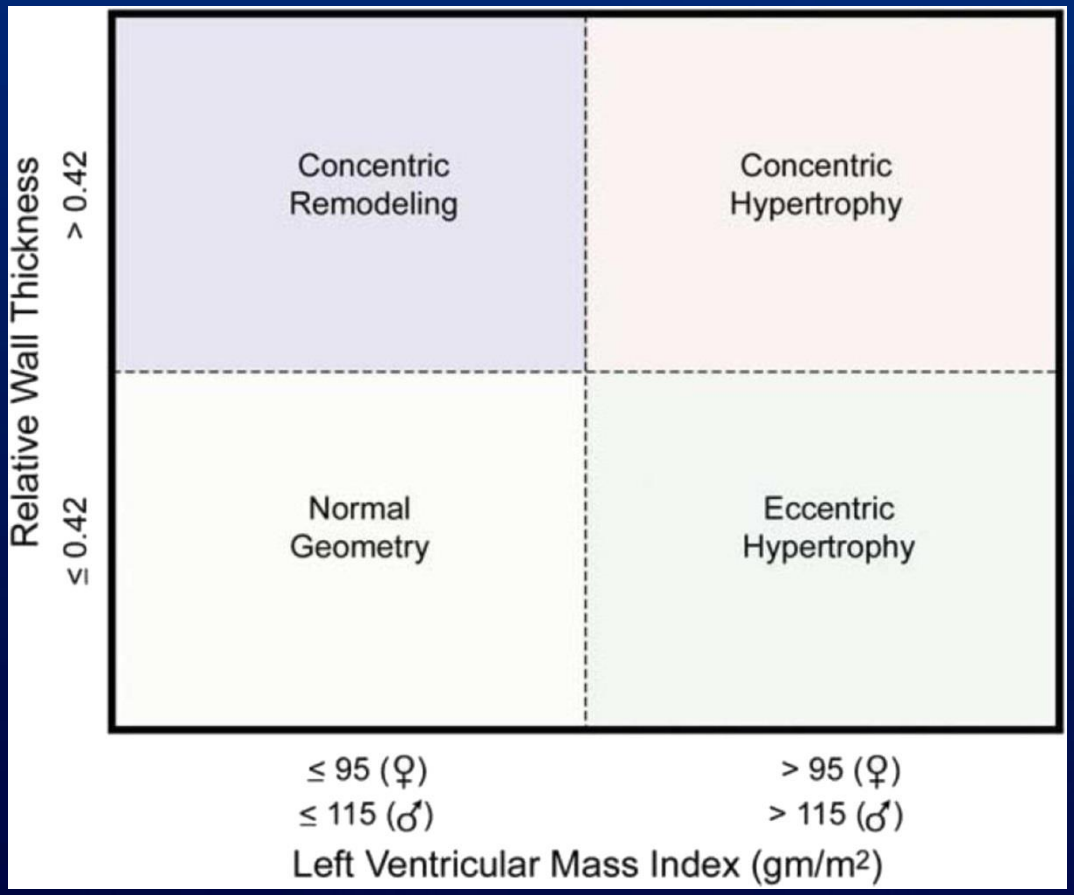
MAYO CLINIC

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

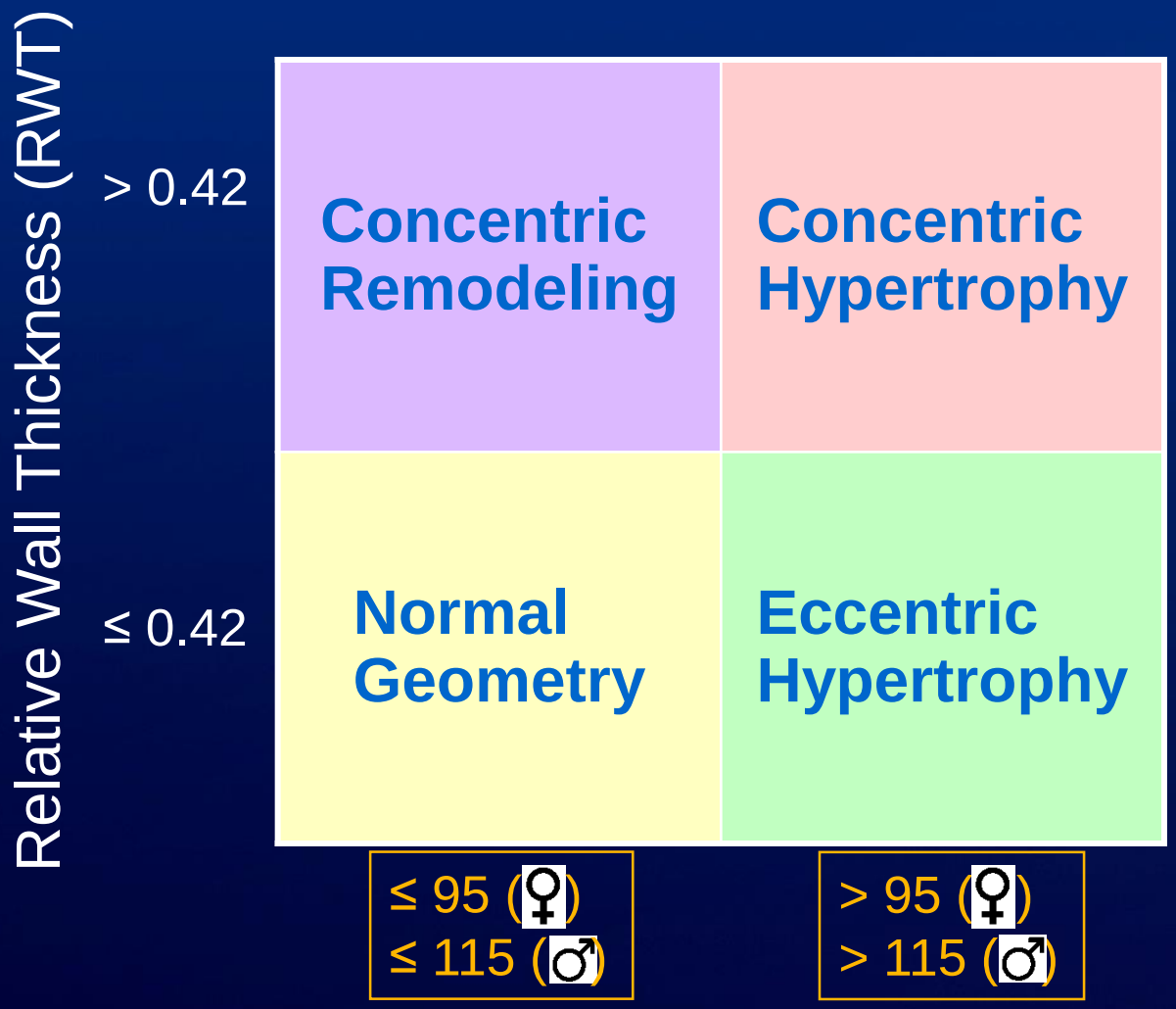
Lang RM et al. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr 2015;28:1-39.

Classification of LV Geometry



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.

Relative Wall Thickness



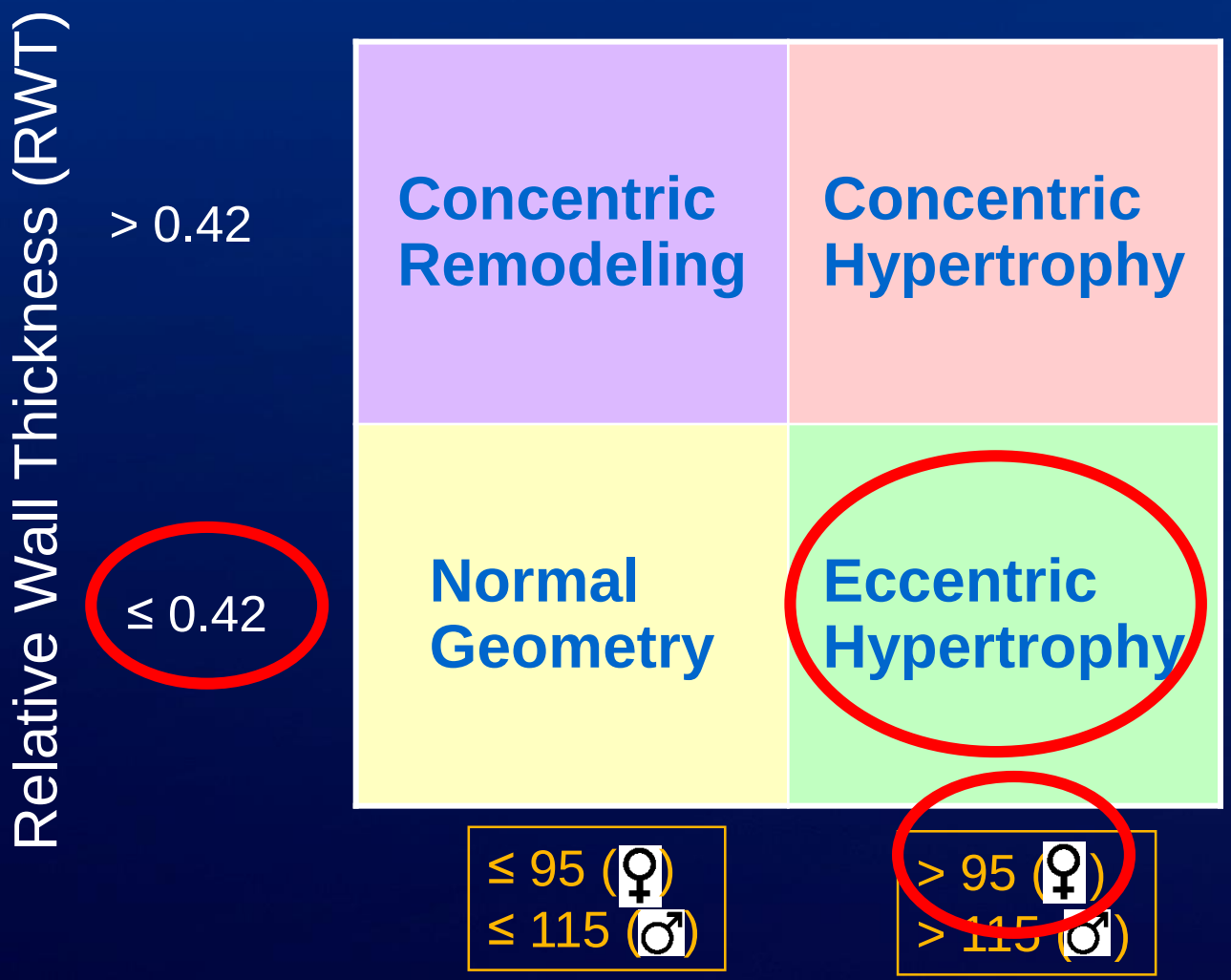
$$RWT = \frac{2 \times PWT_d}{LVID_d}$$

Question

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

MAYO CLINIC

Relative Wall Thickness



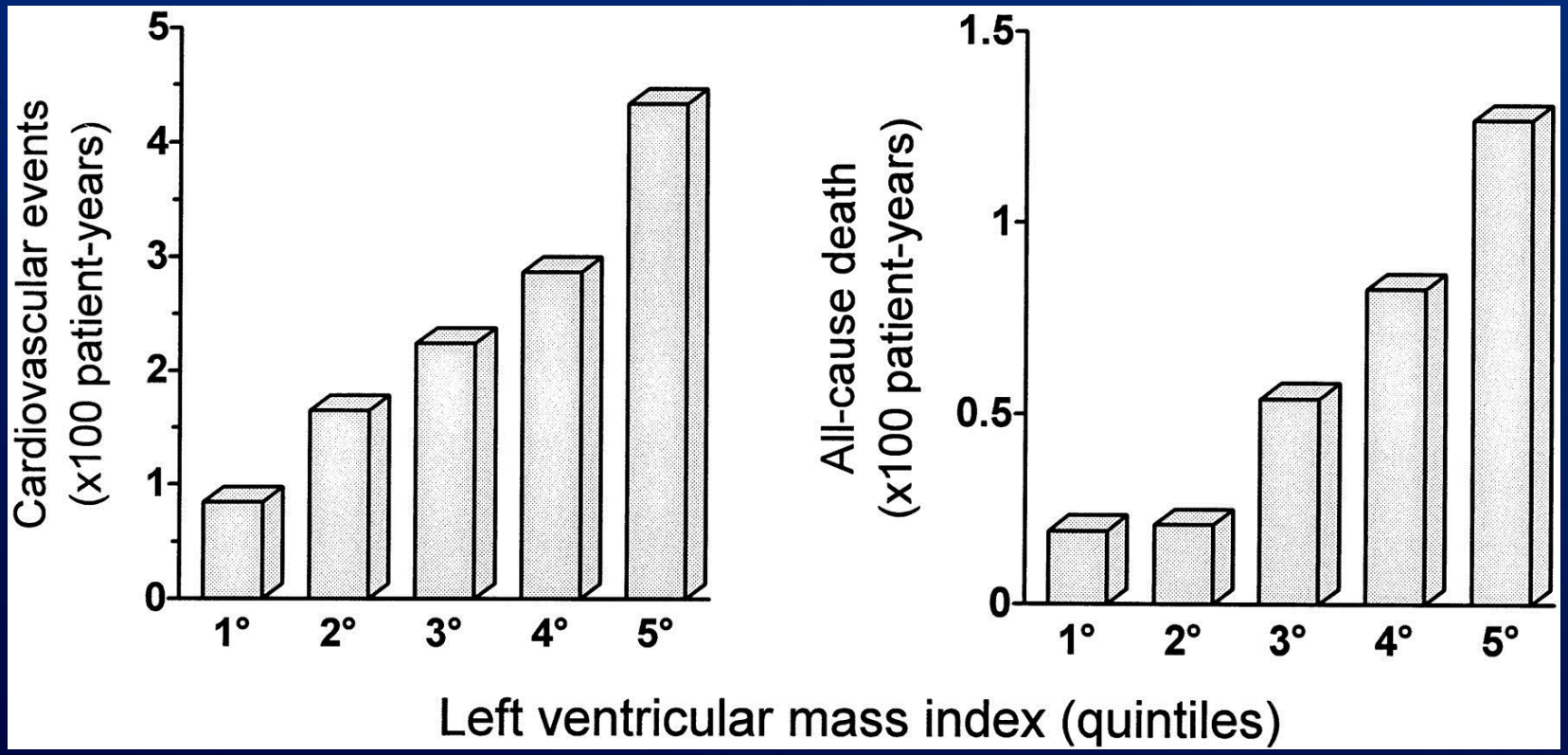
Question

- Which best describes the remodeling of the left ventricle

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

MAYO CLINIC

LV Mass: A Marker of Prognosis



Schillaci G et al. Continuous relation between left ventricular mass and cardiovascular risk in essential hypertension. Hypertension 2000;35:580-6.

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]

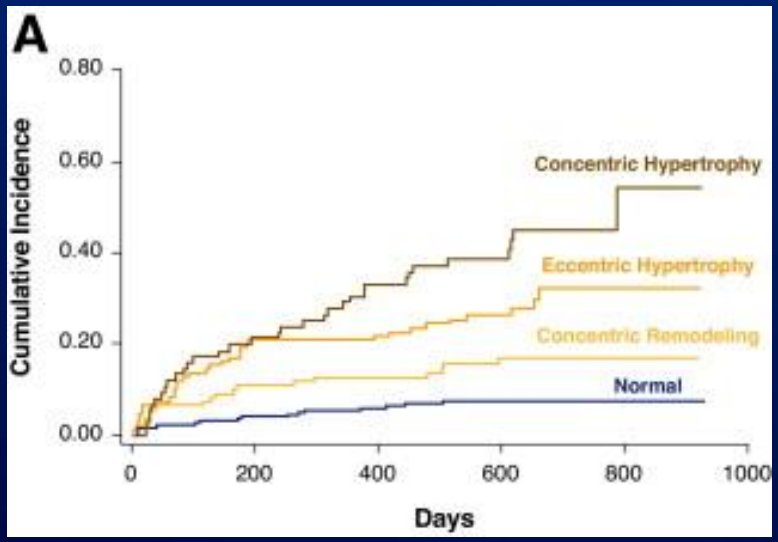
Heart 2016;**102**:1671–1679.

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.

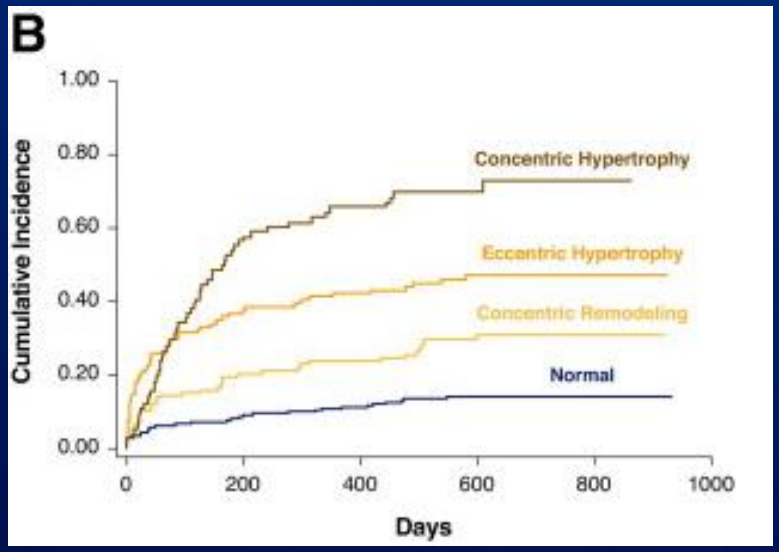
MAYO CLINIC

LV Geometry: Clinical Implications

All Cause Mortality



Cardiovascular Events



MAYO CLINIC

Verma A et al. Prognostic implications of left ventricular mass and geometry following myocardial infarction: the VALIANT (VALsartan In Acute myocardial iNfarcTion) Echocardiographic Study. JACC Cardiovasc Imaging 2008;1:582-91.

MAYO CLINIC

Questions & Discussion