Left ventricle function: an approach

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Jun 2025

Rural POCUS Rounds

THE UNIVERSITY OF BRITISH COLUMBIA
Continuing Professional Development
Faculty of Medicine

Looking back…

Introduction – the basic views

Cardiac arrest

Valves

Right ventricle + pericardium

LV Diastology


Honoured to be presenting
on the lands and waters
of the Haida Nation

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Haida Gwaii Hospital & Health Centre
Daajing Giids, Haida Gwaii BC

Disclosures

No commercial disclosures

Rural Coordination Centre of BC

UBC CPD Continuing Professional Development Medicine

Objectives

LV physiology: systolic and diastolic

Methods to assess LV function

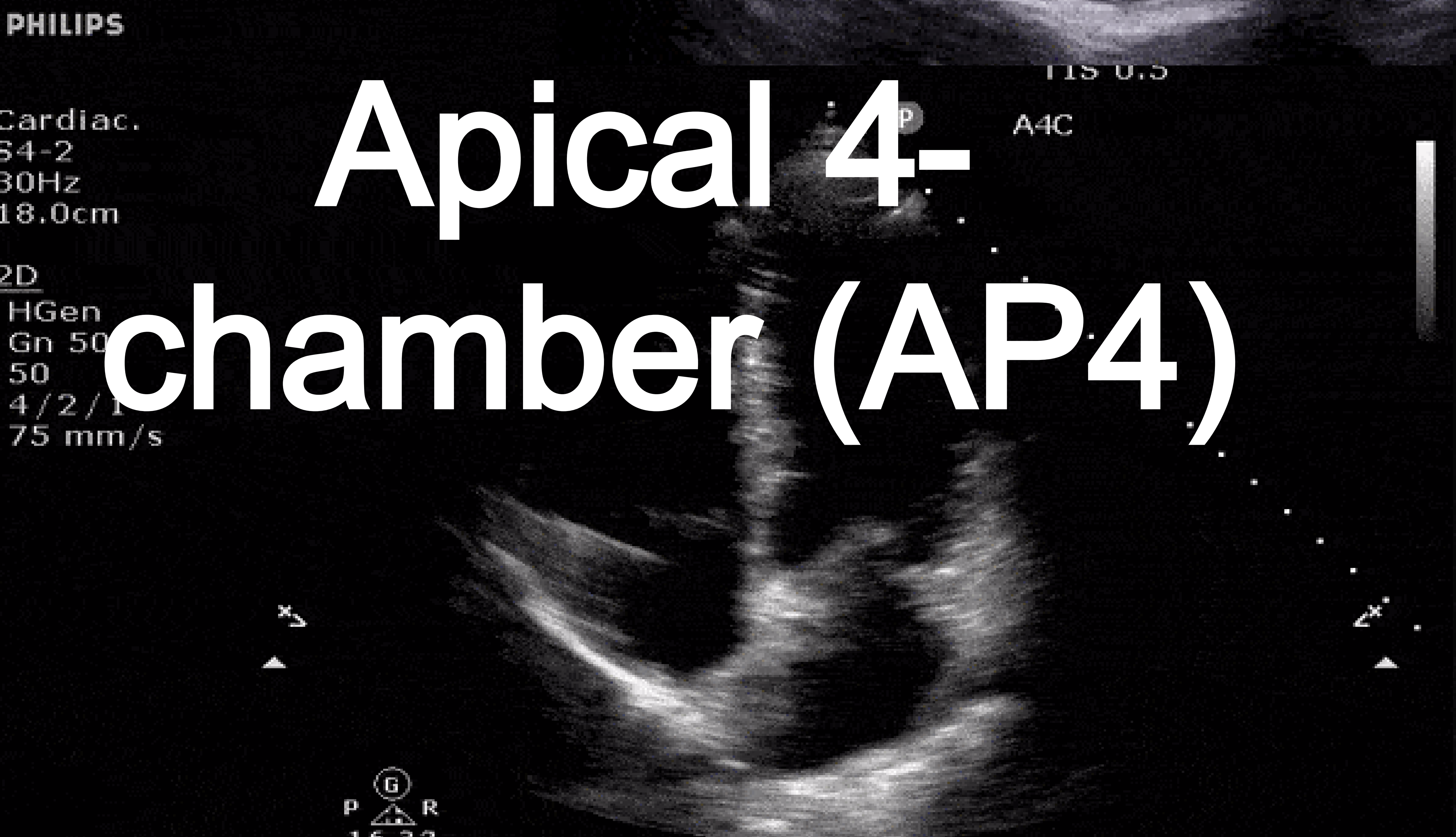
Practice cases – estimating EF


Generate image
Interpret
Integrate


MID
APEX
BASE
LV CAVITY

Parasternal long axis (PLAX)

Apical 4-chamber (AP4)



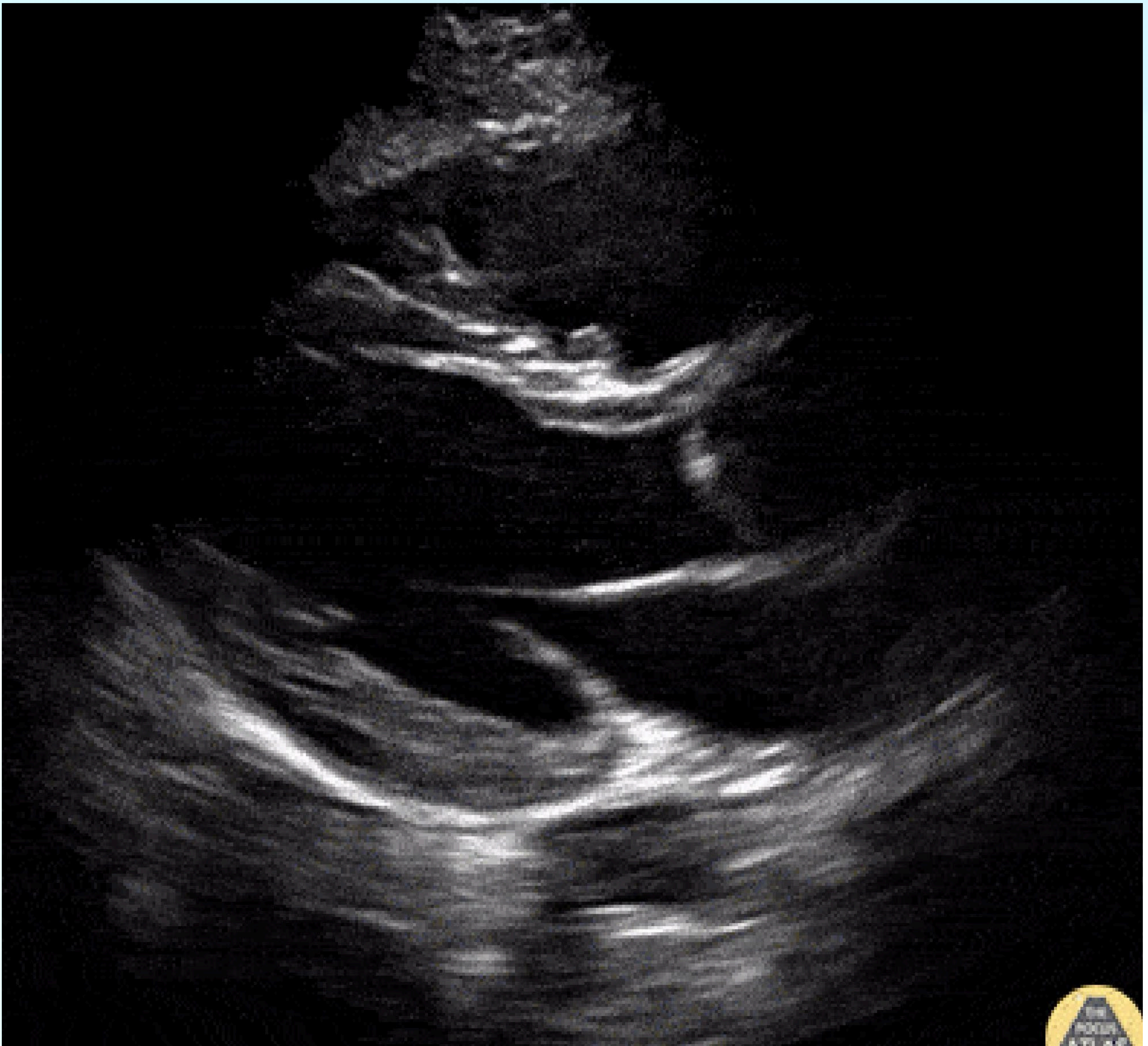
Parasternal short axis (PSAX)

The Left Ventricle

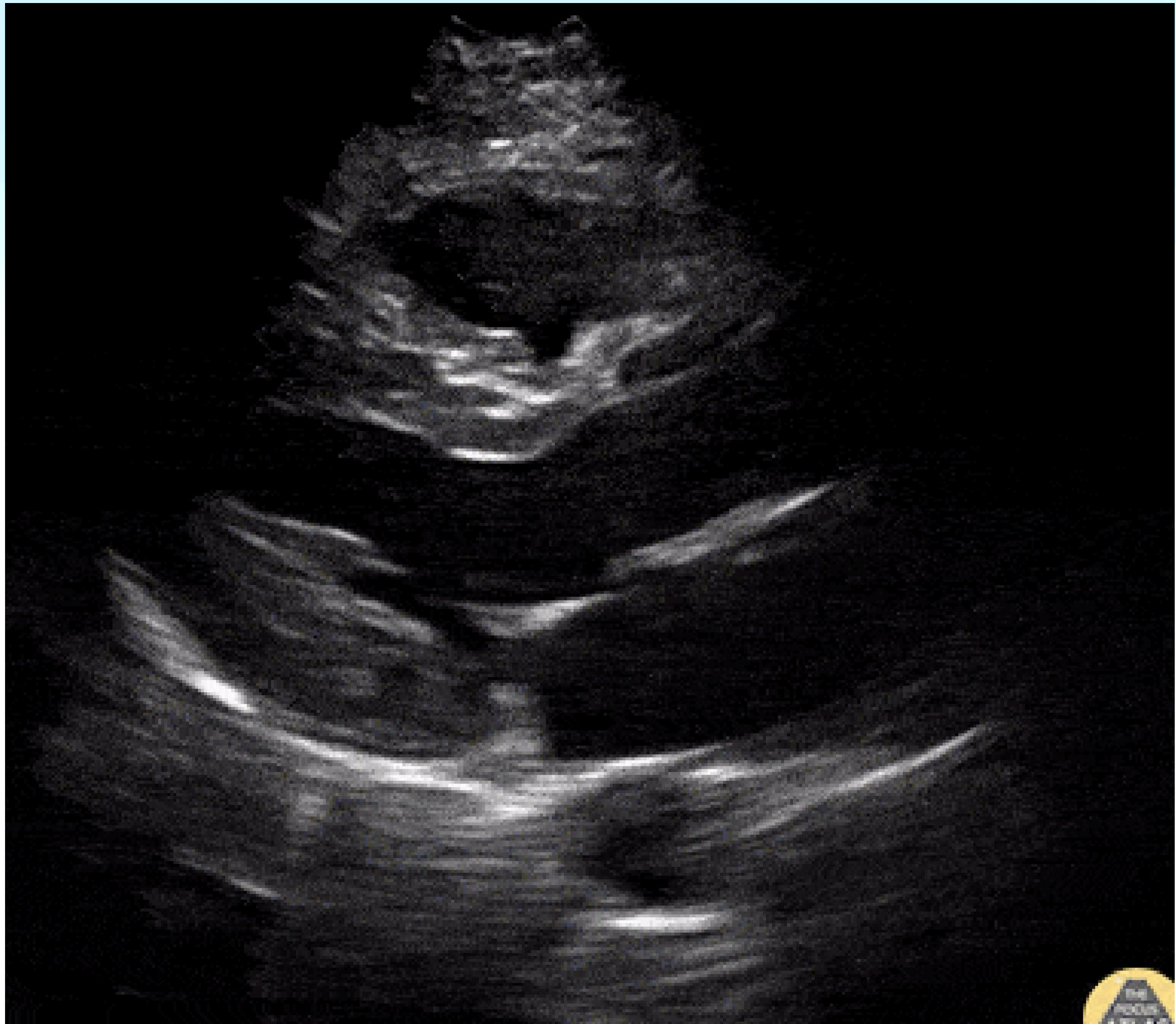
Relax	⟷	Contract
Fills		Empties
DIASTOLE		SYSTOLE

The Left Ventricle

DIASTOLE



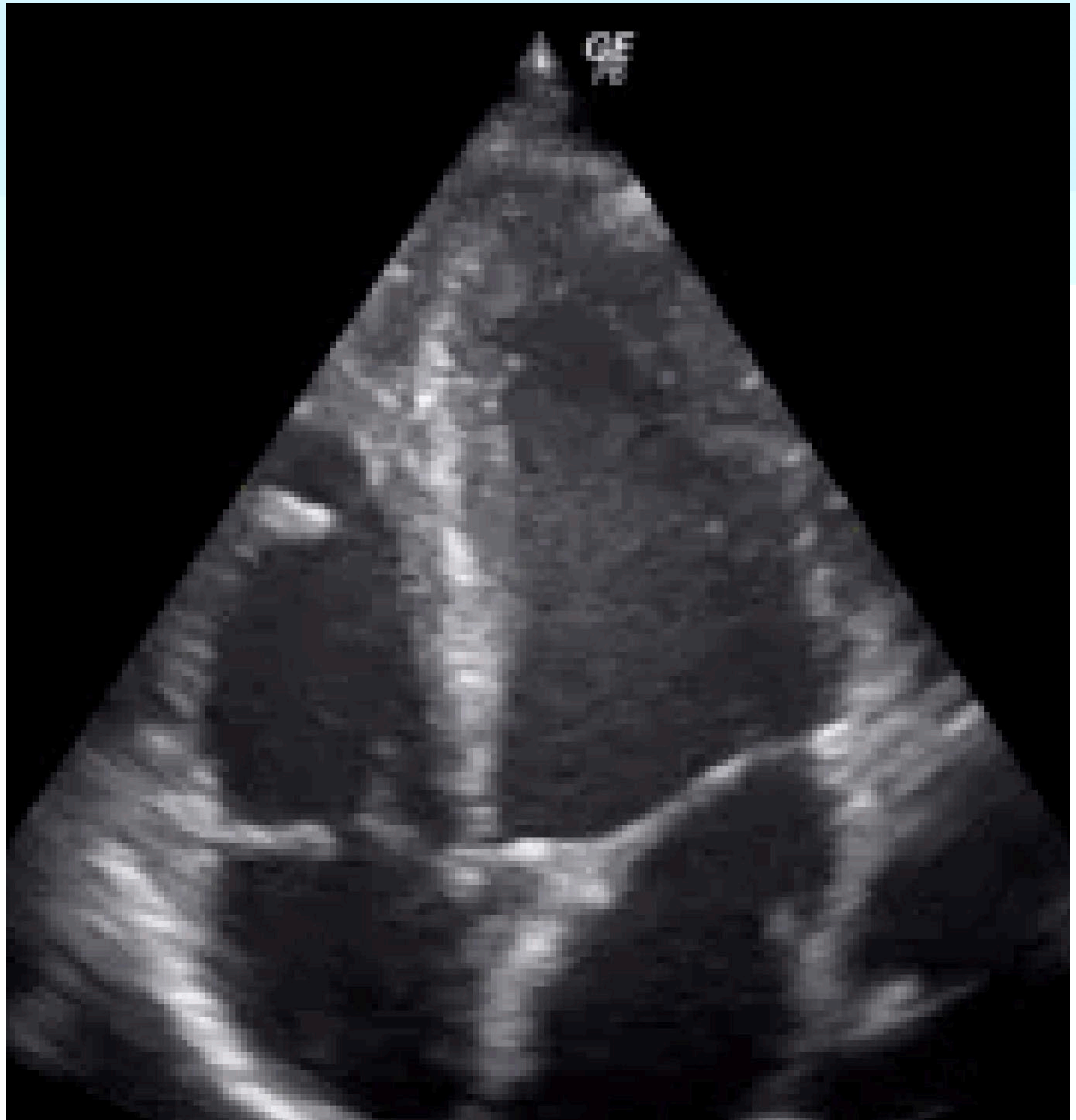
SYSTOLE



The Left Ventricle

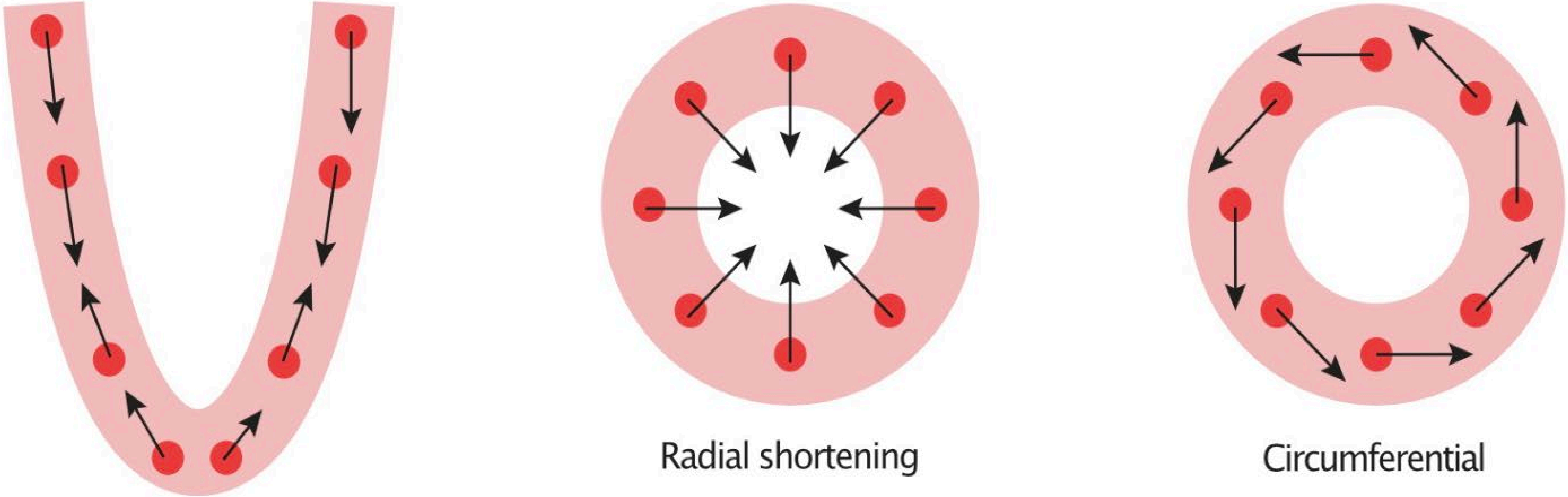
DIASTOLE

SYSTOLE



LV systole = 3 contraction vectors

LV systole = 3 vectors

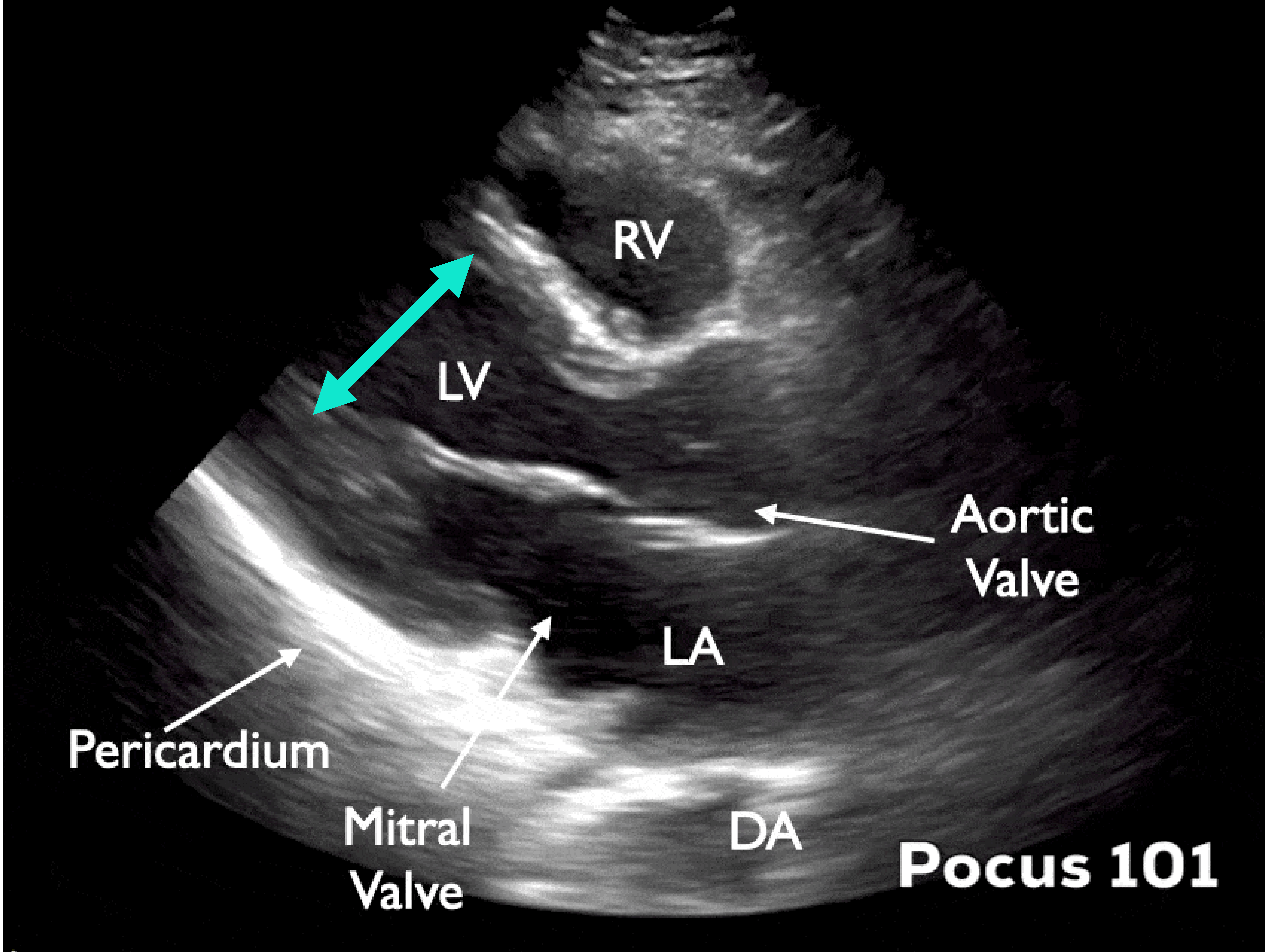


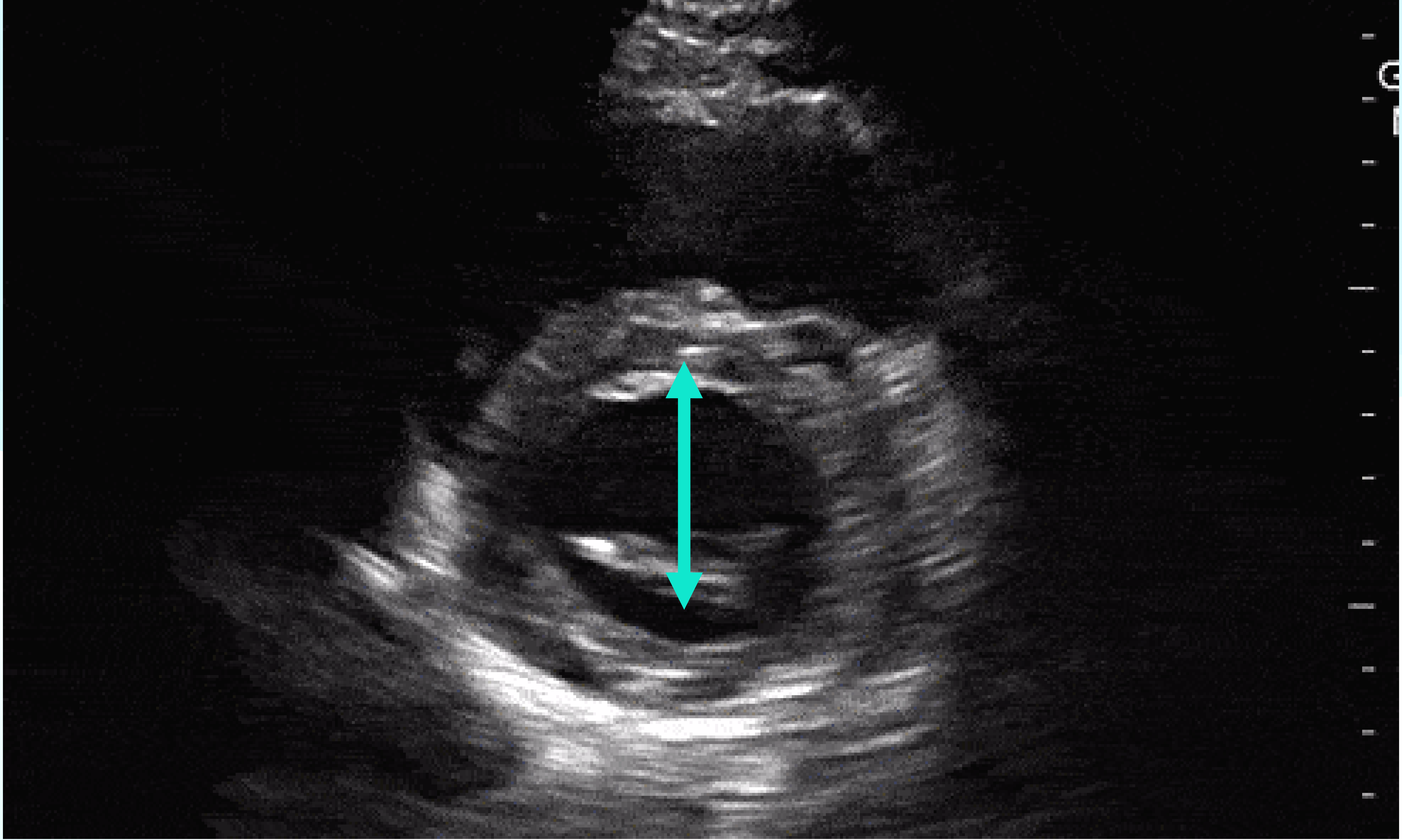
Longitudinal shortening

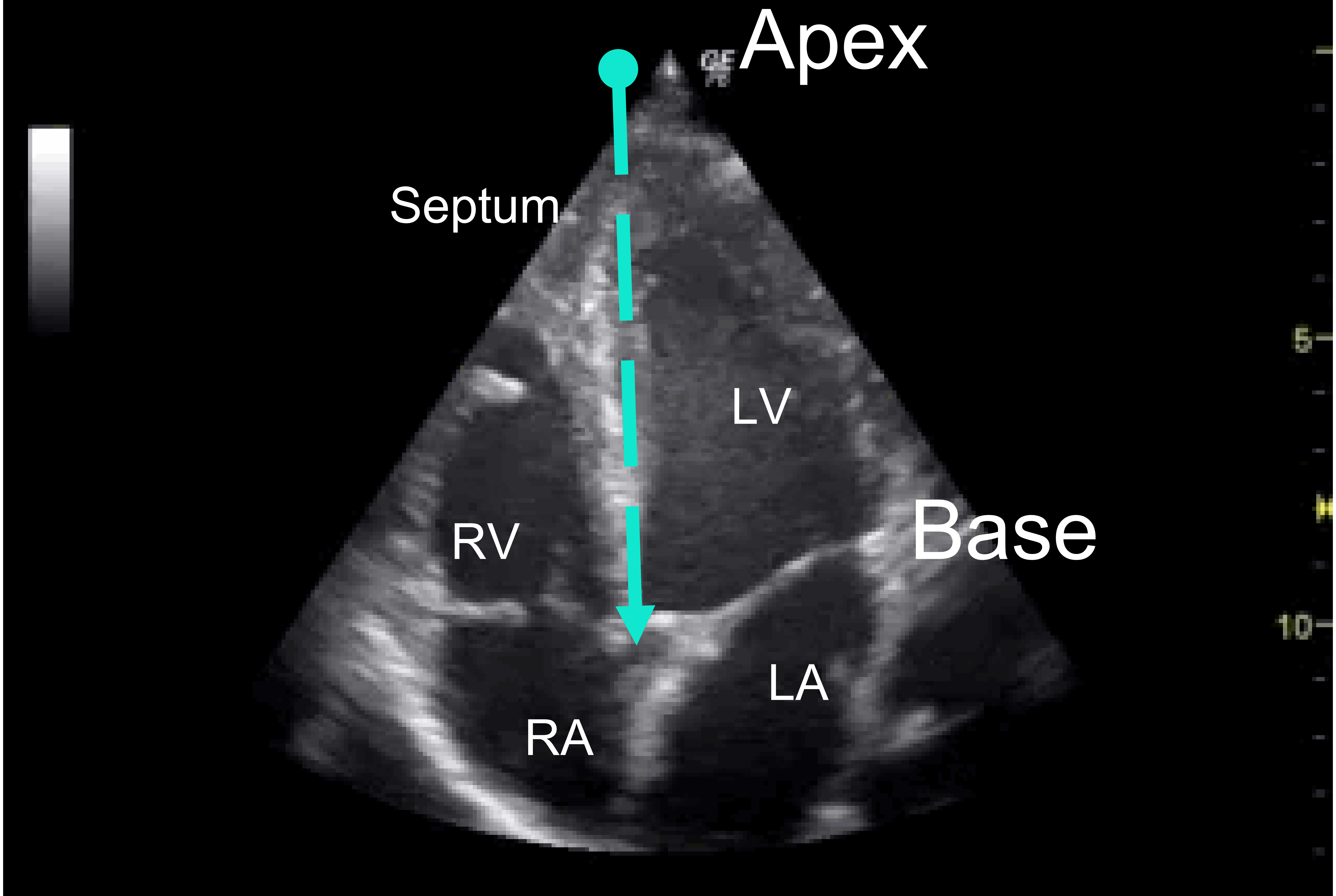
Radial shortening

Circumferential shortening

Credit: ECG Waves Echocardiodraphy. ecgwaves.com


RV
LV
Aortic
Valve
LA
Pericardium
Mitral
Valve
DA
Pocus 101





Apex
Septum
LV
RV
Base
LA
RA
5
10


D
E

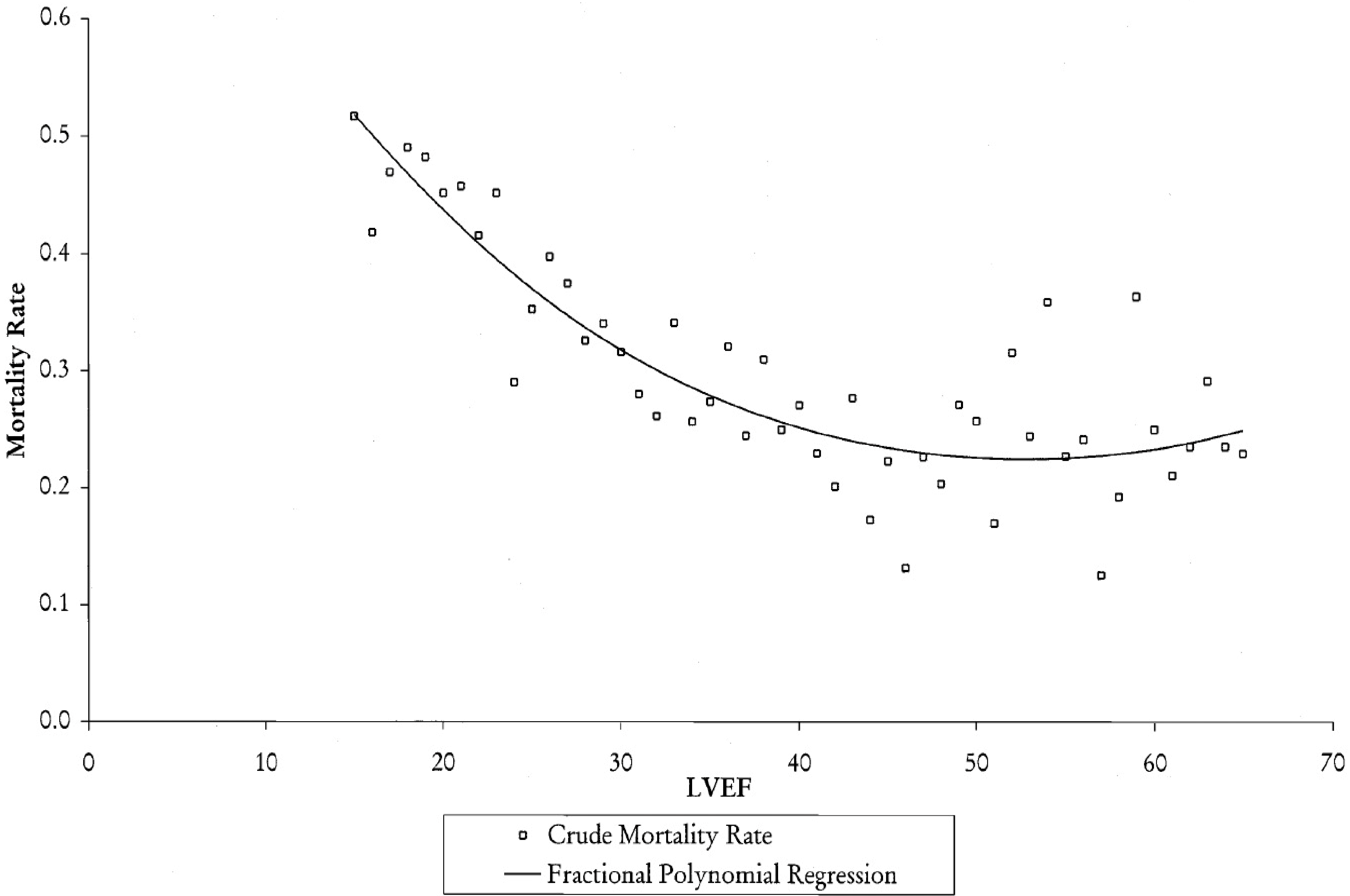
LV dysfunction

Systolic	Diastolic
Low EF	Preserved EF
<40%	>40%

“Mildly reduced EF”

LV dysfunction

HFrEF	HFmrEF	HFnEF
<40%	40-50%	>50%


0.6
0.5
0.4
0.3
0.2
0.1
0.0
Mortality Rate
0
10
20
30
40
50
60
70
LVEF
Crude Mortality Rate
Fractional Polynomial Regression

LV systolic function

1. Simpson’s biplane method
2. EPSS < 7mm
3. Fractional shortening ~ 1/3
4. LVOT VTI
5. ”Eyeball method”

Simpson’s biplane method

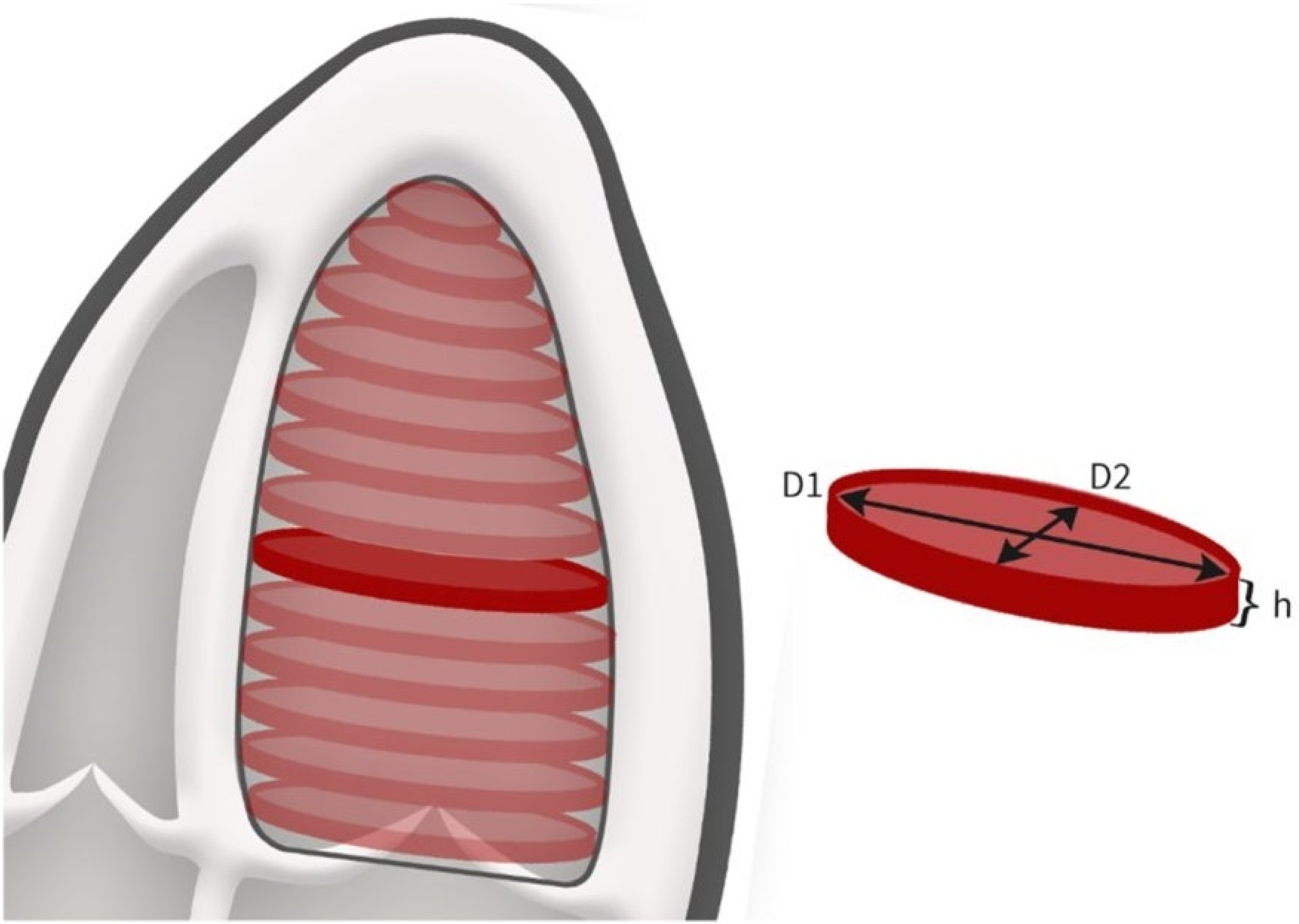
Gold standard for EF
Technically challenging
Time consuming

EDV – ESV / EDV x 100% = EF

Simpson's – HOW TO

1. End diastolic, end systolic
2. Trace LV cavity dimensions
3. Two planes = A4C and A2C

Series of "stacked cylinders"

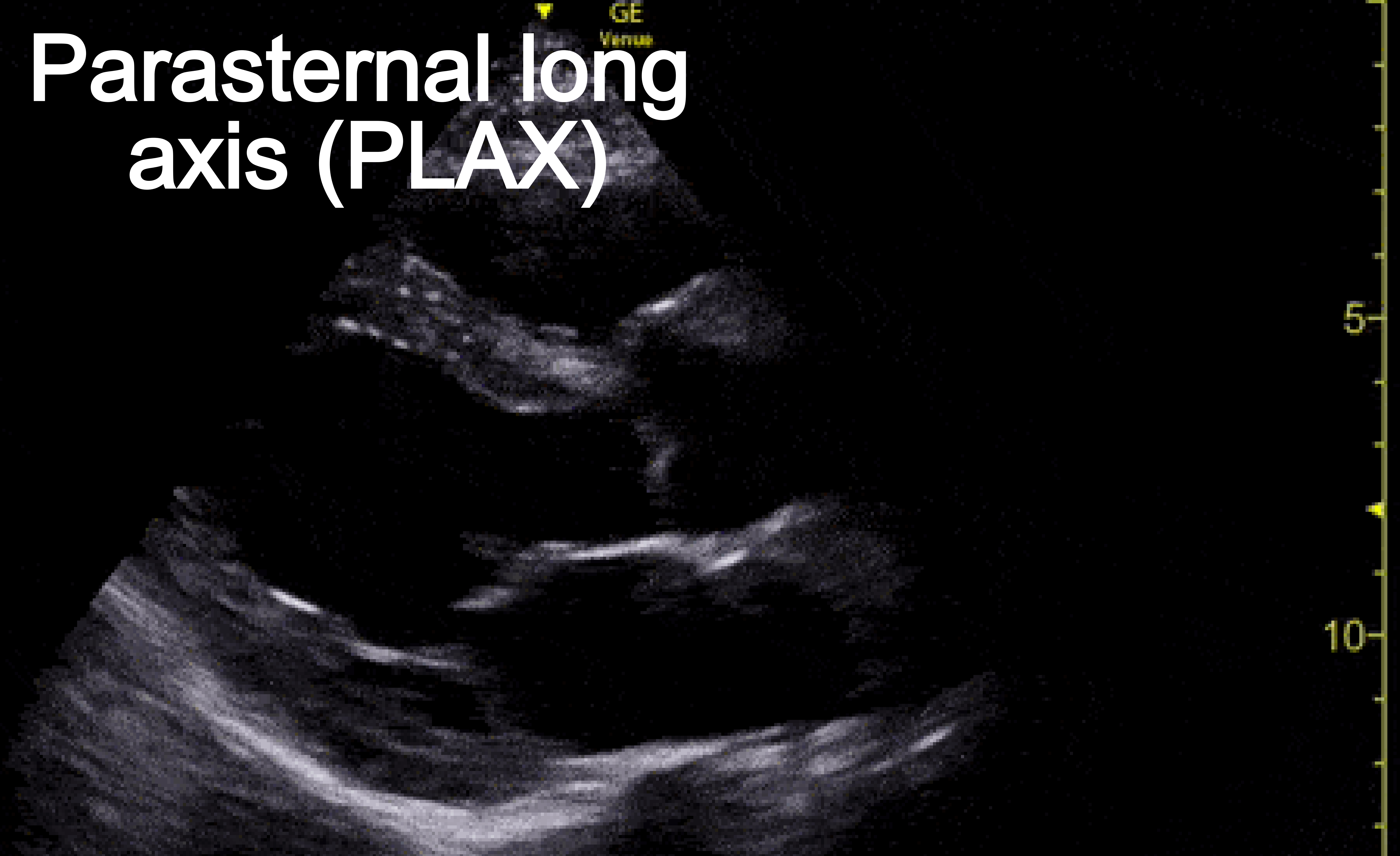

D1
D2
h


A4Cs
LV Length 6.62 cm
LV Area 19.7 cm²
LV Vol 48.2 ml
ESV (A4C) 48.2 ml
EF (A4C) 51.0 %
A2Cs
LV Length 6.79 cm
LV Area 17.4 cm²
LV Vol 38.5 ml
ESV (A2C) 38.5 ml
EF (A2C) 54.2 %
ESV (BP) 43.2 ml
EF (BP) 53.4 %

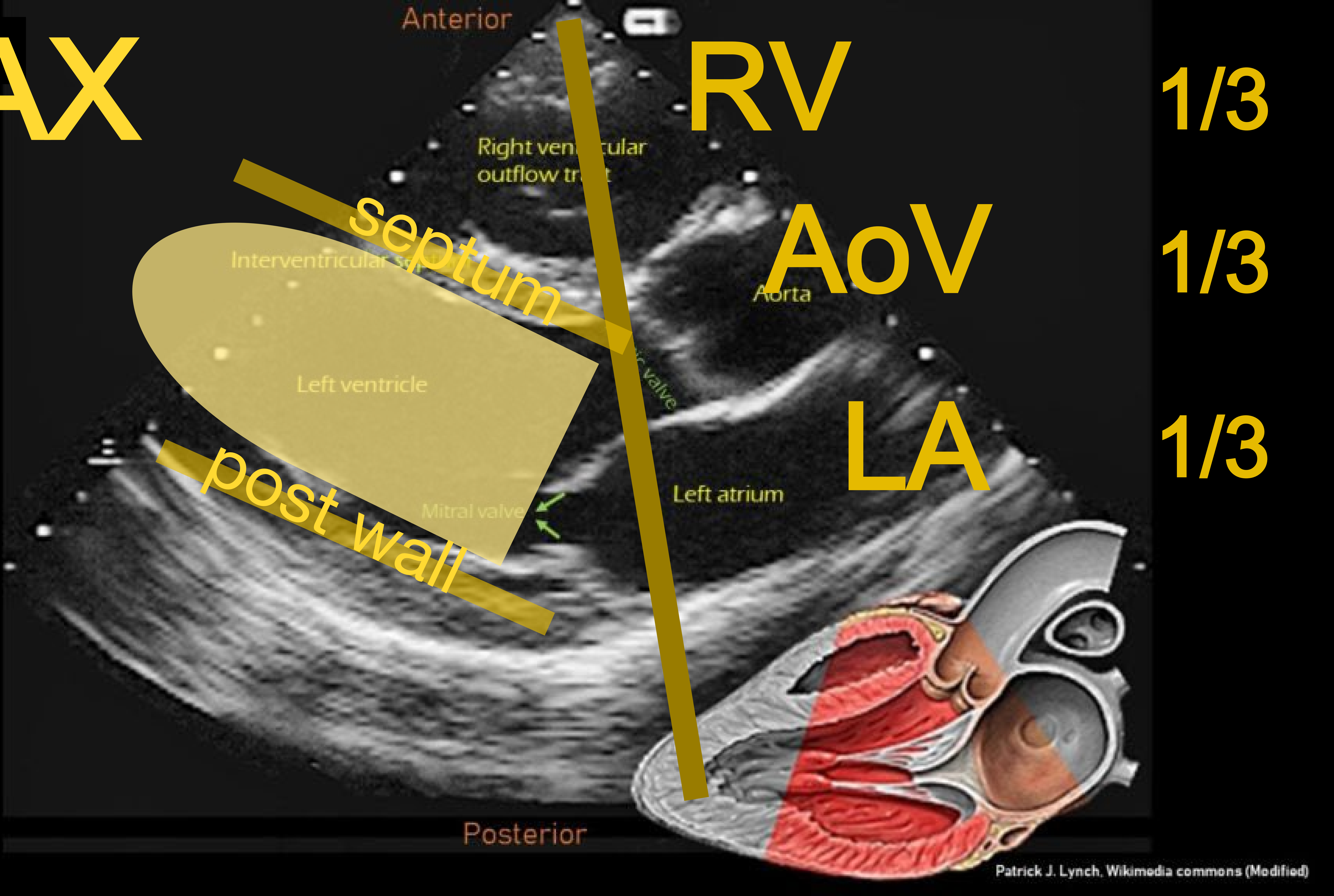
LV systolic function

1. ~~Simpson's biplane method~~
2. EPSS < 7mm
3. Fractional shortening ~ 1/3
4. LVOT VTI
5. "Eyeball method"

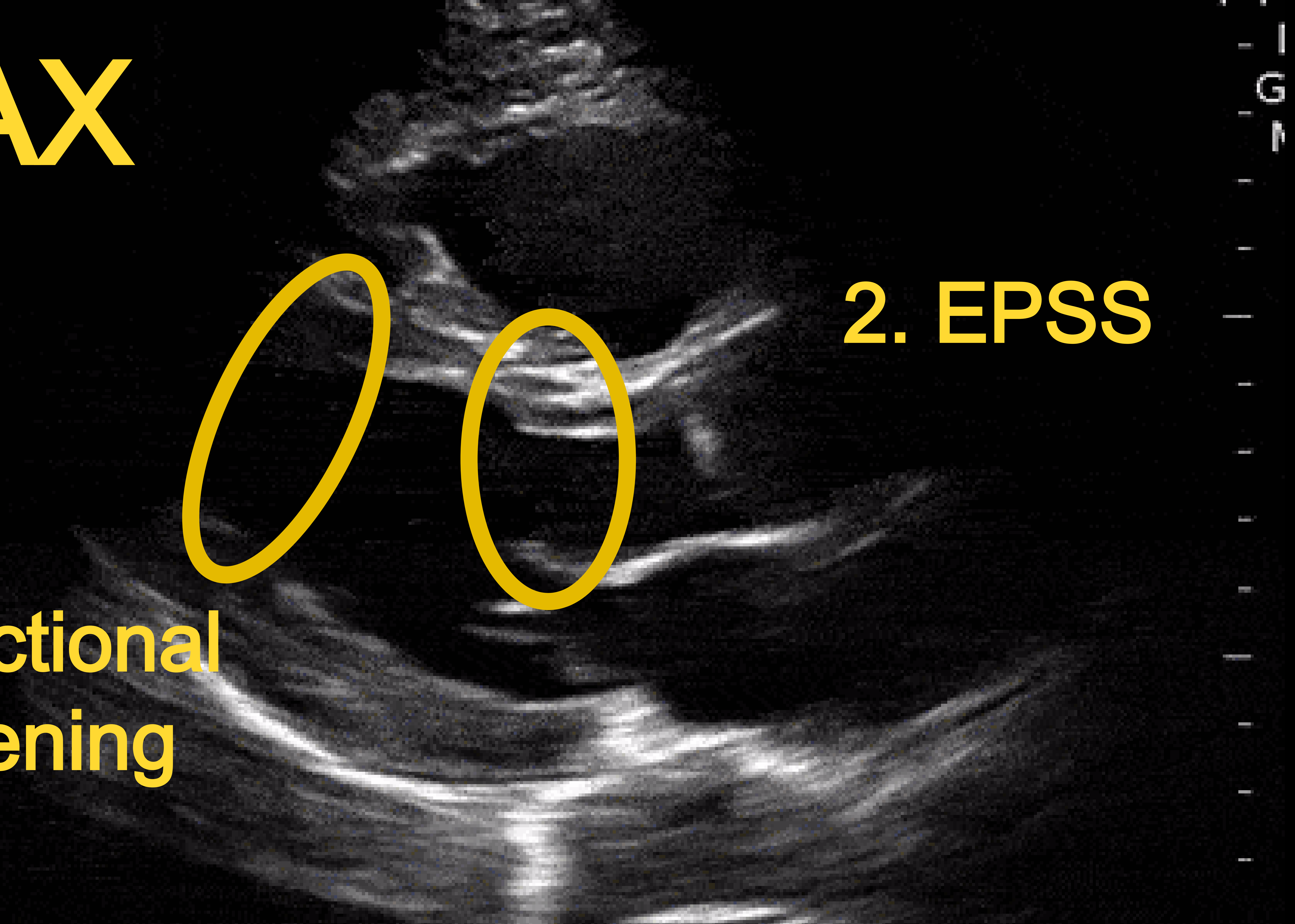
Parasternal long axis (PLAX)



PLAX


Anterior
RV
1/3
Right ventricular outflow tract
septum
Interventricular septum
AoV
1/3
Aorta
Left ventricle
valve
LA
1/3
post wall
Mitral valve
Left atrium
Posterior
Patrick J. Lynch, Wikimedia commons (Modified)

PLAX



PLAX => LV systolic fxn

1. EPSS – normal <7mm
2. Fractional shortening ~ 1/3

2. EPSS

End Point Septal Separation

How close the MV
approaches the septum

$$LVEF = 75.5 - (2.5 \times EPSS)$$

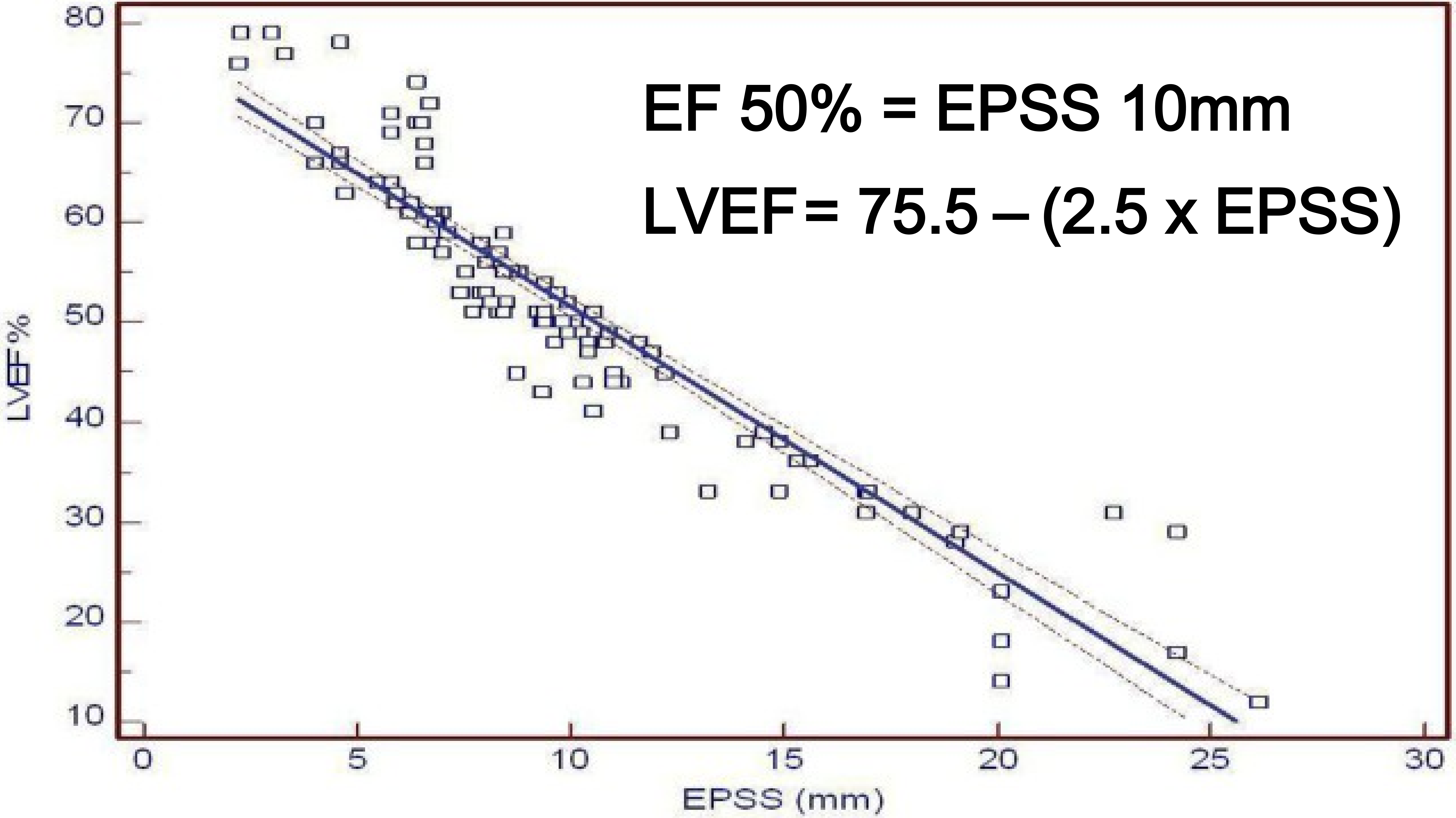

septum
MV
leaflet
5
10


GE
Le
EPSS 3mm
5

Quantitative Estimation of Left Ventricular Ejection Fraction from Mitral Valve E-Point to Septal Separation and Comparison to Magnetic Resonance Imaging

Jay R. Silverstein, MD, Nicholas H. Laffely, MD, and Robert D. Rifkin, MD*

Am J Cardiol 2006;97:137–140)


EF 50% = EPSS 10mm
LVEF= 75.5 – (2.5 x EPSS)
LVEF%
EPSS (mm)
80
70
60
50
40
30
20
10
0
5
10
15
20
25
30

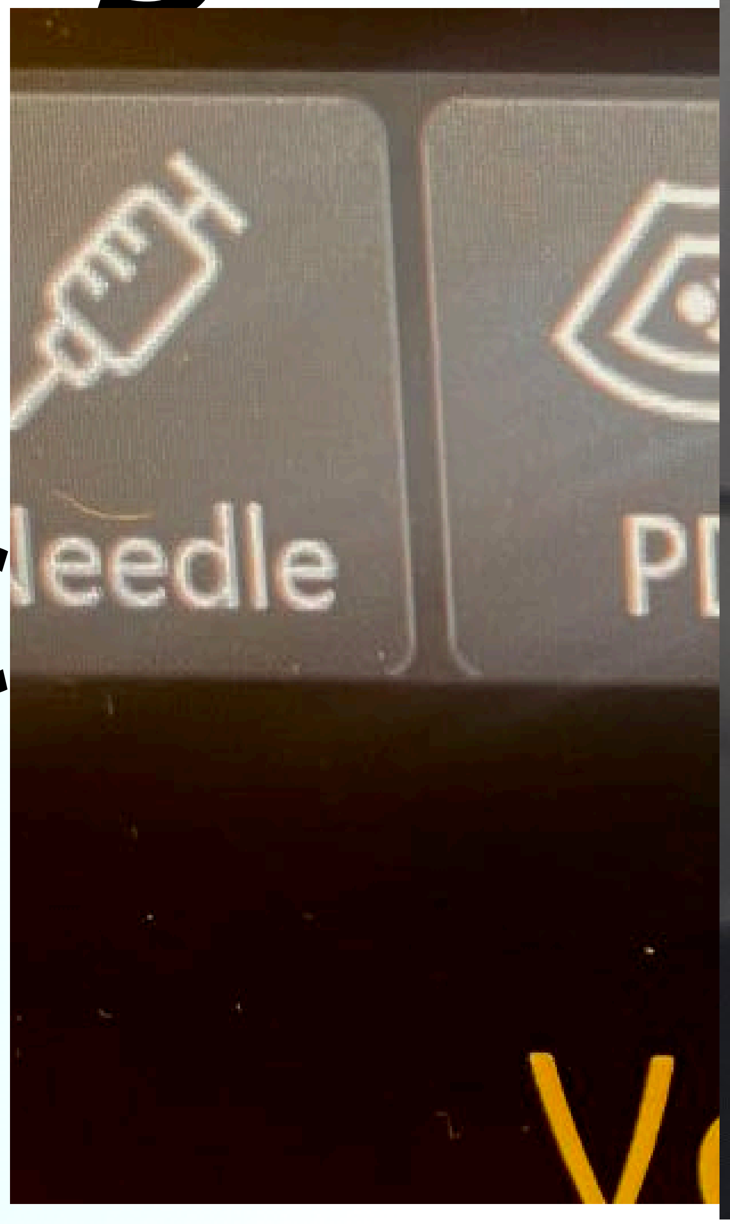

EPSS 20mm
EF 22%
P
G
P R
1.6 3.2

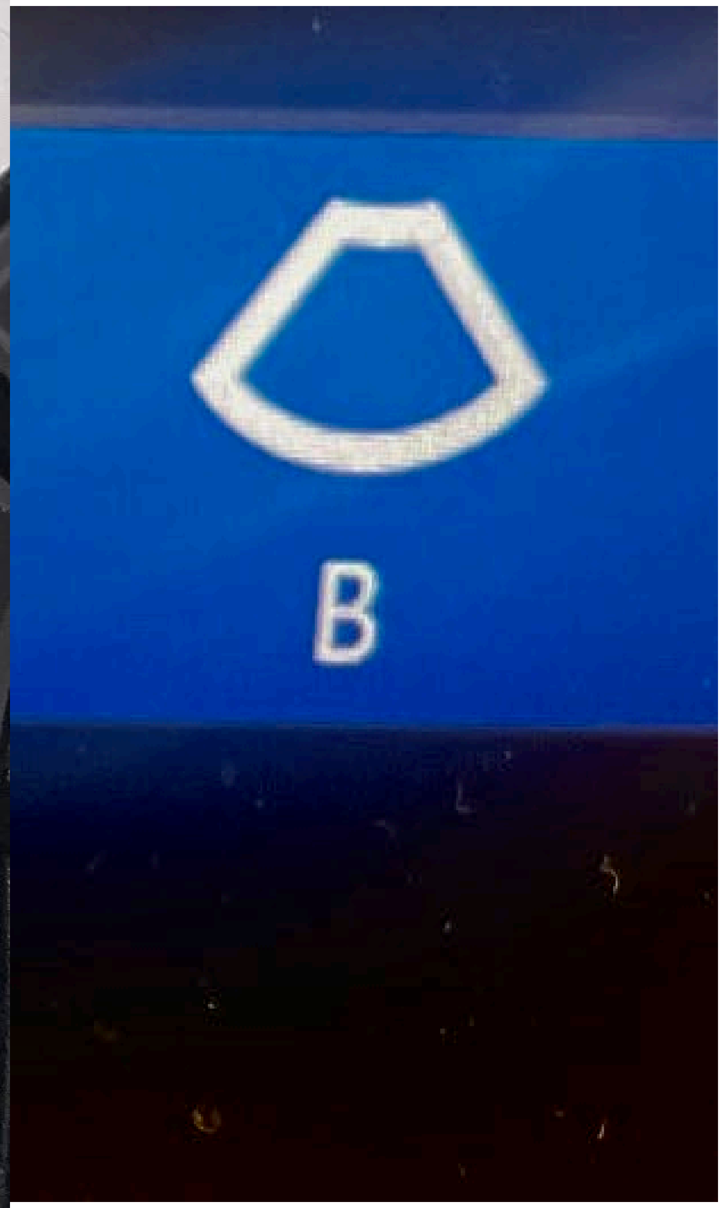
M Mode

“Motion” –

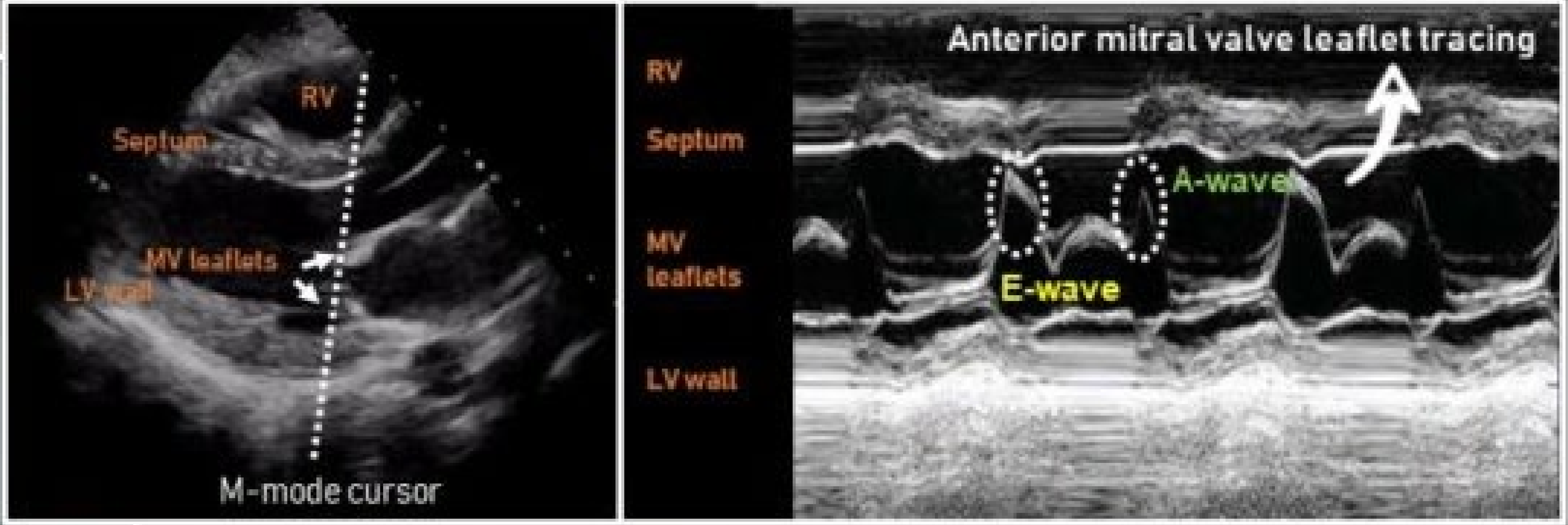
single line on image over time

Ac

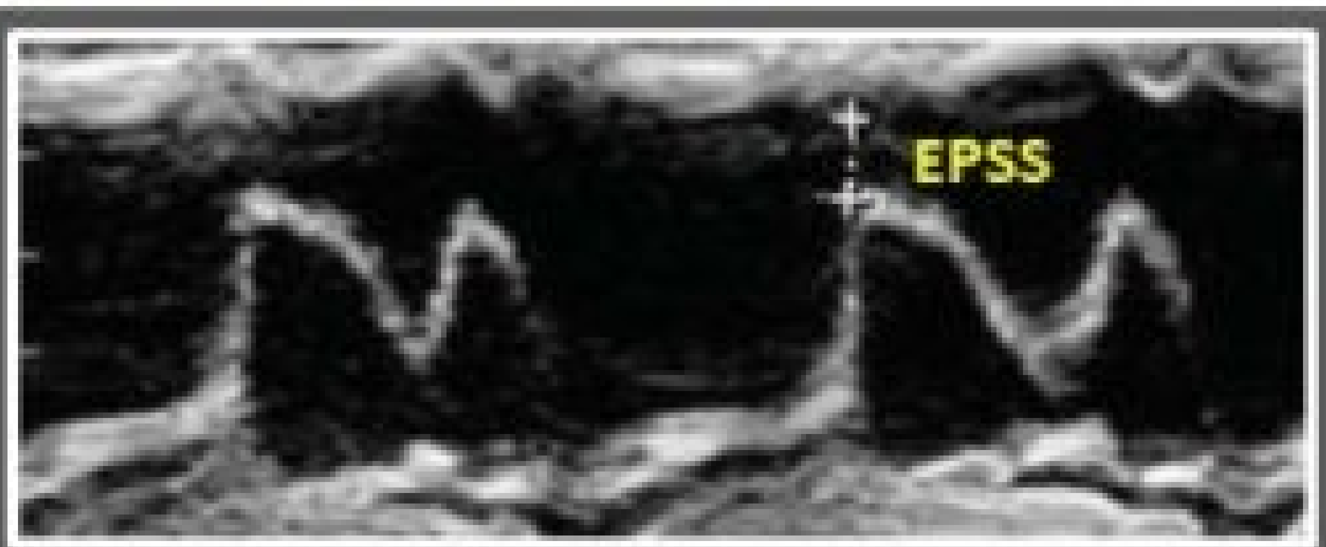




M Mode for EPSS



E-wave: Mitral valve movement during early passive diastolic filling of LV
A-wave: active filling from atrial contraction

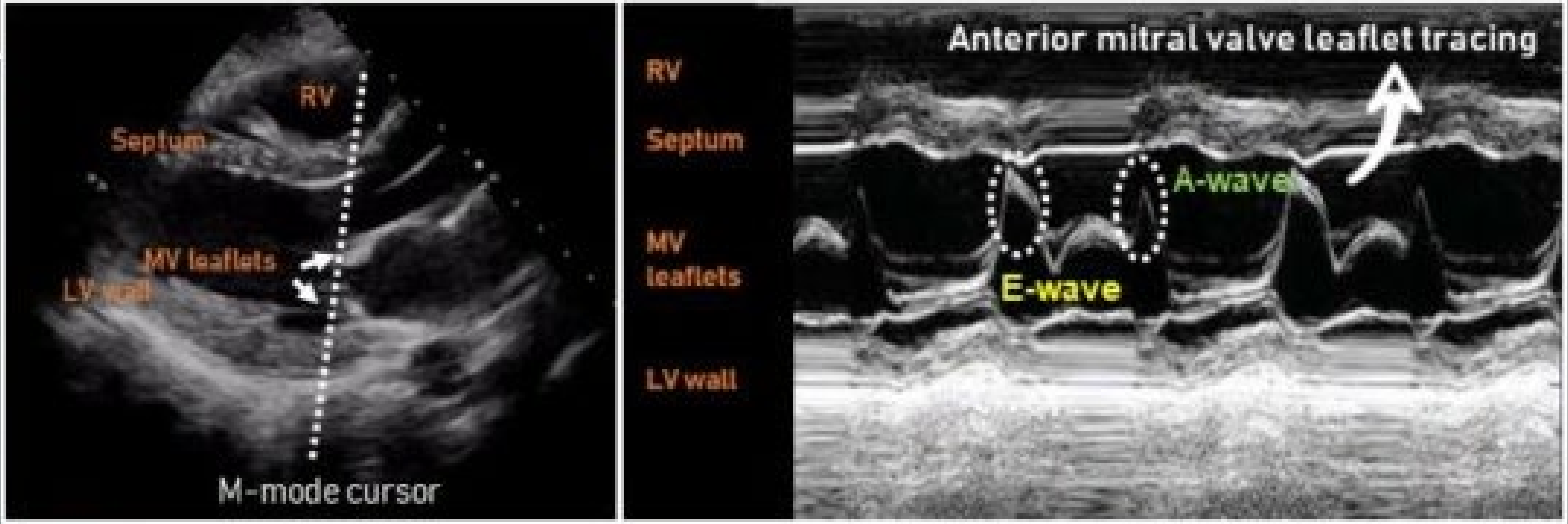


EPSS = E-point Septal Separation = Distance between top of the E-wave and the interventricular septum
Normal EPSS is <7 mm
>7 mm = mitral valve need not or cannot open fully = seen with LV systolic dysfunction, LV dilatation, mitral stenosis, aortic regurgitation

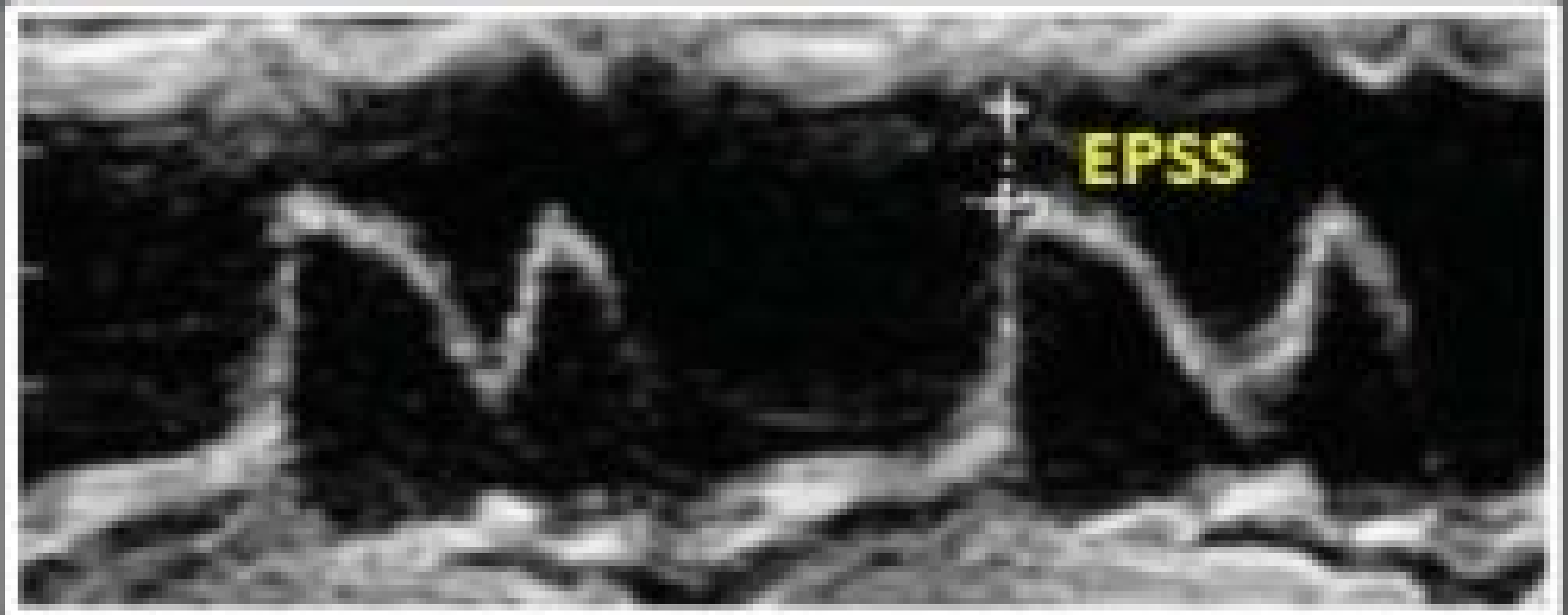
M Mode for EPSS

M Mode for EPSS

E-wave: Mitral valve movement during early passive diastolic filling of LV
A-wave: active filling from atrial contraction



E-wave: Mitral valve movement during early passive diastolic filling of LV
A-wave: active filling from atrial contraction



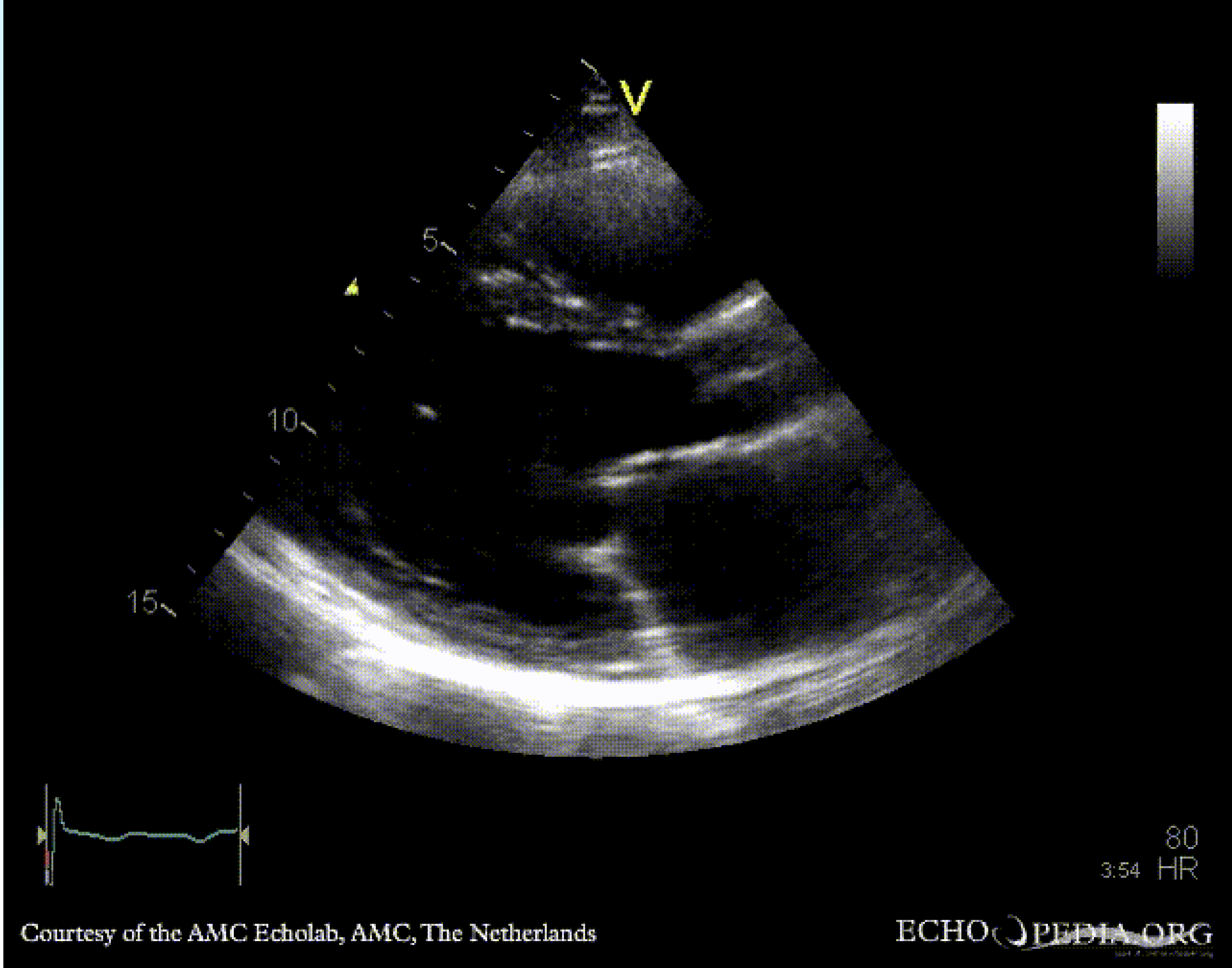
Pitfalls

Mitral valve stenosis

Aortic regurgitation

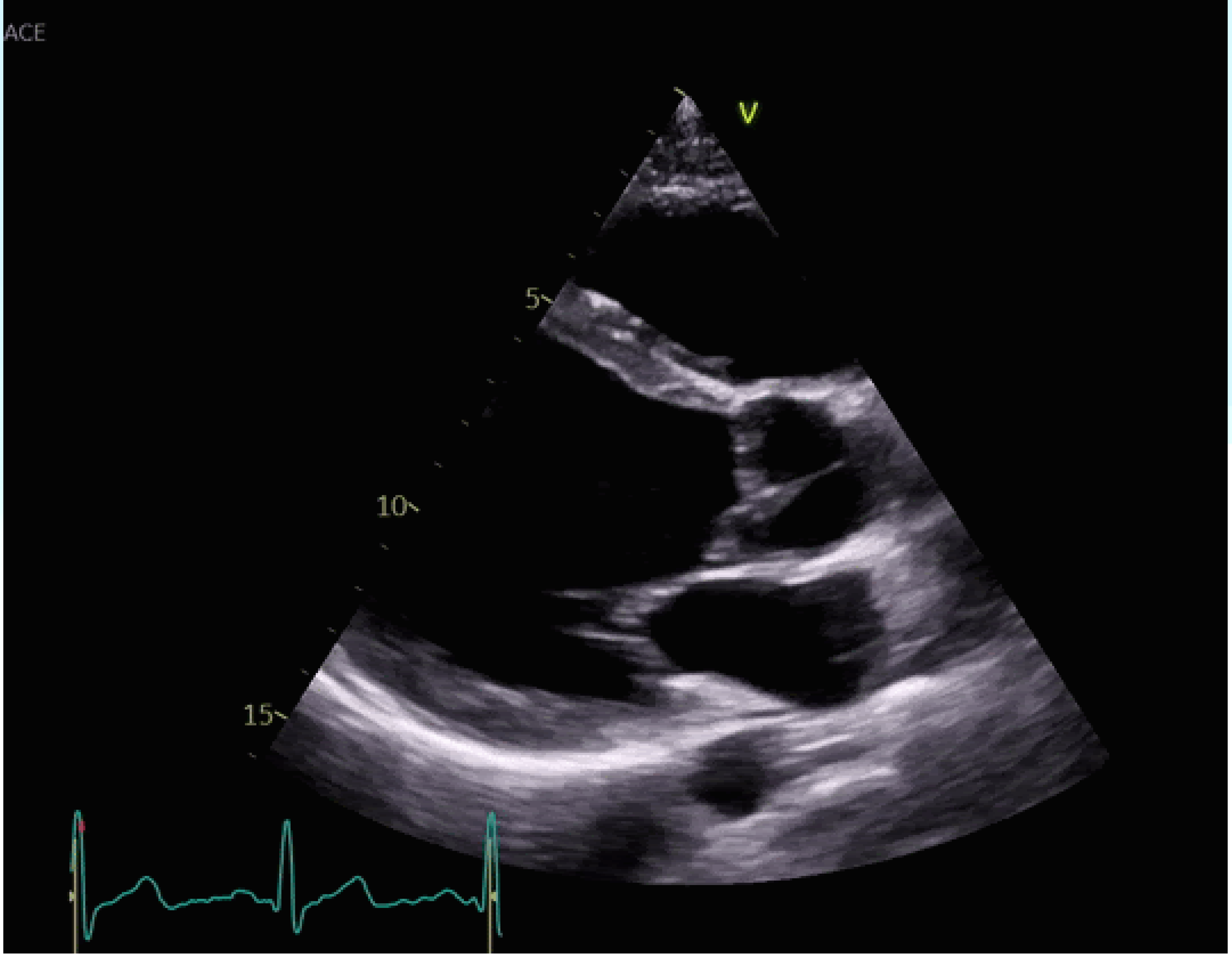
Pitfalls

Mitral valve stenosis



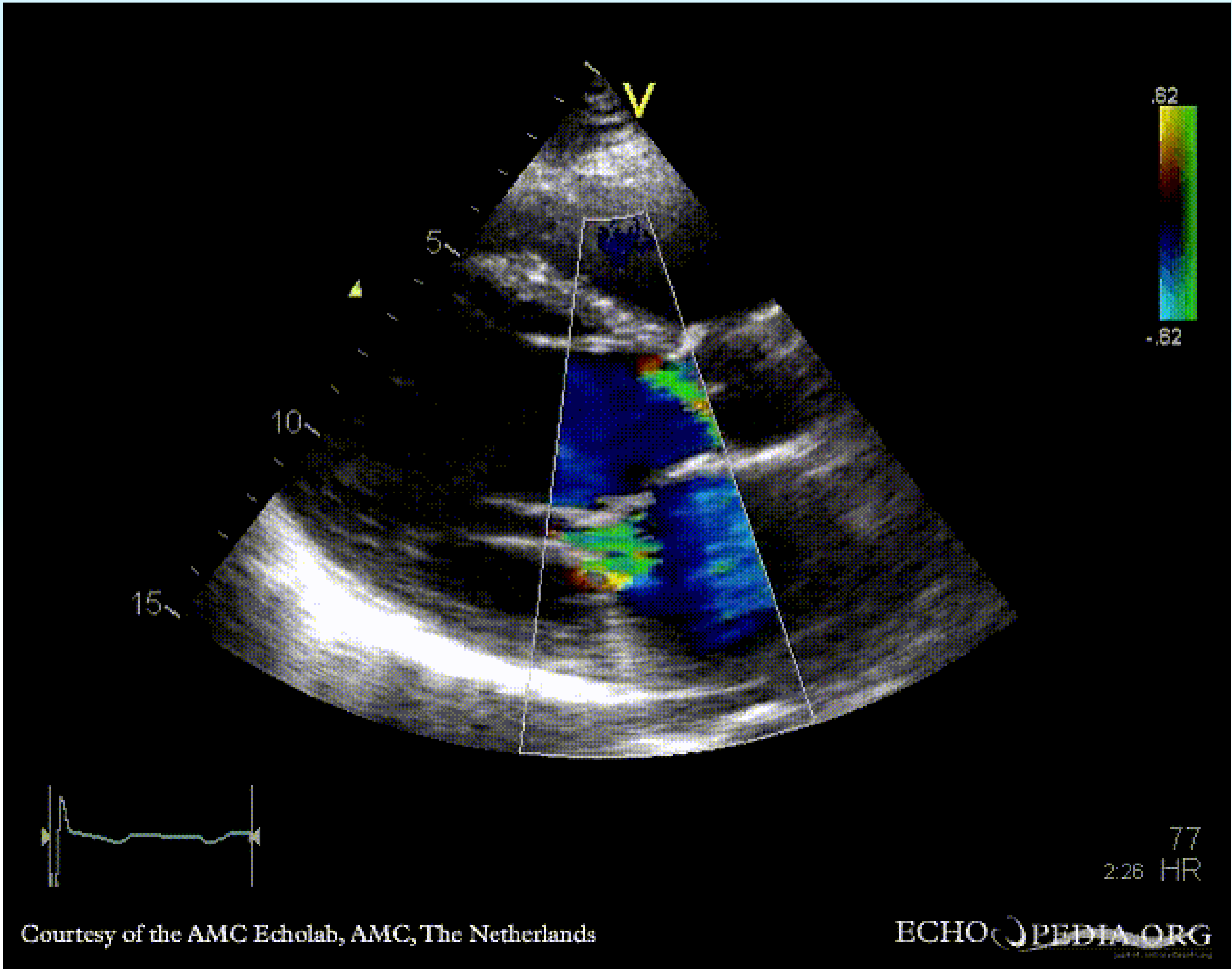
Pitfalls

Aortic regurgitation



Pitfalls

Aortic regurgitation



3. Fractional shortening

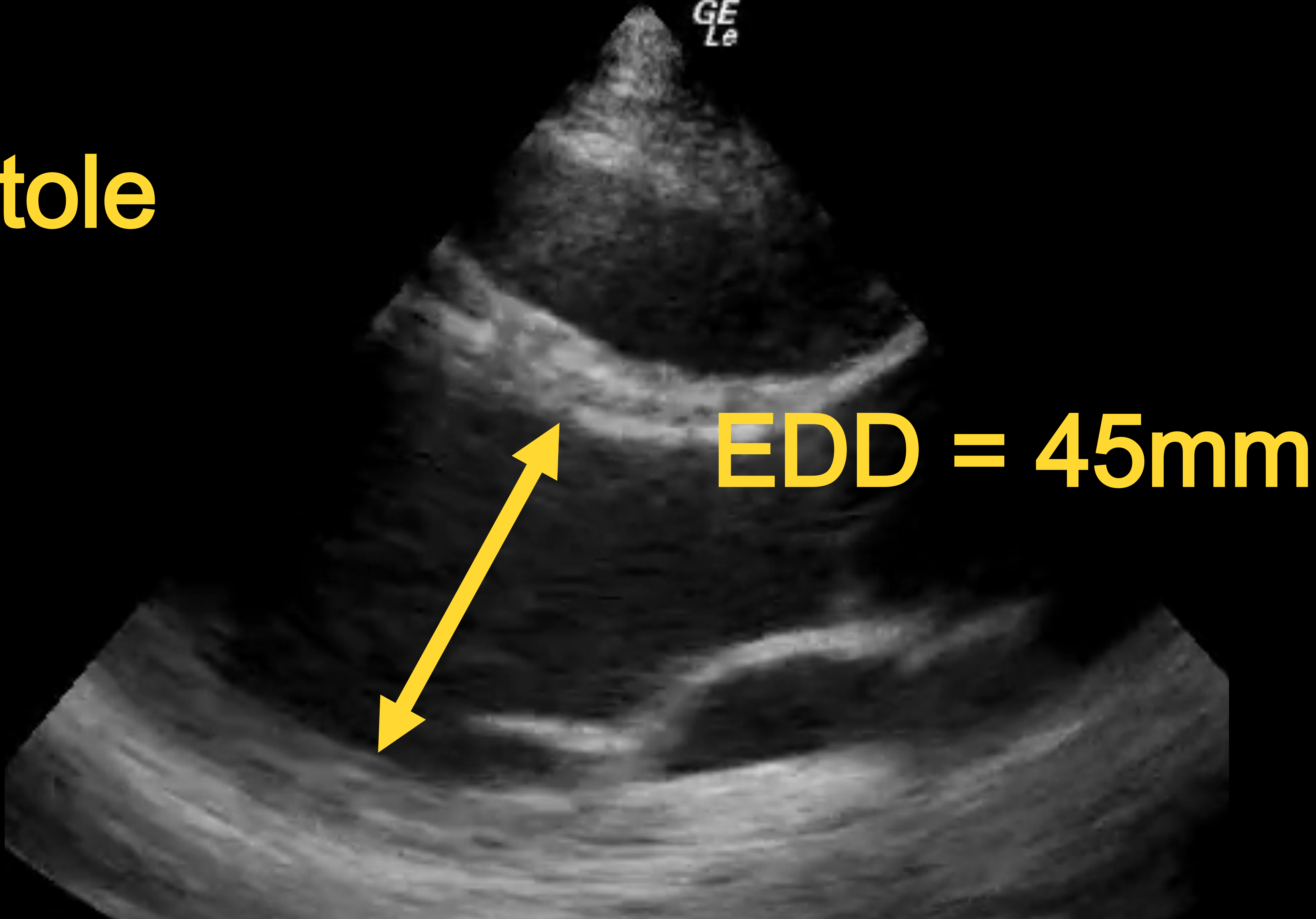
LV Cavity change @ mid papillary level

End diastolic diameter = EDD

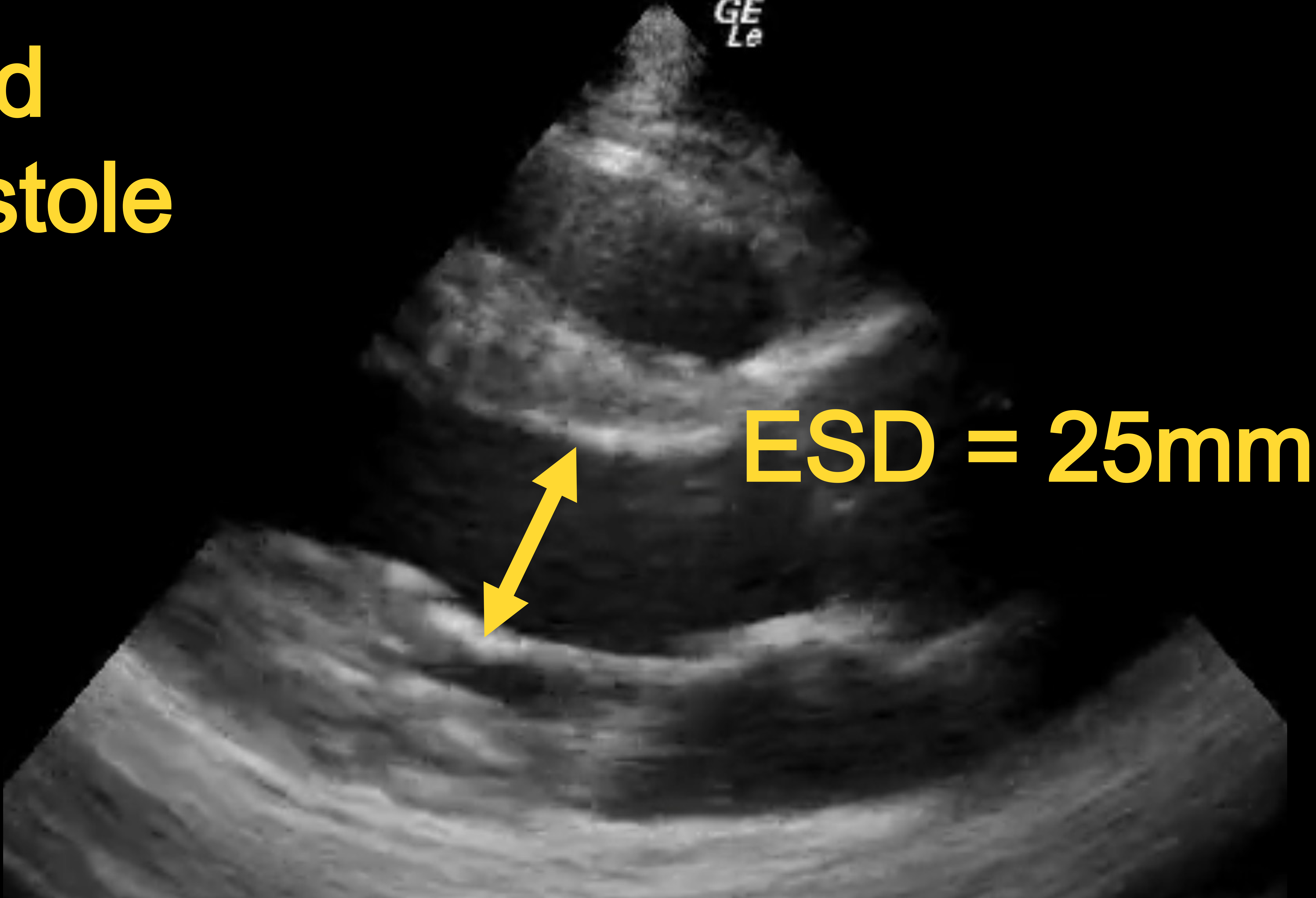
EDD – ESD / EDD = FS

End systolic diameter = ESD

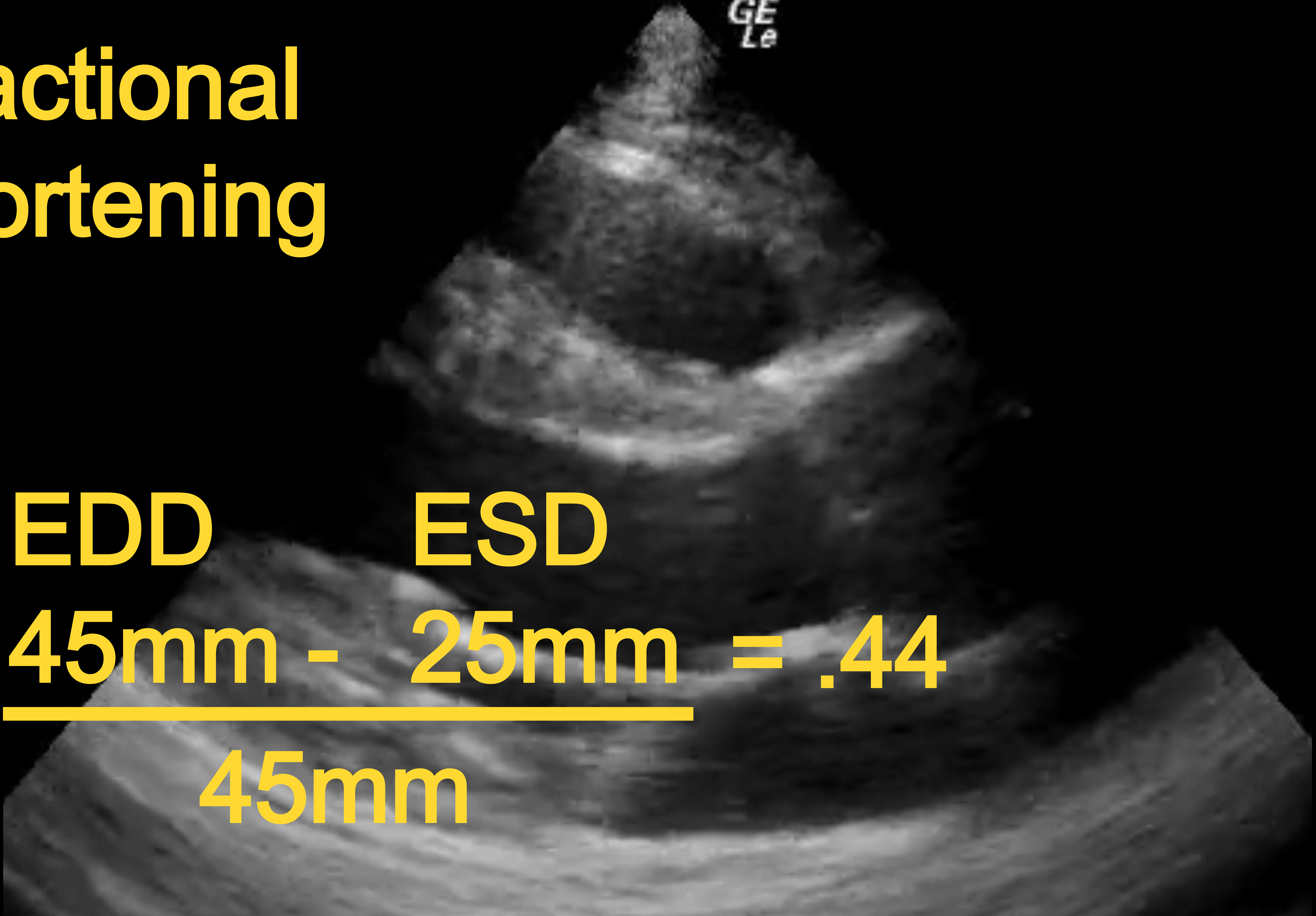
End diastole



End systole

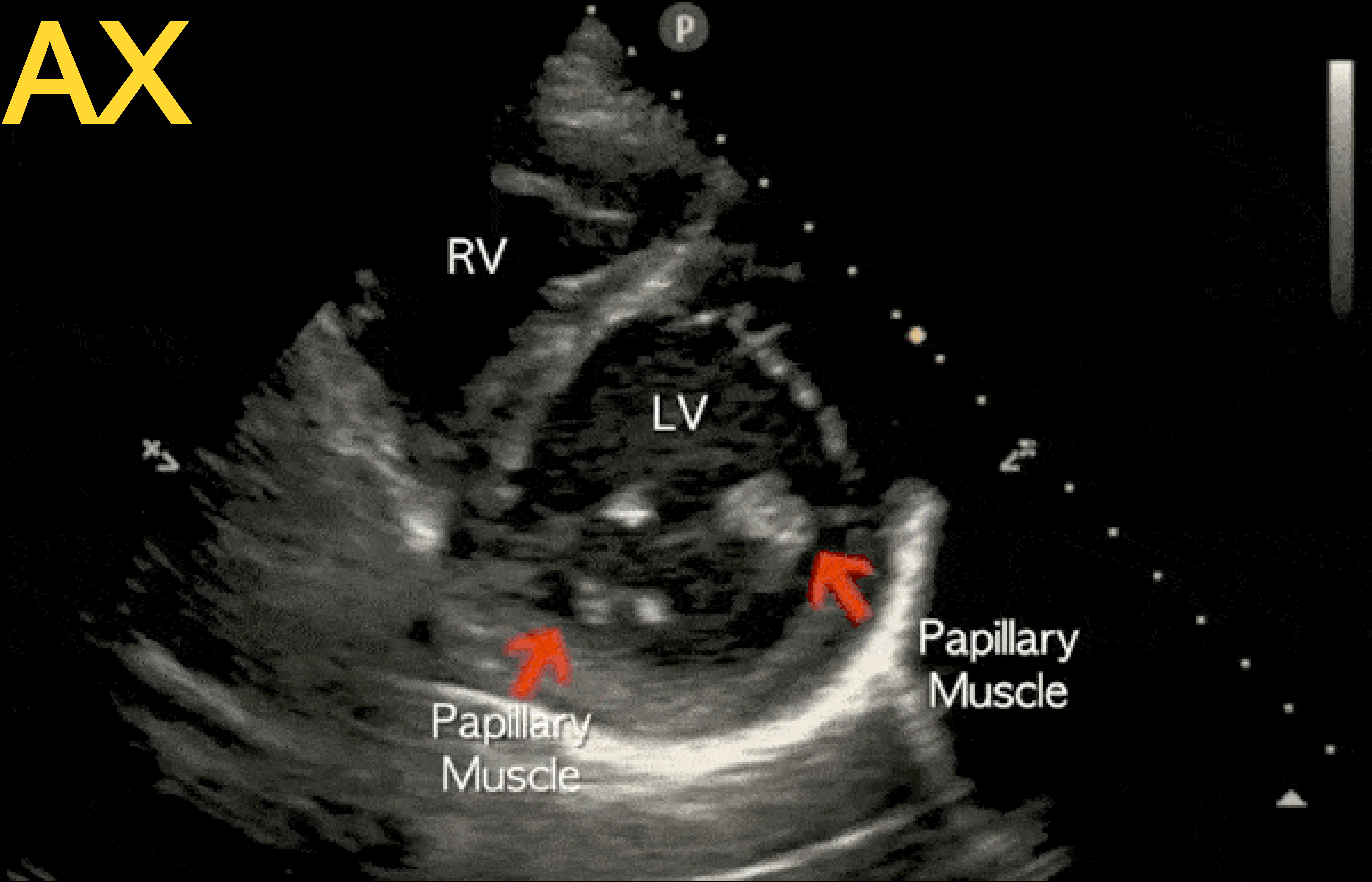


Fractional shortening



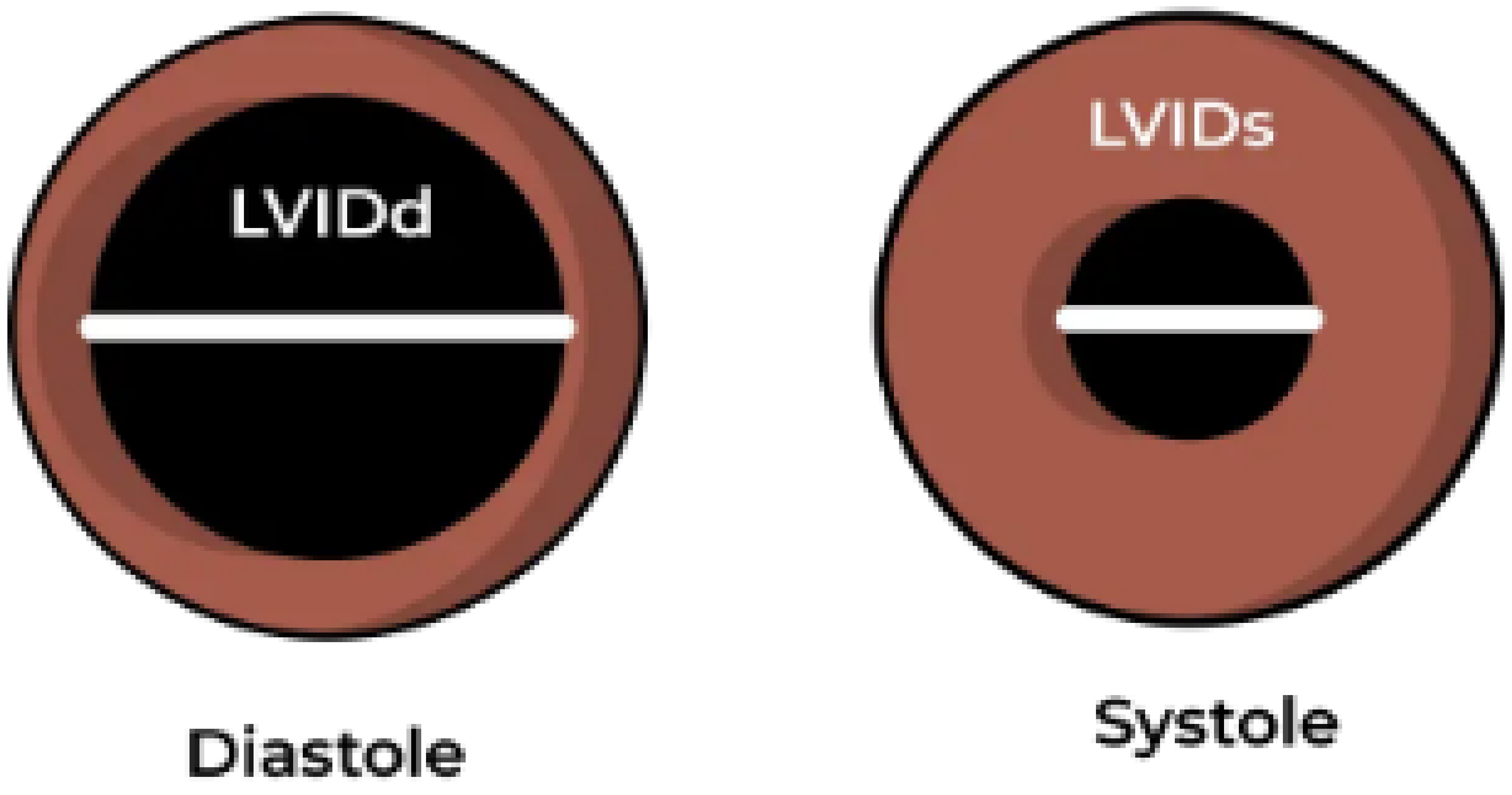
$$\frac{\overset{\text{EDD}}{45\text{mm}} - \overset{\text{ESD}}{25\text{mm}}}{45\text{mm}} = .44$$

PSAX



Teicholz formula

LVEF by Teicholz



$$V_d = [7/(2.4 + LVID_d)] \times LVID_d^3$$

$$V_s = [7/(2.4 + LVID_s)] \times LVID_s^3$$

$$LVEF = (V_d - V_s) / V_d$$


M mode line here
Measure here
V
5
10
15
1 IVSd 0.93 cm
IVSs 1.31 cm
LVIDd 4.60 cm
LVIDs 3.28 cm
LVPWd 1.04 cm
LVPWs 1.26 cm
EDV(Teich) 97.26 ml
ESV(Teich) 43.64 ml
EF(Teich) 55.13 %
SV(Teich) 53.63 ml
%FS 28.57 %
10
15
98

Pitfalls

Wall motion abnormalities

Arrhythmias

LV systolic function

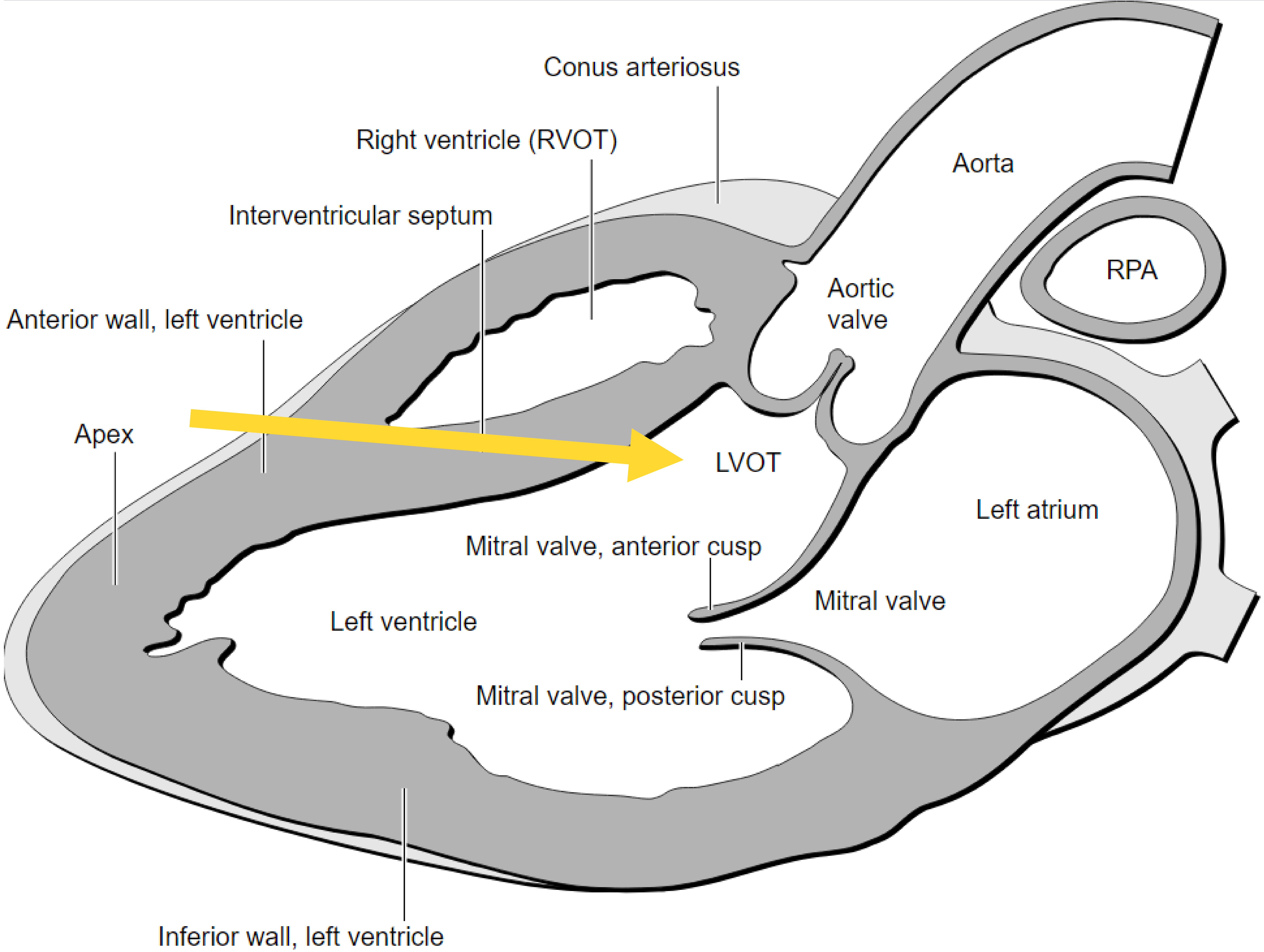
1. ~~Simpson's biplane method~~
2. ~~EPSS < 7mm~~
3. ~~Fractional shortening ~ 1/3~~
4. Stroke volume: LVOT VTI
5. ”Eyeball method”

Stroke volume

Key measure of LV systolic function

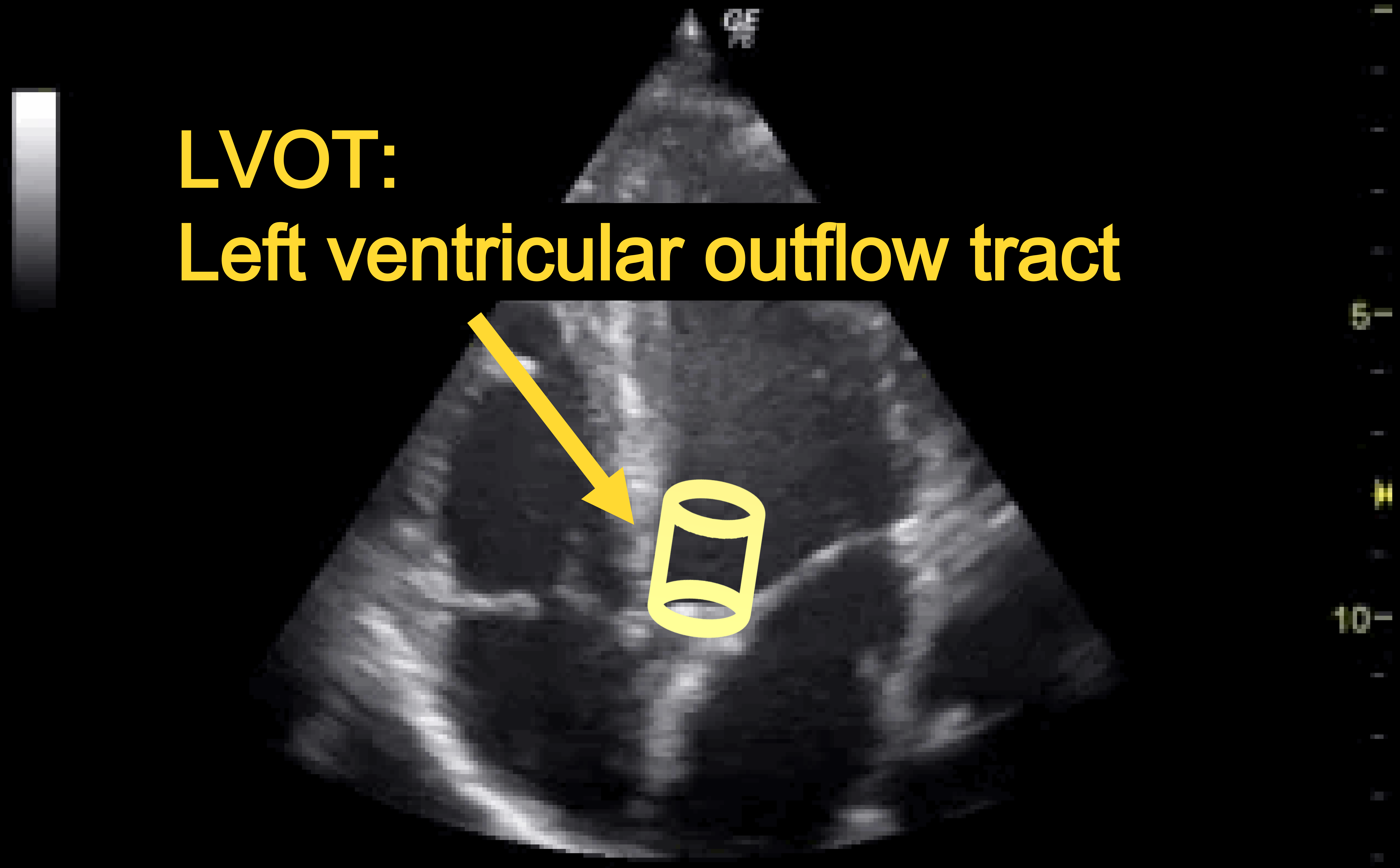
CO = SV x HR

SV = volume of a cylinder of blood being ejected through the LVOT



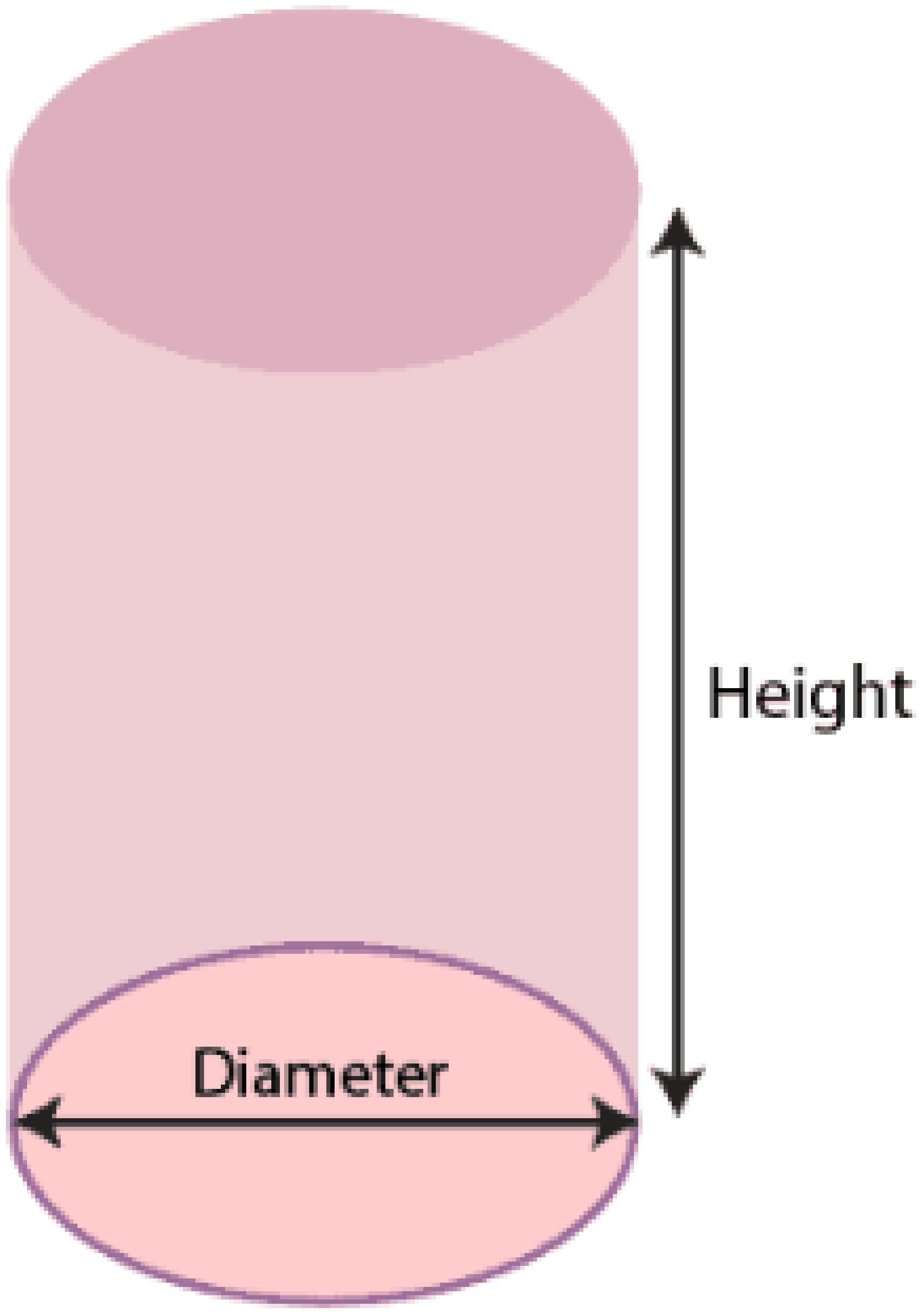
Conus arteriosus
Right ventricle (RVOT)
Interventricular septum
Anterior wall, left ventricle
Apex
Aorta
RPA
Aortic valve
LVOT
Left atrium
Mitral valve, anterior cusp
Mitral valve
Left ventricle
Mitral valve, posterior cusp
Inferior wall, left ventricle

LVOT:
Left ventricular outflow tract



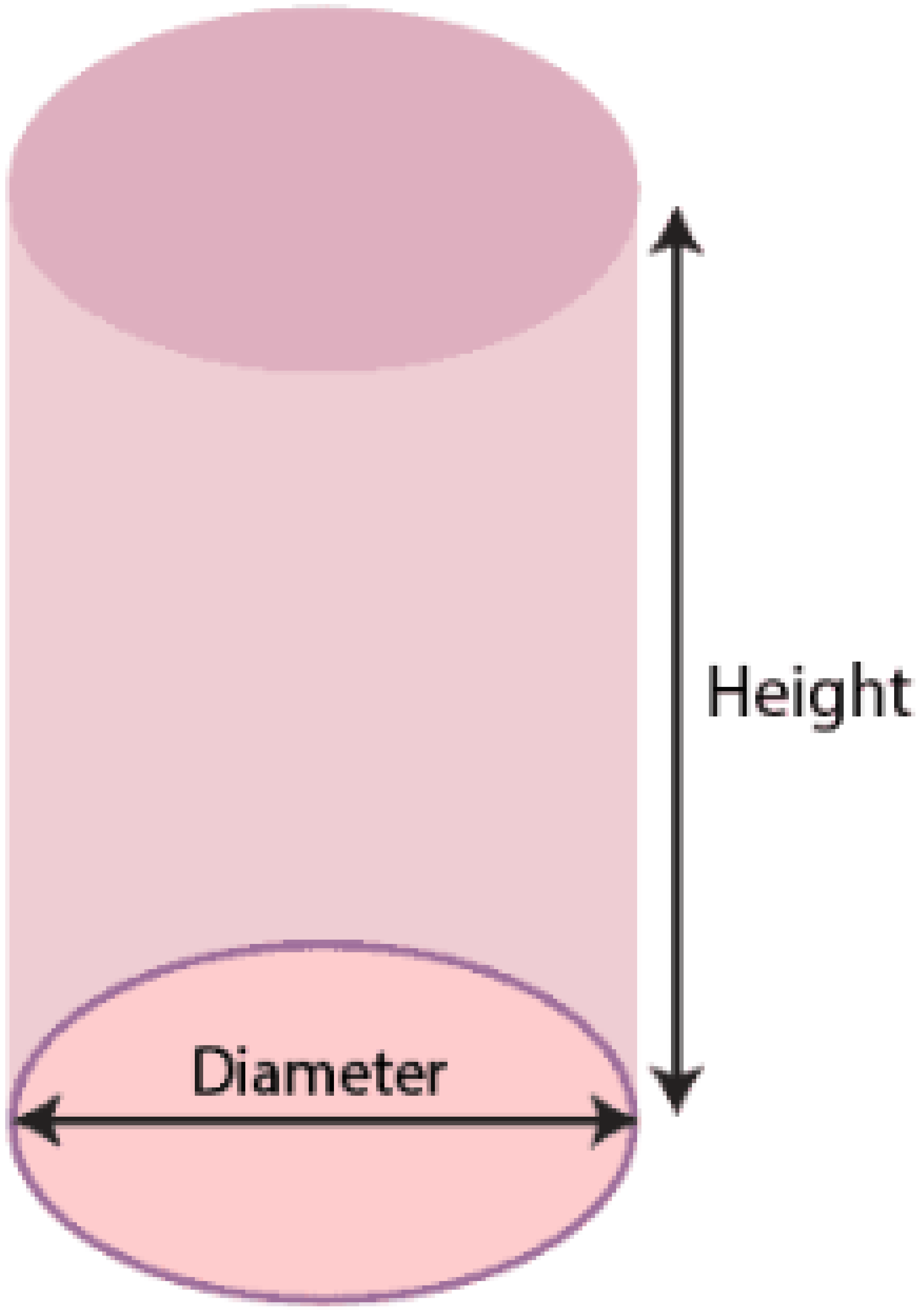
Volume of a **CYLINDER** =

$$\pi \times (\text{Diameter}/2)^2 \times H$$



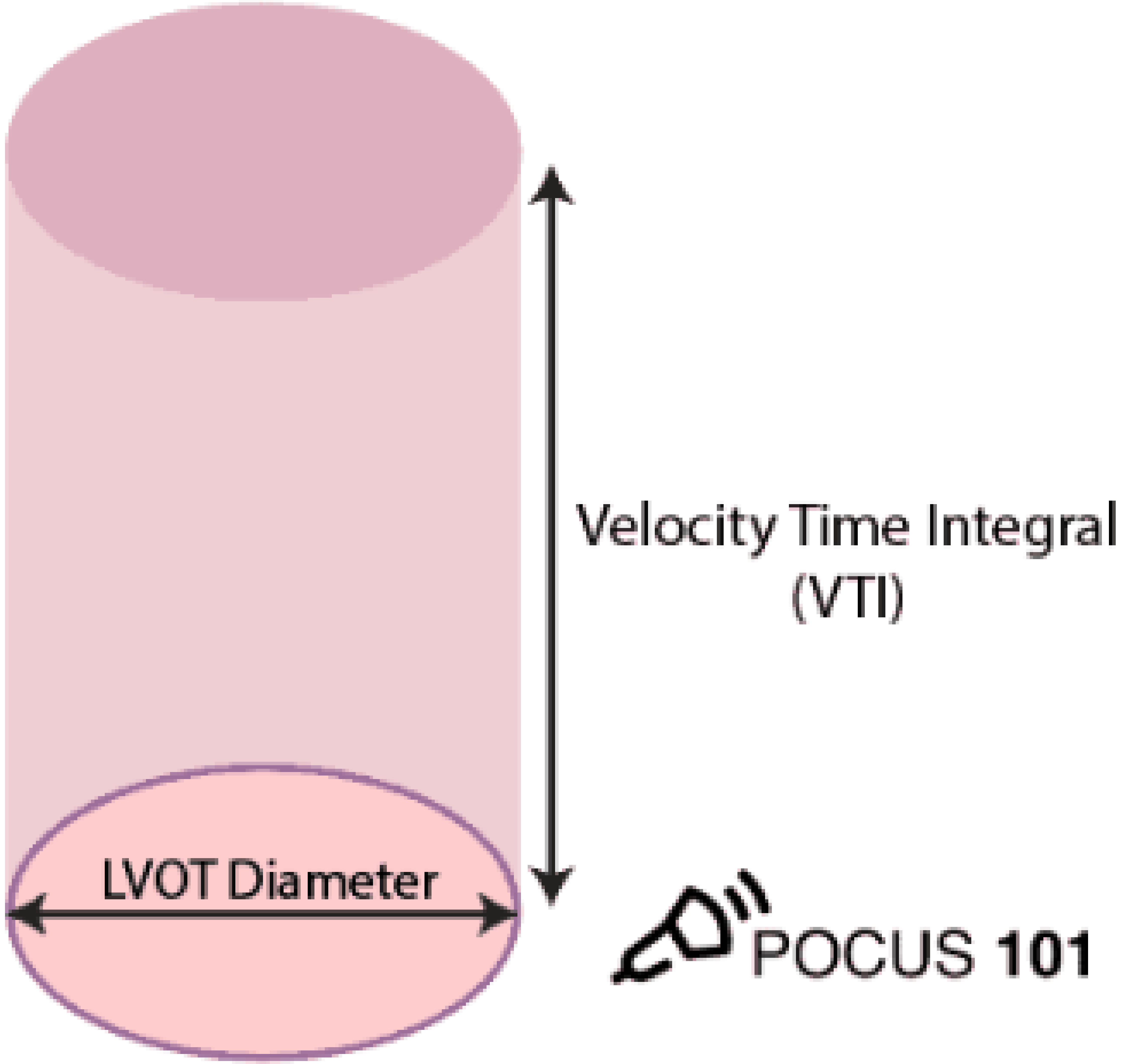
Volume of a **CYLINDER** =

$$\pi \times (\text{Diameter}/2)^2 \times H$$



STROKE VOLUME =

$$\pi \times (\text{LVOT Diameter}/2)^2 \times \text{VTI}$$

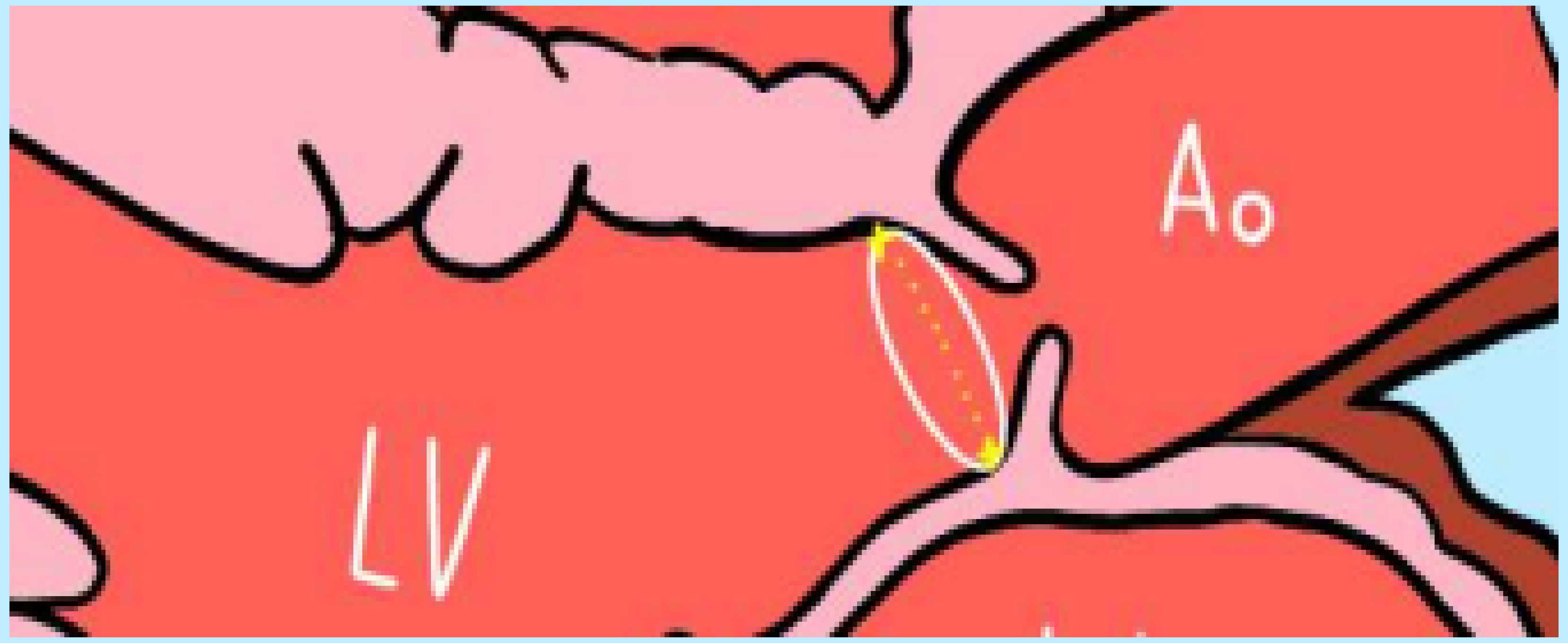


POCUS **101**

Step 1: Calculate LVOT area

CALCULATE LVOT AREA

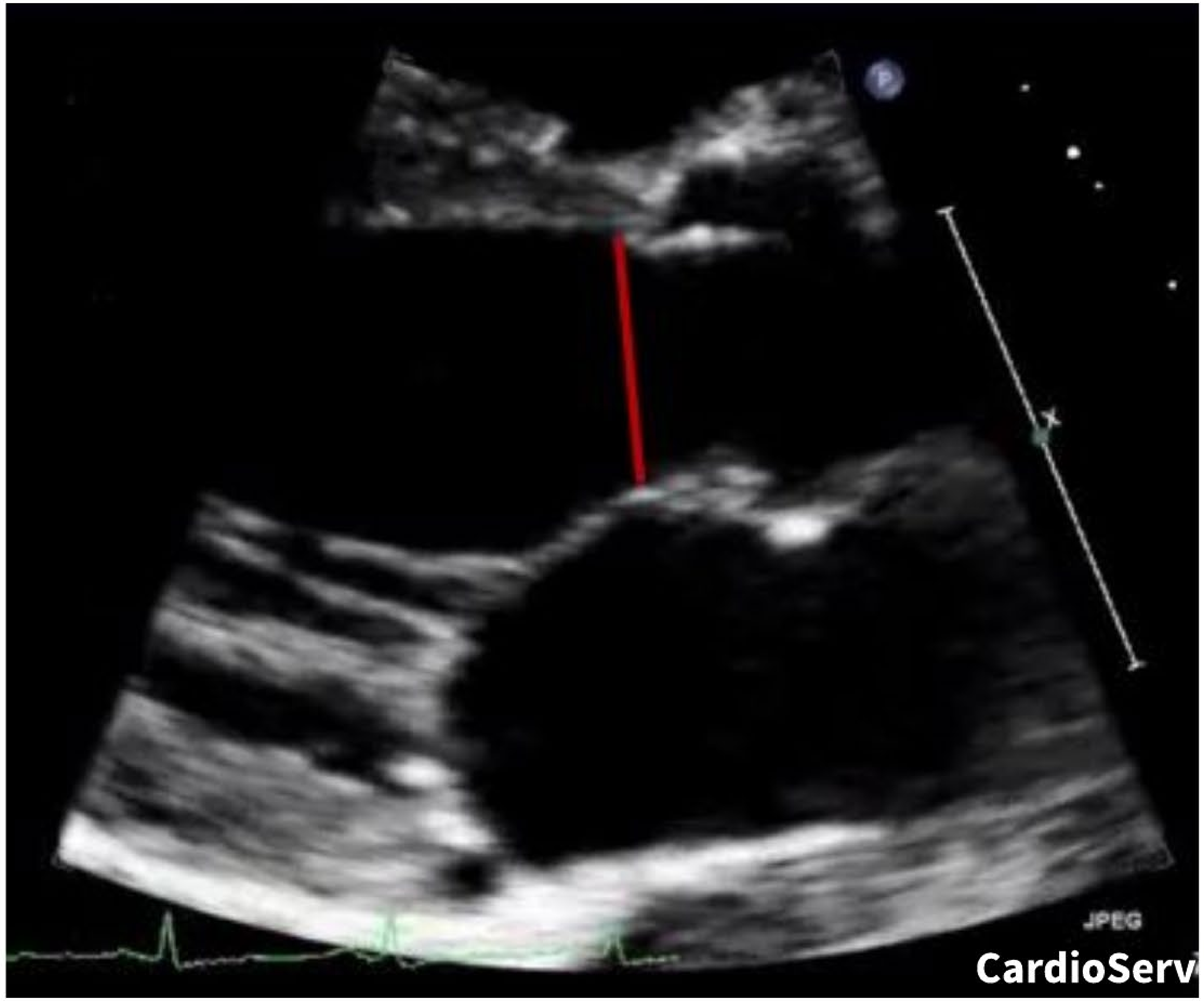
1. PARASTERNAL LONG AXIS VIEW
2. ZOOM INTO LVOT
3. MEASURE LVOT DIAMETER IN CM
4. CALCULATE LVOT AREA USING AREA OF A CIRCLE FORMULA



$$\text{LVOT AREA} = \pi\left(\frac{\_\_\_\text{cm}}{2}\right)^2$$

Step 1: Calculate LVOT area

LVOT Diameter



Parasternal Long Axis

ZOOMED

Inner-Edge to Inner-Edge (I-I)

Mid-Systole

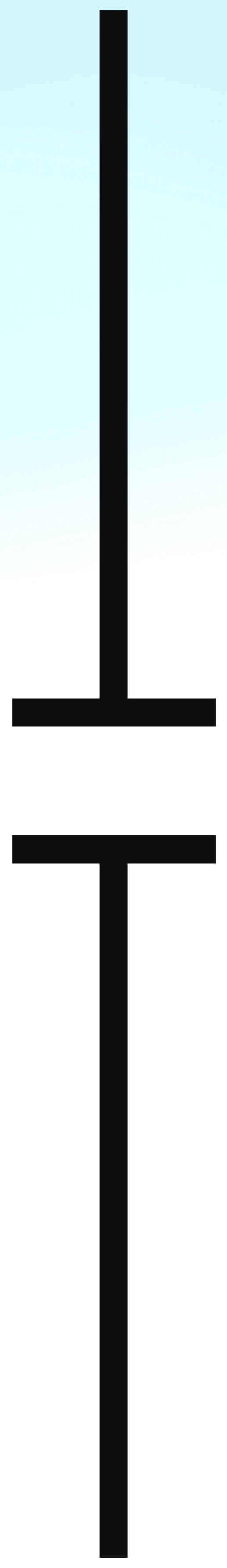
Parallel & Adjacent to AV

Step 2: Calculate LVOT VTI

PW doppler

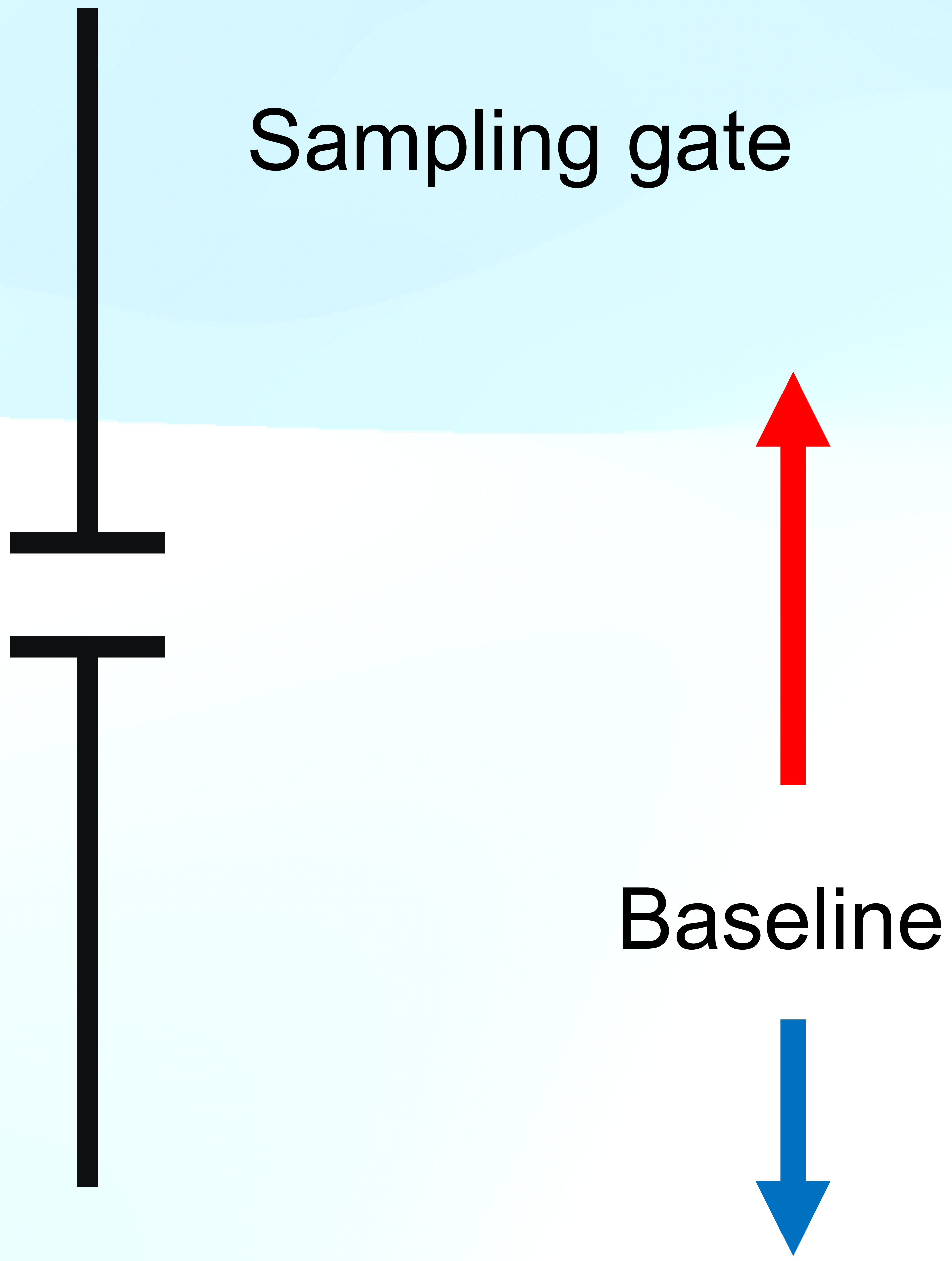
Pulse wave – measures speed of movement, graphed over time

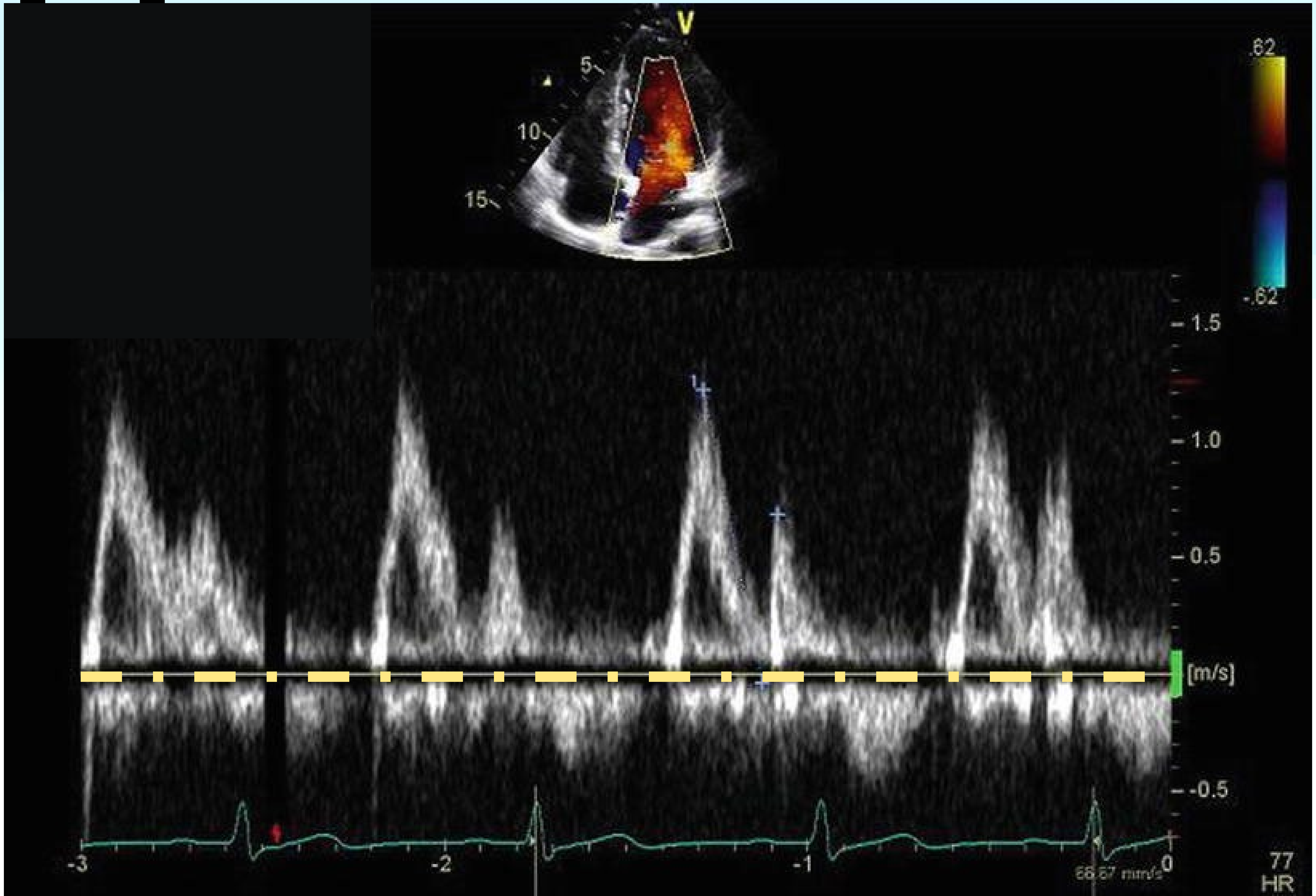
PW doppler



Sampling gate

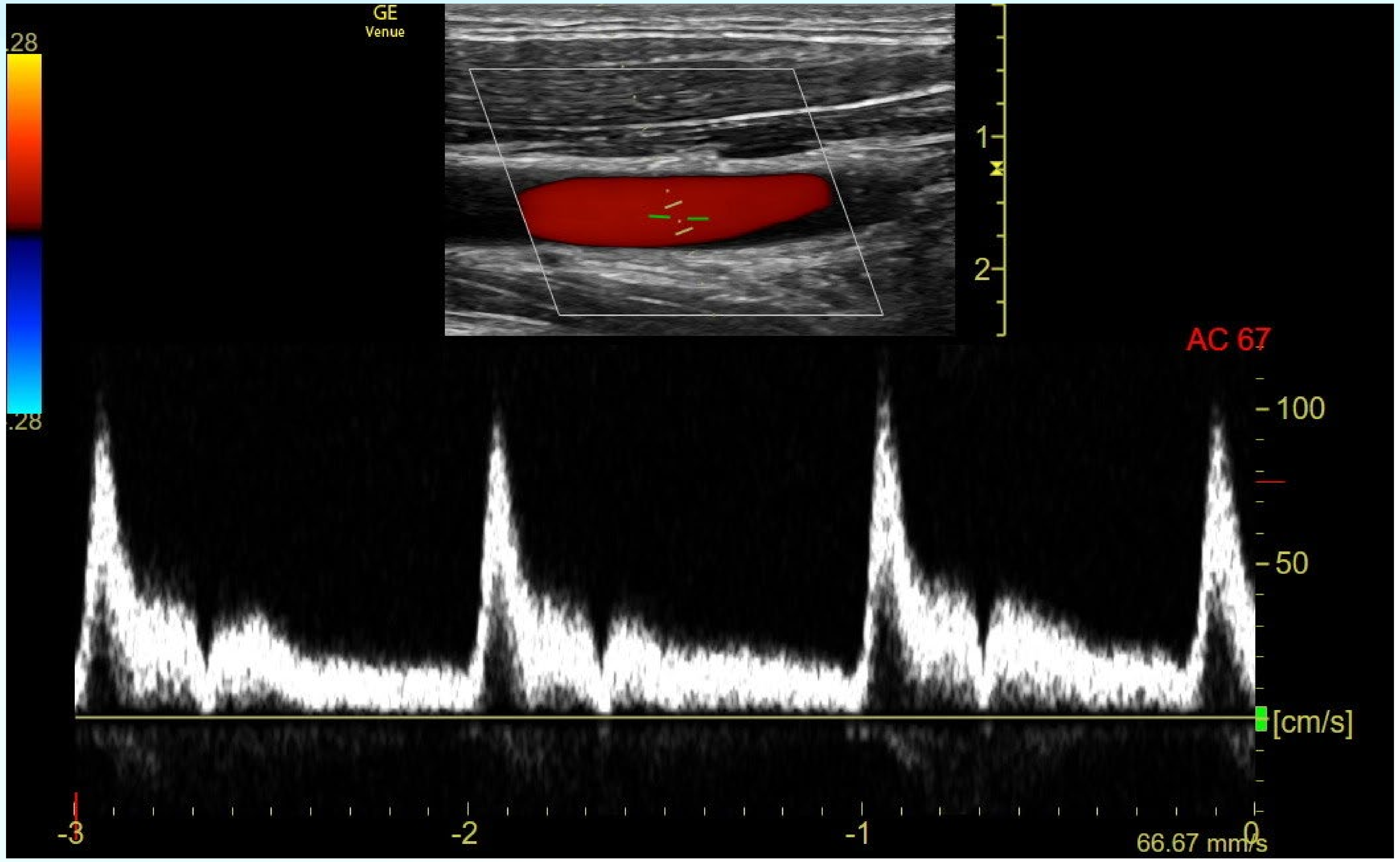
PW doppler

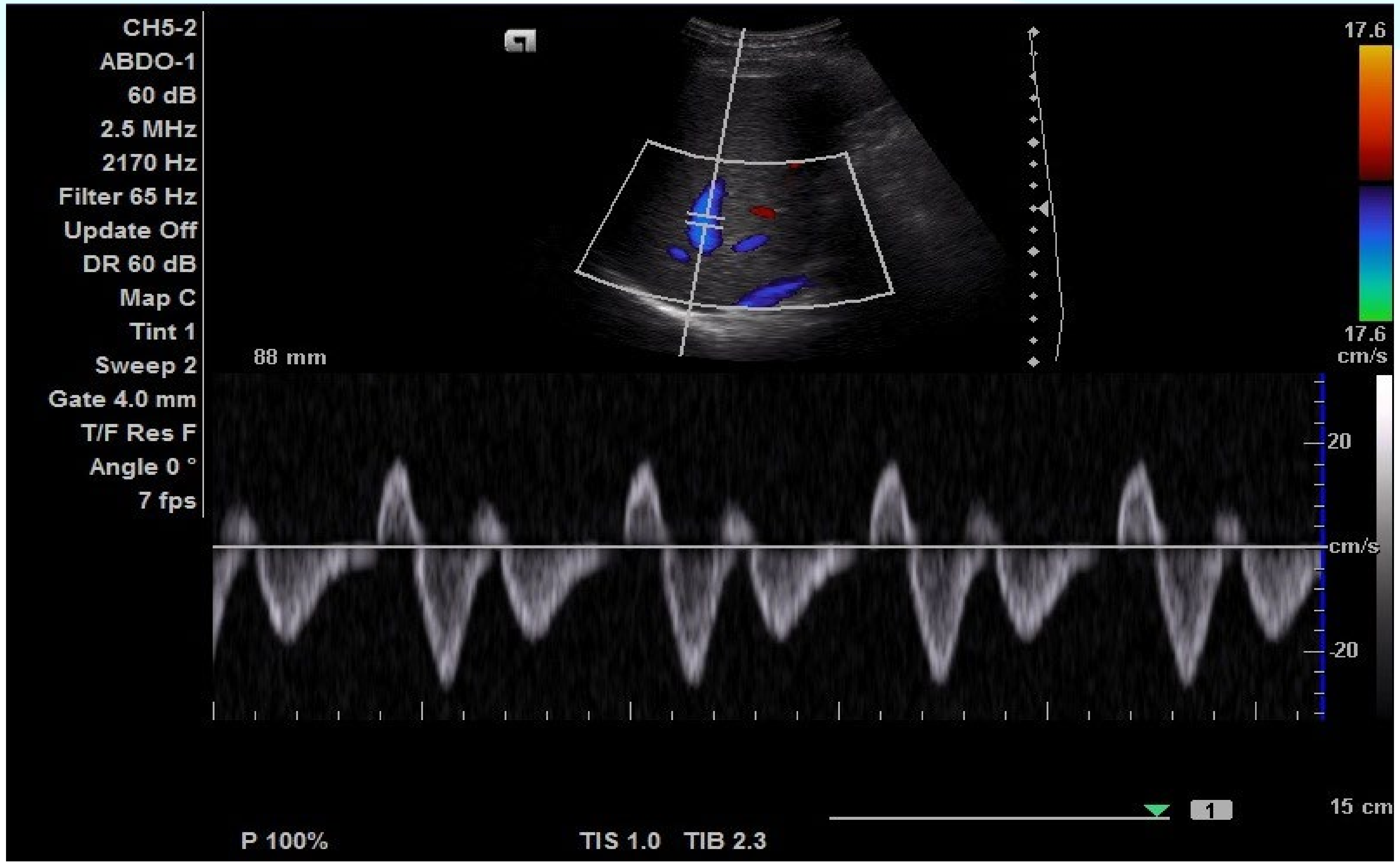


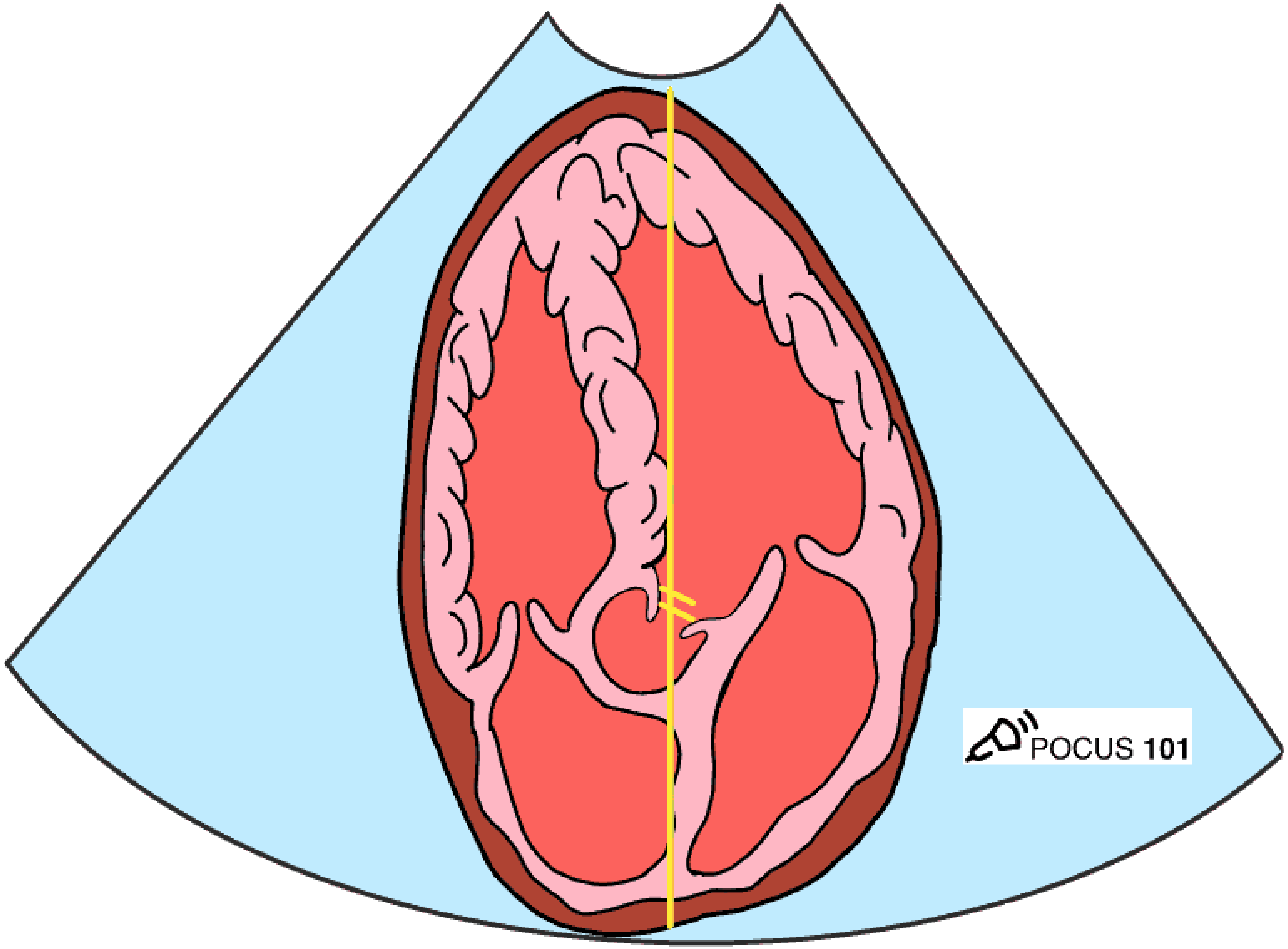


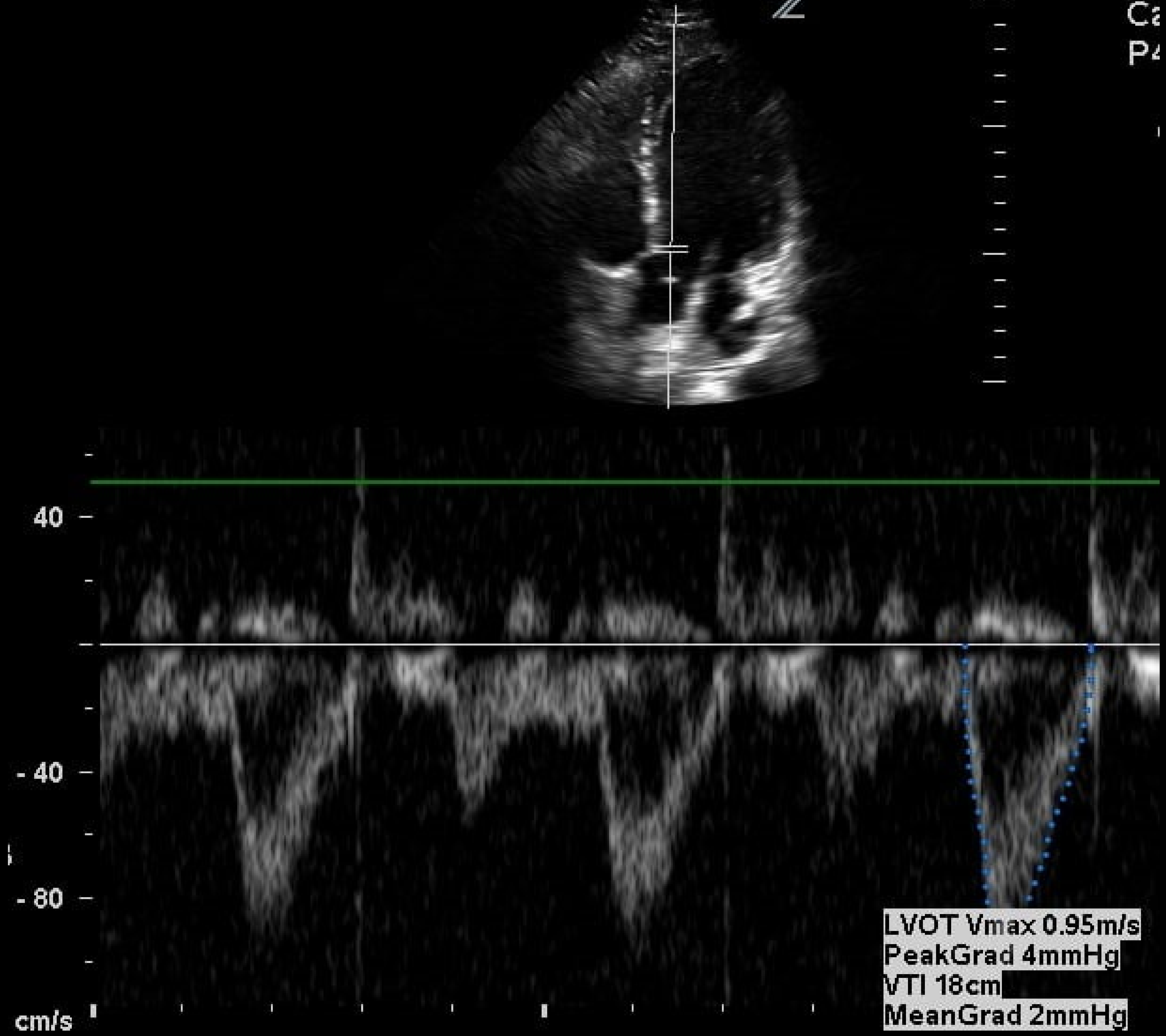
Carotid

Hepatic vein

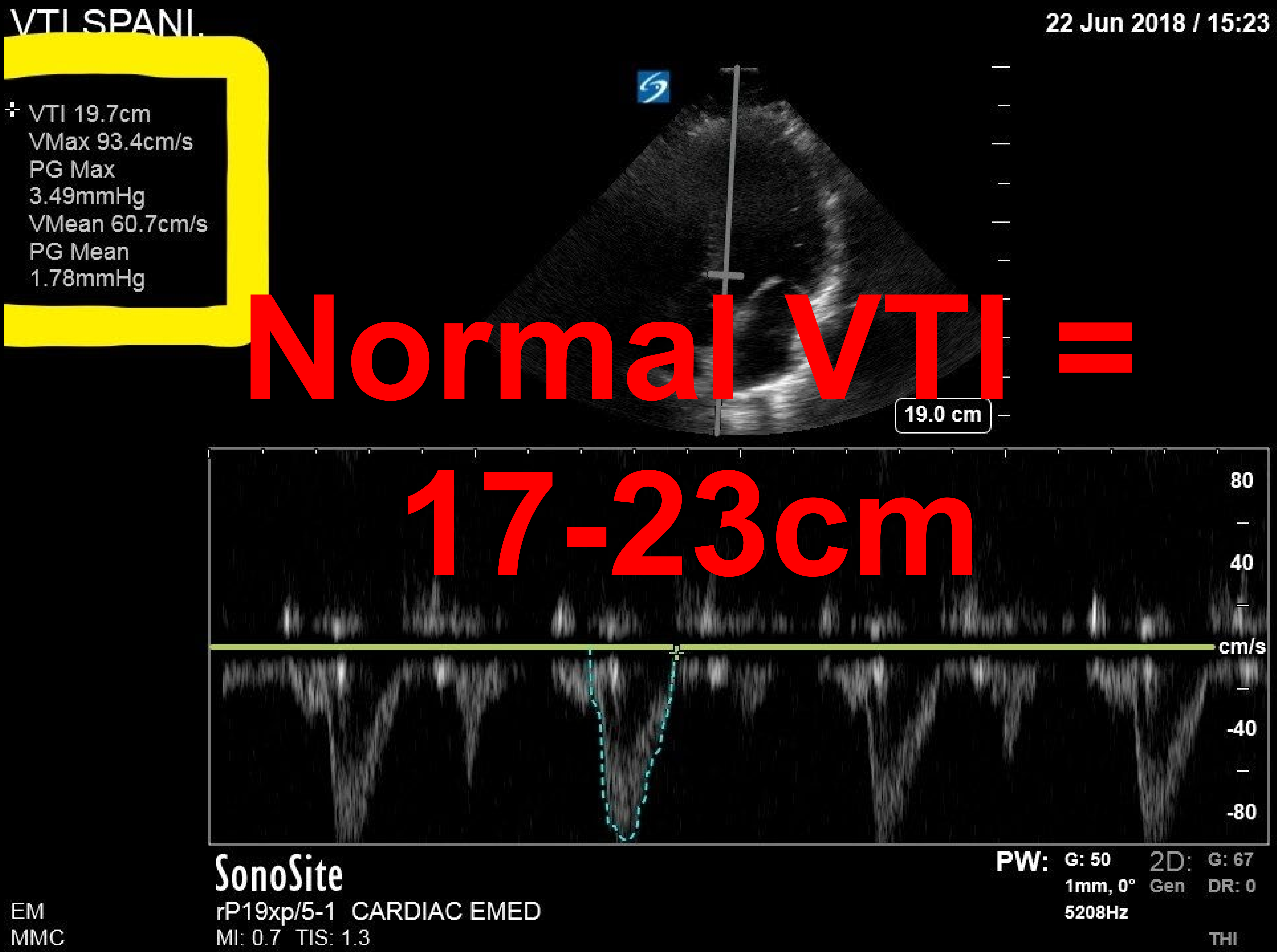





POCUS 101


40
- 40
- 80
cm/s
LVOT Vmax 0.95m/s
PeakGrad 4mmHg
VTI 18cm
MeanGrad 2mmHg

Normal VTI = 17-23cm



SV = LVOT area (cm2) x VTI (cm)

Normal SV = >60ml

5
10
15
CLEVELAND
MEDICAL CENTER
EMERGENCY
MEDICINE

LV systolic function

1. ~~Simpson's biplane method~~
2. ~~EPSS < 7mm~~
3. ~~Fractional shortening ~ 1/3~~
4. ~~Stroke volume: LVOT VTI~~
5. ”Eyeball method”

Eyeballing

"Visually estimated LV ejection fraction"

Cardiovascular Ultrasound

BioMed Central

Research

Open Access

Visually estimated ejection fraction by two dimensional and triplane echocardiography is closely correlated with quantitative ejection fraction by real-time three dimensional echocardiography

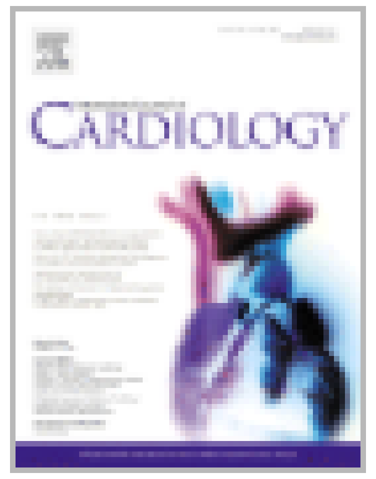
Kambiz Shahgaldi*[1], Pe

Åke Brodin[4] and Reidar

ELSEVIER

International Journal of Cardiology

Volume 101, Issue 2, 25 May 2005, Pages 209-212



THE ANATOLIAN JOURNAL OF CARDIOLOGY

Agreement between visually left ventricular ejection frac echocardiography and quan measurements using cardiac resonance

Visually estimated left ventricular ejection fraction by echocardiography is closely correlated with formal quantitative methods

Petri Gudmundsson [1], Erik Rydberg [2], Reidar Winter [2], Ronnie Willenheimer [2]

What are you "eyeballing"?

- Chamber size during diastole vs. systole?
- Is the endocardium moving inwards during systole?
- Is the myocardium thickening during systole?
- Is the mitral valve leaflet moving towards the septum during diastole?

ACEP = 25-50 supervised scans

CPOCUS = 50 supervised scans

Kimura et al = 20-30 scans

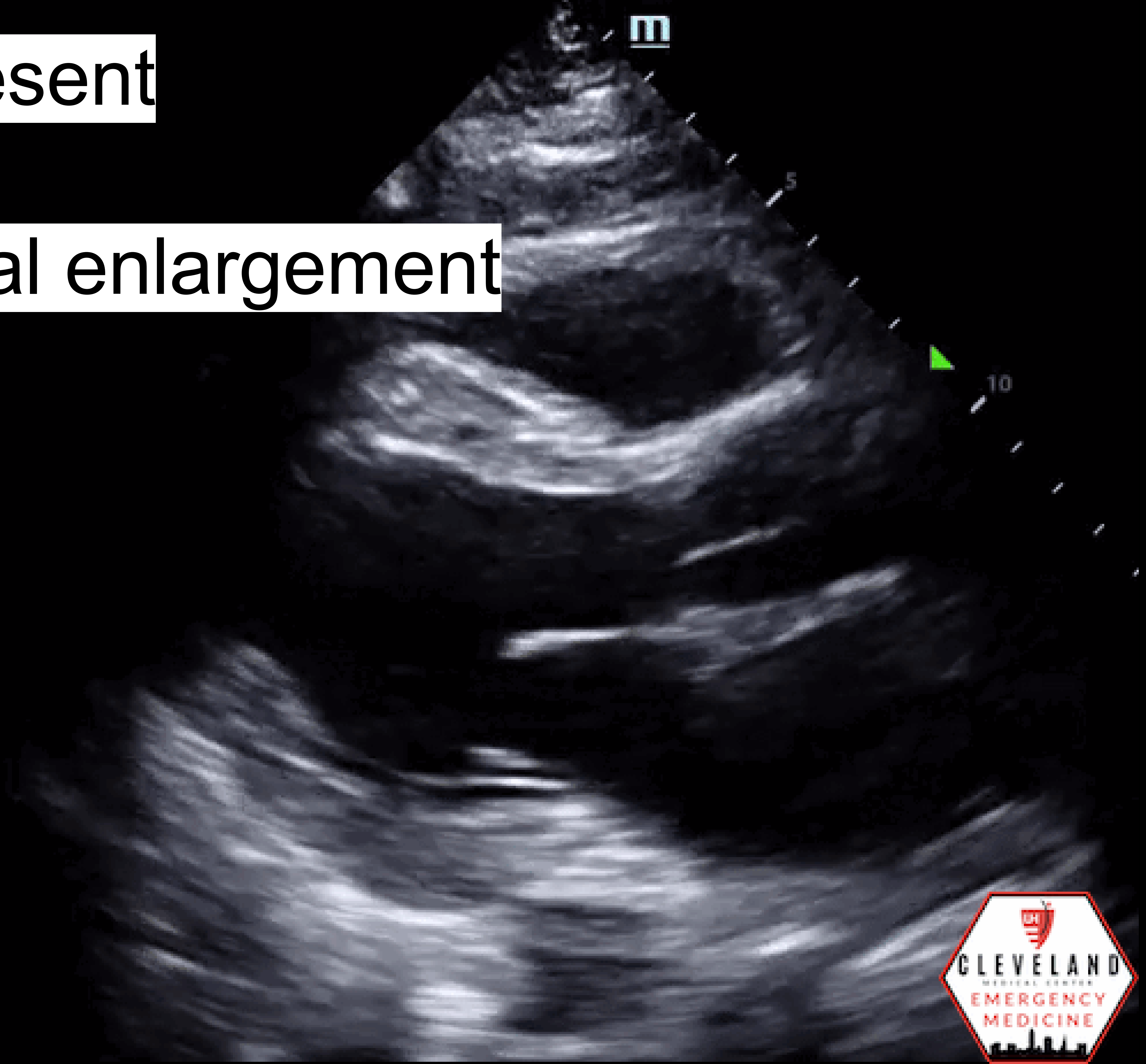

EF 20%
PSLA

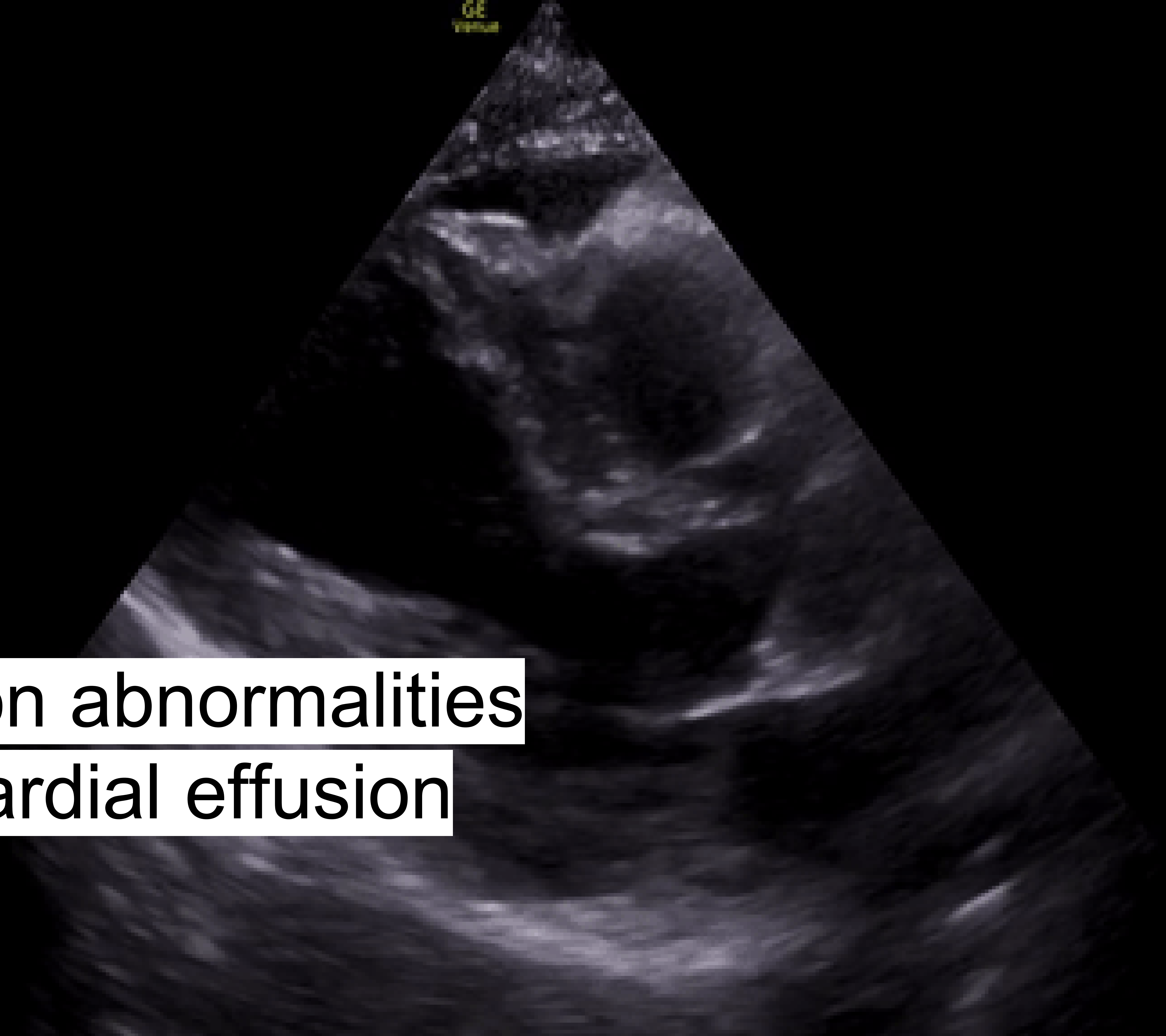
EF 15%

LVH present

EF 30%

Left atrial enlargement





EF 40%

Wall motion abnormalities

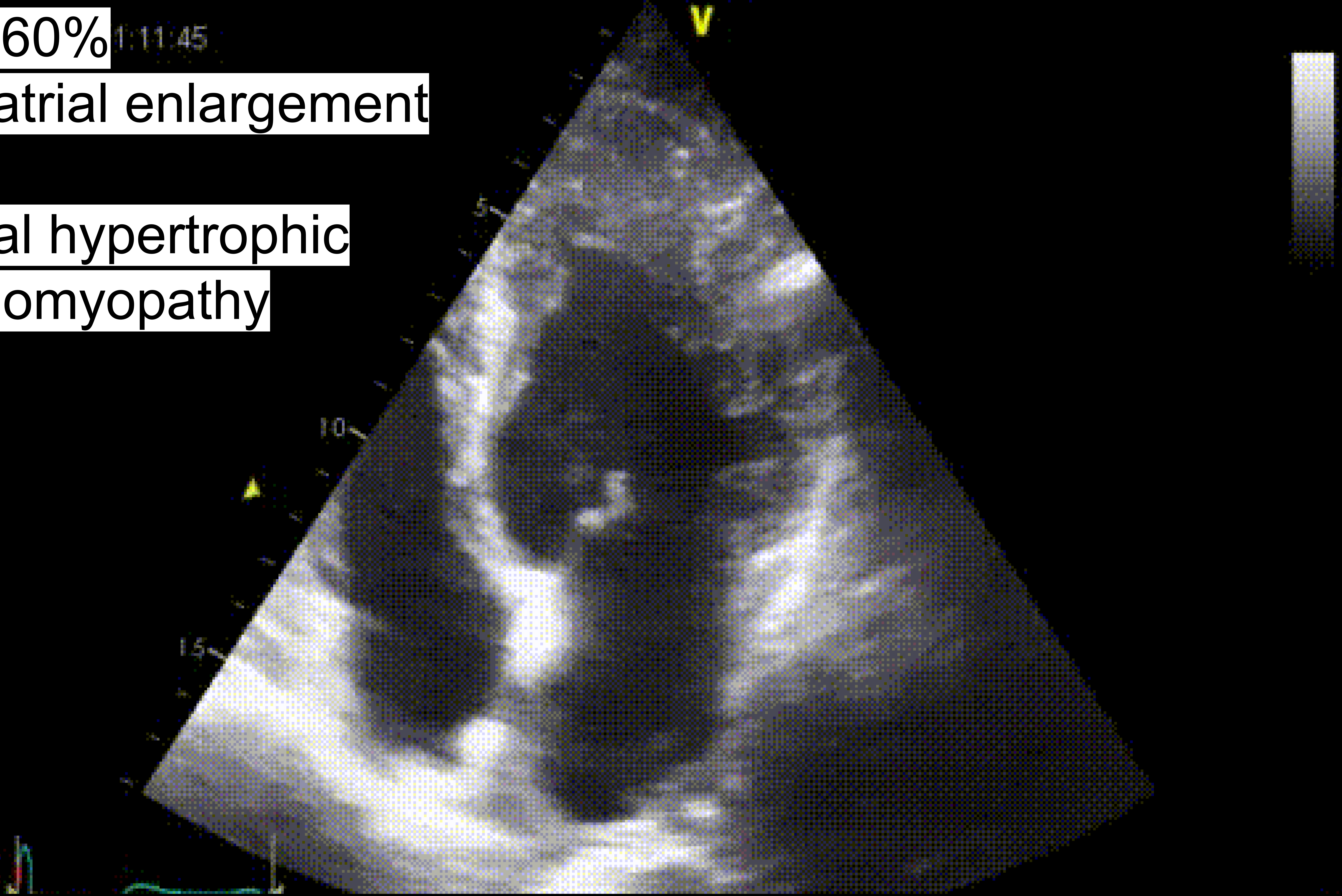
Mild pericardial effusion

EF hyperdyamic
Tachycardia due to
hypovolemia

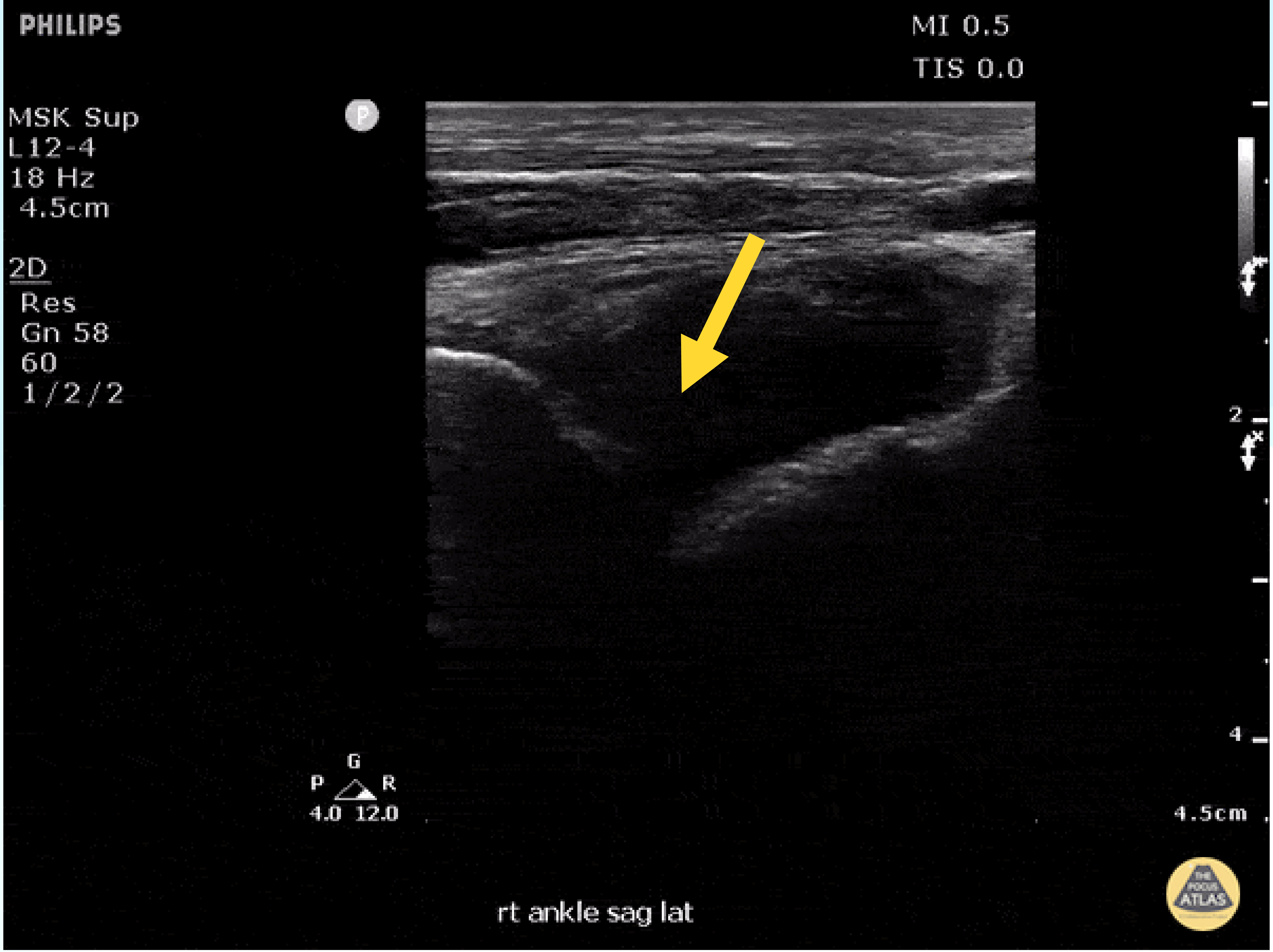
EF >60%

Left atrial enlargement

Apical hypertrophic cardiomyopathy




EF 25%
Biatrial enlargement
LV thrombus


PHILIPS
MI 0.5
TIS 0.0
MSK Sup
L12-4
18 Hz
4.5cm
2D
Res
Gn 58
60
1/2/2
G
P
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Rural POCUS Rounds

AUGUST	Intro to MSK POCUS	Dr Frank Johnson, Sports Medicine Ultrasound
SEPTEMBER	Foot & Ankle	Dr Frank Johnson
OCTOBER	Rheumatology POCUS	Dr Mo Bardi, USSONAR
NOVEMBER	Giant cell arteritis	Dr Irina Sainchuk, CPOCUS
DECEMBER	The Hip: pathology, injections, blocks	Dr Tracy Morton

UBC CPD Medicine
CONTINUING PROFESSIONAL DEVELOPMENT

Rural POCUS Rounds

Rural Coordination Centre of BC

Questions?