

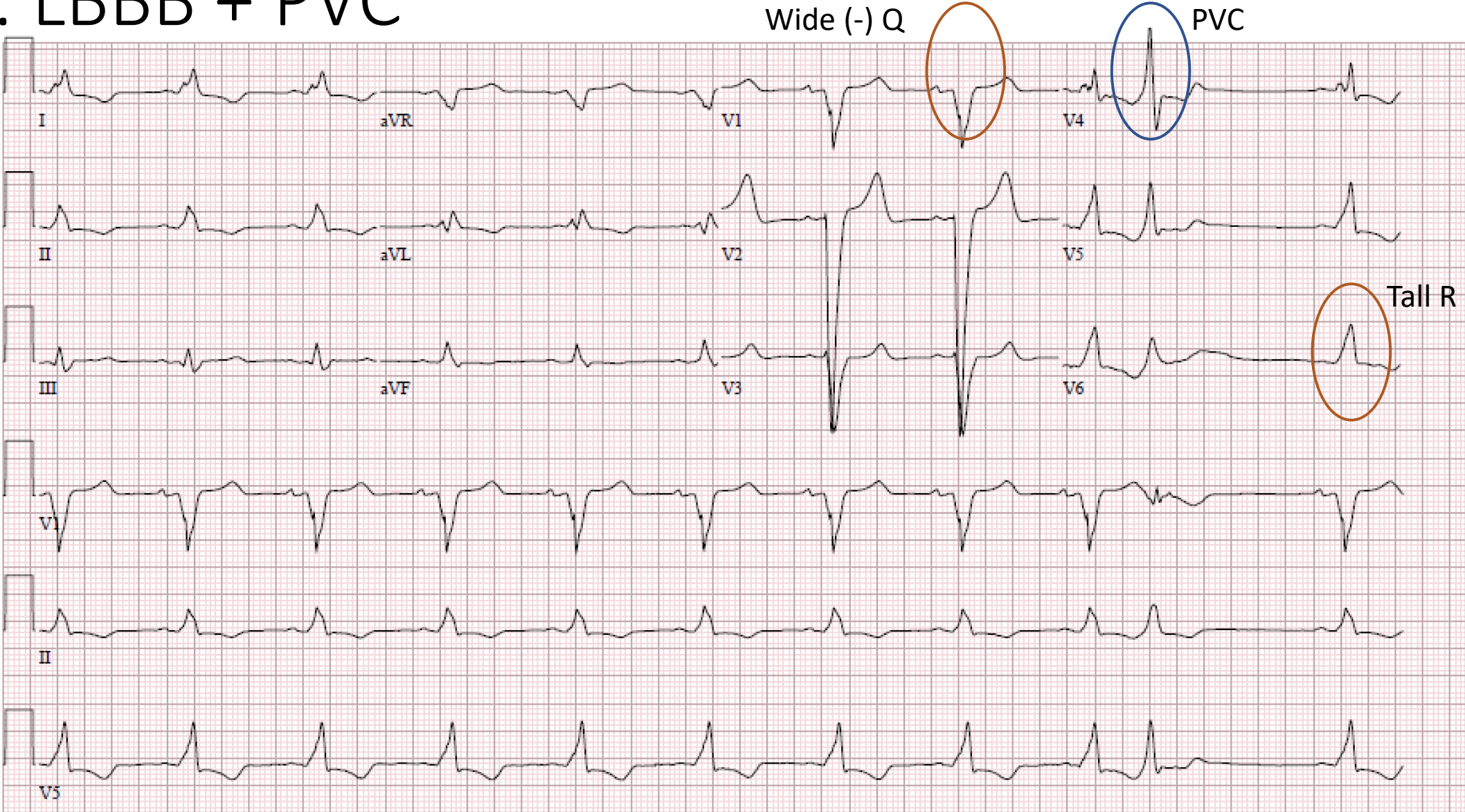
Aortic Stenosis & US

Sarah Kanbour

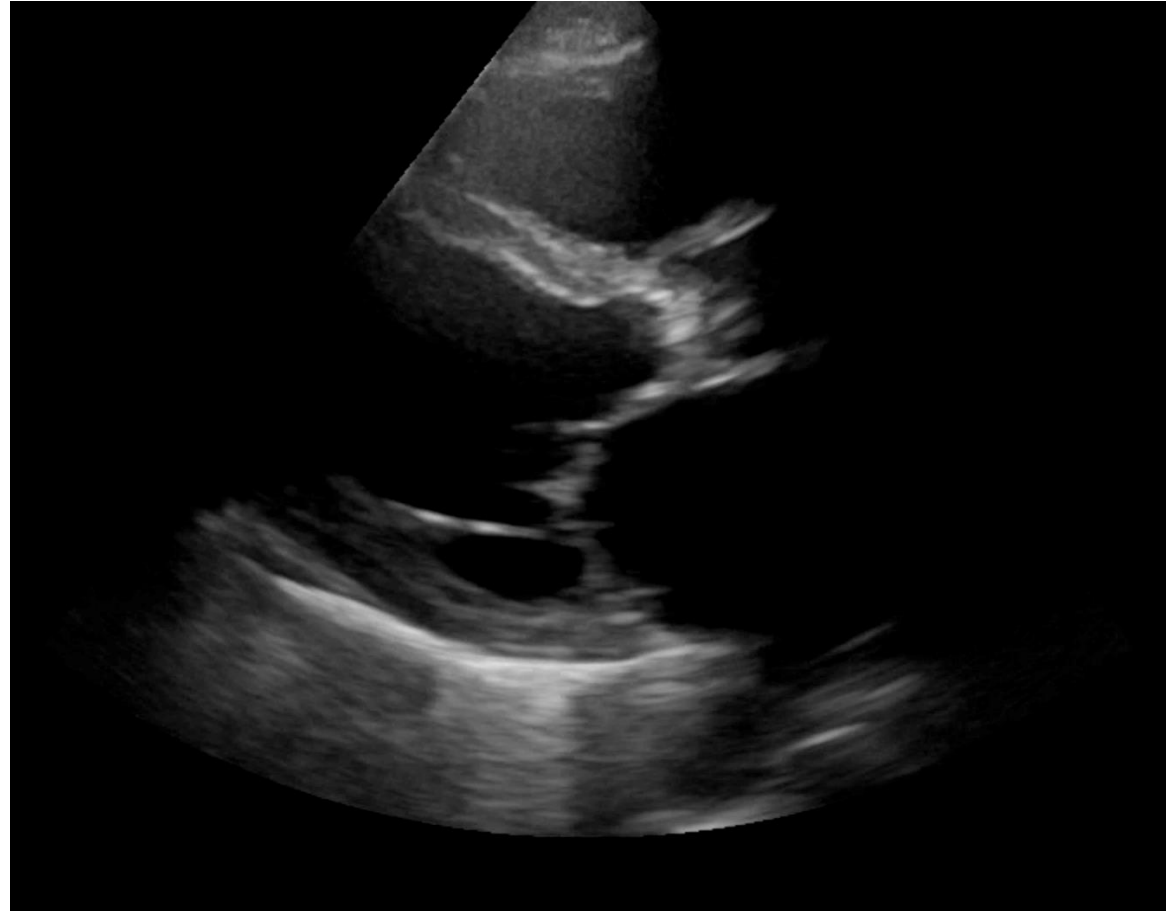
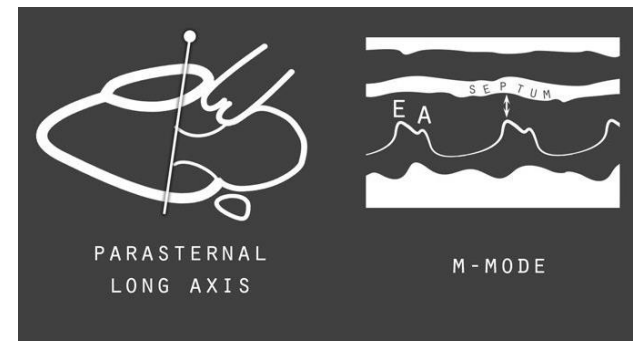
Clinical Presentation

- 80M with **CAD** with CABG in 2010
- CC: **Syncope**, **dyspnea** on exertion, exertional **chest pain**
- Vitals: Afebrile, HR = 90, BP = 110/76, saturating well on RA
- Exam: **anasarca**, **+JVD**, **no murmur**
- Troponin peak **0.8**, BNP **>5000**, Cr **1.6**, LFT Ok
- **Rhinovirus & influenza +**

EKG: LBBB + PVC



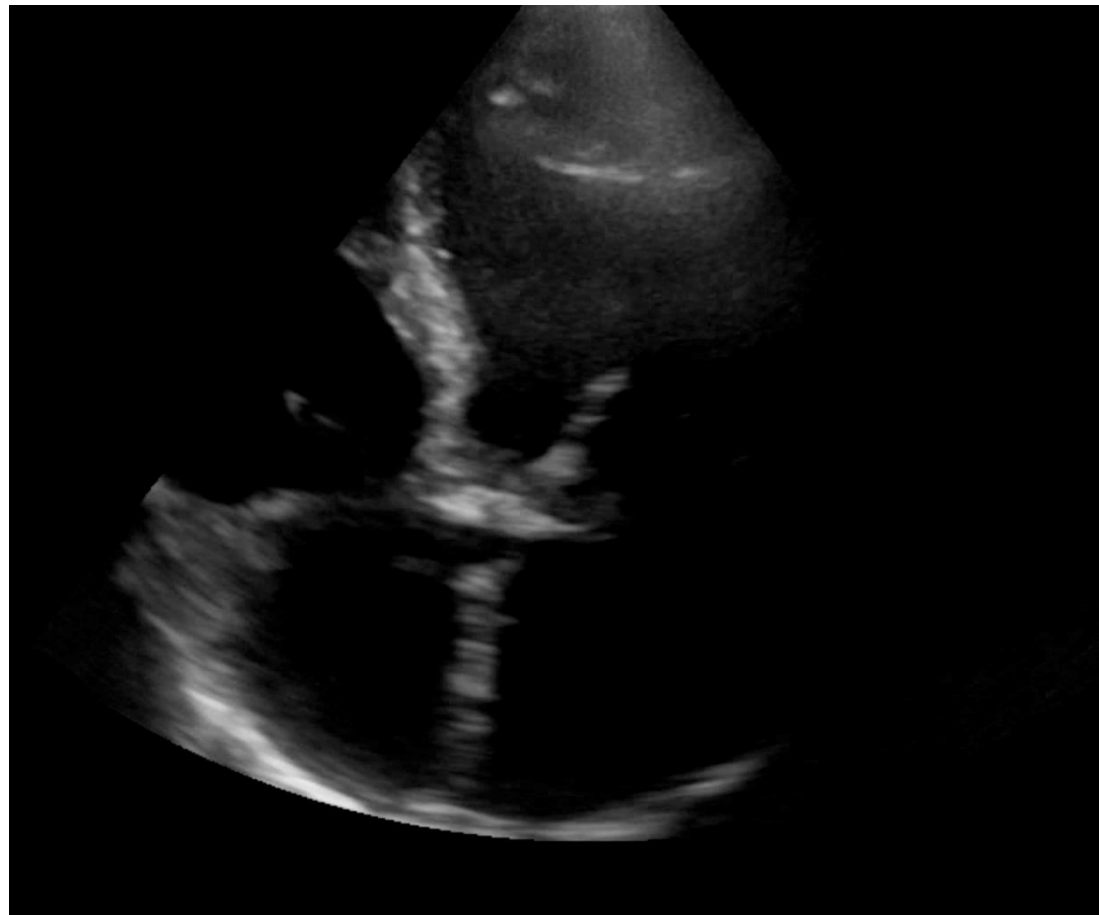
E-Point of Septal Separation



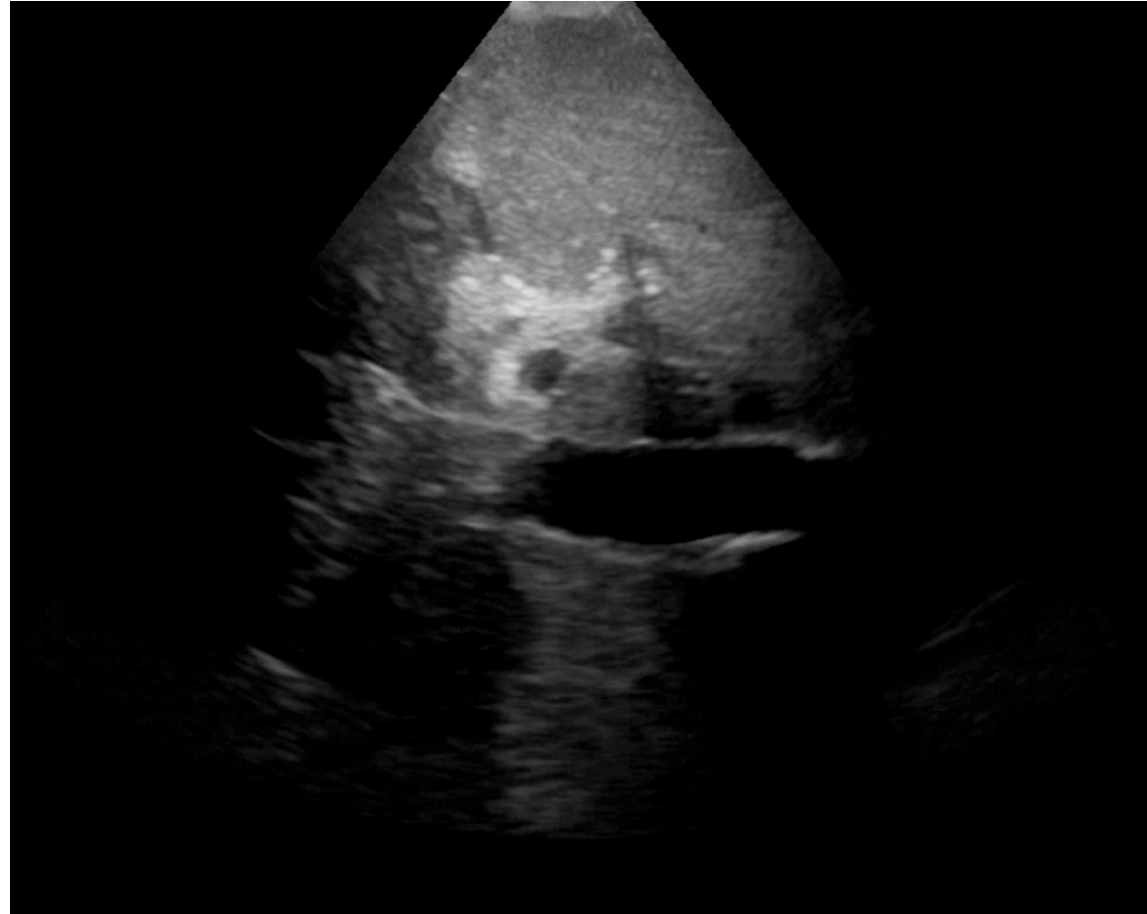
Endocardial Excursion & Myocardial Thickening



Chamber Size



IVC >2 cm & $<50\%$ Respiratory Variation

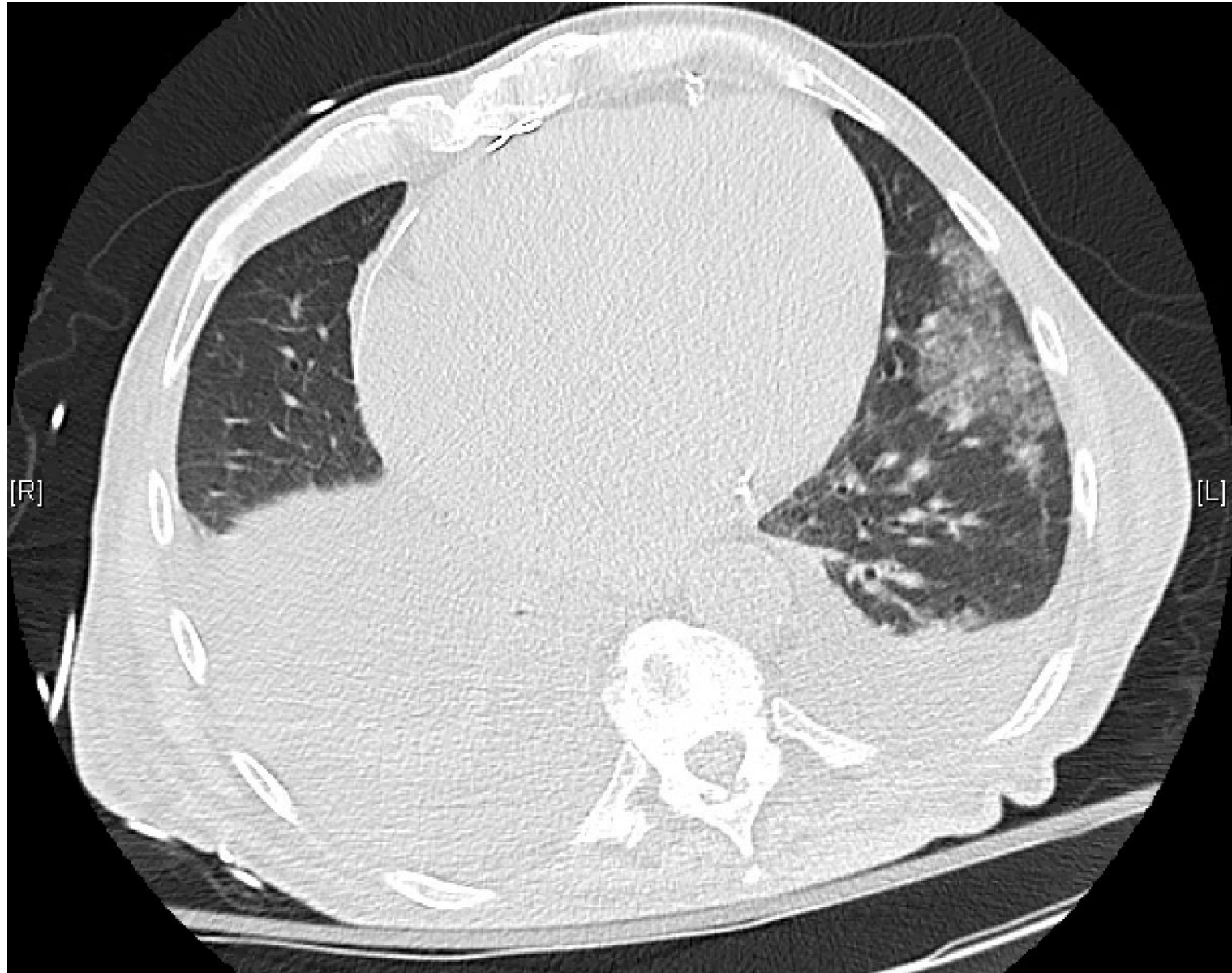


Bedside US

- Reduced ejection fraction:
 - EPSS > 1cm
 - Myocardial thickening < 40% during systole
- Dilated R atria & ventricle
 - RV > 2/3 LV
- Dilated IVC without inspiratory variation
 - IVC > 2 cm with < 50% inspiratory decrease in diameter

CT chest

- Pleural effusions
- Pulmonary edema
- Cardiomegaly
- Large R atria & ventricle



Clinical Course

- He was diuresed
- Refused labs/Foley
- Had **worsening AKI, LFT, lactate**
- Foley drained purulent cloudy urine

- Septic (post viral PNA vs UTI) vs. Cardiogenic vs. Hypovolemic shock (over-diuresis)?
- **Cold** extremities. Bedside echo with severely **reduced EF & large IVC**

Official Echo:

EF 8 %

Aortic Valve Area: 0.8 cm²

LVOT diameter: 4 cm²

LVOT Vmax 0.92 m/s & LVOT VTI 15.6 cm

Aortic Vmax 3.9 m/s & Aortic VTI 75.0 cm

Peak velocity 3.9 m/s

Mean Aortic Gradient: 39 mmHg

Peak Aortic Gradient: 62 mmHg

Est PA Syst Pressure: 55 mmHg

IVC is normal in size (1.5-2.5 cm) but without respiratory variability

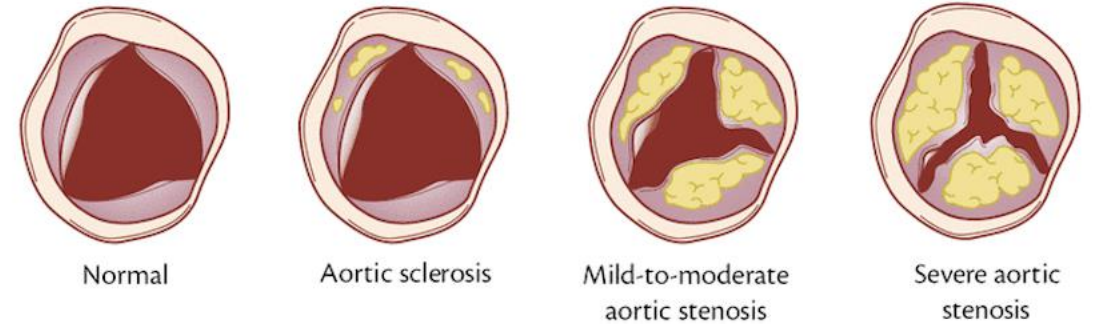
Aortic Valve Assessment by Ultrasound

1. Valve area
2. Mean gradient
3. Peak velocity across the aortic valve
4. Ejection Fraction
 - Low-flow, low-gradient (LF-LG) severe AS with reduced LVEF
 - Low-flow, low-gradient (LF-LG) severe AS with normal LVEF

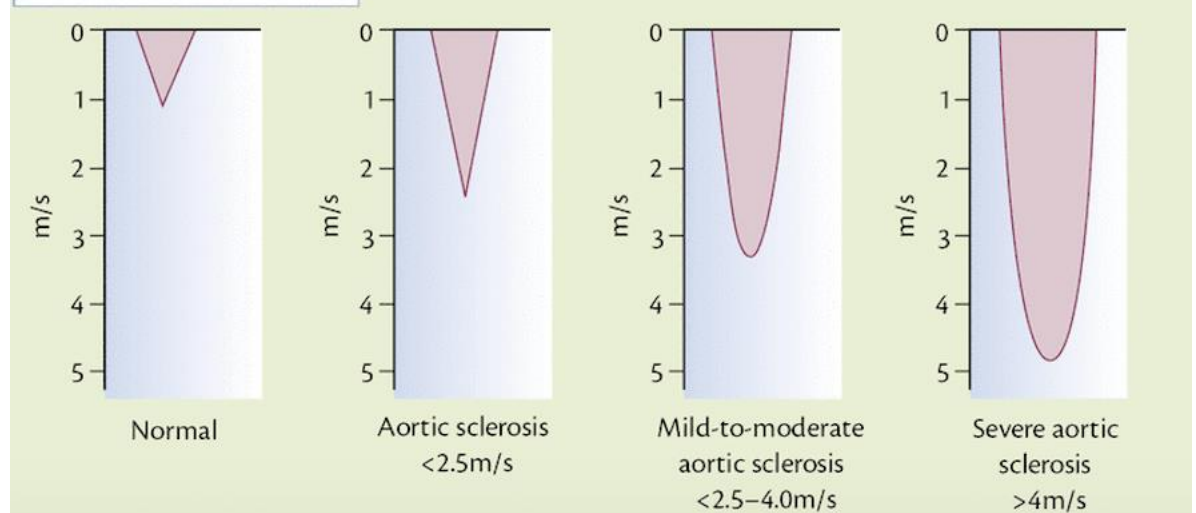
Severe Aortic Stenosis

- Valve area $< 1\text{cm}^2$
- Peak velocity $> 4\text{ m/s}$
- Mean gradient $> 40\text{mmHg}$

(b) Aortic valve anatomy

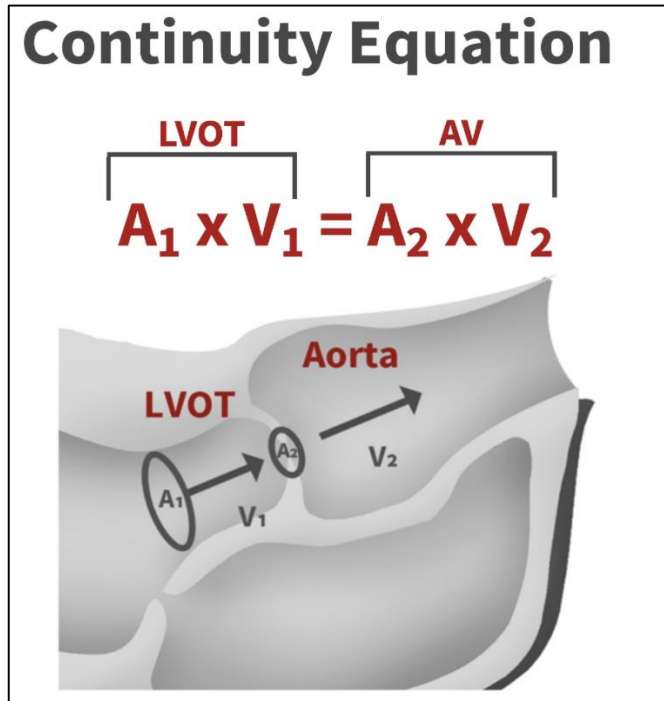


(c) Doppler aortic-jet velocity



Steps in Measurements

Valve area



$$A_2 = \frac{A_1 \times V_1}{V_2}$$

AVA (cm²)

LVOT CSA

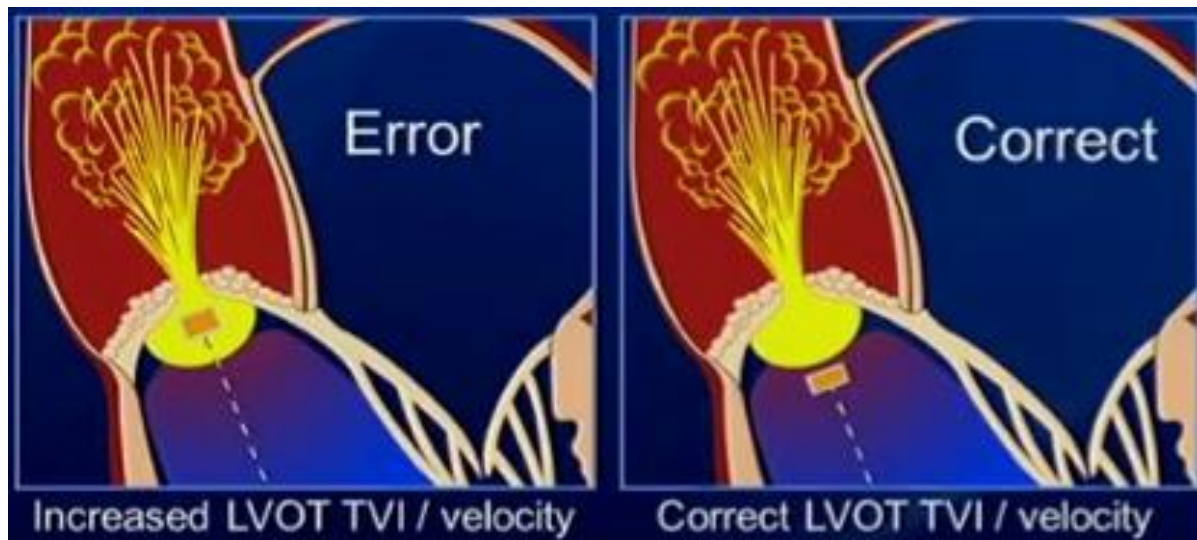
LVOT VTI

Peak AV VTI

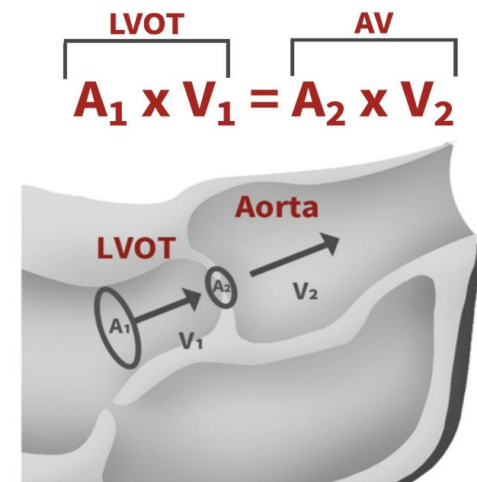
The diagram shows the continuity equation rearranged to solve for A_2 . The variables are defined as follows: A_2 is the Aortic Valve Area (AVA) in cm²; A_1 is the LVOT Cross-sectional Area (CSA); V_1 is the LVOT Velocity Time Integral (VTI); and V_2 is the Peak Aortic Valve Velocity Time Integral (Peak AV VTI). Dotted lines connect the labels to their respective variables in the equation.

A1 (LVOT Diameter)

- Parasternal long axis view
- Zoom on the aortic valve
- Scroll to systole where valve is wide open



Continuity Equation



V1 & V2 Calculation

$$A_2 = \frac{A_1 \times V_1}{V_2}$$

AVA (cm²)

LVOT CSA

LVOT VTI

Peak AV VTI

The diagram illustrates the calculation of the Aortic Valve Area (AVA), denoted as A2. The formula is A2 = (A1 x V1) / V2. A1 is the LVOT CSA (Left Ventricular Outflow Tract Cross-sectional Area), V1 is the LVOT VTI (Left Ventricular Outflow Tract Velocity Time Integral), and V2 is the Peak AV VTI (Peak Aortic Valve Velocity Time Integral). The V2 term in the denominator is circled in red, and a dotted line connects it to the label 'Peak AV VTI'.

V1 (LVOT Velocity)

- Apical 5 chamber view
- Pulsed Wave mode
- Place probe at LVOT
- Get V_{max} & VTI by tracing the jet

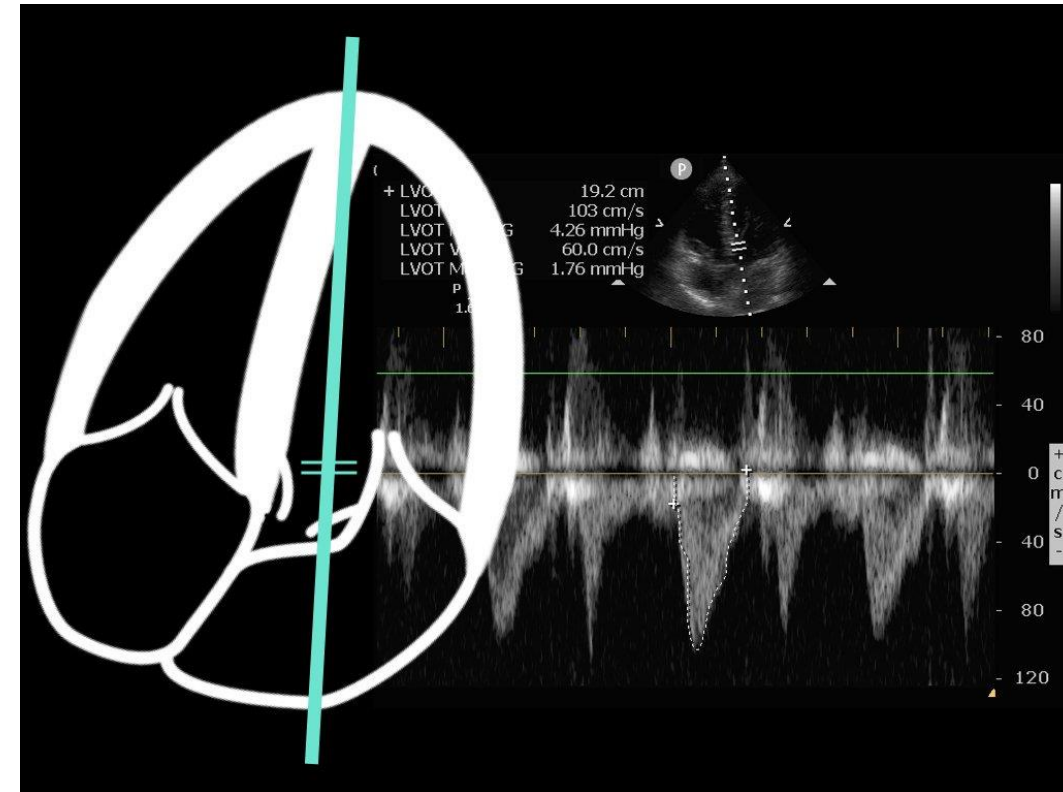
$$A_2 = \frac{A_1 \times V_1}{V_2}$$

AVA (cm²)

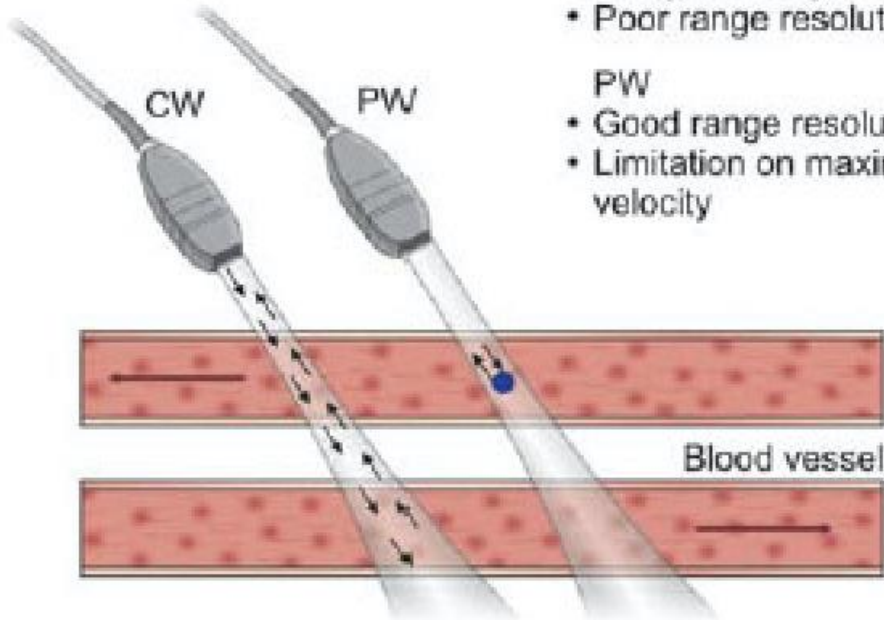
LVOT CSA

LVOT VTI

Peak AV VTI



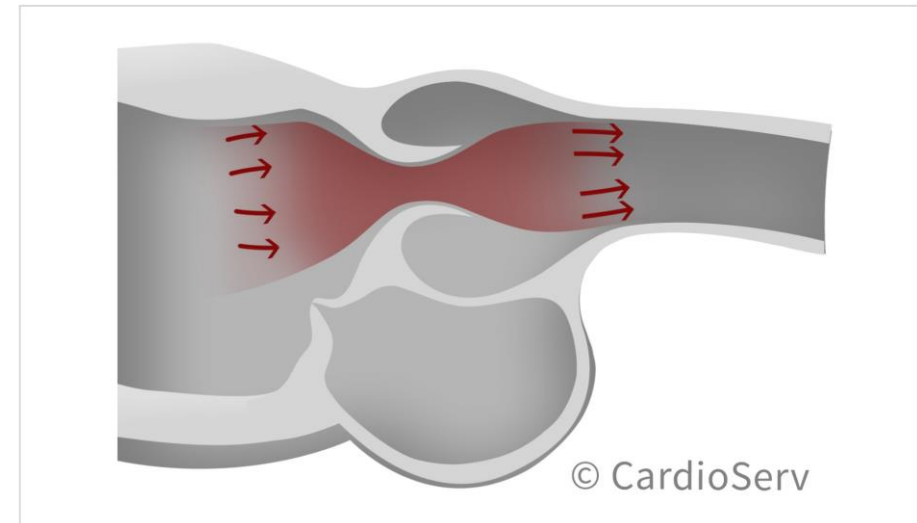
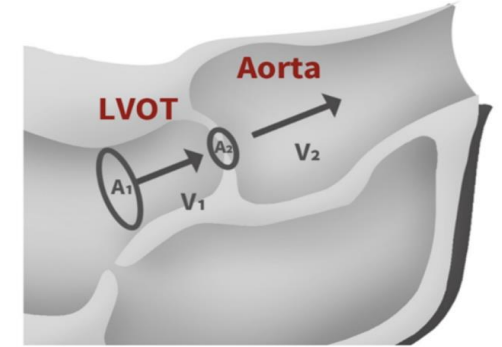
Continuous vs. Pulsed Wave



- CW**
 - Accurate Measurement of high velocity
 - Poor range resolution
- PW**
 - Good range resolution
 - Limitation on maximum velocity

Continuity Equation

$$\overbrace{A_1 \times V_1}^{\text{LVOT}} = \overbrace{A_2 \times V_2}^{\text{AV}}$$



V2 (AV Velocity)

- Apical 5 chamber view
- Continuous Wave mode
- Measure V_{max} to obtain Peak Velocity
- Measure VTI by tracing the jet

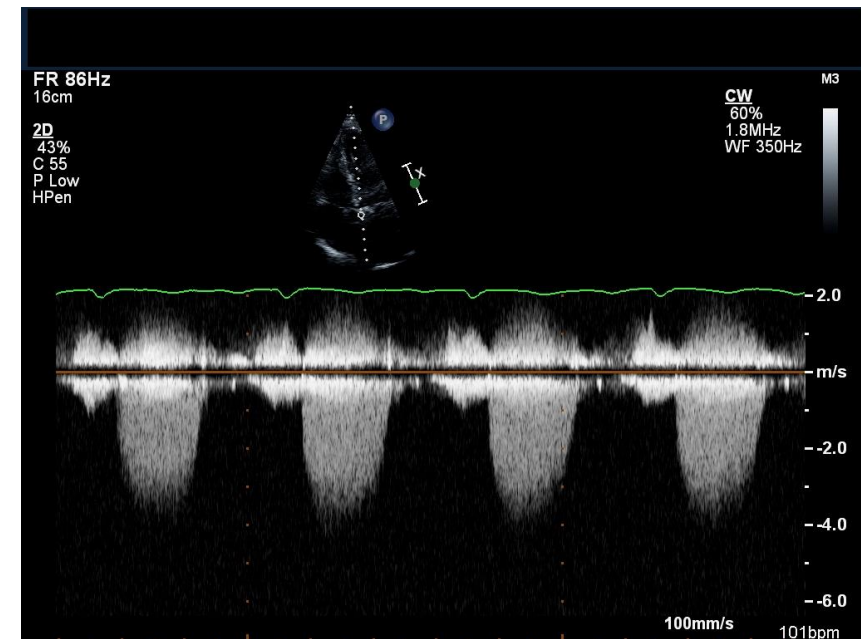
$$A_2 = \frac{A_1 \times V_1}{V_2}$$

AVA (cm²)

LVOT CSA

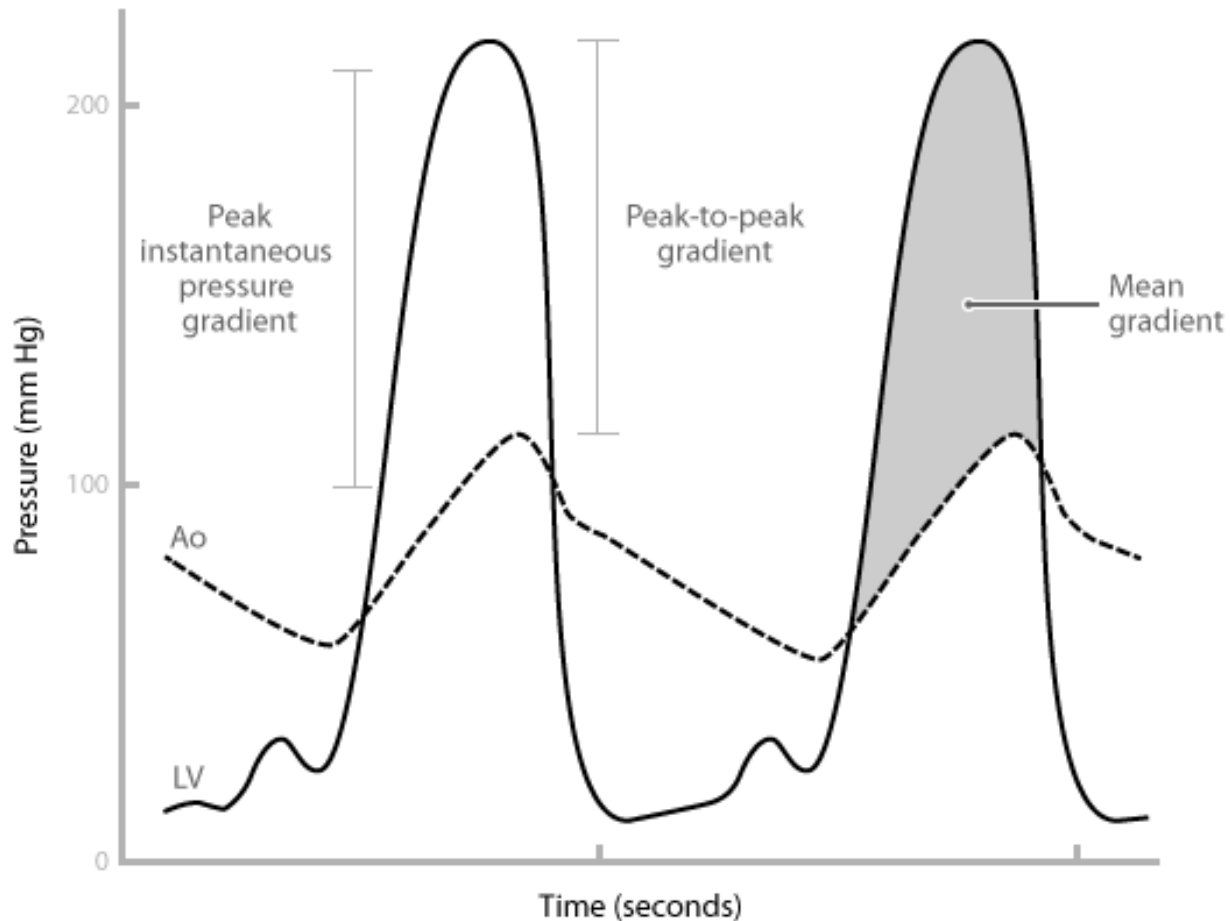
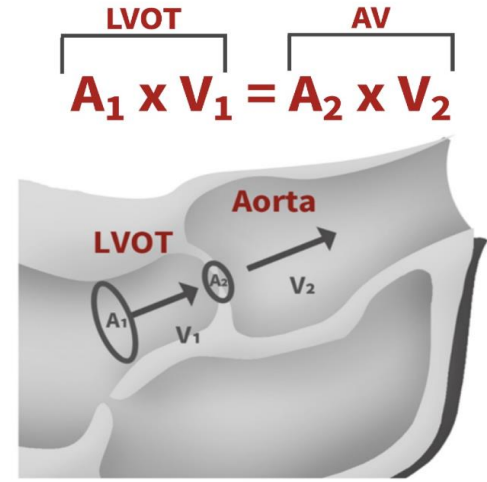
LVOT VTI

Peak AV VTI



AV Mean Gradient

- From AV-VTI, the mean gradient is calculated



Simplified Bernoulli equation

$$\Delta P = 4V_2^2$$

ΔP - Pressure gradient

Severe AS = $\Delta P > 75$ mmHg

Official Echo:

EF 8 %

Aortic Valve Area: 0.8 cm²

LVOT diameter: 4 cm²

LVOT Vmax 0.92 m/s & LVOT VTI 15.6 cm

Aortic Vmax 3.9 m/s & Aortic VTI 75.0 cm

Peak velocity 3.9 m/s

Mean Aortic Gradient: 39 mmHg

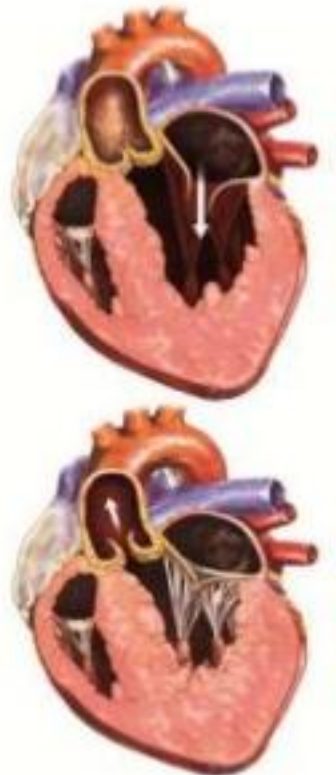
Peak Aortic Gradient: 62 mmHg

Est PA Syst Pressure: 55 mmHg

IVC is normal in size (1.5-2.5 cm) but without respiratory variability

Underestimation of AS severity

- Low-flow, low-gradient (LF-LG) severe AS with **reduced EF** (<40%)
- Low-flow, low-gradient (LF-LG) severe AS with **preserved EF** from restrictive physiology (concentric remodeling, small LV size & reductions in LV compliance and filling)



How to diagnosis & treat low-flow low-gradient (LF-LG) severe AS with reduced LVEF?

- True severe AS vs. **pseudo-severe AS**
- Distinction is essential as true severe AS requires **aortic valve replacement**
- **Dobutamine stress** echo distinguishes true vs. pseudo-severe AS

Dobutamine Stress Echo

- Pseudo-severe AS:

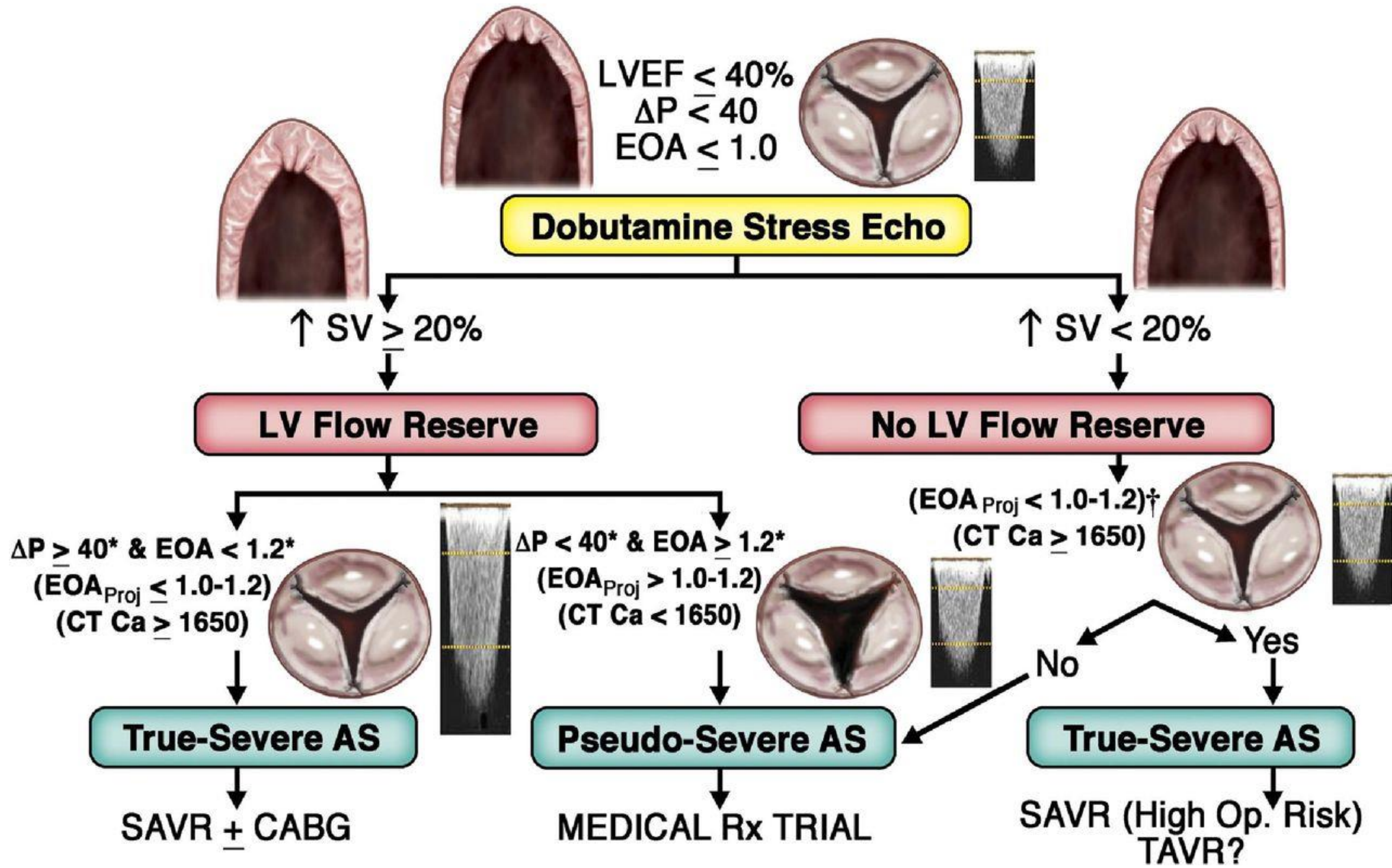
- \uparrow EF \rightarrow \uparrow flow with little \uparrow in gradient with \uparrow AVA

- It is defined as AVA (>1 cm₂) at a flow rate of 250 ml/s

- True severe AS:

- \uparrow EF \rightarrow \uparrow flow with \uparrow in gradient without \uparrow AVA

- 15% of patients with no LV flow reserve have **insufficient flow** (<250 ml/s) to allow accurate AVA measurements.
- **Valve calcification** quantification ($CT_{CA} > 1,650$ AU) distinguishes true severe from pseudo-severe AS.



Citations

- Low-Flow, Low-Gradient Aortic Stenosis With Normal and Depressed Left Ventricular Ejection Fraction Philippe Pibarot, Jean G. Dumesnil Journal of the American College of Cardiology Nov 2012, 60 (19) 1845-1853; DOI: 10.1016/j.jacc.2012.06.051