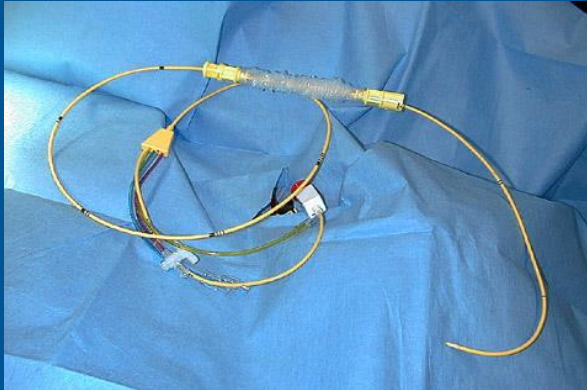


Echo Doppler Assessment of Right and Left Ventricular Hemodynamics

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Professor of Cardiology
Northwell Health-Lenox Hill Hospital
New York, NY

PA CATHETER



Unable to demonstrate:

- Chamber size & Wall Thickness
- Segmental or global wall motion
- Valvular anatomy
- Intracardiac masses
- Pericardial effusion

ECHOCARDIOGRAPHY

- Monitoring of chambers size, volume and motion
- Valve anatomy and pathology
- Intracardiac masses
- Pericardial abnormalities
- Blood flow, cardiac output and shunts
- Intracardiac pressures

The Simplified Bernoulli Equation

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

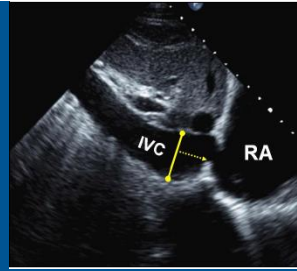


Liv Hatle

P = pressure (mm Hg)

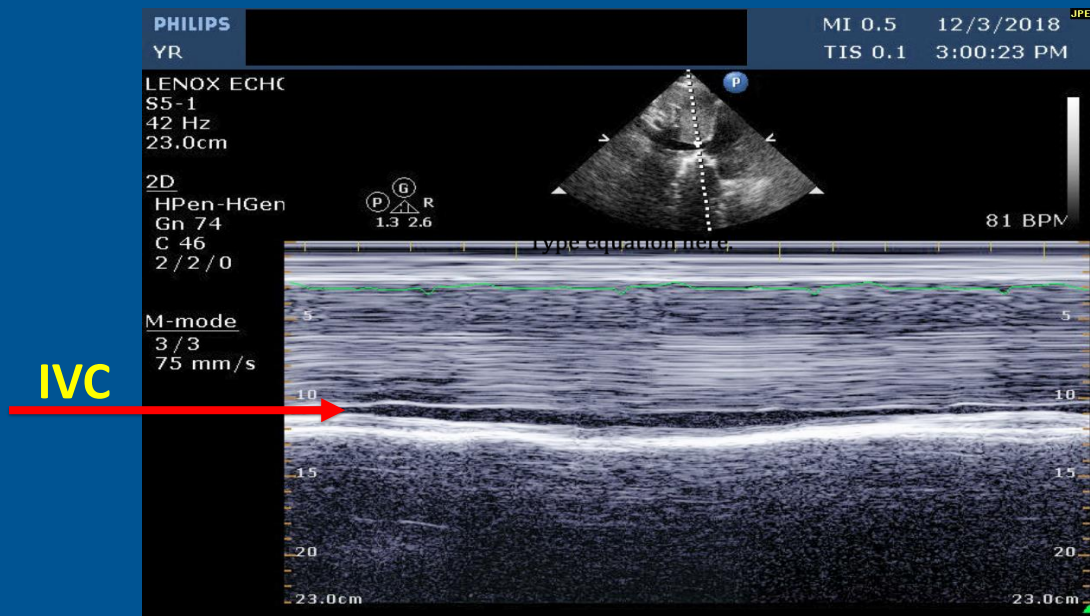
V = velocity (m / sec)

IVC Dimensions

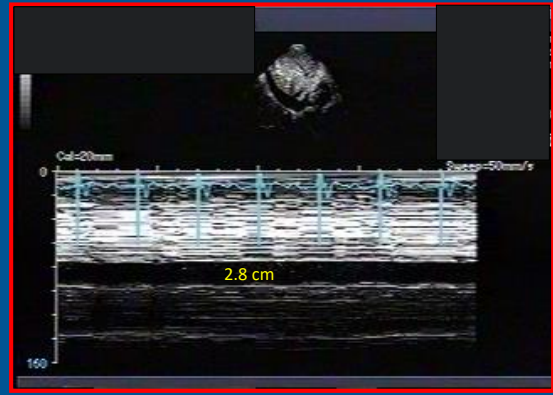
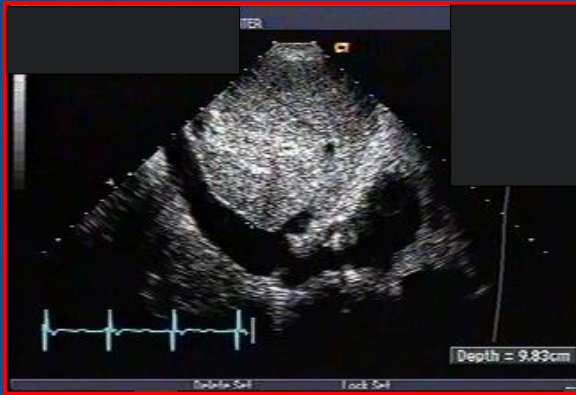


- IVC diameter ≤ 2.1 cm which collapses $>50\%$ with a sniff suggests RA pressure 0-5 mmHg
- IVC diameter > 2.1 cm which collapses $<50\%$ with a sniff suggests RA pressure 10-20 mmHg
- Scenarios where IVC diameter & collapse do not fit this paradigm, an intermediate value of 5-10 mmHg should be used.

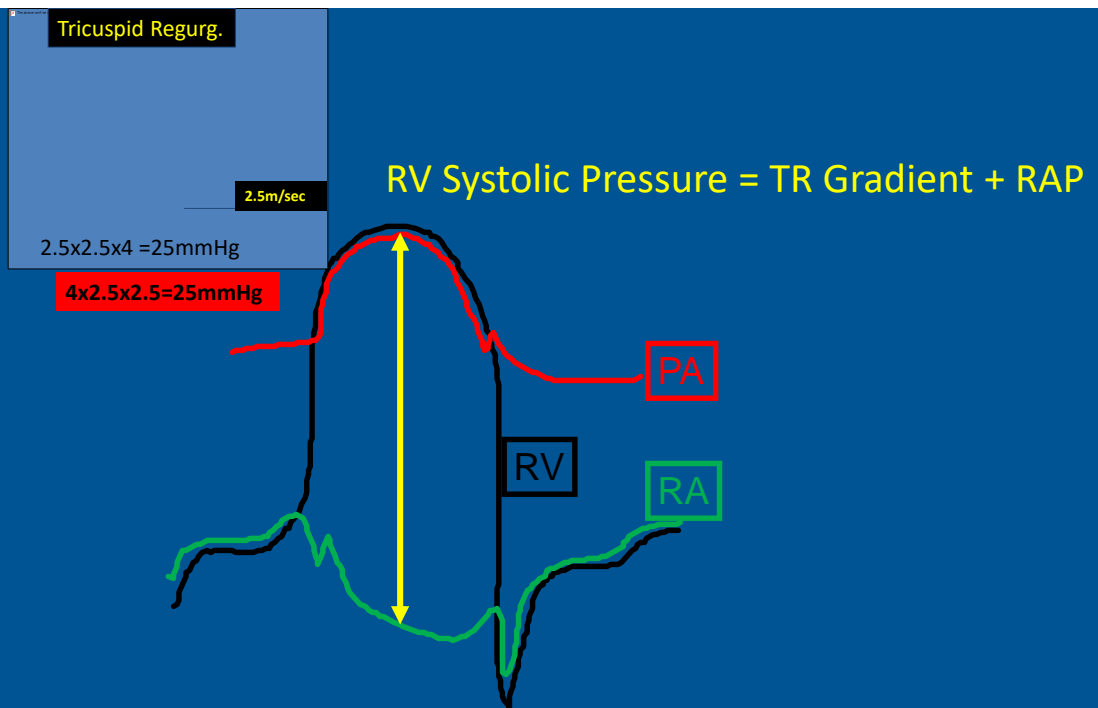
RA Pressure = 2 mmHg



Markedly elevated RA pressure (> 15 mm Hg)



- Note: 1. Dilated IVC
2. Lack of respiratory variation



Evaluation of RV Systolic Pressure

RV systolic pressure = TR gradient + RA pressure

Evaluation of RV Diastolic Pressure

In the absence of TS:

RV diastolic pressure = RA pressure

In the presence of TS:

RV diastolic pressure = RA pressure - TS gradient

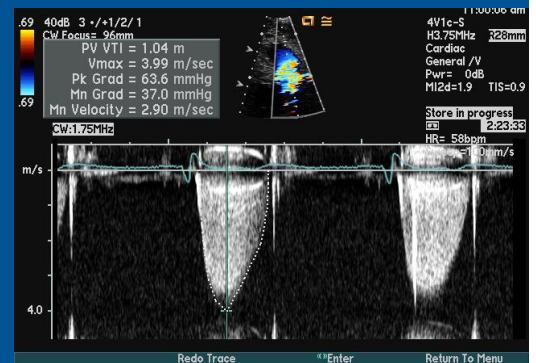
Evaluation of PA Systolic Pressure

In the absence of PS:

PA systolic pressure = RV systolic pressure
= TR gradient + RA pressure

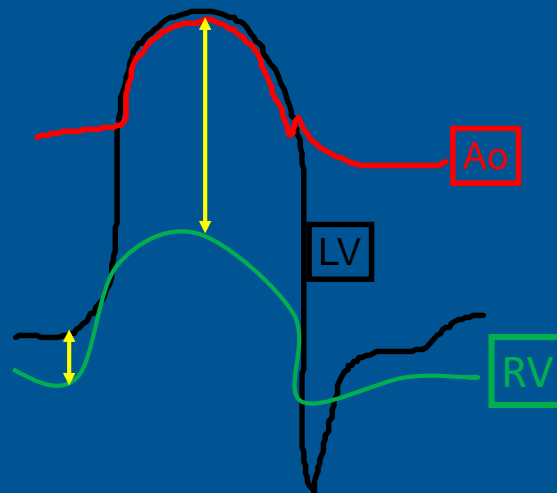
In the presence of PS:

PA systolic pressure = RV systolic pressure - PS gradient

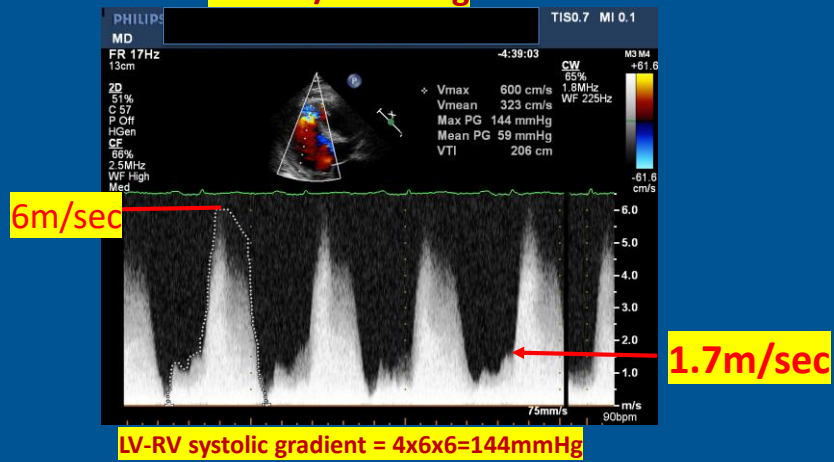


Pressure Gradients in VSD

An alternative (non-TR based) way of estimating RV systolic pressure



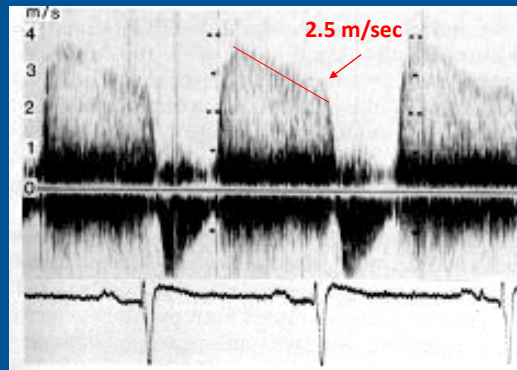
Post MI VSD
BP 175/70mmHg



$$\begin{aligned} \text{RV systolic pressure} &= \\ \text{Systolic BP} - \text{VSD gradient} &= 175 - 144 \\ &= 31 \text{ mmHg} \end{aligned}$$

Polling Question #1

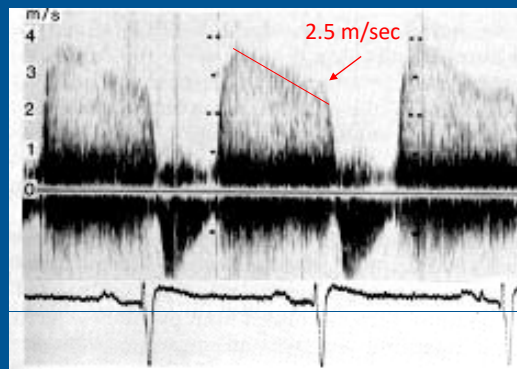
CW of Pulmonic Valve Flow



The study suggests:

1. Severe PS
2. Right heart failure
3. Pulmonary hypertension
4. Constrictive Pericarditis

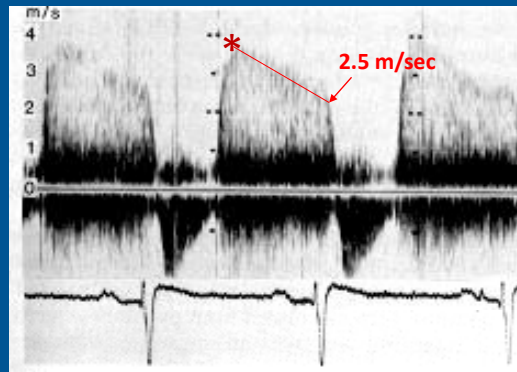
CW of Pulmonic Valve Flow



The study suggests:

1. Severe PS
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CW of Pulmonic Valve Flow

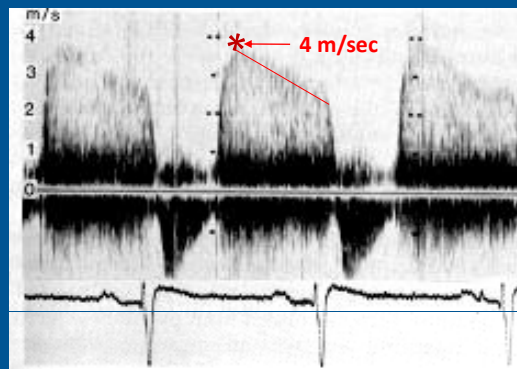


Pulmonary hypertension

Note the end-diastolic velocity of 2.5 m/sec, indicating an end diastolic gradient of 25 mmHg between the PA and RV

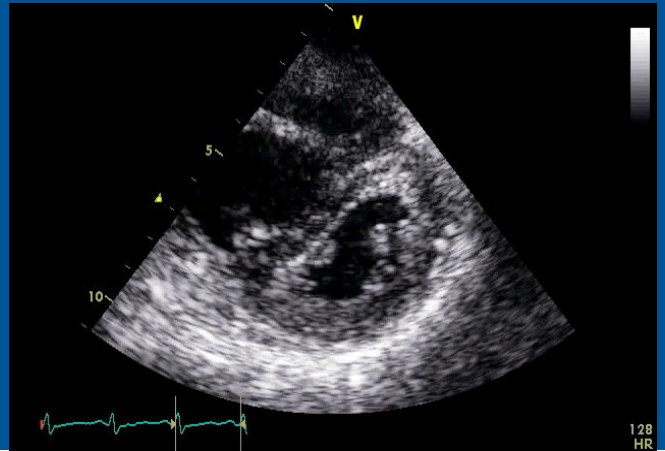
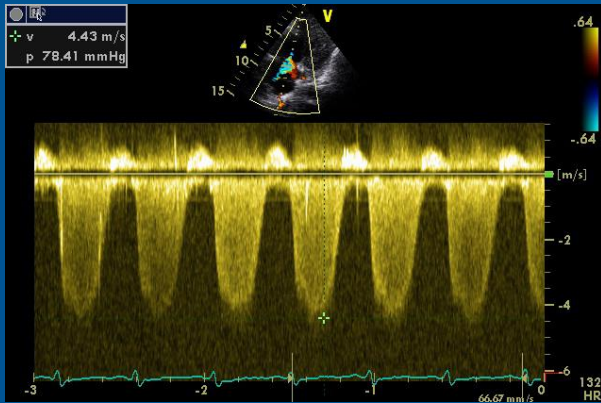
- Mean PA pressure: $4V^2$ (Max PR Velocity)*

CW of Pulmonic Valve Flow



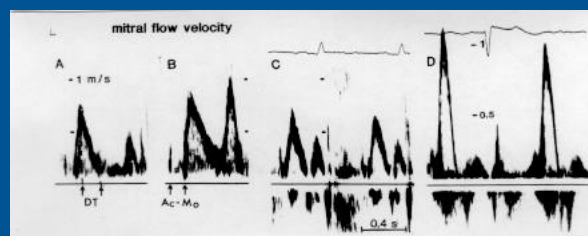
- Mean PA pressure= $4 \times 4^2 + \text{RAP}$

2D in PHT - D shaped LV

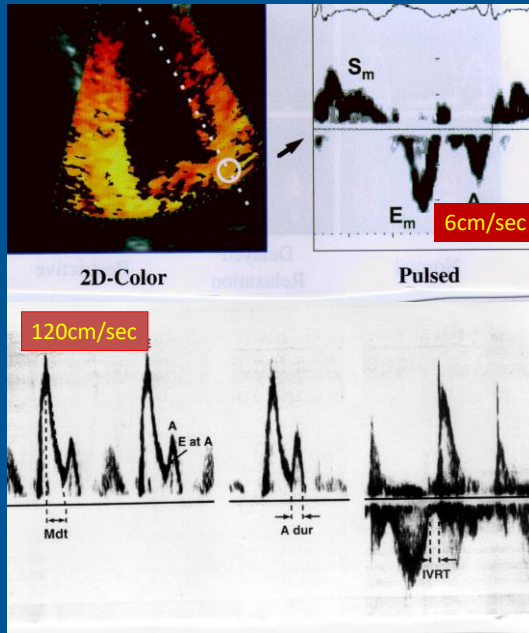


Evaluation of LA Pressure from Transmitral and PV flow

- A. Normal 6 - 12 mm Hg
- B. Abnormal Relax. 8 - 14
- C. Pseudonormal 15 - 22
- D. Restrictive > 22



Calculation of LA pressure



$$LAP = 1.24[(E/e') + 1.9]$$

Nagueh 1999

$$LAP = E/e' + 4$$

$$LAP = 120/6 + 4 = 24 \text{ mmHg}$$

$E/e' = 8$: LA pressure nl

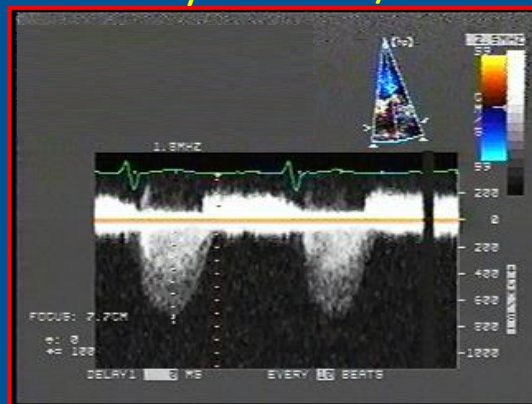
$E/e' = 15$: LA pressure high

Estimating LA Pressure By E/e' May Be Inaccurate In:

1. Mitral Stenosis
2. Mitral annular calcification
3. Prosthetic MV
4. Mitral regurgitation
5. Diffuse severe LV dysfunction

Polling Question #2

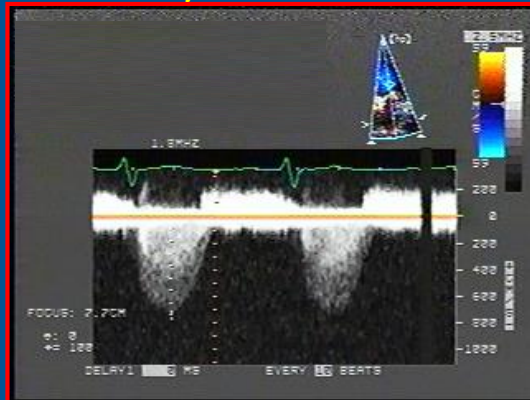
CW of MR Jet in a pt with a BP of 120 / 80
The MR velocity is 7.7 m / sec



The most likely DX is:

1. Aortic Stenosis
2. Aortic Insufficiency
3. High Cardiac Output
4. Pulmonary Embolism

CW of MR Jet in a pt with a BP of 120 / 80
The MR velocity is 7.7 m / sec



The most likely DX is:

1. **Aortic Stenosis**
2. Aortic Insufficiency
3. High Cardiac Output
4. Pulmonary Embolism

CW of MR Jet in a pt with a BP of 120 / 80

Always record the BP!

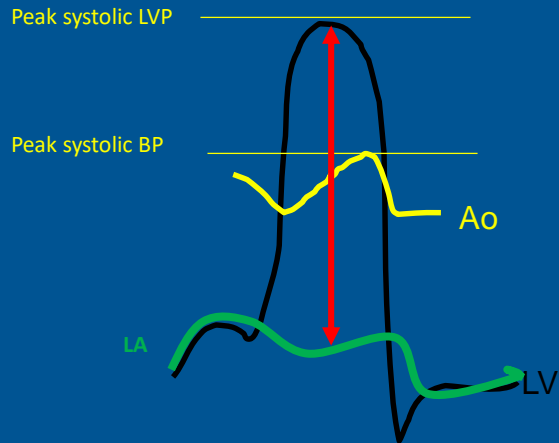
$$4 \times 7.7 \times 7.7 = 237 \text{ mmHg}$$



Aortic Stenosis

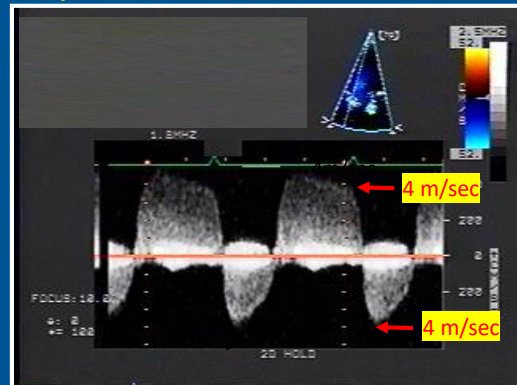
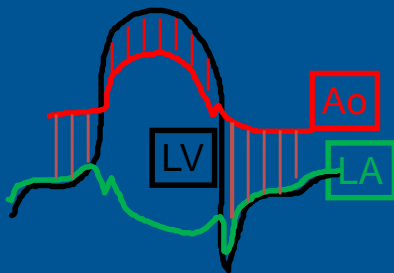
The velocity of the MR jet indicates
a peak systolic LV-LA gradient of 237 mm Hg;
Therefore the Aortic gradient is at least 120 mm Hg.

MR Velocity in AS



CW of Aortic Valve Flow

The BP is 150 / 80

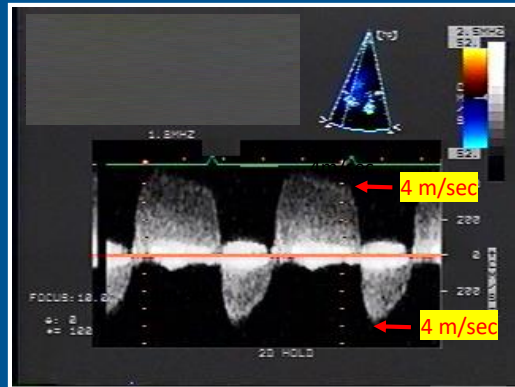
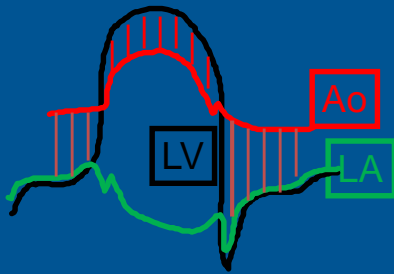


The LV pressure is:

1. 84 / 16
2. 214 / 44
3. 214/16
4. 195/16

CW of Aortic Valve Flow

The BP is 150 / 80

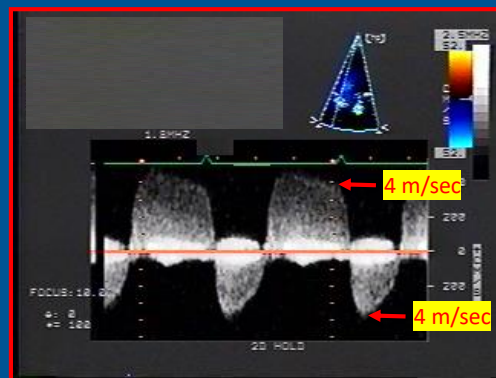
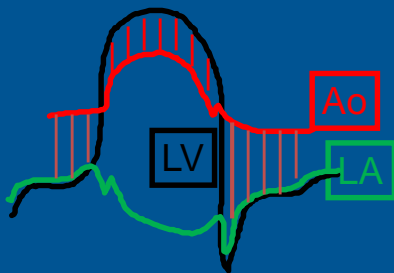


The LV pressure is:

1. 84 / 16
2. 214 / 44
3. 214/16
4. **195/16**

CW of Aortic Valve Flow

The BP is 150 / 80



ANSWER:

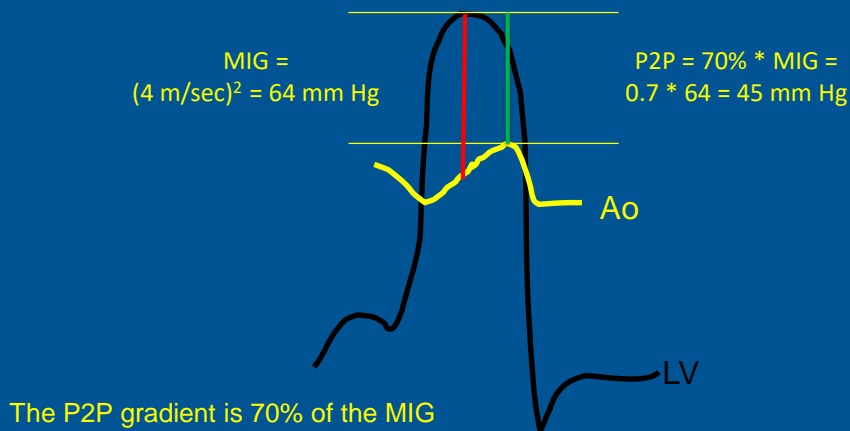
4. **195/16**

LV (sys) = Sys. BP (150) + 70%Ao gradient (45) = 195

LV (dias) = Dias. BP (80) - Ao dias. Gradient (64) = 16

Aortic Valve Gradient

1. Peak - to - Peak Gradient (P2P)
2. Maximum Instantaneous Gradient (MIG)
3. Mean Gradient



Evaluation of LV Systolic Pressure

In pts without aortic valve disease:
 LV systolic pressure = systolic BP

In pts with AS or LVOT obstruction:
 LV systolic pressure = systolic BP + gradient

Evaluation of LV Diastolic Pressure

In pts with AR:

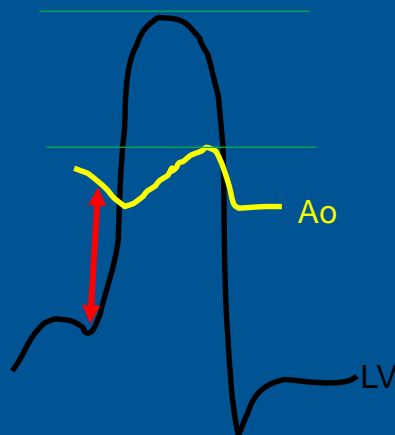
LV end-diastolic pressure = diastolic BP - AR gradient

In the absence of MS:

LVDP = (approx.) LA pressure

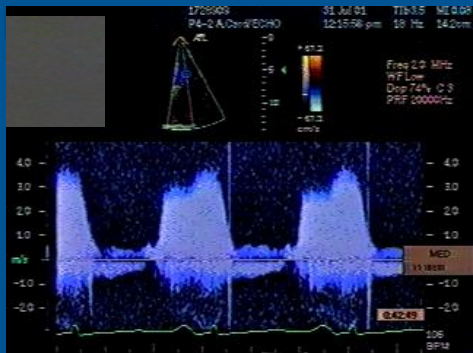
Calculation of LVEDP

Systemic diastolic BP - End Diastolic Aortic Gradient

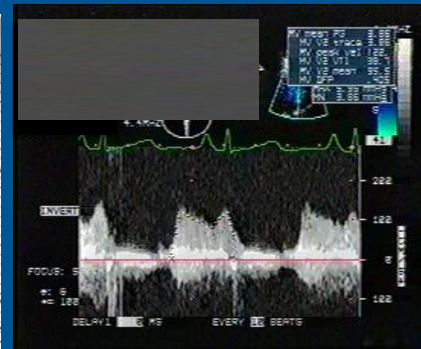
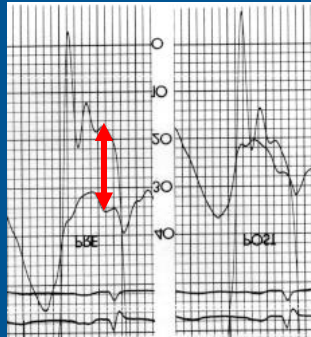


Evaluation of LA Pressure in pt with MS

In MS, LA diastolic pressure = LVDP + Transmitral gradient



Mean MV gradient 16mmHg



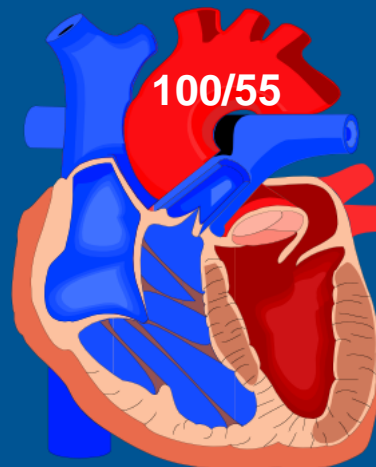
Mean MV gradient 4mmHg

Noninvasive Hemodynamic Study 63-Year-Old female with Dyspnea

BP 100/55

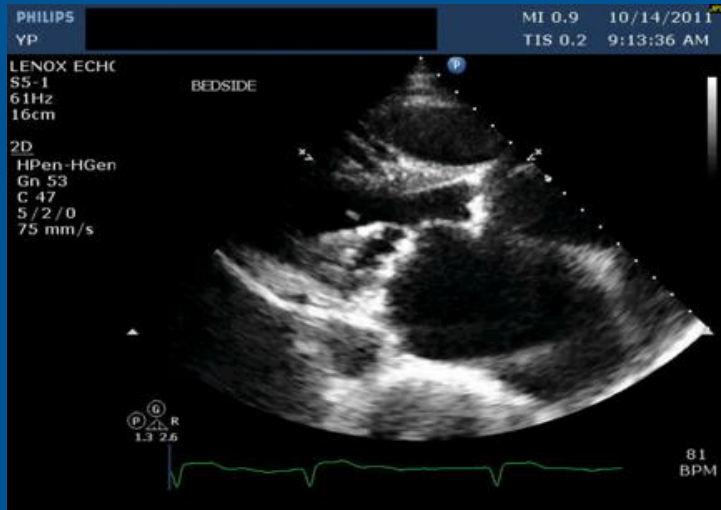
Bibasilar rales

MS, AS, MR, TR murmurs

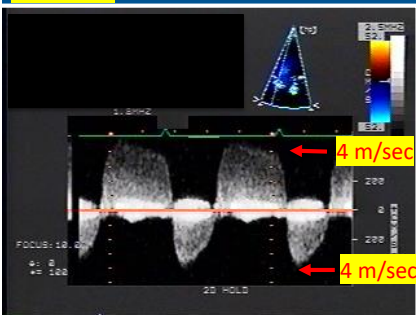


CP1007295-1

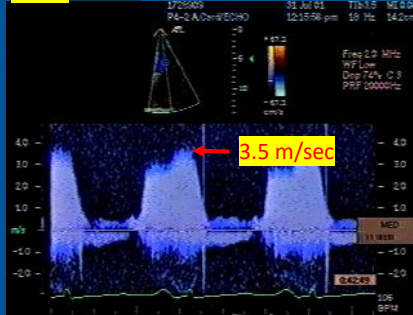
MS + AS



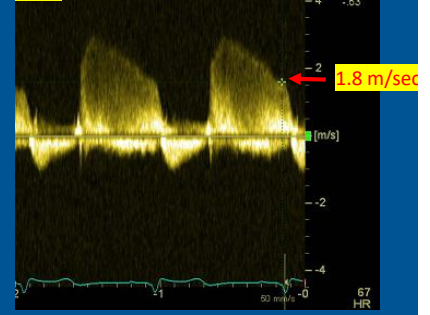
AS, AI



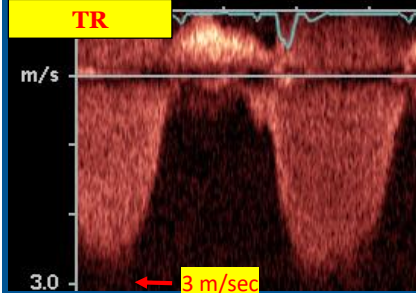
MS



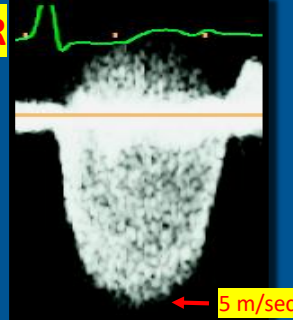
PR



TR

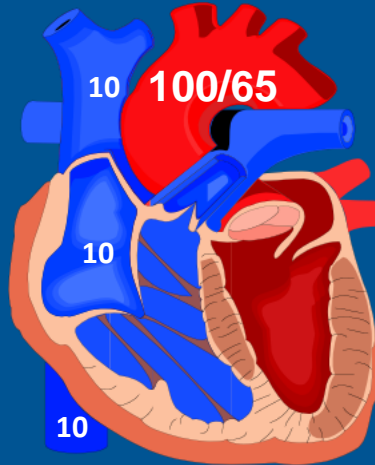
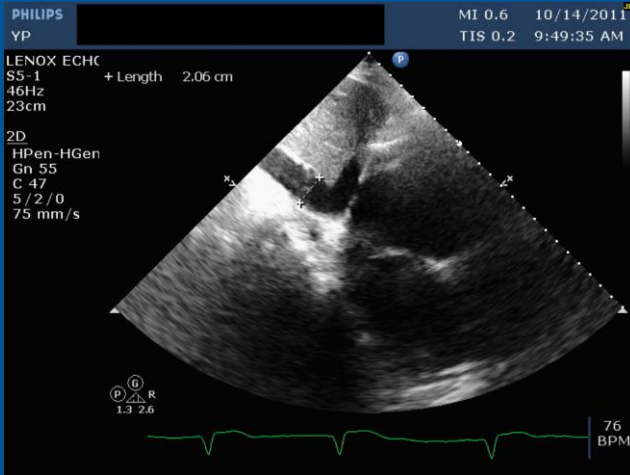


MR



CW Doppler

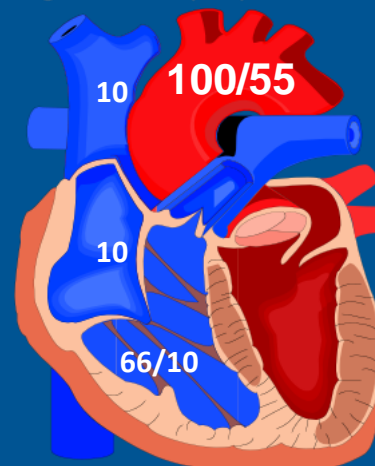
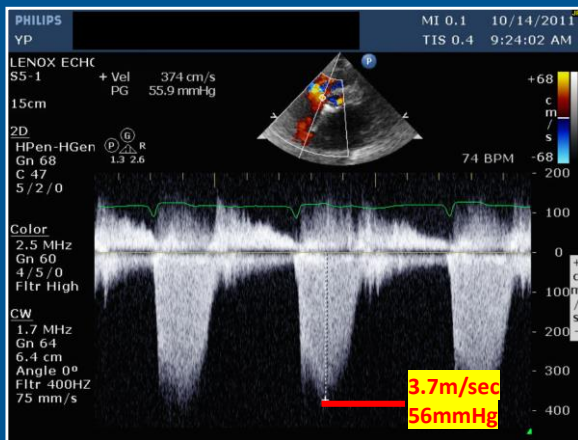
Normal IVC Size 2.0 cm <50% Respiratory Variation



CP1007295-4

RV Pressures

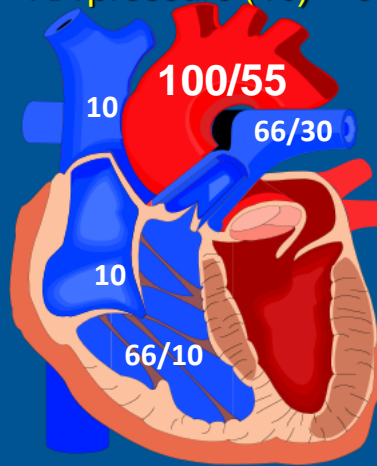
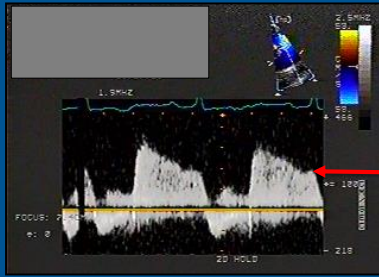
RV systolic = RA pressure (10) + TR gradient (56) = 66 mmHg



In the absence of TS
RV diastolic pressure = RA pressure

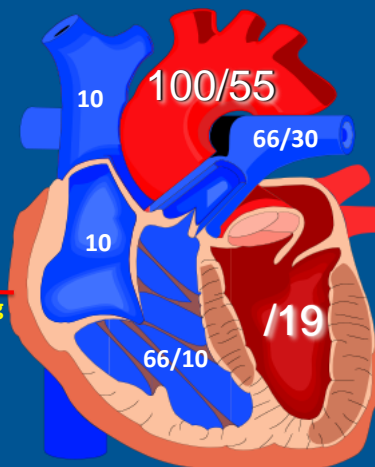
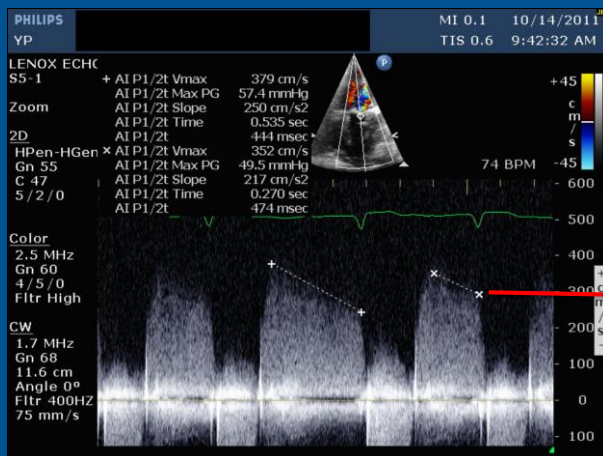
PA Pressure

Systolic = RV systolic (66)
 Diastolic = PR gradient (20) + RA pressure (10) = 30



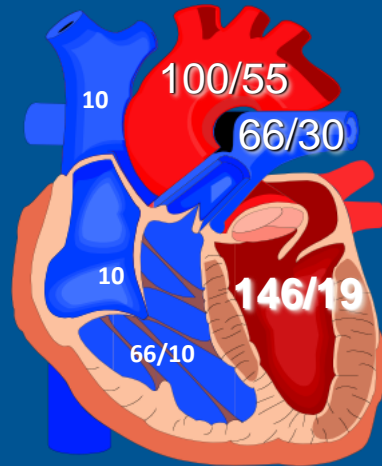
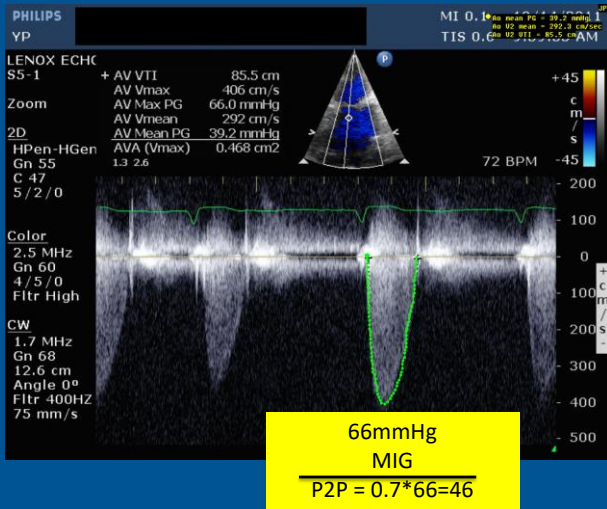
CP1007295-6

LVEDP = aortic diastolic pressure (55) –
 AR gradient (36) = 19mmHg

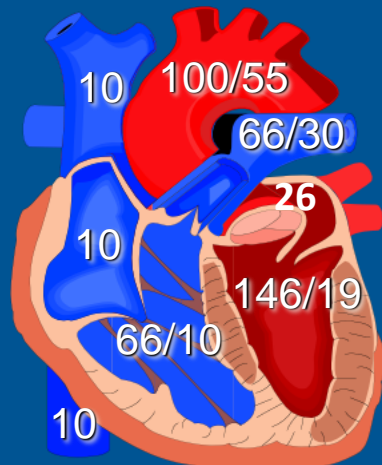
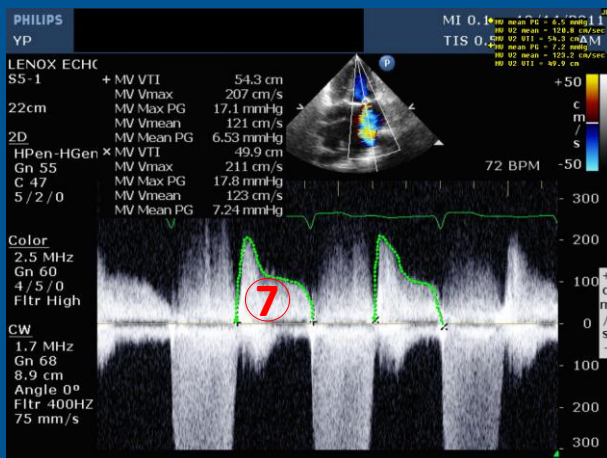


CP1007295-7

LV systolic pressure = aortic systolic pressure (100) + 70% of AV gradient (46) = 146mmHg

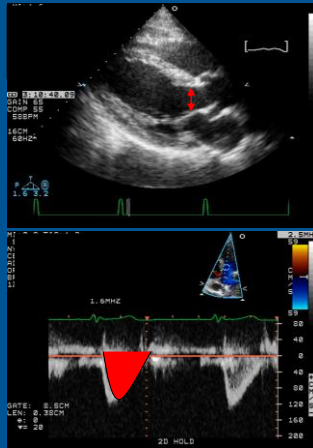


LA pressure = LV diastolic (19) + MV mean gradient (7) = 26mmHg



Calculation of Systemic Blood Flow (SBF)

$$SBF = VTI_{LVOT} \times Area_{LVOT} \times HR$$



D = 2 cm (r=1cm)

VTI = 24 cm

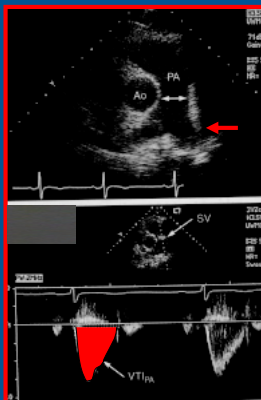
HR = 80

SBF= 6,000 cc

1 x 1 x 3.14 x 24 x 80

Calculation of Pulmonary Blood Flow (PBF)

$$PBF = VTI_{RVOT} \times Area_{RVOT} \times HR$$



Can also be calculated using RV inflow and TV VTI

Calculation of Shunts (ASD, VSD)

If No Shunt Exists, Pulmonary Blood Flow = Systemic Blood Flow

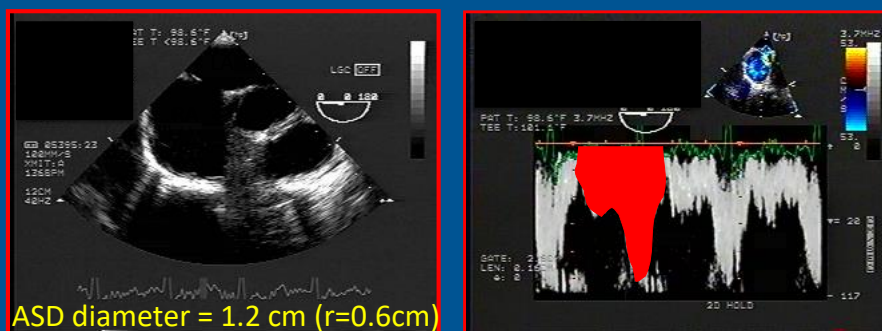
Shunt flow =

1. Pulmonary blood flow - systemic blood flow

- or -

2. ASD or VSD orifice area x Shunt VTI x HR

Calculation of ASD L-to-R Shunt



Shunt Flow = Orifice Area x VTI of shunt x HR
 $= 0.6 \times 0.6 \times 3.14 \times 80 \times 100 = 9\text{L/min.}$

Real time, 3D TEE: Secundum ASD



Conclusions

Normal and abnormal hemodynamics can be evaluated non invasively by Doppler Echocardiography.

Invasive evaluation may be needed for details not seen on Echo, or when the clinical impression is not consistent with the echo-Doppler findings