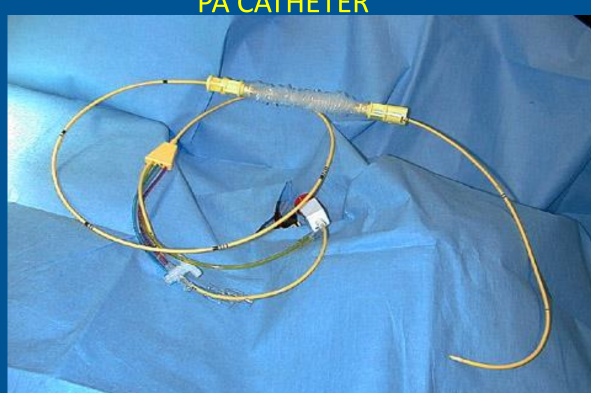
Echo Doppler Assessment of Right and Left Ventricular Hemodynamics

Itzhak Kronzon, MD, FASE
Lenox Hill Hospital
New York, NY

PA CATHETER



Unable to demonstrate:
- **Chamber size & Wall Thickness**
- **Segmental or global wall motion**
- **Valvular anatomy**
- **Intracardiac masses**
- **Pericadial 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

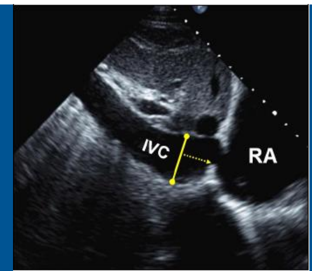
$$\Delta P = 4V^2$$

P = pressure (mm Hg)
V = velocity (m / sec)

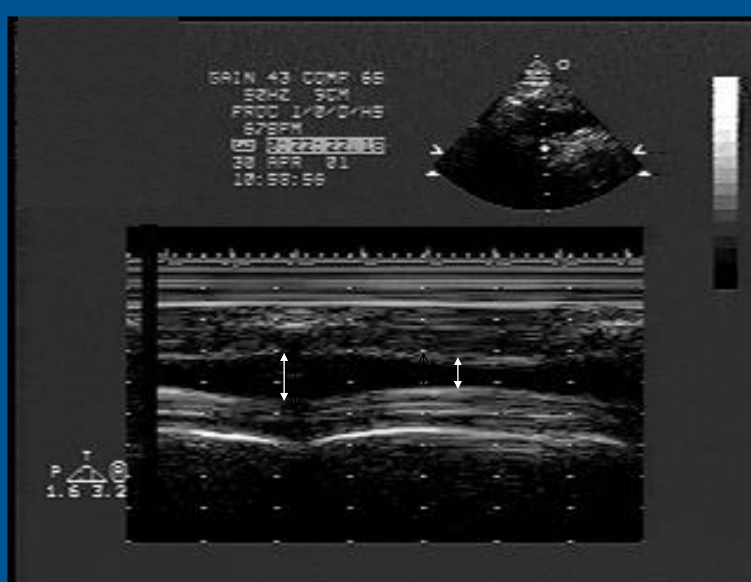
Liv Hatle

RA pressure

IVC Dimensions

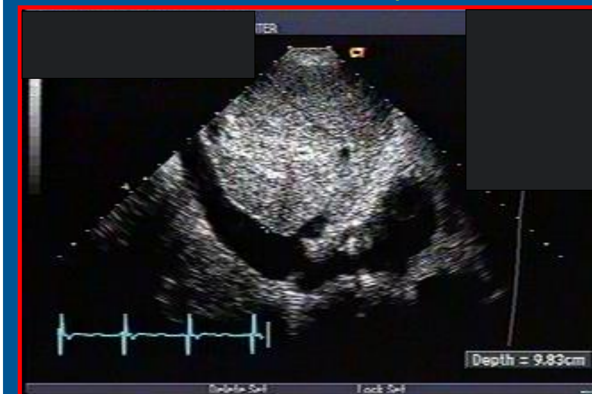


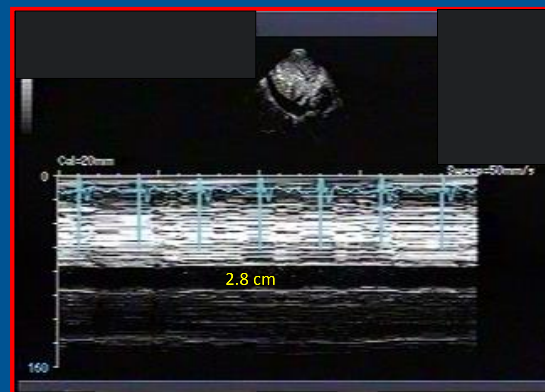
- IVC diameter ≤ 2.1 cm which collapses >50% with a sniff suggests RA pressure 0-5 mmHg
- IVC diameter > 2.1 cm which collapses <50% with a sniff suggests RA pressure 10-20 mmHg
- Scenarios where IVC diameter & collapse do not fit this paradigm, an intermediate value of 5-10 mmHg should be used.



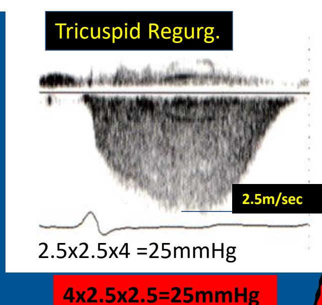
RA Pressure = 5 mmHg

Markedly elevated RA pressure (> 15 mm Hg)

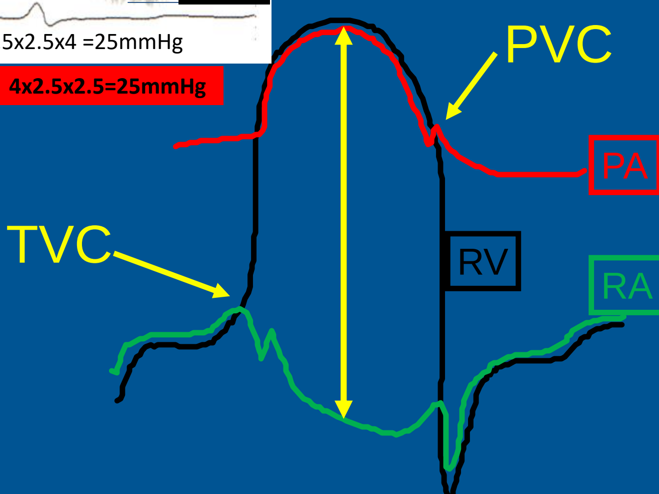




Note: 1. Dilated IVC
2. Lack of respiratory variation



RV Systolic Pressure = TR Gradient + RAP



Evaluation of RV Systolic Pressure

RV systolic pressure = TR gradient + RA pressure

Evaluation of RV Diastolic Pressure

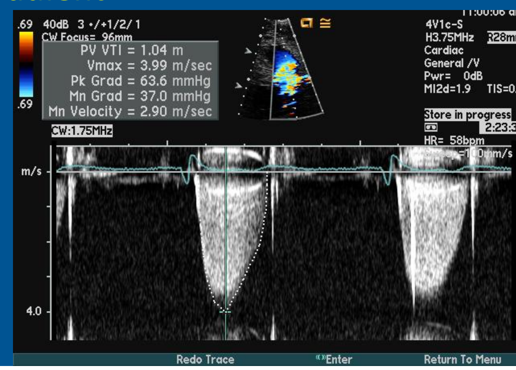
In the absence of TS:
RV diastolic pressure = RA pressure

In the presence of TS:
RV diastolic pressure = RA pressure - TS gradient

Evaluation of PA Systolic Pressure

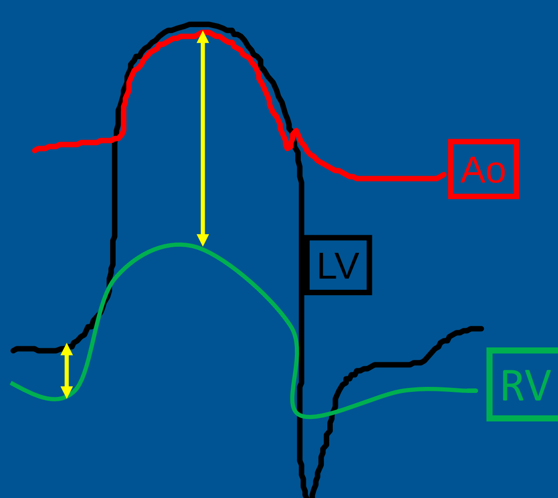
In the absence of PS:
PA systolic pressure = RV systolic pressure
= TR gradient + RA pressure

In the presence of PS:
PA systolic pressure = RV systolic pressure - PS gradient

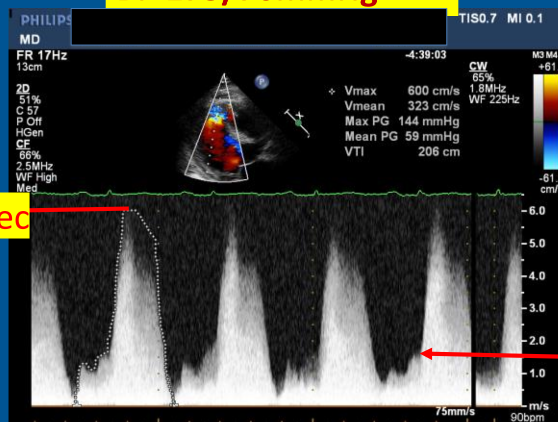


Pressure Gradients in VSD

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



Post MI VSD
BP 175/70mmHg

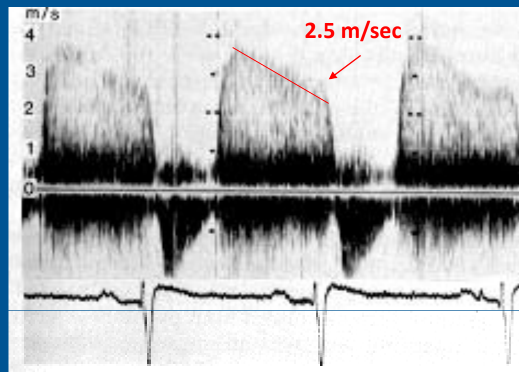


LV-RV systolic gradient = 4x6x6=144mmHg

RV systolic pressure =
Systolic BP - VSD gradient = 31 mmHg

Polling Question #1

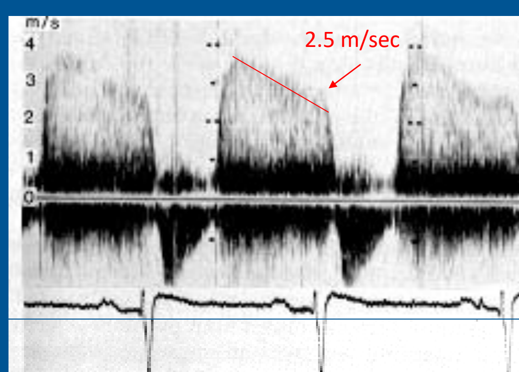
CW of Pulmonic Valve Flow



The study suggests:

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

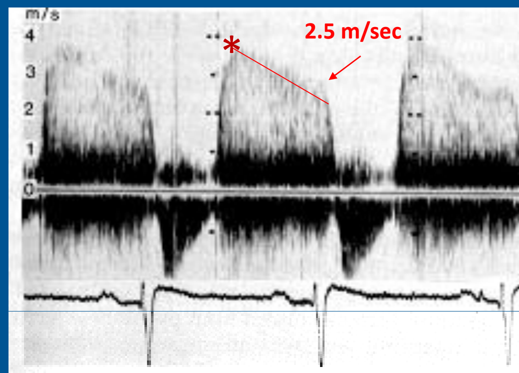
CW of Pulmonic Valve Flow



The study suggests:

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

CW of Pulmonic Valve Flow



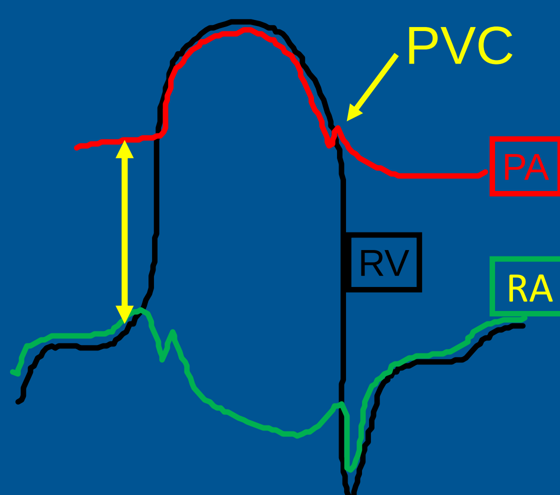
Pulmonary hypertension

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)*

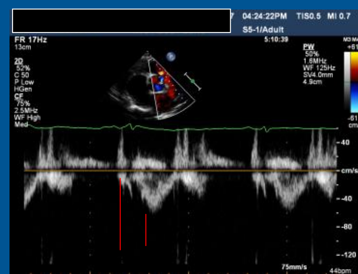
Evaluation of PA Diastolic Pressure

PA diastolic pressure = PR end diastolic gradient + RA(V) pressure



RVOT Acceleration time

No TR or PR?
RVOT outflow
Acceleration time (AcT)



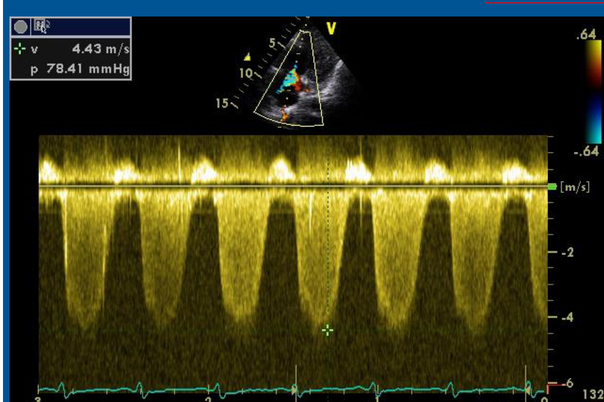
Mean PAP = 79 - (0.45 x AcT)

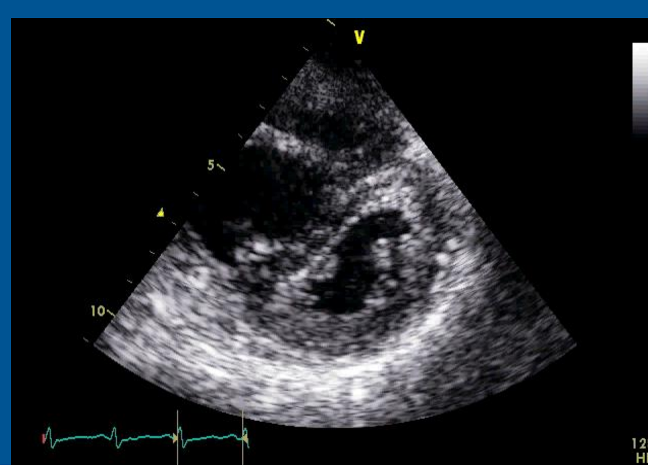
Normal AcT > 120msec

If AcT<90msec, peak PA systolic pressure is more than 60 mmHg

Mean PAP = 79 – (0.45 * 90) = 79 - 40 = 39 mmHg

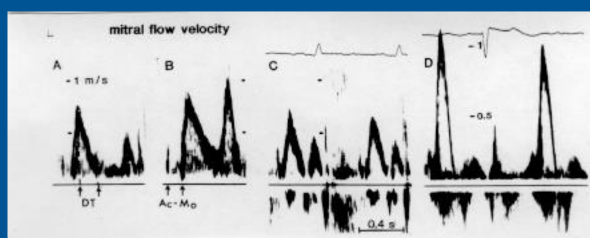
2D in PHT - D shaped LV



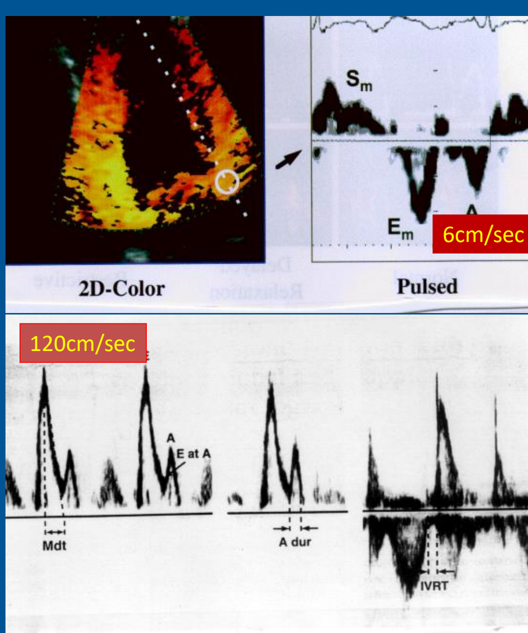


Evaluation of LA Pressure from Transmitral and PV flow

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 mmHg

E/e' = 8: LA pressure nl

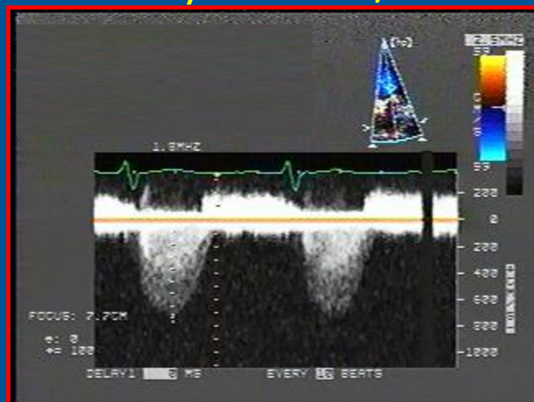
E/e' = 15: LA pressure high

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

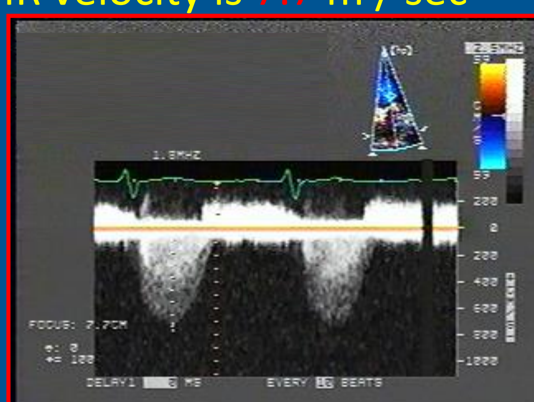
CW of MR Jet in a pt with a BP of 120 / 80
The MR velocity is 7.7 m / sec



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

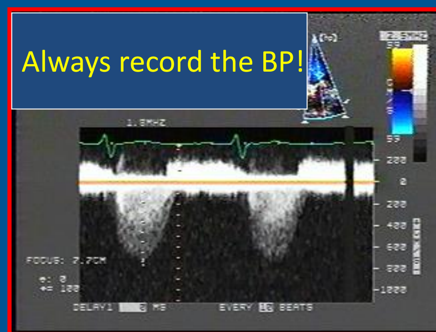


The most likely DX is:

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

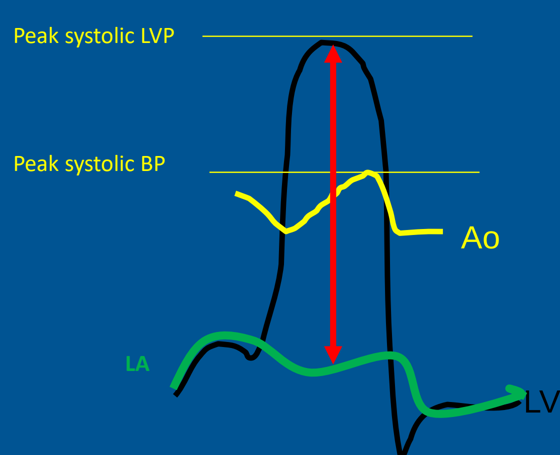
4x7.7x7.7=237mmHg



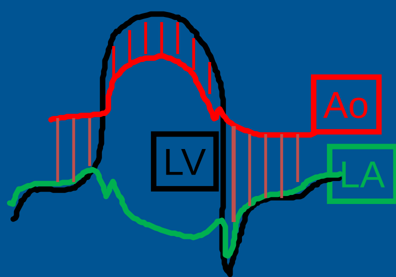
Aortic Stenosis

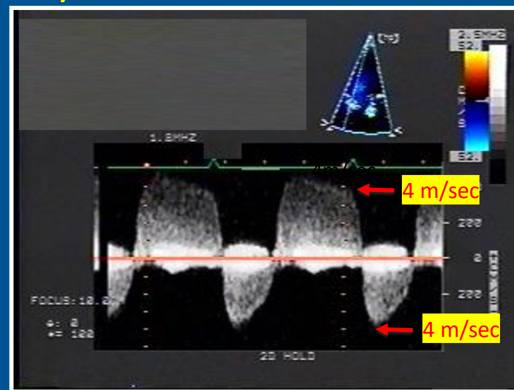
The velocity of the MR jet indicates
a peak systolic LV-LA gradient of 237 mm Hg;
Therefore the Aortic gradient is at least 120 mm Hg.

MR Velocity in AS



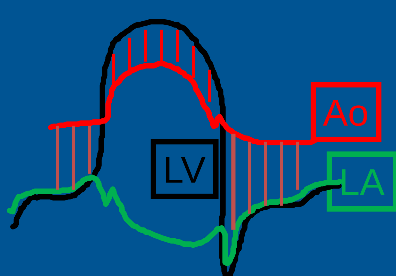
CW of Aortic Valve Flow
The BP is 150 / 80

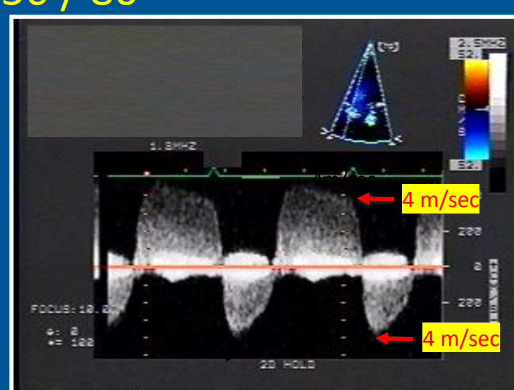




The LV pressure is:
1. 84 / 16
2. 214 / 44
3. 214/16
4. 195/16

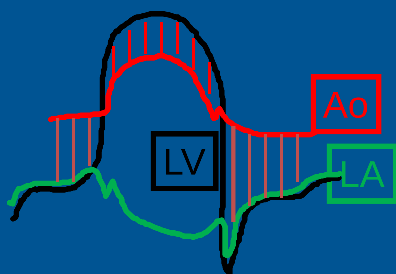
CW of Aortic Valve Flow
The BP is 150 / 80

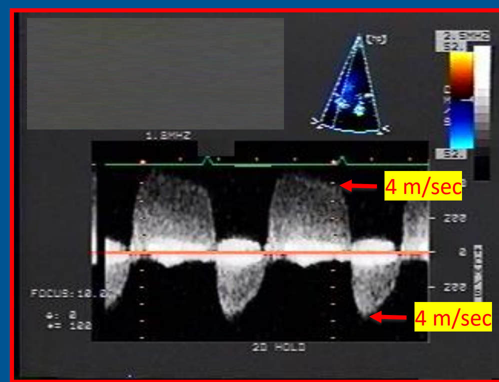




The LV pressure is:
1. 84 / 16
2. 214 / 44
3. 214/16
4. **195/16**

CW of Aortic Valve Flow
The BP is 150 / 80

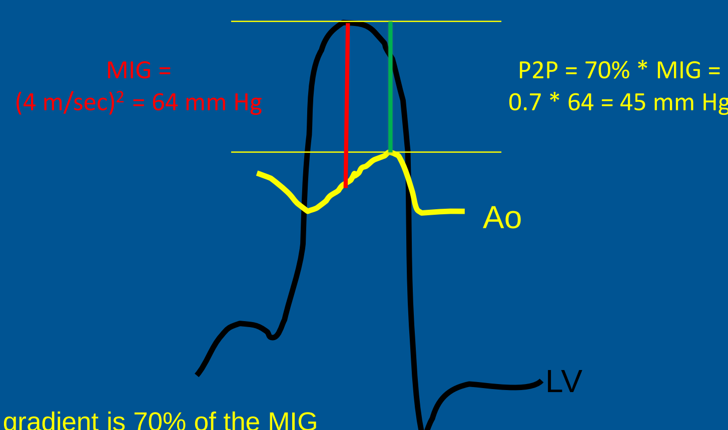




ANSWER:
4. 195/16
LV (sys)= Sys. BP (150) + 70%Ao gradient (45) = 195
LV (dias) = Dias. BP (80) - Ao dias. Gradient (64) = 16

Aortic Valve Gradient

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



The P2P gradient is 70% of the MIG

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

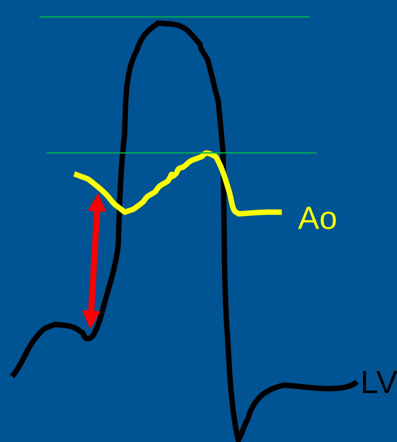
Evaluation of LV Diastolic Pressure

In pts with AR:
LV end-diastolic pressure = diastolic BP - AR gradient

In the absence of MS:
LVDP = (approx.) LA pressure

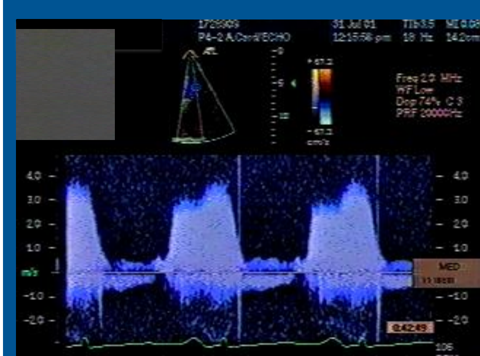
Calculation of LVEDP

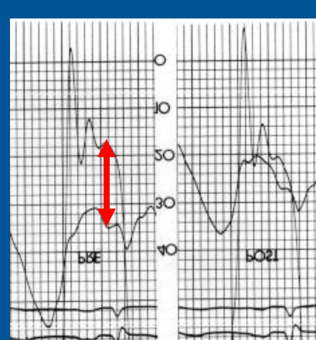
Systemic diastolic BP - End Diastolic Aortic Gradient

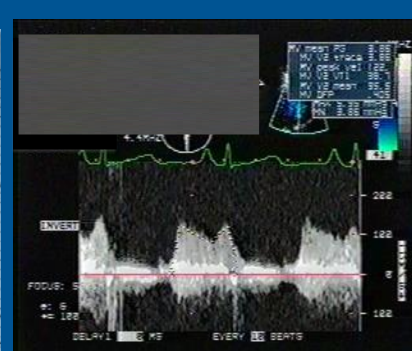


Evaluation of LA Pressure in pt with MS

In MS, LA diastolic pressure = LVDP + Transmitral gradient


Mean MV gradient 16mmHg



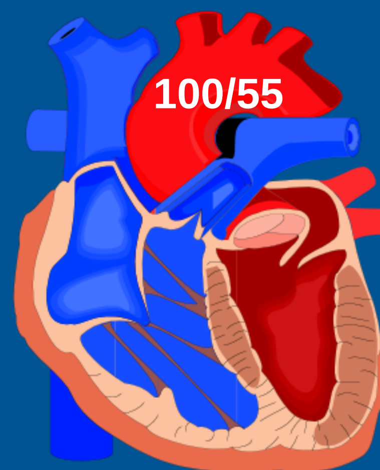

Mean MV gradient 4mmHg

Noninvasive Hemodynamic Study
63-Year-Old female with Dyspnea

BP 100/55

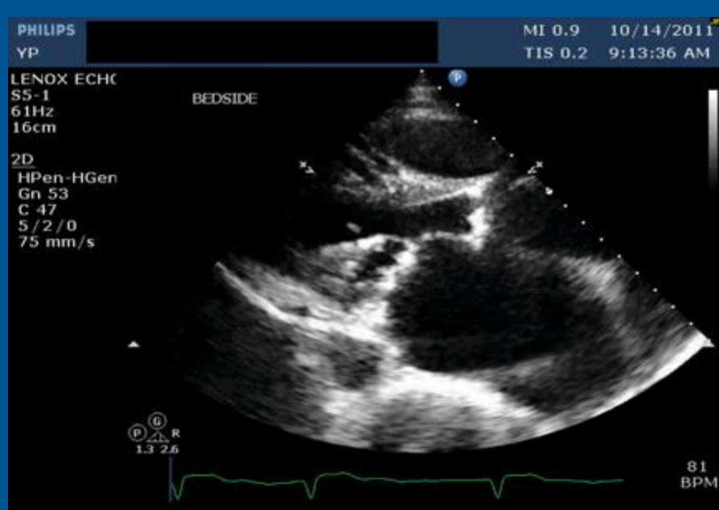
Bibasilar rales

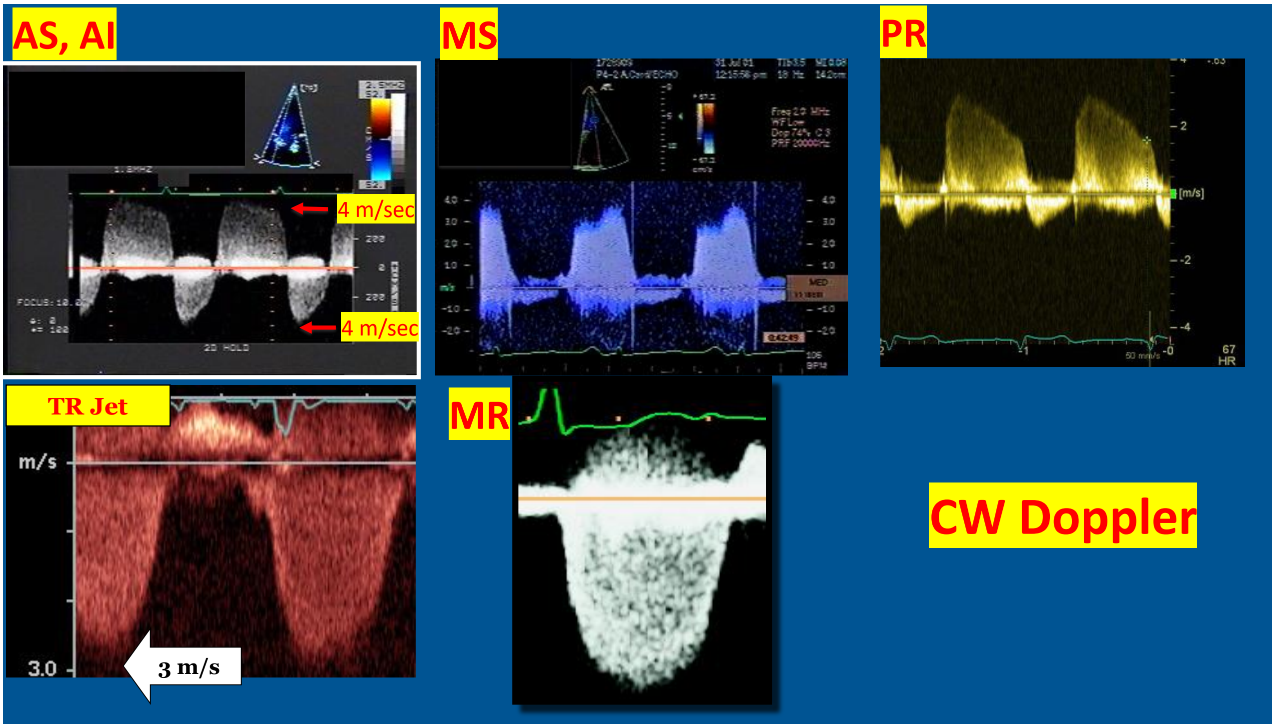
MS, AS, MR, TR murmurs



CP1007295-1

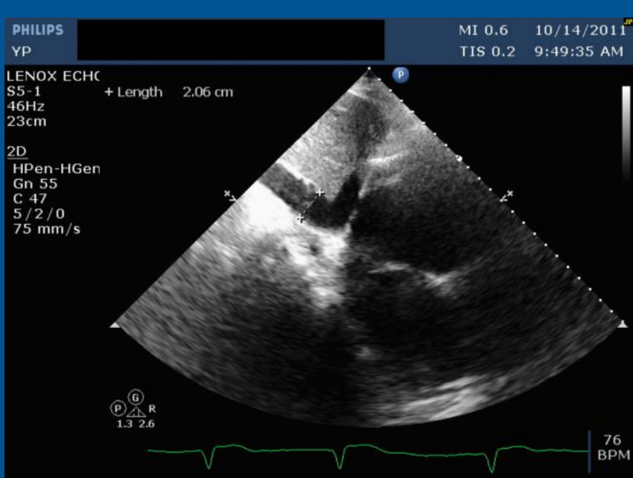
MS + AS

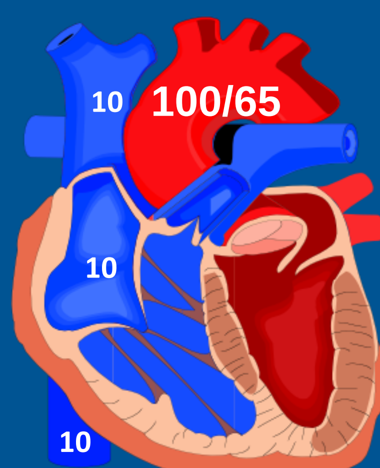




Normal IVC Size 2.0 cm

<50% Respiratory Variation

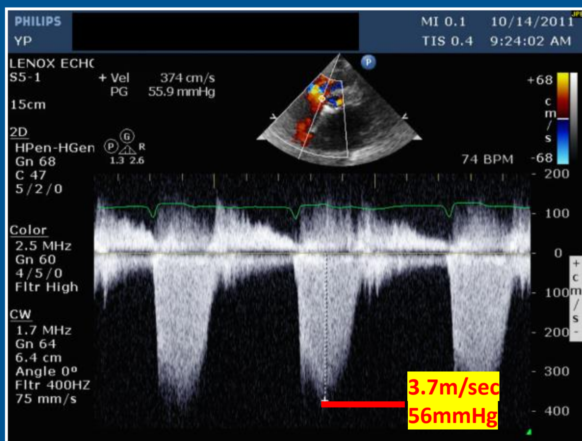


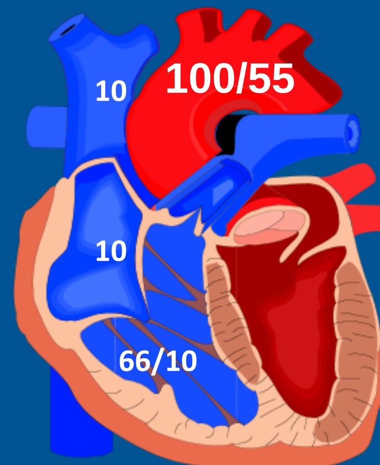


CP1007295-4

RV Pressures

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

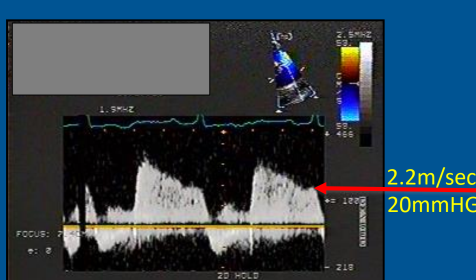


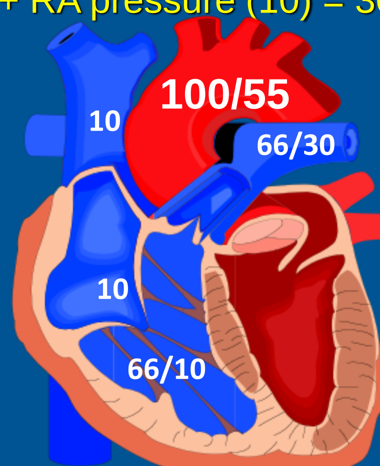


In the absence of TS
RV diastolic pressure = RA pressure

PA Pressure

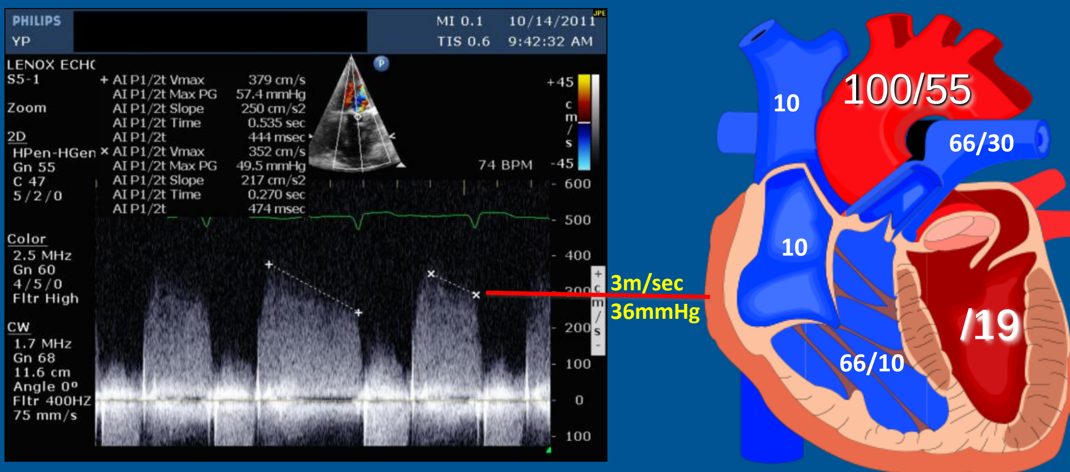
Systolic = RV systolic (66)
Diastolic = PR gradient (20) + RA pressure (10) = 30





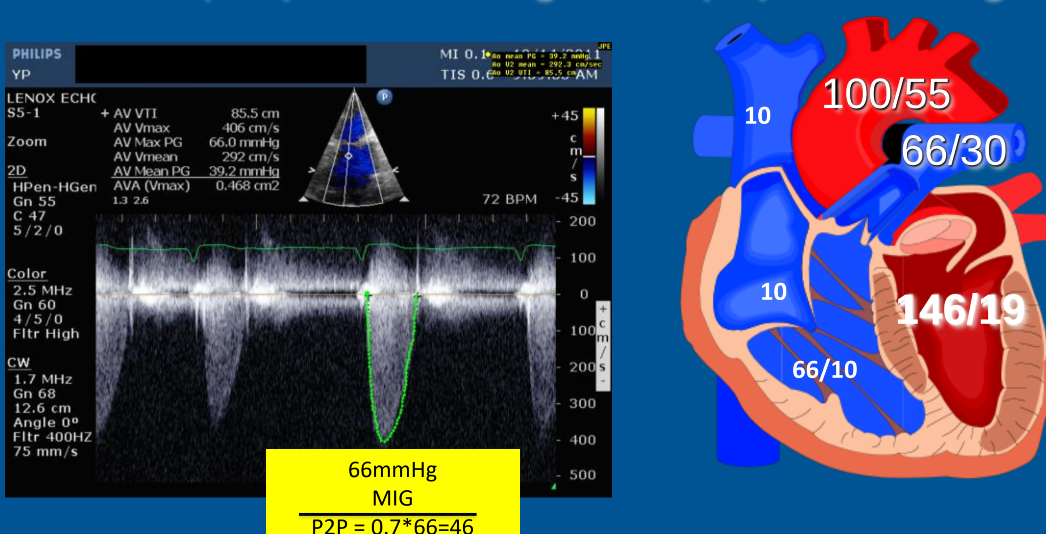
CP1007295-6

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

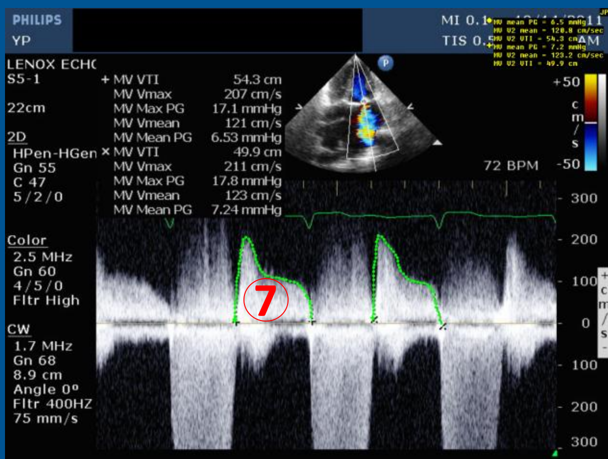


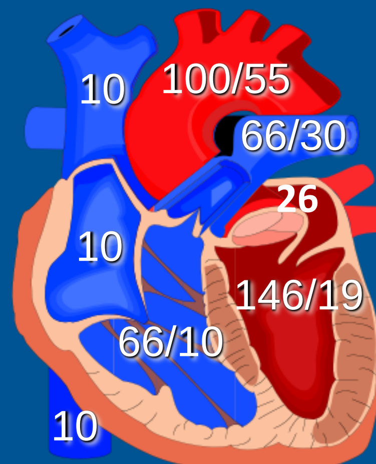
CP1007295-7

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



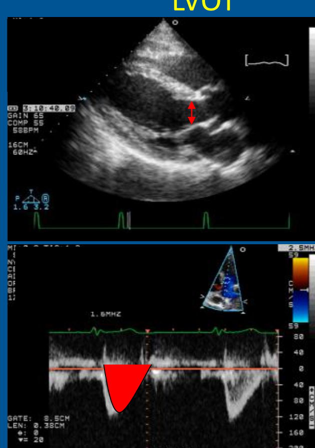
LA pressure = LV diastolic (19) + MV mean gradient (7) = 26mmHg





Calculation of Systemic Blood Flow

SBF = VTI_{LVOT} X $Area_{LVOT}$ X HR

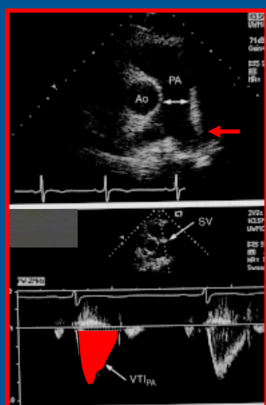


D = 2 cm
VTI = 24 cm
HR = 80

SBF= 6,000 cc
1 x 1 x 3.14 x 24 x 80

Calculation of Pulmonary Blood Flow

$C.O. = VTI_{RVOT} \times Area_{RVOT} \times HR$



Can also be calculated using RV inflow and TV VTI

Calculation of Shunts (ASD, VSD)

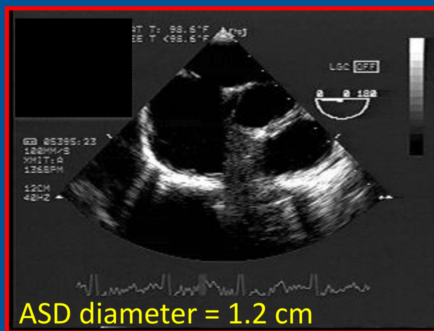
Shunt flow =

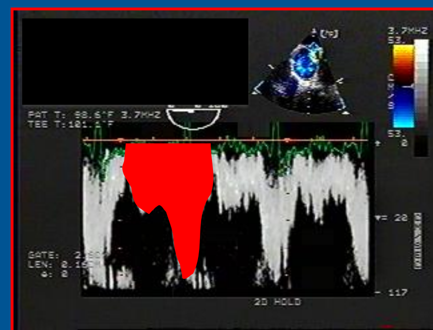
1. Pulmonary blood flow - systemic blood flow

- or -

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

Calculation of ASD L-to-R Shunt

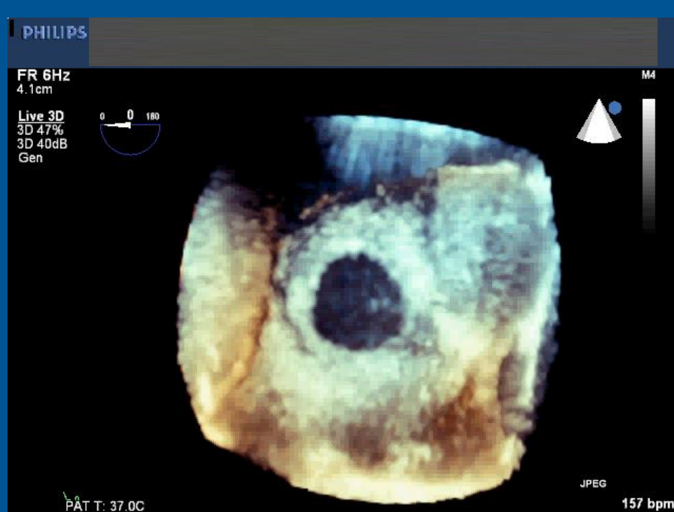




Shunt Flow = Orifice Area x VTI of shunt x HR

= 0.6 x 0.6 x 3.14 x 80 x 100 = 9L/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