Echo Doppler Assessment of Right and Left Ventricular Hemodynamics.

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The Simplified Bernoulli Equation

\[ \Delta P = 4V^2 \]

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 = 5 mmHg
Markedly elevated RA pressure (> 15 mm Hg)

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

RV Syst Pressure = TR Gradient + RAP

Tricuspid Regurg.

4x2.5x2.5=25mmHg
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
67 y.o. with acute MI and heart failure

Post MI VSD
BP 175/70mmHg

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

LV-RV systolic gradient = 4x6x6=144mmHg
The study suggests:
1. Severe PS
2. Right heart failure
3. Pulmonary hypertension
4. Constrictive Pericarditis

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 gradient + RA(V) pressure

Pulmonary Artery Mean Pressure

PA mean P = 0.6 x PASP + 1.95mmHg
Severe PHT

1. No A wave
2. Systolic “flying W”
3. No diastolic posterior motion

RVOT Acceleration time

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
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 = E/e' + 4

LAP = 120/6 + 4 = 24 mmHg

E/e’ = 8: LA pressure nl
E/e’ = 15: LA pressure high
Patient with small ASD after Mitral Valvuloplasty

Estimated RA pressure 10mmHg. What is the peak LAP?

A) 10mmHg  
B) 20mmHg  
C) 35mmHg  
D) 60mmHg

Calculation of LA pressure in a pt with ASD

\[ \text{LAP} = \text{RAP} + \text{ASD max gradient} \]

\[ \text{LAP} = 10 + 50 = 60 \text{mmHg} \]
Pulmonary Vascular Resistance

PVR = (mean PAP - mean PCWP)/C.O.

Another method

PVR = 10 (Peak TR Velocity/RVOT VTI + 0.16)

PVR = Wood’s units
TR Velocity = m/sec
RVOT TVI = cm

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
MR Velocity in AS

Peak systolic LVP

Peak systolic BP

Ao

LA

LV

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.

Always record the BP!

$4 \times 7.7 \times 7.7 = 237 \text{ mm Hg}$
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

Aortic Valve Gradient

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

\[
MIG = (4 \text{ m/sec})^2 = 64 \text{ mm Hg}
\]

\[
P2P = 70\% \times MIG = 0.7 \times 64 = 45 \text{ mm Hg}
\]

The P2P gradient is 70% of the MIG
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

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
Estimating LA Pressure by $E/e'$
May Be Inaccurate in:

- Mitral Stenosis
- Mitral annular calcification
- Prosthetic MV
- Mitral regurgitation
- Diffuse severe LV dysfunction

Evaluation of LA Pressure in pt with MS

In MS, LA diastolic pressure = $\text{LVDP} + \text{transmitral gradient}$

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

MMS + AS
MMR + AR

TR + PR
Normal IVC Size 2.0 cm
<50% Respiratory Variation

RV Pressures
RV systolic = RA pressure (10) + TR gradient (56) = 66 mm Hg

In the absence of TS
RV diastolic pressure = RA pressure
**PA Pressure**

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

LVEDP = aortic diastolic pressure (55) – AR gradient (36) = 19mmHg
LV systolic pressure = aortic systolic pressure (100) + 70% of AV gradient (46) = 146mmHg

PV = 0.7 * 66 = 46

LA pressure = LV diastolic (19) + MV mean gradient (7) = 26mmHg
Calculation of Systemic Blood Flow

$$\text{SBF} = \text{VTI}_{\text{LVOT}} \times \text{Area}_{\text{LVOT}} \times \text{HR}$$

- $D = 2 \text{ cm}$
- $\text{VTI} = 24 \text{ cm}$
- $\text{HR} = 80$

$$\text{SBF} = 6,000 \text{ cc}$$
$$1 \times 1 \times 3.14 \times 24 \times 80$$

Calculation of Pulmonary Blood Flow

$$\text{C.O.} = \text{VTI}_{\text{RVOT}} \times \text{Area}_{\text{RVOT}} \times \text{HR}$$

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

**Pulmonary Vascular Resistance**

PVR = \( \frac{\text{mean PAP} - \text{mean PCWP}}{\text{C.O.}} \)

Another method

\( \text{PVR} = 10 \left( \frac{\text{Peak TR Velocity}}{\text{RVOT VTI} + 0.16} \right) \)

PVR = Wood’s units
TR Velocity = m/sec
RVOT VTI = cm

Normal = 2 Wood’s units
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.