Echo Doppler Assessment of Right and Left Ventricular Hemodynamics

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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

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

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

Liv Hatle
RA pressure

**IVC Dimensions**

- IVC diameter $\leq 2.1$ 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

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

Polling Question #1
The study suggests:
1. Severe PS
2. Right heart failure
3. Pulmonary hypertension
4. Constrictive Pericarditis
CW of Pulmonic Valve Flow

2.5 m/sec

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 \times \text{AcT})

Normal AcT > 120msec

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

\[
\text{Mean PAP} = 79 - (0.45 \times 90) = 79 - 40 = 39 \text{ mmHg}
\]
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

\[ \text{LAP} = \frac{1.24 \times (E/e') + 1.9}{1.24} \]

Nagueh 1999

LAP = \( \frac{E}{e'} + 4 \)

LAP = \( \frac{120}{6} + 4 \) = 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

Always record the BP!

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

Peak systolic LVP

Peak systolic BP

Ao

LA

LV
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
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CW of Aortic Valve Flow
The BP is 150 / 80

**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

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**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

Evaluation of LA Pressure in pt with MS

In MS, LA diastolic pressure = LVDP + Transmitral gradient
Noninvasive Hemodynamic Study

63-Year-Old female with Dyspnea

BP 100/55

Bibasilar rales
MS, AS, MR, TR murmurs

MS + AS
**Normal IVC Size 2.0 cm**

*<50% Respiratory Variation*
**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
LVEDP = aortic diastolic pressure (55) – AR gradient (36) = 19mmHg

LV systolic pressure = aortic systolic pressure (100) + 70% of AV gradient (46) = 146mmHg
LA pressure = LV diastolic (19) + MV mean gradient (7) = 26 mmHg

Calculation of Systemic Blood Flow

\[ SBF = VTI_{LVOT} \times Area_{LVOT} \times HR \]

- **D** = 2 cm
- **VTI** = 24 cm
- **HR** = 80

\[ SBF = 6,000 \text{ cc} \]

\[ 1 \times 1 \times 3.14 \times 24 \times 80 \]
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 \times Shunt VTI \times 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.