Pulmonary Hypertension and the Role of Echocardiography

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No disclosures

Companion to RV presentation
Pulmonary Artery Pressure = Pump X Load

RV function

Pulmonary Resistance & Compliance

Left heart Left atrial pressure
The degree of pulmonary hypertension is best based on the degree of RV dysfunction not the PA pressure.
Role of Echocardiography

- Assess pressures, PVR
- Assess RV function
- Assess the left heart
- Provide prognostic information
- Identify underlying causes
  - Distinguish pre- from post-capillary PHTN

Assessing PA pressures during stress
Definitions
## Pulmonary Artery Pressures

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>PHTN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic</strong></td>
<td>20-30</td>
<td>&gt;30</td>
</tr>
<tr>
<td><strong>Diastolic</strong></td>
<td>5-12</td>
<td>&gt;12</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>10-20</td>
<td>&gt;25</td>
</tr>
</tbody>
</table>
Update Clinical Classification of Pulmonary Hypertension

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Le Kremlin-Bicêtre and Paris, France; London, United Kingdom; Edmonton, Alberta, Canada; Sydney, Australia; Marburg, Germany; Madrid, Spain; Kerala, India; Boston, Massachusetts; Chicago, Illinois; Graz, Austria; Nashville, Tennessee; and São Paulo, Brazil

Table 1: Updated Classification of Pulmonary Hypertension

1. Pulmonary arterial hypertension
   1.1 Idiopathic PAH
   1.2 Heritable PAH
   1.2.1 BMPR2
   1.2.2 ALK-1, ENG, SMAD9, CAV1, KCNK3
   1.2.3 Unknown
   1.3 Drug and toxin induced
   1.4 Associated with:
      1.4.1 Connective tissue disease
      1.4.2 HIV infection
      1.4.3 Portal hypertension
      1.4.4 Congenital heart diseases
      1.4.5 Schistosomiasis
   1. Persistent pulmonary hypertension of the newborn (PPHN)

2. Pulmonary hypertension due to left heart disease
   2.1 Left ventricular systolic dysfunction
   2.2 Left ventricular diastolic dysfunction
   2.3 Valvular disease
   2.4 Congenital/acquired left heart inflow/outflow tract obstruction and congenital cardiomyopathies

3. Pulmonary hypertension due to lung diseases and/or hypoxia
   3.1 Chronic obstructive pulmonary disease
   3.2 Interstitial lung disease
   3.3 Other pulmonary diseases with mixed restrictive and obstructive pattern
   3.4 Sleep-disordered breathing
   3.5 Alveolar hypoventilation disorders
   3.6 Chronic exposure to high altitude
   3.7 Developmental lung diseases

4. Chronic thromboembolic pulmonary hypertension (CTEPH)

5. Pulmonary hypertension with unclear multifactorial mechanisms
   5.1 Hematologic disorders: chronic hemolytic anemia, myeloproliferative disorders, splenectomy
   5.2 Systemic disorders: sarcoidosis, pulmonary histiocytosis, lymphangioleiomyomatosis
   5.3 Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders
   5.4 Others: tumoral obstruction, fibrosing mediastinitis, chronic renal failure, segmental PH

*Stn WSHH Nice 2013: Main modifications to the previous Dana Point classification are in bold.
BMPR = bone morphogenetic protein receptor type II; CAV1 = caveolin-1; ENG = endoglin;
HIV = human immunodeficiency virus; PAH = pulmonary arterial hypertension.
IPAH = idiopathic pulmonary artery hypertension; APAH = associated pulmonary artery hypertension.
Pulmonary arterial hypertension (pre-capillary PHTN)

• PHTN in which PCWP ≤ 15 mmHg and PVR > 3 WU
Back to echo....

Calculating PA pressure
PA systolic pressure

Assume PASP = RVSP
Calculating RV pressure


RA and RV pressure readings

tricuspid regurgitation velocity recordings

\[ 4 \times (\text{TR velocity})^2 = \text{RVP-RAP} \]

\[ 4 \times (\text{TR velocity})^2 + \text{RAP} = \text{RVSP} \]
Contrast can help....
Right atrial pressure
What is the right atrial pressure?

<table>
<thead>
<tr>
<th>IVC</th>
<th>∆ with resp</th>
<th>RAP (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.1 cm</td>
<td>collapse &gt; 50%</td>
<td>0-5 (3)</td>
</tr>
<tr>
<td>&gt;2.1 cm</td>
<td>Dec &lt; 50%</td>
<td>10-20 (15)</td>
</tr>
<tr>
<td>&lt;2.1 cm</td>
<td>Dec &lt; 50%</td>
<td>5-10 (8)</td>
</tr>
<tr>
<td>&gt;2.1 cm</td>
<td>Dec &gt; 50%</td>
<td>5-10 (8)</td>
</tr>
</tbody>
</table>

ASE Guidelines
1-2 cm from IVC-RA junction

- Limitations:
  - inadequate inspiratory effort
  - “losing” the image
Relation of mean right atrial pressure to echocardiographic and Doppler parameters of right atrial and right ventricular function.

Nagueh SF, Kopelen HA, Zoghbi WA.

- **Systolic filling fraction**: $\frac{Vs}{Vs + Vd} < 55\%$ sensitive and specific for increased RA pressure
- Abnormal: A wave is larger than systolic S wave

**Normal**: Systolic predominance in hep. vein flow

**Abnormal**: $Vs/Vd < 1$ (e.g., High RA pressure)
Normal values

Peak TR velocity \( \leq 2.8 - 2.9 \text{ m/s} \)

Peak systolic pressure 35 or 36 mm Hg* (assuming an RA pressure of 3 to 5 mm Hg)
• You can’t calculate the RV pressure....

• When TR is unrestricted:
  – Large color flow jet dimension
  – Failure of leaflet coaptation
  – When TR jet is laminar or shows little mosaic
When is the RV systolic pressure ≠ PA pressure?

• When there is:

A gradient across the RVOT
When there is PS

1. Calculate RVSP in the usual fashion
   \[ \text{RVSP} = 4 \text{TRvel}^2 + \text{RAP} \]
2. Calculate RV-PA gradient
   \[ \text{gradient} = 4V^2 \]
3. Subtract gradient from RVSP
   \[ \text{PASP} = \text{RVSP} - \text{gradient} \]

You must evaluate the RVOT!
• PASP = 83 - 44 = 39 mmHg
Clinical Correlates and Reference Intervals for Pulmonary Artery Systolic Pressure Among Echocardiographically Normal Subjects

by Brendan M. McQuillan, Michael H. Picard, Marcia Leavitt, and Arthur E. Weyman

Circulation
Volume 104(23):2797-2802
December 4, 2001
Relation between PASP and age (A) and BMI (B).

Brendan M. McQuillan et al. Circulation. 2001;104:2797-2802
Pulmonary Artery Acceleration Time

- Modal velocity
- Level of leaflets
- Inversely related to HR (consider only for 60-100 bpm)
- Highly variable!
  - Beat to beat
  - Location
  - RV function

<table>
<thead>
<tr>
<th>Condition</th>
<th>Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>120 - 140</td>
</tr>
<tr>
<td>Borderline</td>
<td>100</td>
</tr>
<tr>
<td>Usually PHTN</td>
<td>&lt;80 - 90</td>
</tr>
<tr>
<td>Severe PHTN</td>
<td>&lt; 60</td>
</tr>
</tbody>
</table>
Flying W

- Timing may reflect location of “obstruction”
PA diastolic pressure
PA Diastolic Pressure

- PA - RV = 22 mmHg
- RAP = 3 mmHg
- PAD = 25 mmHg
Mean PA pressure
Mean PAP
Method 1

\[ P_{\text{mean}} = 0.6 \times P_{A_{SP}} + 2 \text{ mm Hg} \]
Mean PAP
Method 2

\[ \text{mPAP} = 28\text{mmHg} + \text{RAP} \]
Mean PAP
Method 3

\[ P_{A_{\text{mean}}} = \frac{P_{A_s} + 2 \times P_{A_d}}{3} \]
Mean PAP
Method 4
Not recommended

\[ PA_{\text{mean}} = 79 - 0.45 \times PAcT \]
Pulmonary Vascular Resistance
Pulmonary Vascular Resistance

- PVR = PA-LA /CO
  normal = 0.5-1.5
  (Wood units)

PVR = 10('TRV/VTI)+0.16

Note: does not consider HR

- Abbas et al JACC 2003; 41:1021
Haddad et al
(PVRI >15 WU/m²)

SPAP / (HR x TIVRVT) = 0.076

Area under the curve = 0.887
Consider calculating when..

- Calculated PASP unexpectedly high
- Known or suspected increased PV flow
  - ASD, VSD, post valvotomy severe PR, high output state (exercise)

- Note: neither method addresses LA pressure, will overestimate PVR if LA pressure is high
The RV in PHTN
• Multiple views
• Multiple techniques
  – Qualitative
  – Quantitative
• Multiple views
• Multiple techniques
  – Qualitative
  – Quantitative
Echocardiographic Markers of Prognosis

- TAPSE < 15
- RV Tei Index > 0.88
- RV FAC decreasing
- Pericardial effusion
- LV eccentricity index
Eccentricity Index

A measure of septal displacement in systole or diastole

• Eccentricity Index
  \[ EI = \frac{D2}{D1} \]
  
  \( D1 = \) minor axis diameter perpendicular to IVS
  
  \( D2 = \) minor axis diameter parallel to IVS

Stress Echocardiography in Pulmonary Hypertension
Normal response to exercise

Limited normative data
Indications for Testing

• Elucidating symptoms
• High risk groups
  – Family members/Genotype positive
  – CT disease
  – HIV
• ?High altitude
• Treadmill vs. bicycle
• Role of assessing RV contractile reserve is uncertain
Summary

• The echo assessment of pulmonary hypertension is more than the peak TR jet
• Must consider pressures and ventricular function
• Echo is an excellent tool to do both
Thank you!