Cardiac Hemodynamics

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Topics

• Basics of Cardiac Hemodynamics
• Hemodynamics in Valvular Heart Disease
• Hemodynamics in Cardiomyopathies
• Hemodynamics in Pericardial Disease
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Basics of Cardiac Hemodynamics

- First living human cardiac catheterization was performed in 1929 by Dr. Werner Forssmann at age 25 and shared the 1956 Nobel Prize in Medicine.
- Proper cardiac diagnosis and disease management relies on accurate hemodynamics.
- Adequate flushing of catheters, avoidance of bubbles and equipment calibration (transducer placed at the mid-chest level).
- **Underdampening** – vigorous catheter movement or air bubble oscillation produces artifact in peaks and dips of the pressure waveform.
- **Overdampening** – catheter kink or blood, contrast media or air in catheter can result in reduced pressure transmission.
(a) Underdampening of pressure waveforms results when either excessive catheter movement or air bubble oscillations produce artifacts in peaks and dips of the pressure waveform, with falsely elevated systolic pressure. (b) Catheter kink or blood, contrast media, or air in the catheter can result in reduced pressure transmission and overdampening of the pressure waveform, with smooth contour of the waveform and falsely low diastolic pressure. (c) normal waveform. (s) systolic (d) diastolic (e) end-diastolic pressure.
Right Atrial Pressure Waveform

“v” wave – Atrial “Venous” or Passive Filling
“a” wave – Atrial contraction
“c” wave – Closure and protrusion of the tricuspid valve into the right atrium
“x” descent – Relaxation of RA (pulling of tricuspid annulus downward by RV contraction)
“y” descent – TV opening and RA emptying into RV
Examples of Common Abnormalities in RA filling

• Increased “a” wave
  - Tricuspid stenosis
  - Right Heart Failure
  - Decreased RV compliance
  - Pulmonary HTN
• Cannon “a” wave
  - Atria contracting against closed TV (i.e. VT, 3rd degree AVB)
• Absent “a” wave
  - Atrial flutter or fibrillation
• Elevated “v” wave
  - Tricuspid regurgitation
• Prominent “y” descent
  - Tricuspid regurgitation
• Prominent “x” and “y” descents
  - Constriction/Restriction
• Slow “y” descent
  - Tricuspid stenosis
  - Tamponade
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A Simplified Valve Formula for the Calculation of Stenotic Cardiac Valve Areas


SUMMARY We have simplified the Gorlin formula and have compared our measurements of the aortic or mitral valve area, using the original Gorlin formula and the simplified valve formula in 100 consecutive patients. The valve area was measured by the simplified formula as cardiac output (l/min) divided by the square root of pressure differences across the valve.

In patients with aortic stenosis of varying severity there was excellent correlation between the original Gorlin formula and the simplified formula ($r = 0.96$, $y = 0.99x + 0.01$, $\text{SEE} = \pm 0.10$, $p < 0.001$). The correlation was unchanged when the peak gradient was used instead of the mean gradient in the simplified formula. Excellent correlation was also seen in patients with mitral stenosis of varying severity ($r = 0.94$, $y = 0.97x - 0.02$, $\text{SEE} = \pm 0.19$; $p < 0.001$). The simplicity of the formula makes it easy to memorize and use.
Mitral Stenosis
(diastolic gradient LV vs. PW or LA pressure)

Grolin Formula:

\[
MVA \ (cm^2) = \frac{\text{Cardiac output (mL/min)} \times \text{Diastolic filling period (sec)} \times \text{Heart rate (beats/min)}}{44.3 \times 0.85 \times \sqrt{\text{mean gradient (mm Hg)}}}
\]
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Hypertrophic Obstructive Cardiomyopathy

An increase in the intra-cavitary gradient following a premature ventricular contraction (PVC) is seen in HOCM as a result of increased myocardial contractility. The post PVC beat (arrow) is associated with a reduction in aortic systolic pressure and pulse pressure known as the Brokenbrough-Braunwald-Morrow sign. (LV) Left ventricle, (Ao) Aorta.
Left Ventricle Outflow Gradient Pre-and Post Alcohol Septal Ablation
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Dip and Plateau Configuration (RV filling)
Constrictive Pericarditis and Restrictive Cardiomyopathy
Sensitivity and Specificity of Hemodynamic Parameters

<table>
<thead>
<tr>
<th></th>
<th>Constrictive pericarditis</th>
<th>Restrictive cardiomyopathy</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEDP-RVEDP*</td>
<td>≤ 5 mm Hg</td>
<td>&gt; 5 mm Hg</td>
<td>60</td>
<td>38</td>
</tr>
<tr>
<td>Pulmonary artery systolic pressure</td>
<td>&lt; 55 mm Hg</td>
<td>&gt; 55 mm Hg</td>
<td>93</td>
<td>24</td>
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<tr>
<td>Right ventricular systolic and EDP</td>
<td>&gt; 1/3</td>
<td>≤ 1/3</td>
<td>93</td>
<td>38</td>
</tr>
<tr>
<td>Respiratory variation in mean right atrial pressure</td>
<td>Absent</td>
<td>Present</td>
<td>93</td>
<td>48</td>
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<tr>
<td>Left ventricular diastolic rapid filling wave</td>
<td>&gt; 7 mm Hg</td>
<td>≤ 7 mm Hg</td>
<td>93</td>
<td>57</td>
</tr>
<tr>
<td>Ventricular interdependence</td>
<td>Present</td>
<td>Absent</td>
<td>100</td>
<td>95</td>
</tr>
</tbody>
</table>

*LV, left ventricle; RV, right ventricle; EDP, end-diastolic pressure
Restrictive Cardiomyopathy (ventricular concordance of right and left ventricle pressures)

Constrictive Pericarditis (ventricular discordance)
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THANK YOU