The purpose of the present work is to develop an algebraic formula for PRSW in terms of parameters characterizing the critical mechanical properties of the left ventricle and the systemic vasculature. Preload Recruitable Stroke Work May Not Be a Valid Index of Cardiac Contractility

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Pressure-volume loop shows changes in the left ventricle's blood pressure and volume during a cardiac cycle, which consists of diastole and systole.

Increasing end-diastolic volume (preload) creates larger loops (stroke work).

Pumped blood travels from arteries to microvasculature and then veins.

Arterial pressure must overcome venous pressure for blood to flow.

Microvasculature resists blood flow.

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What is PRSW?

• The slope of left ventricular stroke work & end diastolic volume

• Deemed to be a load-independent index of cardiac contractility

• Has been shown to increase with inotropes and remain relatively constant with changes in systemic resistance

Purpose

• To develop an algebraic formula for PRSW in terms of parameters characterizing the critical mechanical properties of the left ventricle and systemic vasculature.

PRSW = \frac{\Delta SW}{\Delta Vedlv}

Purpose Statement

PRSW = \frac{\Delta SW}{\Delta Vedlv}

Assumptions

• End-systolic pressure-volume relationship (ESPVR) is linear

• End-diastolic pressure-volume relationship (EDPVR) is nonlinear

• Pressure-volume loop is approximated by a rectangle

• End-systolic pressure (Pes) is approximated by MAP

• Ea \approx (HR)(Rs)

• MAP is either perfectly regulated (1st case) or not (2nd case)

• Under normal conditions, the baroreflex increases or decreases Rs in order to counter changes to MAP

• Under extreme conditions, MAP can no longer be maintained and thus, Rs becomes constant

Variables

<table>
<thead>
<tr>
<th>SW</th>
<th>stroke work</th>
<th>Vedlv</th>
<th>left ventricular end diastolic volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vedlv</td>
<td>leftventricular unstressed end-systolic volume</td>
<td>Emaxlv</td>
<td>left ventricular maximum end-systolic elastance</td>
</tr>
<tr>
<td>Vedlv</td>
<td>left ventricular end systolic volume</td>
<td>Ea</td>
<td>effective arterial elastance</td>
</tr>
<tr>
<td>MAP</td>
<td>mean arterial pressure</td>
<td>HR</td>
<td>heart rate</td>
</tr>
<tr>
<td>Ppv</td>
<td>pulmonary venous pressure</td>
<td>Rs</td>
<td>systemic resistance</td>
</tr>
<tr>
<td>Psv</td>
<td>systemic venous pressure</td>
<td>PRSW</td>
<td>preload recruitable stroke work</td>
</tr>
</tbody>
</table>

Model Equations

1st case: PRSW \approx MAP at the lower range of Vedlv

2nd case: PRSW \approx 2(MAP)(EF) at the lower range of Vedlv

Means of Solving 1st and 2nd Cases

1st case: solve eqs. 1-3 for SW, Veslv, Ppv

2nd case: solve eqs. 1-4 for SW, Veslv, Ppv, and MAP

Take the derivative of the SW solutions in terms of Vedlv

Resultant Equations

1st case: PRSW = Psv + a + b Vedlv + 1-b Vedlv \cdot Emaxlv

2nd case: PRSW = Psv + a + b Vedlv + 1-b Vedlv \cdot Emaxlv

Discussion

• For case 1, PRSW is mainly determined by MAP at the lower Vedlv range

• For case 2, PRSW is mainly determined by preload, HR, and Rs, in addition to contractility at the lower Vedlv range

• PRSW cannot be treated as only an index of contractility

• 2(MAP)(Ejection Fraction) provides a non-invasive way of determining PRSW, contrasting with traditional vena cava occlusion

References

