Hemodynamics

Transpulmonary thermodilution
Thermodilution CO

\[ CO = \frac{(T_b - T_i) \times V_i \times K}{\int_0^\infty \Delta T_b \, dt} \]
If volume ↑ and CO remains ≈ than MTt ↑
If total volume and CO remain ≈ than $D_{st} \uparrow$ with $\uparrow MV$. 

TPTD and volume measurements

Mixing volume < 20% total volume

Mixing volume > 20% total volume
$\text{CO} \times \text{MTt} = \text{total volume between injection point and detection point}$

$\text{CO} \times \text{DSt} = \text{volume of the largest mixing chamber}$
CO measurement in PA versus Aorta

n = 449
y = 0.96 x 1.02 [l/min]
r = 0.97, p<0.0001

Systematic higher CO measurement with TPTD probably due to indicator loss

GEDV is a better estimate of preload compared to CVP or PCWP.
Value of PCWP and ITBV

Patients with severe sepsis

Same results for cardiogenic shock - ARDS and patients with liver cirrhosis

Bindels AJ. Crit Care 2000;4:193-199
GEDV and sepsis

% patients with SV ↑ > 15%

546 ± 52 ml/m²  681 ± 60 ml/m²  907 ± 86 ml/m²

Chest 2003;124:1900-1908
GEDV and cardiac surgery

Cardiac Function Index
Measure of Left Ventricular Systolic Function

CFI = CI/GEDV

% change in CFI vs % change in LVEF

n = 24
r = 0.65
p = .0001

Volume therapy

Dobutamine

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Measurement premises

- Thermal indicator reaches and equilibrates equally in all lung regions

- Central circulation volumes are a small number of individual well-mixed compartments each with a monoexponential temperature decay with time (no shunt)

Redistribution of perfusion towards regions of poor aeration (thermally silent) artificially elevates the measurement of EVLW

Costa ELV. Anesthesiology 2009;111:933-935
Cross-talk phenomenon

10-month-old child
Injection femoral vein
Detection femoral artery
Clinically low cardiac output
Estimated 2.3 l/min/m²

10-month-old child
Injection femoral vein
Detection femoral artery
Clinically high cardiac output
Calculated 4.2 l/min/m²
Cross-talk phenomenon

Rhesus-monkey
Injection IVC
Detection femoral artery
Profound shock

Normal
Diffusion
Diffusion
Low cardiac output and increased EVLW

- Further fluid challenges are likely to increase pulmonary edema and worsen oxygenation
- Inodilator could be beneficial by increasing CO and decreasing pulmonary capillary pressure
Relation between PCWP and EVLW

\[ y = 0.1083x + 9.347, \ n = 72 \]
\[ r = 0.08, \ F = 0.45, \ p = 0.5 \]

Time 0 = Occlusion point = point when the wedged curve diverges from the non-wedged one

Pcap estimated by the visual method

Pcap estimated by the mathematical method

Exponential curve fitting period from 0.3 to 2 seconds after occlusion
EVLWI (ml/kg)

\[ \text{EVLWI (ml/kg)} \]

\[ \text{PaO}_2 / \text{FiO}_2 \text{ (mm Hg)} \]

Compliance (mL/cm H\text{2}O)

LIS

Day 1

Day 3

Kuskov VV. CCM 2006;34:1647-1653

Single indicator EVLW and lung injury

N = 38
Septic shock + ALI
<table>
<thead>
<tr>
<th>Patient</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean chest x-ray score</td>
<td>360</td>
<td>45</td>
<td>350</td>
<td>30</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>9</td>
<td>10</td>
<td>16</td>
<td>7.1</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>meningococcal disease</td>
<td>post resuscitation</td>
<td>meningococcal disease</td>
<td>Post Fallot correction</td>
</tr>
<tr>
<td>FiO2</td>
<td>0.4</td>
<td>0.35</td>
<td>0.6</td>
<td>0.35</td>
</tr>
<tr>
<td>PEEP (cmH₂O)</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>PaO₂ (kPa)</td>
<td>9.7</td>
<td>14</td>
<td>10.2</td>
<td>11.9</td>
</tr>
<tr>
<td>PaO₂/FiO2 (kPa)</td>
<td>24.3</td>
<td>40</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td>A-a gradient (kPa)</td>
<td>22.9</td>
<td>11.4</td>
<td>41.2</td>
<td>14.9</td>
</tr>
<tr>
<td>CI (l/min/m²)</td>
<td>5.3</td>
<td>3.9</td>
<td>4.8</td>
<td>3</td>
</tr>
<tr>
<td>GEDVI (ml/m²)</td>
<td>435</td>
<td>618</td>
<td>566</td>
<td>404</td>
</tr>
<tr>
<td>EVLWI (ml/kg)</td>
<td>13</td>
<td>18</td>
<td>12</td>
<td>19.5</td>
</tr>
</tbody>
</table>
24 critically ill children
108 measurements
EVLW and fluid therapy

Bindels AJGH. Neth J Med 2000;57:82-93
Bindels AJGH. Am J Cardiol 1999;84:1158-1163
Relation between CO and EVLW

Cardiac output

EVLW

Preload