How to learn central venous pressure measurement with US:

The TeachPort Study

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IUA, Praha
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Part 1
What is known:

Trained vascular physician + High-end ultrasound machine
Aim of the study (part 1)

- Feasability and accuracy of CVP measurements using a high-end US machine vs. simple portable US machine
- Feasability and accuracy of CVP measurements by «non-vascular specialists» (after short training phase)

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Training

- Three 1h sessions
- 30 measurements on healthy volunteers
- Randomly selected different levels of periphereal venous pressure (induced by inflated sphygmomanometer at the upper arm)
- «Goldstandard»: vascular physicians

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Aim of the study

Thalhammer C et al., Resuscitation 2009;80:1130-1136
- Surgical intensive care unit
- Central venous catheter clinically indicated

Ready – Steady – Go!

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Study design

- Technique: as mentioned
- Measured contralateral to subclavian catheters
- Best visible superficial vein at the forearm
- Corrected for the same level of atrium height as in cathether CVP measurement
- Feasability: maximum time of investigation 8 min.
# Patient characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>male/female</td>
<td>34 / 16</td>
<td>68 / 32</td>
</tr>
<tr>
<td>Age* (years)</td>
<td>67 ± 14.5</td>
<td>--</td>
</tr>
<tr>
<td>Ventilated patients</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>Diameter of the vein* (mm)</td>
<td>2.4 ± 0.9</td>
<td>--</td>
</tr>
</tbody>
</table>

*mean± SD

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Thalhammer C et al., Resuscitation 2009;80:1130-1136
## Results

<table>
<thead>
<tr>
<th>Investigator</th>
<th>US device</th>
<th>Time (min)</th>
<th>Feasibility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vasc. expert</td>
<td>high end</td>
<td>3.2 ± 1.4</td>
<td>92</td>
</tr>
<tr>
<td>Student</td>
<td>high end</td>
<td>4.2 ± 1.9</td>
<td>90</td>
</tr>
<tr>
<td>Vasc. expert</td>
<td>portable</td>
<td>2.9 ± 1.6</td>
<td>88</td>
</tr>
<tr>
<td>IC specialist</td>
<td>portable</td>
<td>3.7 ± 1.9</td>
<td>88</td>
</tr>
</tbody>
</table>

n.s. n.s.

Thalhammer C et al., Resuscitation 2009;80:1130-1136
# Results

<table>
<thead>
<tr>
<th>Group</th>
<th>CVP invasive mmHg*</th>
<th>CVP non invasive mmHg*</th>
<th>Mean difference mmHg*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All investigators</td>
<td>12.3 ± 4.8</td>
<td>9.8 ± 4.5</td>
<td>-2.5 ± 4.0</td>
</tr>
<tr>
<td>Vasc. expert / high end</td>
<td>12.4 ± 4.8</td>
<td>9.3 ± 4.8</td>
<td>-3.1 ± 4.4</td>
</tr>
<tr>
<td>Student / high end</td>
<td>12.3 ± 5.0</td>
<td>9.9 ± 4.0</td>
<td>-2.4 ± 3.8</td>
</tr>
<tr>
<td>Vasc. expert / portable</td>
<td>12.4 ± 4.8</td>
<td>10.0 ± 4.4</td>
<td>-2.4 ± 3.7</td>
</tr>
<tr>
<td>IC specialist / portable</td>
<td>12.2 ± 4.8</td>
<td>9.9 ± 4.8</td>
<td>-2.2 ± 4.1</td>
</tr>
<tr>
<td>High end US</td>
<td>12.3 ± 4.8</td>
<td>9.6 ± 4.4</td>
<td>-2.8 ± 4.1</td>
</tr>
<tr>
<td>Portable US</td>
<td>12.3 ± 4.8</td>
<td>10.0 ± 4.6</td>
<td>-2.3 ± 3.9</td>
</tr>
<tr>
<td>Vascular experts</td>
<td>12.4 ± 4.8</td>
<td>9.6 ± 4.6</td>
<td>-2.8 ± 4.1</td>
</tr>
<tr>
<td>Trainees</td>
<td>12.2 ± 4.8</td>
<td>9.9 ± 4.4</td>
<td>-2.3 ± 4.0</td>
</tr>
</tbody>
</table>

*mean ± SD (Range 3 – 25)

n.s.
XXV World Congress IUA, TeachPort

(A) expert, high-end
\[ r = 0.58 \]
\[ y = 0.5889x + 1.9595 \]
\[ r = 0.58 \]

(B) trainee, high-end
\[ r = 0.65 \]
\[ y = 0.5174x + 3.5114 \]
\[ r = 0.65 \]

(C) expert, portable
\[ r = 0.68 \]
\[ y = 0.6161x + 2.4110 \]
\[ r = 0.68 \]

(D) trainee, portable
\[ r = 0.62 \]
\[ y = 0.6252x + 2.3297 \]
\[ r = 0.62 \]

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Part 2
Aim of the study (part 2)

➢ To test, whether the established US measurement method is precise enough to detect respiratory pressure changes during mechanical ventilation

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Respiratory changes in CVP

- Compressibility of the veins is depending on respiratory cycle

- The deeper the respiration, the larger the pressure amplitude

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Technique

• Lower CVP:
  first time complete collaps of the vein

• Upper CVP:
  persistent complete collaps of the vein during a whole respiratory cycle

• Team:
## Patient characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value (range)</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>20</td>
<td>--</td>
</tr>
<tr>
<td>male/female</td>
<td>13 / 7</td>
<td>--</td>
</tr>
<tr>
<td>Age* (years)</td>
<td>65.5</td>
<td>--</td>
</tr>
<tr>
<td>Diameter of the vein** (mm)</td>
<td>2.0±1.2</td>
<td></td>
</tr>
<tr>
<td>Ventilated patients</td>
<td>20</td>
<td>--</td>
</tr>
<tr>
<td>Blood pressure** (mmHg)</td>
<td>74</td>
<td>(45-101)</td>
</tr>
<tr>
<td>Mean airway pressure** (mmHg)</td>
<td>11.6</td>
<td>(7-21)</td>
</tr>
<tr>
<td>Respiratory rate** (/min)</td>
<td>15.4</td>
<td>9-32</td>
</tr>
<tr>
<td>Tidal volume** (ml)</td>
<td>611</td>
<td>500 – 800</td>
</tr>
</tbody>
</table>

*median, ** mean

Thalhammer C et al., Resuscitation 2009;80:1130-1136
# Results

<table>
<thead>
<tr>
<th>Group</th>
<th>invasive mmHg*</th>
<th>non invasive mmHg*</th>
<th>Mean difference mmHg*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal CVP</td>
<td>12.2 ± 3.9</td>
<td>13.8 ± 3.9</td>
<td>+1.6</td>
</tr>
<tr>
<td>Maximal CVP</td>
<td>17.5 ± 5.2</td>
<td>18.6 ± 4.0</td>
<td>+0.8</td>
</tr>
<tr>
<td>Respiratory change</td>
<td>5.5</td>
<td>4.8</td>
<td></td>
</tr>
</tbody>
</table>

*mean ± SD

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Minimal CVP

Maximal CVP

$y = 0.6484x + 3.2507$

$r = 0.66$

$y = 0.9374x + 0.3426$

$r = 0.71$

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Conclusion (part 1)

- Non invasive CVP measurement with US is feasible and accurate

- No difference with respect to quality of US system or experience of the investigator (adequate transducer and training provided)
Conclusion (part 2)

- Non invasive CVP measurement method is accurate to distinguish higher and lower CVP levels during respiration.

- This has to be considered when examining patients with spontaneous deep respiration or mechanical ventilation to avoid underestimation of the real CVP.

Thalhammer C et al., Resuscitation 2009;80:1130-1136
Thank you for your attention