Hemodilution with hypercapnia worsens cerebral autoregulation during normothermic cardiopulmonary bypass

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Disclosure

Neither I or the co-authors have any conflict of interest to disclose
Introduction

Postoperative neurological impairment is still a major concern

Moreover, disturbances of cerebral autoregulation lead to cognitive impairment
Introduction

In addition, hemodilution is known to adversely affect cognitive outcome.

What is the effect of hemodilution and $p_a\text{CO}_2$ level on cerebral autoregulation?
Methods

• 40 adult male patients
• Dynamic cerebral autoregulation
• Baseline: metronome triggered breathing
Methods

• Intraoperative: cyclic changes of indexed pump flow

→ hypocapnia  \( (p_a \text{CO}_2 = 30 \text{ mmHg}) \)
→ normocapnia  \( (p_a \text{CO}_2 = 40 \text{ mmHg}) \)
→ hypercapnia  \( (p_a \text{CO}_2 = 50 \text{ mmHg}) \)
Methods

• Autoregulation index (ARI)

• Cerebral blood flow velocity (CBFV)

• Cerebral carbon dioxide reactivity (CO₂R)

\[
cerebral\ CO₂R_{abs} = \Delta S_{ct\ O₂}/\Delta p_a\ CO₂
\]

\[
cerebral\ CO₂R_{rel} = \left(\frac{cerebral\ CO₂R_{abs}}{S_{ct\ O₂;40\ mmHg}}\right) \times 100\%
\]
## Results

Median hematocrit value on bypass: 28%

<table>
<thead>
<tr>
<th></th>
<th>n=40</th>
<th>≥28% (n=21)</th>
<th>&lt;28% (n=19)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60.1</td>
<td>58.9</td>
<td>61.2</td>
<td>ns</td>
</tr>
<tr>
<td>BSA (m²)</td>
<td>2.1</td>
<td>2.1</td>
<td>2.0</td>
<td>ns</td>
</tr>
<tr>
<td>preoperative hematocrit (%)</td>
<td>44.0</td>
<td>46.0</td>
<td>43.0</td>
<td>0.002</td>
</tr>
<tr>
<td>ABP (mmHg)</td>
<td>86.0</td>
<td>86.0</td>
<td>85.7</td>
<td>ns</td>
</tr>
<tr>
<td>$S_{ct}O_2$ (%)</td>
<td>71.9</td>
<td>72.0</td>
<td>71.0</td>
<td>ns</td>
</tr>
<tr>
<td>CBFV (cm/s)</td>
<td>40.3</td>
<td>39.3</td>
<td>41.8</td>
<td>ns</td>
</tr>
<tr>
<td>ARI</td>
<td>7.5</td>
<td>7.4</td>
<td>7.5</td>
<td>ns</td>
</tr>
</tbody>
</table>
Autoregulation index

- hematocrit = 44%
- hematocrit ≥ 28%
- hematocrit < 28%

ARI

baseline  p_aCO_2 30 mmHg  p_aCO_2 40 mmHg  p_aCO_2 50 mmHg
Cerebral carbon dioxide reactivity

<table>
<thead>
<tr>
<th>CO$<em>2$R ($%S</em>{ct}O_2$/mmHg)</th>
<th>≥28% (n=21)</th>
<th>&lt;28% (n=19)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute, hypocapnia</td>
<td>11.3</td>
<td>6.0</td>
<td>0.018</td>
</tr>
<tr>
<td>Relative, hypocapnia</td>
<td>17.3</td>
<td>9.0</td>
<td>0.018</td>
</tr>
<tr>
<td>Absolute, hypercapnia</td>
<td>17.3</td>
<td>20.3</td>
<td>0.856</td>
</tr>
<tr>
<td>Relative, hypercapnia</td>
<td>27.0</td>
<td>30.8</td>
<td>0.705</td>
</tr>
</tbody>
</table>
Conclusion

• Hemodilution negatively affects cerebral autoregulation

• The combination of hemodilution (hematocrit < 28%) and hypercapnia worsens cerebral autoregulation even further
Take home points

• Avoid excessive hemodilution

• Tight $p_a \text{CO}_2$ control