Ultra-low tidal volumes and extracorporeal carbon dioxide removal (hemolung® RAS) in ards patients. a clinical feasibility study

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Introduction
Ventilation of ARDS patients with low tidal volume (Vt) is performed in order to minimize ventilation induced lung injury. This strategy, however, may induce hypercapnic acidosis, promote derecruitment and, in some individuals, induce alveolar overdistention despite the use of low Vt. Extracorporeal CO₂ removal can help minimizing hypercapnic acidosis and to further reduce Vt (i.e. ultraprotective ventilation).

Objectives
To evaluate the effect of extracorporeal CO₂ removal in ARDS during ultraprotective ventilation in terms of lung mechanics and gas exchange.

Methods
We studied 9 ARDS patients, in whom ultraprotective ventilation (i.e. Vt 4 ml/kg PBW) was implemented by means of an extracorporeal CO₂ removal system [Hemolung® Respiratory Assist System (RAS), ALung, Pittsburgh]. Anticoagulation with unfractionated heparin to reach an aPTT target range of 1.5-2 was used. We compared baseline ventilation with ultraprotective ventilation (combining Vt of 4 ml/kg PBW and Hemolung®), in terms of lung mechanics and gas exchange. We collected arterial blood gases, respiratory and hemodynamic variables, and mixed expired gases at baseline and after 60 minutes of stabilization at ultraprotective ventilation. Statistical analysis: 2-tailed Student’s t-test. Statistical significance p < 0.05.

Results
Five men and four women with ARDS where studied (8 pneumonias and 1 abdominal sepsis). Age was 61 ± 14 years, SAPS II at admission 48 ± 28 and ICU mortality 22% (2/9). Seven of these patients were treated with prone positioning during mechanical ventilation. Cannulation was done via femoral vein in all patients, using “ad hoc” 15.5 Fr catheters. Hemolung® allowed a CO₂ removal rate of 84 ± 9 mL/min, with blood flow 447 ± 35 mL/min, at constant sweep gas flow (10 L/min of O₂) and pump speed (1400 RPM).

Table 1.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>BASELINE</th>
<th>4ml/kg PBW + Hemolung®</th>
<th>T-TEST p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vt (mL/kg PBW)</td>
<td>64 ± 1</td>
<td>4 ± 0</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Vt (mL)</td>
<td>374 ± 55</td>
<td>238 ± 47</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>RR (bpm)</td>
<td>24 ± 3</td>
<td>28 ± 6</td>
<td>0.027</td>
</tr>
<tr>
<td>VE (mL/min) [=Vt*RR]</td>
<td>8798 ± 1297</td>
<td>6639 ± 1679</td>
<td>0.004</td>
</tr>
<tr>
<td>PEEP (cmH2O)</td>
<td>11 ± 1</td>
<td>13 ± 4</td>
<td>0.227</td>
</tr>
<tr>
<td>Pplat (cmH2O)</td>
<td>24 ± 4</td>
<td>22 ± 3</td>
<td>0.074</td>
</tr>
<tr>
<td>Crs (mL/cmH2O) [=Vt/Pplat-PEEP]</td>
<td>30 ± 9</td>
<td>30 ± 11</td>
<td>0.998</td>
</tr>
<tr>
<td>ΔP [cmH2O] [=Pplat-PEEP]</td>
<td>13 ± 3</td>
<td>9 ± 6</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Anticoagulation with unfractionated heparin to reach an aPTT target range of 1.5-2 was used. We compared baseline ventilation with ultraprotective ventilation (combining Vt of 4 ml/kg PBW and Hemolung®), in terms of lung mechanics and gas exchange. We collected arterial blood gases, respiratory and hemodynamic variables, and mixed expired gases at baseline and after 60 minutes of stabilization at ultraprotective ventilation. Statistical analysis: 2-tailed Student’s t-test. Statistical significance p < 0.05.

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Unfractionated heparin dose was 200 ± 78 mg/day and aPTT was 1.56 ± 0.18. During catheter insertion a bolus of 0.6 ± 0.2 mg/kg mg was administered. Hemolung® total days were 5.3 ± 6.2 (range 1 to 22). No significant haemorrhage or hemolysis needing transfusion, device malfunction, insertion and/or withdrawal complications occurred. We report a significant reduction in minute ventilation and alveolar minute ventilation (75% and 66%, respectively), dead space (68%), and driving pressure (69%), without significant changes in arterial blood gases when ultraprotective strategy was implemented, as compared to baseline (see tables 1 and 2).

Conclusions
Hemolung® system allows ultraprotective ventilation, while maintaining adequate arterial blood gases and significantly decreasing the intensity of ventilator assistance. The technique appears to be useful and safe.

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Reference

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