Feasibility of fully automated closed-loop ventilation (Intellivent-ASV) for patients with traumatic brain injuries in the ICU.

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INTELLiVENT-ASV

Recently released fully automated closed-loop ventilation.

Kurashiki Central Hospital
INTELLiVENT-ASV

- Automatically controls ventilator settings based on the targets for ventilation and oxygenation.

- The clinician needs to set targets for etCO₂ and SpO₂ for the patients.

- Automatically sets oxygenation (PEEP, FiO₂) and ventilation (mandatory rate, inspiratory time, tidal volume, and inspiratory pressure) parameters.

- Provides an automated weaning protocol.
INTELLiVENT-ASV

- Several studies evaluating the safety and feasibility for ventilated ICU patients have already been reported.

✓ RCT
  - Post cardiac surgery patients
  - COPD

- Other reports, including the patients with ARDS, pediatric patients and so on, have also been reported.
Neuro-protective strategy for Traumatic Brain Injury patients

- Avoid hypotension
- Avoid hypoxemia
- Maintain normocapnia
- Avoid hyperthermia
- Control blood glucose
- Head elevation etc....
The aim of this study is to evaluate the feasibility of maintaining normocapnia by using INTELLiVENT-ASV for traumatic brain injury patients in the ICU.
Method

- Retrospective chart review.

- Kurashiki Central Hospital in Okayama (Japan). 8-bed medical-surgical adult ICU. 6000 trauma patients admit to ED annually.

- From June 2014 to December 2014.
Method

Inclusion:
All consecutive patients with traumatic brain injuries requiring neuro-protective strategy.

Exclusion:
- Patients under 18 years of age.
- Demised within 24 hours.
Method

☐ Automated ventilation (AV) group:

The Intellivent system adjusts Tidal Volume (TV), respiratory rate (RR), FiO₂ and PEEP based on the patient’s EtCO₂ and SpO₂. Only manual setting in the AV group was the patient’s height and sex to determine initial minute ventilation.

☐ Conventional ventilation (CV) group:

CV was administered by the treating intensivists. Both pressure control ventilation (PCV) and pressure support ventilation (PSV) were applied. TV was set at 8-10ml/kg, RR at 12-20/min, and PEEP at 5-8cmH₂O for initial settings and adjusted on demand based on arterial blood gas assessments.

**ABG:** Every 6 hours and on demand for the first 24 hrs.
Method

✓ **Primary outcome:**
- Level of PaCO₂

✓ **Secondary outcome:**
- The numbers of manual intervention
- The numbers of time that showed unacceptable PaCO₂ (>45mmHg, <35mmHg)
Method

Statistical analysis:

- Values are expressed as median (25-75th interquartile range) or number (%).

- Continuous variables are analyzed using Wilcoxon’s rank-sum test, and categorical variables are analyzed using the chi-squared test.

- The results were declared significant with p values <0.05.
## Result

### - Patients characteristics -

<table>
<thead>
<tr>
<th></th>
<th>AV</th>
<th>CV</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>45 (21-69)</td>
<td>63 (27-78)</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>Sex(male)</strong></td>
<td>5 (100%)</td>
<td>6 (86%)</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>ISS</strong></td>
<td>36 (29-49)</td>
<td>29 (27-36)</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>AIS(Head)</strong></td>
<td>4 (3.5-5.0)</td>
<td>4 (3.0-5.0)</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>Chest trauma</strong></td>
<td>4 (80%)</td>
<td>5 (71%)</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>Smoker</strong></td>
<td>1 (20%)</td>
<td>4 (57%)</td>
<td>0.20</td>
</tr>
</tbody>
</table>

No. (%) or Median (IQR)
Result
- Level of PaCO₂ -

PaCO₂ (AV)

PaCO₂ (CV)
### Result

- **PaO2 and PaCO2 in 24 hours** -

<table>
<thead>
<tr>
<th></th>
<th>PaCO2 (mmHg)</th>
<th>PaO2 (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KH</td>
<td>41(40.9-41.1)</td>
<td>145(143-151)</td>
</tr>
<tr>
<td>KY</td>
<td>35.7(35.3-37.3)</td>
<td>75.9(69.3-78.2)</td>
</tr>
<tr>
<td>CN</td>
<td>44.1(43.4-45.2)</td>
<td>110(104.8-115.3)</td>
</tr>
<tr>
<td>FM</td>
<td>43.6(40.8-45.4)</td>
<td>117.5(109.8-124.0)</td>
</tr>
<tr>
<td>IR</td>
<td>43.3(39.8-44.1)</td>
<td>159(146-166)</td>
</tr>
</tbody>
</table>

**Median (IQR)**

<table>
<thead>
<tr>
<th></th>
<th>PaCO2 (mmHg)</th>
<th>PaO2 (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>YM</td>
<td>42.5(40.7-42.5)</td>
<td>124.5(108.8-146.3)</td>
</tr>
<tr>
<td>MM</td>
<td>41.6(39.4-43.6)</td>
<td>127.5(107-130.8)</td>
</tr>
<tr>
<td>FY</td>
<td>45.2(42.3-46.2)</td>
<td>143.5(138.3-173)</td>
</tr>
<tr>
<td>KN</td>
<td>43.7(43.3-44.5)</td>
<td>133(120.3-155.5)</td>
</tr>
<tr>
<td>YS</td>
<td>40.3(37.4-40.9)</td>
<td>158(134.5-200.5)</td>
</tr>
<tr>
<td>KM</td>
<td>37.5(34.3-42.2)</td>
<td>187(176.8-191.5)</td>
</tr>
<tr>
<td>TT</td>
<td>49.0(47.3-51.0)</td>
<td>199(195-215)</td>
</tr>
</tbody>
</table>

**Median (IQR)**
## Result

<table>
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<th>CV</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PaCO₂ (mmHg)</strong></td>
<td>43.3 (38.4-43.9)</td>
<td>42.1 (40.3-45.2)</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Manual intervention</strong></td>
<td>2 (1-2.5)</td>
<td>5 (3-7)</td>
<td>0.007</td>
</tr>
<tr>
<td><strong>Unacceptable PaCO₂</strong></td>
<td>1 (0-2)</td>
<td>1 (0-3)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Unacceptable PaCO₂: > 45mmHg or < 35mmHg

Median (IQR)
Limitations

- Single center, retrospective chart review.

- Small sample size.

- The duration of neuro-protection was limited to first 24 hours post trauma.

- Closed loops in these systems rely on the availability and quality of the EtCO2 and SpO2 signals.
Conclusion

- Intellivent-ASV can be alternative or even better device for maintaining adequate ventilation with TBI patients.

- The reduction of manual intervention decreases workload, the risk of human errors, and may reduce inadequate ventilation time.