Spontaneous breathing efforts during ARDS ventilation

Laurent Brochard
Conflicts of interest

• Our clinical research laboratory has received research grants for clinical research projects from the following companies:
  – Maquet (NAVA)
  – Covidien (PAV+)
  – Dräger (SmartCare)
  – General Electric (FRC)
  – Respirationics (NIV)
  – Fisher Paykel (Optiflow)
### Acute Respiratory Distress Syndrome

<table>
<thead>
<tr>
<th>Timing</th>
<th>Within 1 week of a known clinical insult or new/worsening respiratory symptoms</th>
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</thead>
<tbody>
<tr>
<td>Chest Imaging (^a)</td>
<td>Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules</td>
</tr>
<tr>
<td>Origin of Edema</td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload; Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present</td>
</tr>
</tbody>
</table>

| Oxygenation \(^b\) | Mild \(200<\frac{\text{PaO}_2}{\text{FiO}_2}\leq 300\) with PEEP or CPAP \(\geq 5\text{ cmH}_2\text{O}\) | Moderate \(100<\frac{\text{PaO}_2}{\text{FiO}_2}\leq 200\) with PEEP \(\geq 5\text{ cmH}_2\text{O}\) | Severe \(\frac{\text{PaO}_2}{\text{FiO}_2}\leq 100\) with PEEP \(\geq 5\text{ cmH}_2\text{O}\) |

\(^a\) Chest X-ray or CT Scan  
\(^b\) If altitude higher than 1000m, correction factor should be made as follows: \(\frac{\text{PaO}_2}{\text{FiO}_2} \times \frac{\text{barometric pressure}}{760}\)  
\(^c\) This may be delivered non-invasively in the Mild ARDS group
Increasing Severity of Lung Injury

- Mild ARDS
- Moderate ARDS
- Severe ARDS

Low Tidal Volume Ventilation

- Low – Moderate PEEP
- NIV
- Higher PEEP

Increasing Intensity of Intervention

- ECMO
- HFO
- Neuromuscular Blockade
- Prone Positioning

Ferguson N et al ICM 2012
Why is spontaneous breathing desirable?

- Preserve Respiratory Muscle Function (avoid VIDD)
- Improve VA/Q and Regional Ventilation

Neuromuscular Blockers in Early Acute Respiratory Distress Syndrome

PNO 4% vs 12%

Papazian L. NEJM 2010
Modes of ventilation

• Controlled MV
• Assist Control?
• Bilevel Pressure Ventilation?
• Pressure Support ventilation?
Volume Assist-Control

Flow (L/sec)

Paw (cm H₂O)

Akouniamaki E et al CHEST in press
Pressure Assist-Control

Paw (cm H2O)

Flow (L/sec)

Akouniamaki E et al CHEST in press
Entrainment: reverse triggering

Akouniamaki E et al CHEST in press
Spontaneous Breathing (CPAP)

PCV
Volume vs. Pressure-targeted modes: what’s the difference?

**Volume-control:**
TransPulmonary Pressure is controlled

**Pressure-control:**
TransPulmonary Pressure is NOT controlled
Long-Term Effects of Spontaneous Breathing During Ventilatory Support in Patients with Acute Lung Injury

CHRISTIAN PUTENSEN, SABINE ZECH, HERMANN WREGGE, JÖRG ZINSERLING, FRANK STÜBER, TILMANN VON SPIEGEL, and NORBERT MUTZ

Airway pressure release ventilation versus assist-control ventilation: a comparative propensity score and international cohort study

High and low Paw with APRV/BIPAP (white squares) and ACV (black circles). Daily ratio of PaO2 to FiO2 (grey columns cases and white columns controls)
Outcomes of patients included in the matched-case study

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Cases N = 234</th>
<th>Controls N = 234</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days of mechanical ventilation, median (interquartile range)</td>
<td>3 (2, 5)</td>
<td>3 (2, 6)</td>
<td>0.61</td>
</tr>
<tr>
<td>Days of weaning, median (interquartile range)</td>
<td>1 (1, 2)</td>
<td>1 (1, 2)</td>
<td>0.28</td>
</tr>
<tr>
<td>Reintubation, n (%)</td>
<td>10/140 (7)</td>
<td>10/139 (7)</td>
<td>0.99</td>
</tr>
<tr>
<td>Tracheostomy, n (%)</td>
<td>46 (20)</td>
<td>25 (11)</td>
<td>0.007</td>
</tr>
<tr>
<td>Length of stay in the intensive care unit, median (interquartile range)</td>
<td>6 (3, 14)</td>
<td>6 (3, 12)</td>
<td>0.11</td>
</tr>
<tr>
<td>Mortality in the intensive care unit, n (%)</td>
<td>65 (28)</td>
<td>78 (33)</td>
<td>0.19</td>
</tr>
<tr>
<td>Length of stay in the hospital, median (interquartile range)</td>
<td>18 (11, 38)</td>
<td>17 (8, 31)</td>
<td>0.05</td>
</tr>
<tr>
<td>Mortality in the hospital, n (%)</td>
<td>81 (35)</td>
<td>90 (38)</td>
<td>0.50</td>
</tr>
</tbody>
</table>
Pressure-Preset Modes

No i-synchronization
- APRV

Partial i-synchronization
- BIPAP, DuoPAP, BiVent,
- Bilevel, etc.

Full i-synchronization
- BIPAPAssist, BiPAP PS Assist Pressure controlled, etc.

Akoumianaki E et al. ESICM 2012
VT change in the presence of spontaneous breaths according to i-synchronization

No spontaneous breaths
METHODS: settings

Artificial lung settings
• $C_{Rrs}$: 30 ml/cmH$_2$O
• $R_{Rrs}$: 5 cmH$_2$O/lt/min
• $P_{mus}$: -10 cmH$_2$O
• RR: 20, 30 br/min
• Ti: 0.8 sec

Ventilator settings
• $PAW_{insp}$: 30 cmH$_2$O
• PEEP: 15 cmH$_2$O
• RR: 15/min
• I:E ratios: 1:3 and 3:1
RESULTS: I:E 1/3, RR 20

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**Tidal volume (ml)**

- **No i-Synchronization**
- **Partial i-Synchronization PS 0**
- **Partial i-Synchronization PS 15**
- **Full i-Synchronization**

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**Coefficient of variation (%)**

- **Tidal volume**
- **Coefficient of variation**
RESULTS: I/E 3:1, RR 20

Tidal volume (ml)

Coefficient of variation (%)

--- x --- Tidal volume
--- ◊ --- Coefficient of variation
Bench study: preliminary conclusions

- In the presence of spontaneous breathing the same settings across different Pressure-Preset modes lead to different values of $V_T$, Ptp and breathing variability.

- As i-synchronization increases, VT and Ptp increase while variability decreases.

- These effects of i-synchronization are less pronounced at higher I:E ratio.

- Clinicians should be aware that i-synchronization may be harmful when high VT is undesirable (ARDS).
Proposal for APRV settings 24-48h after inclusion
Sedation plus paralysis

- Thigh = 1.0 à 1.2 sec
- Tlow = 2.0 à 0.8 sec
- Phigh = 30 cmH2O
- Plow = Express
- (RR = 20 à 30 cpm)
- Vt = 6 ml/kg

Positive End-Expiratory Pressure Setting in Adults With Acute Lung Injury and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial

JAMA 2008
BIPAP APRV (EXPRESS) at H24:

- Target sedation based on (SB) as a % of total Vmn total
- Delta Pressure for Vt ≤ 6 ml/kg
The mode of ventilation allowing SB may depend on the stage/severity of ARDS

- Early: controlled with NMBA, (no entrainment?)
- At 48h: non synchronous pressure targeted ventilation (« APRV »)
- Later: synchronous pressure targeted ventilation (« Assist Pressure Control, Pressure Support Ventilation »)
Thank you!

http://mechanicalventilation.wordpress.com/