Plateau and driving pressure during assisted ventilation

Giacomo Bellani, MD, PhD
University of Milan-Bicocca
A.O. San Gerardo
Monza (Italy)
Conflicts of Interest

INSTITUTIONAL:
- Research grants from:
  - Draeger

PERSONAL
- Consultancy fee from: Draeger, Dimar
- Lecturing fees: Draeger, GE Healthcare, Getinge
- Co-owner and president of ReviewerCredits.com
The Comparison of Spontaneous Breathing and Muscle Paralysis in Two Different Severities of Experimental Lung Injury*

Takeshi Yoshida, MD1,2; Akinori Uchiyama, MD, PhD2; Nariaki Matsuura, MD, PhD3; Takashi Mashimo, MD, PhD2; Yuji Fujino, MD, PhD3

(Crit Care Med 2013; 41:536–545)
The dark side of spontaneous breathing

- Sedation
- Muscle Atrophy
- Hemodynamics
- Better V/Q match

The bright side of spontaneous breathing

- Monitoring is Crucial!
- Risk of high Vt
- High inspiratory pressure
- Asynchronies
- $O_2$ Consumption
What is «inspiratory pressure?»

\[ P_{\text{peak}} = 20 \text{ cmH}_2\text{O} \]

\[ P_{\text{peak}} = 10 \text{ cmH}_2\text{O} \]
Sometimes pressures are hidden..
Airway pressure

Transpulm. pressure

Bellani et al. Critical Care (2016) 20:142
PRESSURE SUPPORT

\[ P_{\text{musc}} \geq 0 \]

Pressure

Flow

Volume

Insp. Hold

\[ P_{\text{vent}} \]

\[ P_{\text{ao}} \]

\[ P_{\text{res}} \]

\[ P_{\text{el}} \]

\[ P_{\text{musc}} \]

Ospedale San Gerardo
PRESSURE SUPPORT

Patient relaxes
Insp.- hold

$P_{\text{plateau}}$

Pressure
Flow
Volume

$P_{\text{vent}}$

$P_{\text{ao}}$

$P_{\text{res}}$

$P_{\text{el}}$

$P_{\text{musc}}$

Critical Care Canada Forum

Ospedale San Gerardo
Plateau Pressure during PSV: end inspiratory hold

PIP=20 cmH$_2$O

Plat=19 cmH$_2$O

PIP=10 cmH$_2$O

Plat=19 cmH$_2$O
Do spontaneous and mechanical breathing have similar effects on average transpulmonary and alveolar pressure? A clinical crossover study

Critical Care (2016) 20:142

Giacomo Bellani¹,²,⁴, Giacomo Grasselli²,³, Maddalena Teglia-Drog¹,², Tommaso Mauri³, Andrea Coppadoro⁴, Laurent Brochard⁵,⁶ and Antonio Pesenti¹,²,³
Pplat in PSV with commercial ventilators

Bellani G et al., ICM 2018
Can the Plateau Be Higher Than the Peak Pressure?

Hassan Sajjad¹, Gregory A. Schmidt¹, Roy G. Brower², and Michael Eberlein¹

¹Division of Pulmonary, Critical Care, and Occupational Medicine, University of Iowa Hospitals and Clinics, Iowa City, Iowa; and ²Division of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, Maryland
Presence of active efforts

Courtesy of Benitez JA and Serrano
Hypothesis:
Driving Pressure during Assisted Ventilation in Patients with Acute Respiratory Distress Syndrome is associated with Outcome
Study Design

Single center, observational, retrospective study.
Screened all patients who underwent at least four consecutive days of invasive mechanical ventilation.

**Inclusion criteria:**
- Age greater than 18 years
- At least 24 consecutive hours of controlled mechanical ventilation followed by at least 72 consecutive hours of PSV
- Diagnosis of ARDS

**Exclusion criteria:**
- Pregnancy
- Air leaks (*bronchopleural fistula, pneumothorax*)
Screened (n=1981)

Not included (n=1813)
<18 yrs, <5 days MV, not ARDS,
(not >24 h CMV then >24 h PS)

Included (n=168)
>24 h CMV, Then >24 h PS

Excluded (n=1)
Bronchopleural Fistula

Excluded (n=13)
No Pplat Available

Final (n=154)
Full data available

Bellani G et al., submitted
Reliability of Pplat during PSV
Correlation with CT scan Volume

Bellani G et al., submitted
<table>
<thead>
<tr>
<th></th>
<th>Non-Survivors (n=34)</th>
<th>Survivors (n=120)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure Support (cmH₂O)</strong></td>
<td>10.2 ±2.5</td>
<td>9.3 ±2.6</td>
<td>0.073</td>
</tr>
<tr>
<td><strong>Peak Pressure (cmH₂O)</strong></td>
<td>20.0 ±3.8</td>
<td>20.8 ±4.6</td>
<td>0.359</td>
</tr>
<tr>
<td><strong>Plateau Pressure (cmH₂O)</strong></td>
<td>21.7 [18.9-24.7]</td>
<td>22 [18.8-24.9]</td>
<td>0.893</td>
</tr>
<tr>
<td><strong>PEEP (cmH₂O)</strong></td>
<td>9.9 ±2.8</td>
<td>11.5 ±3.3</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Driving Pressure (cmH₂O)</strong></td>
<td>11.4 [9.0-14.0]</td>
<td>10.0 [8.3-11.3]</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>Tidal Volume (mL·kg⁻¹)</strong></td>
<td>6.7 ±1.5</td>
<td>7.6 ±1.6</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Respiratory Rate (min⁻¹)</strong></td>
<td>17.2 [14.3-19.8]</td>
<td>15.4 [13.0-17.9]</td>
<td>0.004</td>
</tr>
<tr>
<td><strong>C_RS (mL/cmH₂O)</strong></td>
<td>40.1 [29.8-50.0]</td>
<td>51.1 [42.2-61.1]</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>PaO₂/FiO₂ ratio</strong></td>
<td>224.1 [174.3-258.8]</td>
<td>232.5 [200.8-291.3]</td>
<td>0.121</td>
</tr>
<tr>
<td><strong>PaCO₂ (mmHg)</strong></td>
<td>45.4 [42.3-51.2]</td>
<td>45.3 [42.3-49.7]</td>
<td>0.855</td>
</tr>
</tbody>
</table>

Bellani G et al., submitted
Association with outcome

<table>
<thead>
<tr>
<th>Quartiles of Driving Pressure</th>
<th>Quartiles of Peak Pressure</th>
<th>Quartiles of Respiratory System Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔP during assisted ventilation (cmH₂O)</td>
<td>Peak Pressure during assisted ventilation (cmH₂O)</td>
<td>Crs during assisted ventilation (ml/cmH₂O)</td>
</tr>
<tr>
<td>Number of patients in subsample</td>
<td>Number of patients in subsample</td>
<td>Number of patients in subsample</td>
</tr>
<tr>
<td>37</td>
<td>46</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Odds Ratio (95% CI)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL 1 (includes Driving Pressure)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.06 (1.02-1.11)</td>
</tr>
<tr>
<td>SOFA Score</td>
<td>1.23 (1.05-1.44)</td>
</tr>
<tr>
<td>Vₜ during PS (mL/Kg IBW)</td>
<td>0.49 (0.33-0.72)</td>
</tr>
<tr>
<td>PEEP during PS (cmH₂O)</td>
<td>0.80 (0.67-0.97)</td>
</tr>
<tr>
<td>ΔP during PS (cmH₂O)</td>
<td>1.56 (1.24-1.95)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Odds Ratio (95% Confidence Intervals)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL 2 (includes Respiratory System Compliance)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.07 (1.03-1.12)</td>
</tr>
<tr>
<td>SOFA Score</td>
<td>1.22 (1.05-1.43)</td>
</tr>
<tr>
<td>PEEP during PS (cmH₂O)</td>
<td>0.75 (0.62-0.91)</td>
</tr>
<tr>
<td>Crs (% of predicted)</td>
<td>0.88 (0.83-0.93)</td>
</tr>
</tbody>
</table>

Bellani G et al., submitted
Conclusion

- Spontaneous assisted breathing requires careful monitoring
- $P_{\text{plat}}$ can be accurately measured during PSV, same meaning as during CMV (can be higher than $P_{\text{peak}}$!)
- Both DP and Compliance strongly associated with outcome
- If prospectively confirmed, driving pressure might be a useful management target during assisted ventilation