Protective ventilation for ALL patients

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Conflicts of interest

I declare

NO conflicts of interest
To perform Large multicenter clinical studies, randomized controlled trials, and meta-analyses

http://www.provenet.eu/
Ventilator-Induced Lung Injury


A Ventilation at low lung volume

B Ventilation at high lung volume

C Structural consequences

- BAROTRAUMA
- VOLUTRAUMA
- BIOTRAUMA

Pelosi P for the PROVE Network (www.provenet.eu)
Use of Lower Tidal Volumes Benefits Patients with ARDS


- RCT, USA
- 821 ARDS patients
- 6 vs. 12 ml/kg
- stopped early
Use of Lower Tidal Volumes Benefits Patients with ARDS

Putensen C. *Ann Internal Med.* 2009; **151**:566

- 1,297 patients with ARDS from 6 RCTs
- outcome: hospital death

<table>
<thead>
<tr>
<th></th>
<th>No</th>
<th>Low $V_T$ at similar PEEP</th>
<th>High $V_T$ at similar PEEP</th>
<th>Odds ratio</th>
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</thead>
<tbody>
<tr>
<td>Brochard</td>
<td>116</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Brower</td>
<td>52</td>
<td>13/26</td>
<td>12/26</td>
<td>1.17 [0.39 – 3.47]</td>
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<tr>
<td>Brower</td>
<td>861</td>
<td>134/342</td>
<td>171/429</td>
<td>0.68 [0.51 – 0.90]</td>
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<tr>
<td>Stewart</td>
<td>120</td>
<td>30/60</td>
<td>28/60</td>
<td>1.14 [0.56 – 2.34]</td>
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<table>
<thead>
<tr>
<th></th>
<th>No</th>
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<th>Odds ratio</th>
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<td>Amato</td>
<td>53</td>
<td>13/29</td>
<td>17/24</td>
<td>0.33 [0.11 – 1.05]</td>
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<tr>
<td>Villars</td>
<td>95</td>
<td>17/50</td>
<td>24/45</td>
<td>0.41 [0.18 – 0.94]</td>
</tr>
</tbody>
</table>

[METANALYSIS]

Pelosi P for the PROVE Network ([www.provenet.eu](http://www.provenet.eu))
LungSafe – Practice of Ventilation in ICUs Worldwide
Bellani G JAMA. 2016 Feb 23;315(8):788-800

- international observational study
- 2,396 patients with mild, moderate or severe ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation in Intensive Care Unit—patients with the Acute Respiratory Distress Syndrome (ARDS)

- Protective ventilation includes:
  - Tidal volume size
    - 6–8 ml/kg predicted body weight

  - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

Ventilation in Intensive Care Unit—patients with Uninjured Lungs

- Protective ventilation includes:
  - Tidal volume size
    - 6–8 ml/kg predicted body weight

In non ARDS patients lower $V_T$ + lower PEEP are associated with a shorter length of ICU stay.


MD <0 favors strategy A (Low $V_T$/Low PEEP)
Use of Lower Tidal Volumes Benefits Patients without ARDS


- 2,184 ICU patients without ARDS from 7 studies
- outcome: duration of ventilation

Pelosi P for the PROVE Network (www.provenet.eu)
Use of Lower Tidal Volumes Benefits Patients without ARDS

Serpa Neto A. Crit Care Med. 2015; 43:4155

- 2,184 ICU patients without ARDS from 7 studies
- outcome: hospital stay and ARDS development

Pelosi P for the PROVE Network (www.provenet.eu)
• international observational study
• 1,022 patients without ARDS
• 40% of patients $(V_T > 8 \text{ ml/Kg PBW})$
4 New Trials of Low Tidal Volume Ventilation in Patients *without* ARDS

- ‘PReVENT’
- ‘EPALI’
- ISIC–IMIC
- a new ARDS Network trial

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation in Intensive Care Unit–patients with the Acute Respiratory Distress Syndrome (ARDS)

Ventilation in Intensive Care Unit–patients with Uninjured Lungs

Protective ventilation includes:

- Tidal volume size 6–8 ml/kg predicted body weight
  - evidence comes from 2 RCTs [4] and 1 meta–analysis [5]

Protective ventilation includes:

- Tidal volume size 6 ml/kg predicted body weight
  - evidence comes from 2 RCTs [31,32], 1 meta–analysis and 2 IPD meta–analyses [17,18,33]*

Ventilation During General Anesthesia for Surgery

Protective ventilation includes:

- Tidal volume size 6–8 ml/kg predicted body weight
  - evidence comes from 2 RCTs [4] and 1 meta–analysis [5]

Protective ventilation includes:

- Tidal volume size 6–8 ml/kg predicted body weight
  - evidence comes from 2 RCTs [4] and 1 meta–analysis [5]

Intraoperative Use of Low $V_T$ Benefits Surgery Patients without ARDS


- 2,127 surgery patients from 15 studies of intraoperative ventilation
- outcome: PPCs
• international observational study
• 8,241 patients
• 8.1 [7.2–9.1] mL/kg PBW
Ventilation During General Anesthesia for Surgery

Protective ventilation includes:

- Tidal volume size < 8 ml/kg predicted body weight
  - Evidence comes from 3 RCTs [15,22,23] and 2 meta-analyses [14,18]

Ventilation in Intensive Care Unit—patients with Uninjured Lungs

Protective ventilation includes:

- Tidal volume size 6 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [31,32], 1 meta-analysis and 2 IPD meta-analyses [17,18,33]*

- Tidal volume size 6–8 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

Ventilation in Intensive Care Unit—patients with the Acute Respiratory Distress Syndrome (ARDS)

Protective ventilation includes:

- Tidal volume size 6–8 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

- Mild ARDS
- Moderate and severe ARDS

High PEEP Prevents Alveolar Collapse but Increases Hyperinflation

Samary C. Anesthesiology 2015; 123:423

- 48 healthy rats
- intratracheal challenge with *E. coli* LPS
- 1 H of ventilation after 24 H
Use of Higher PEEP Benefits Patient with Moderate or Severe ARDS

Briel M. JAMA 2010; 303:865

- 2,299 ICU patients with ARDS from 3 investigations
- outcome: death

Pelosi P for the PROVE Network (www.provenet.eu)
LungSafe – Practice of Ventilation in ICUs Worldwide

Bellani G JAMA. 2016 Feb 23;315(8):788-800

PEEP in ARDS

- international observational study
- 2,396 patients with mild, moderate or severe ARDS

Mild ARDS 7.4 cmH₂O – Moderate ARDS 8.3 cmH₂O – Severe ARDS 10.1 cmH₂O

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation During General Anesthesia for Surgery

Protective ventilation includes:

- Tidal volume size: < 8 ml/kg predicted body weight

  *evidence comes from 3 RCTs [15, 22, 23] and 2 meta-analyses [14, 18]*

Ventilation in Intensive Care Unit–patients with Uninjured Lungs

Protective ventilation includes:

- Tidal volume size: 6 ml/kg predicted body weight

  *evidence comes from 2 RCTs [31, 32], 1 meta-analysis and 2 IPD meta-analyses [17, 18, 33]*

- Tidal volume size: 6–8 ml/kg predicted body weight

  *evidence comes from 2 RCTs [4] and 1 meta-analysis [5]*

- Level of PEEP: 5–10 cm H₂O

  *evidence comes from 3 RCTs [7, 8, 9] and 1 IPD meta-analysis [10]*

Ventilation in Intensive Care Unit–patients with the Acute Respiratory Distress Syndrome (ARDS)

- mild ARDS

  Protective ventilation includes:

  - Tidal volume size: 6 ml/kg predicted body weight

    *evidence comes from 2 RCTs [31, 32], 1 meta-analysis and 2 IPD meta-analyses [17, 18, 33]*

  - Level of PEEP: 5–10 cm H₂O

    *evidence comes from 3 RCTs [7, 8, 9] and 1 IPD meta-analysis [10]*

- moderate and severe ARDS

  Protective ventilation includes:

  - Tidal volume size: 6–8 ml/kg predicted body weight

    *evidence comes from 2 RCTs [4] and 1 meta-analysis [5]*

  - Level of PEEP: ≥ 10 cm H₂O

    *evidence comes from 3 RCTs [7, 8, 9] and 1 IPD meta-analysis [10]*

Associations between PEEP and outcome of patients without ARDS at onset of ventilation: a systematic review and meta-analysis of randomized controlled trials


**Low PEEP** = 2.0 ± 2.8 cmH$_2$O  
**High PEEP** = 9.7 ± 4.0 cmH$_2$O

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>High PEEP</th>
<th>Low PEEP</th>
<th>Risk Ratio</th>
<th>Year</th>
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<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
</tr>
<tr>
<td>1.3.2 Hospital Mortality</td>
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<tr>
<td>Weigelt JA</td>
<td>16</td>
<td>45</td>
<td>17</td>
<td>34</td>
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<td>Pepe PE</td>
<td>13</td>
<td>44</td>
<td>18</td>
<td>48</td>
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<td>Nelson LD</td>
<td>5</td>
<td>20</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Carroll GC</td>
<td>6</td>
<td>22</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Michalopoulos A</td>
<td>0</td>
<td>21</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Manzano F</td>
<td>19</td>
<td>64</td>
<td>16</td>
<td>63</td>
</tr>
<tr>
<td>Lesur O</td>
<td>9</td>
<td>30</td>
<td>14</td>
<td>33</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>246</td>
<td>246</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total events 68  
Total 72

Heterogeneity: $\tau^2 = 0.04$; $\chi^2 = 6.74$, $df = 5$ ($P = 0.24$); $I^2 = 26$

Test for overall effect: $Z = 0.82$ ($P = 0.41$)

**High PEEP:** No effect on duration of MV – Lower rate of ARDS (high $I^2$)
PRoVENT – Practice of Ventilation in ICUs Worldwide


- international observational study
- 1,022 patients without ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation in Intensive Care Unit–patients with the Acute Respiratory Distress Syndrome (ARDS)

- Mild ARDS
  - Tidal volume size: 6–8 ml/kg predicted body weight
  - Level of PEEP: ≥ 10 cm H₂O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta–analysis [10]

- Moderate and severe ARDS
  - Tidal volume size: 6–8 ml/kg predicted body weight
  - Level of PEEP: 5–10 cm H₂O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta–analysis [10]

Ventilation in Intensive Care Unit–patients with Uninjured Lungs

- Protective ventilation includes:
  - Tidal volume size: < 8 ml/kg predicted body weight
  - Evidence comes from 3 RCTs [15,22,23] and 2 meta–analyses [14,18]

- Protective ventilation includes:
  - Tidal volume size: 6 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [31,32], 1 meta–analysis and 2 IPD meta–analyses [17,18,33]*

- Protective ventilation includes:
  - Tidal volume size: 6–8 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [4] and 1 meta–analysis [5]

Ventilation During General Anesthesia for Surgery

- Protective ventilation includes:
  - Tidal volume size: < 8 ml/kg predicted body weight
  - Evidence comes from 3 RCTs [15,22,23] and 2 meta–analyses [14,18]

- Level of PEEP (< 6 cmH₂O)
  - Convincing RCT evidence is lacking 2 meta–analysis

PEEP Does not Protect Surgery Patients *without* ARDS against PPCs

Hemmes S. *Lancet* 2014; 384:495

- RCT, worldwide
- 900 major abdominal surgery–patients
- 12 vs. 0–2 cm H₂O

‘PROVHILO’, INTERNATIONAL MULTI–CENTER RCT

Pelosi P for the PROVE Network ([www.provenet.eu](http://www.provenet.eu))
Benefit of LP–MV is Better Explained by $V_T$–reductions than PEEP–increases


- 2,127 surgery pts
- from 15 studies of intraoperative ventilation
- outcome: PPC

Pelosi P for the PROVE Network (www.provenet.eu)
international study
8,241 patients
PEEP 4.0 [0.0–5.0] cm H₂O; PEEP 0 and 5 cm H₂O most frequently used

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation During General Anesthesia for Surgery

Protective ventilation includes:

- Tidal volume size < 8 ml/kg predicted body weight
  - Evidence comes from 3 RCTs [15,22,23] and 2 meta-analyses [14,18]

- Level of PEEP ≤ 2 cm H$_2$O
  - Evidence comes from 1 RCT [25] and 1 IPD meta-analysis [14]

Ventilation in Intensive Care Unit—patients with Uninjured Lungs

Protective ventilation includes:

- Tidal volume size 6 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [31,32], 1 meta-analysis and 2 IPD meta-analyses [17,18,33]*

- Level of PEEP (< 6 cm H$_2$O)
  - ??
  - Convincing RCT evidence is lacking 2 meta-analysis

Ventilation in Intensive Care Unit—patients with the Acute Respiratory Distress Syndrome (ARDS)

- Mild ARDS
  - Tidal volume size 6–8 ml/kg predicted body weight
    - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

- Moderate and severe ARDS
  - Tidal volume size 6–8 ml/kg predicted body weight
    - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

- Level of PEEP
  - ≤ 2 cm H$_2$O
    - Evidence comes from 1 RCT [25] and 1 IPD meta-analysis [14]

- 5–10 cm H$_2$O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta-analysis [10]

- ≥ 10 cm H$_2$O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta-analysis [10]

Driving Pressure - Power: the “Polar stars”


\[ \Delta P = P_{\text{plat}, rs} - \text{PEEP} = \frac{V_T}{\text{Cst}} = \frac{V_T}{\text{EELV}} \]

Stress \( \sigma = \frac{\Delta F}{\Delta S} \) (PL)

Energy = \( \Delta P^2 \times (2 \times \text{Est}) \)

Strain \( \varepsilon = \frac{\Delta L}{L_0} \left( \frac{V_T}{\text{EELV}} \right) \)

Power = Energy / Time

Intensity = Power / Area
LungSafe – Practice of Ventilation in ICUs Worldwide

Bellani G JAMA. 2016 Feb 23;315(8):788-800

Pplat and Mortality in ARDS

- international observational study
- 2,396 patients with mild, moderate or severe ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
Driving pressure and survival in the ARDS


Pelosi P for the PROVE Network (www.provenet.eu)
2,396 pts with mild, moderate or severe ARDS
IPD Metaanalysis of studies in ARDS–patients Receiving ELS

Serpa-Neto A et al Intensive Care Med. 2016 Sep 1. [Epub ahead of print]

- 653 patients from 12 studies
- RR for hospital death
- median settings in the first 3 days

<table>
<thead>
<tr>
<th></th>
<th>ALL N = 653</th>
<th>ECMO N = 545</th>
<th>ECCO$_{2}$R N = 108</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR [95%–CI] (p-value) for hospital death</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$V_t$, ml/kg PBW</td>
<td>0.97 [0.87–1.08] (p = 0.602)</td>
<td>0.94 [0.83–1.06] (p = 0.294)</td>
<td>1.03 [0.80–1.32] (p = 0.817)</td>
</tr>
<tr>
<td>PEEP, cm H$_2$O</td>
<td>0.97 [0.92–1.02] (p = 0.249)</td>
<td>0.97 [0.91–1.03] (p = 0.323)</td>
<td>0.92 [0.83–1.02] (p = 0.125)</td>
</tr>
<tr>
<td>Pplat, cm H$_2$O</td>
<td>1.03 [0.97–1.09] (p = 0.298)</td>
<td>1.03 [0.97–1.10] (p = 0.308)</td>
<td>0.94 [0.81–1.10] (p = 0.454)</td>
</tr>
<tr>
<td>$\Delta P$, cm H$_2$O</td>
<td>1.07 [1.02–1.12] (p = 0.004)</td>
<td>1.06 [1.01–1.12] (p = 0.029)</td>
<td>1.19 [1.04–1.35] (p = 0.009)</td>
</tr>
</tbody>
</table>

adjusted for risk of death, age and severity of ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
LungSafe – Practice of Ventilation in ICUs Worldwide

Bellani G JAMA. 2016 Feb 23;315(8):788-800

• 2,396 pts with mild, moderate or severe ARDS
LungSafe – Potentially modifiable factors contributing to outcome from ARDS
Laffey GC et al. Intensive Care Med 2016 (Epub Ahead of Print)

- 2,396 pts with mild, moderate or severe ARDS
- Higher PEEP, lower plateau and driving P, & lower respiratory rate are associated with better survival

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation in Intensive Care Unit–patients with the Acute Respiratory Distress Syndrome (ARDS)

- mild ARDS
  - Protective ventilation includes:
  - Tidal volume size: 6–8 ml/kg predicted body weight
  - Level of PEEP: 5–10 cm H₂O
  - Driving pressure (< 15 cmH₂O)

- moderate and severe ARDS
  - Protective ventilation includes:
  - Tidal volume size: 6–8 ml/kg predicted body weight
  - Level of PEEP: ≥ 10 cm H₂O
  - Driving pressure (< 15 cmH₂O)

Ventilation in Intensive Care Unit–patients with Uninjured Lungs

- Protective ventilation includes:
  - Tidal volume size: 6 ml/kg predicted body weight

- Level of PEEP: ≤ 2 cm H₂O

Ventilation During General Anesthesia for Surgery

- Protective ventilation includes:
  - Tidal volume size: < 8 ml/kg predicted body weight

- Level of PEEP: ≤ 2 cm H₂O

PRoVENT – Practice of Ventilation in ICUs Worldwide


- international observational study
- 1,022 patients without ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
PRoVENT – Practice of Ventilation in ICUs Worldwide


- 1,022 patients without ARDS

Pelosi P for the PROVE Network (www.provenet.eu)
<table>
<thead>
<tr>
<th><strong>Ventilation During General Anesthesia for Surgery</strong></th>
<th><strong>Ventilation in Intensive Care Unit—patients with Uninjured Lungs</strong></th>
<th><strong>Ventilation in Intensive Care Unit—patients with the Acute Respiratory Distress Syndrome (ARDS)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protective ventilation includes:</strong></td>
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<td><strong>Protective ventilation includes:</strong></td>
</tr>
<tr>
<td>Tidal volume size</td>
<td>Tidal volume size</td>
<td>Tidal volume size</td>
</tr>
<tr>
<td>&lt; 8 ml/kg predicted body weight</td>
<td>6 ml/kg predicted body weight</td>
<td>6–8 ml/kg predicted body weight</td>
</tr>
<tr>
<td>evidence comes from 3 RCTs [15,22,23] and 2 meta–analyses [14,18]*</td>
<td>evidence comes from 2 RCTs [31,32], 1 meta–analyses and 2 IPD meta–analyses [17,18,33]*</td>
<td>evidence comes from 2 RCTs [4] and 1 meta–analysis [5]</td>
</tr>
<tr>
<td>Level of PEEP</td>
<td>Level of PEEP</td>
<td>Level of PEEP</td>
</tr>
<tr>
<td>≤ 2 cm H₂O</td>
<td>(&lt; 6 cmH₂O)</td>
<td>5–10 cm H₂O</td>
</tr>
<tr>
<td>evidence comes from 1 RCT [25] and 1 IPD meta–analysis [14]</td>
<td><strong>Convincing RCT evidence is lacking 1 meta-analysis</strong></td>
<td>evidence comes from 3 RCTs [7,8,9] and 1 IPD meta–analysis [10]</td>
</tr>
<tr>
<td>Driving pressure (&lt; 13 cmH₂O)</td>
<td>Driving pressure (&lt; 15 cmH₂O)</td>
<td>Driving pressure (&lt; 15 cmH₂O)</td>
</tr>
<tr>
<td>Plateau pressure (&lt; 20 cmH₂O)</td>
<td>Plateau pressure (&lt; 25-27 cmH₂O)</td>
<td>Plateau pressure (&lt; 25-27 cmH₂O)</td>
</tr>
<tr>
<td>??</td>
<td>?????</td>
<td>suggestion comes from several studies and 1 IPD meta–analysis [10]</td>
</tr>
<tr>
<td>studies are lacking</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intraoperative protective mechanical ventilation and risk of postoperative respiratory complications: hospital based registry study

Ladha K et al. BMJ 2015;351:h3646

![Graph showing odds ratio of postoperative pulmonary complications vs. plateau pressure fourth (associated range, cm H2O).](image)
Driving Pressure (\(\Delta P,_{rs}\)) & PPCs


HIGHER DRIVING PRESSURES (>13 cmH\(_2\)O) INCREASE THE RISK OF PPCs

2,679 patients from 15 RCTs

Pelosi P for the PROVE Network (www.provenet.eu)
Ventilation During General Anesthesia for Surgery

**Protective ventilation includes:**

- **Tidal volume size**
  - < 8 ml/kg predicted body weight
  - Evidence comes from 3 RCTs [15,22,23] and 2 meta-analyses [14,18]

- **Level of PEEP**
  - ≤ 2 cm H$_2$O
  - Evidence comes from 1 RCT [25] and 1 IPD meta-analysis [14]

- **Driving pressure (< 13 cmH$_2$O)**
  - Plateau pressure (< 17 cmH$_2$O)
  - Suggestion comes from several studies and 1 IPD meta-analysis [10]

Ventilation in Intensive Care Unit–patients with Uninjured Lungs

**Protective ventilation includes:**

- **Tidal volume size**
  - 6 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [31,32], 1 meta-analysis and 2 IPD meta-analyses [17,18,33]*

- **Level of PEEP (< 6 cmH$_2$O)**
  - Convincing RCT evidence is lacking 1 meta-analysis

- **Driving pressure (< 13 cmH$_2$O)**
  - Plateau pressure (< 20 cmH$_2$O)
  - Studies are lacking

Ventilation in Intensive Care Unit–patients with the Acute Respiratory Distress Syndrome (ARDS)

**Protective ventilation includes:**

- **Tidal volume size**
  - 6–8 ml/kg predicted body weight
  - Evidence comes from 2 RCTs [4] and 1 meta-analysis [5]

- **Level of PEEP**
  - 5–10 cm H$_2$O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta-analysis [10]

- **Driving pressure (< 15 cmH$_2$O)**
  - Pplat (< 25-27 cmH$_2$O)
  - Suggestion comes from several studies and 1 IPD meta-analysis [10]

**mild ARDS**

Moderate and severe ARDS

- **Level of PEEP**
  - ≥ 10 cm H$_2$O
  - Evidence comes from 3 RCTs [7,8,9] and 1 IPD meta-analysis [10]

- **Driving pressure (< 15 cmH$_2$O)**
  - Pplat (< 25-27 cmH$_2$O)
  - Suggestion comes from several studies and 1 IPD meta-analysis [10]

Protective Mechanical Ventilation
In ALL patients

LOWER IS BETTER
...except higher PEEP in severe ARDS (?)
Use of Lower Tidal Volumes Benefits Patients without ARDS

Determann R. *Crit Care* 2010; 14:R1

- RCT, the Netherlands
- 150 patients at risk for ARDS
- 6 vs. 10 ml/kg
- stopped early

Pelosi P for the PROVE Network (www.provenet.eu)
Use of Higher PEEP Does not Benefit Patients without ARDS


- RCT, USA
- 92 ICU patients without ARDS
- 8 vs. 0 cm H₂O PEEP

[Randomized Controlled Trial]

Pelosi P for the PROVE Network ([www.provenet.eu](http://www.provenet.eu))
Use of Higher PEEP May Benefit Patient without ARDS

Manzano F. Crit Care Med 2008; 36:2225

- RCT, Spain
- 131 ICU patients without ARDS
- 5–8 vs. 0 PEEP
- no mortality or LOS differences

Pelosi P for the PROVE Network (www.provenet.eu)