Mechanical Ventilation
Year in Review - 2013

Bruce P. Krieger, MD, FACP, FCCP
Clinical Professor of Medicine (courtesy)
University of Florida - Jacksonville
Professor of Medicine (vol)
University of Miami
Medical Director Critical Care Center
Memorial Hospital Jacksonville

I have no conflicts of interest to disclose,
just interesting conflicts
Mechanical Ventilation - Methodology
Year in Review - 2013

◊ Methods
- Online and manual search of relevant journals
- 134 articles concerning aspects of MVS screened

◊ Criteria for inclusion
- Clinical, adult human studies
- Clinically relevant
  - Either: novel, controversial, confirmatory, pragmatic, cute
  - Grading system...what I thought would be of interest
  - Reviewed rigorous studies, smaller journals, debates, editorials
  - Review included the “popular “articles from major journals
Historically, which was the first method to provide effective positive pressure?

a) volume - controlled ventilation
b) pressure - controlled ventilation
c) time - cycled ventilation
d) CPAP via mask
e) iron lung (the Drinker ventilator)
Use of NIPPV in Acute Respiratory Failure
Population Study 2000-2009

◊ Nationwide Inpatient Sample 11,659,668 pts
➢~1,000 hospitals (~20% of all pts in US)-billing data

![Graph showing incidence of COPD and non-invasive ventilation over time.](image-url)

- No COPD: Mechanical ventilation via endotracheal tube
- COPD: Mechanical ventilation via endotracheal tube
- COPD: Non-invasive ventilation (**250% increase**)
- No COPD: Non-invasive ventilation (**400% increase**)

Incidence/100,000 US residents

Year:
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
Use of NIPPV in Acute Respiratory Failure
Population Study 2000-2009

◊ NIPPV failure higher in non-COPD pts (p<0.001)

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COPD (n=409,062)</td>
<td>Reference</td>
</tr>
<tr>
<td>Sepsis (n=12,962)</td>
<td>1.07 (0.97-1.19)</td>
</tr>
<tr>
<td>Heart failure (n=153,489)</td>
<td>1.08 (1.04-1.13)</td>
</tr>
<tr>
<td>Asthma (n=24,438)</td>
<td>1.18 (1.09-1.28)</td>
</tr>
<tr>
<td>Pneumonia (n=78,162)</td>
<td><strong>1.70 (1.51-1.93)</strong></td>
</tr>
<tr>
<td>Neuro Dx (n=9,075)</td>
<td>0.95 (0.89-1.01)</td>
</tr>
</tbody>
</table>

◊ Failed NIPPV had **HIGHER** hosp mortality vs ETT

➢ Odds Ratio = 1.14 (1.11-1.17; p < 0.001)

“First Do No Harm”
Disease Categories Treated with NIPPV

◊ Obstructive lung disease
  ➢ COPD, upper airway obstruction
  ➢ Asthma, cystic fibrosis

◊ Acute cardiogenic pulmonary edema

◊ Restrictive lung diseases
  ➢ Chest wall deformities, muscular dystrophies
  ➢ Obesity Hypoventilation Syndrome (OHS)

◊ Do-not-intubate situations

◊ Hypoxemic respiratory failure
  ➢ ARDS, trauma, post-operative
  ➢ Immunocompromised host
  ➢ Pneumonia

Hill, Nicholas, Editor. NIPPV: Principles & Applications. Armonk, NY; Futura, 2001

NIPPV in Acute Hypercarbic OHS vs COPD

(PaCO2 = 84 vs 86; pH=7.22 vs 7.22)
Carillo A, Torres A, et al. AJRCCM 2012; 186:1279-1285

◊ Spanish Study of NIPPV
  ➢ 1/97-12/10, n = 3,075 used NIPPV
  ➢ 173 (6%) had OHS
  ➢ 543 (18%) had COPD
    • 184 had co-existing OHS

◊ Success rate (BiPAP 12/5 initial)
  • No ETT, better ABG
  • Alive & conscious > 24 hrs after ICU discharge
  ➢ OHS 94%; COPD 89%
    • P = 0.11

◊ Conclusion
  ➢ OK to use NIPPV for acute hypercarbic OHS exacerbations
“Weaning” or “Liberation”

“Wean”
- to accustom to loss of mother’s milk
- get along without some special comfort or object of desire

“Liberate”
- to free from domination; unload; unshackle; unburden; disencumber; disentangle; deoppilate

Working Definition

Transition from mechanical support to stable spontaneous breathing
Is Weaning an Art...  
...or a Science?

◊ Weaning
  ➢ often making a mountain out of a molehill

◊ Most patients (80%) do not need to be weaned

◊ Most “weaning failures” are the clinician’s failure to predict an imbalance between supply and demand

Weaning Strategies

◊ It’s about time
◊ Wait until Monday
◊ Recovery room wean
◊ Sink or swim
◊ Untie their hands
◊ OOPS
The Weaning Index (WI)
In Search of the Holy Grail of Weaning

◊ WI = RSBI x EI x VDI (threshold < 101)
  ➢ EI – elastance index = PIP/P_{I_{max}} (threshold < 1)
   • PIP determined with Vt = 8 ml/kg
  ➢ VDI = ventilatory demand index = Ve/10 (threshold< 1)
   • Ve while fully controlled on AC; idea based on Sahn 1973
  ➢ RSBI (f/Vt) while on CPAP 0 & PS 0 for one minute

◊ Single institution study; n = 59
  ➢ ARDS (17), PNA (13), COPD (9), ICH (6), pancreatitis (3)
The Weaning Index (WI)

In Search of the Holy Grail of Weaning

◊ Weaning protocol

- Screening trial x 10 min on SIMV 10, PEEP 5, PS 10
  - If RR < 25, changed to CPAP 0 & PS 0
- RSBI while on CPAP 0 & PS 0 for one min
  - If RSBI < or = 105, patient extubated

◊ Results

<table>
<thead>
<tr>
<th>WI &lt; or = 100</th>
<th>Success</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>WI &gt; 100</td>
<td>1</td>
<td>16</td>
</tr>
</tbody>
</table>

- Sensitivity 40/41 = 0.975
- Specificity 16/18 = 0.89

PPV = 40/42 = 0.95
NPV = 16/17 = 0.94

Diagnostic Accuracy = 95.9%
### The Weaning Index (WI)

*In Search of the Holy Grail of Weaning*


<table>
<thead>
<tr>
<th>Study</th>
<th>Test</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yang &amp; Tobin (1991)</td>
<td>f/Vt</td>
<td>97</td>
<td>64</td>
<td>78</td>
<td>95</td>
</tr>
<tr>
<td>Jabous, et al (1991)</td>
<td>PTI x Ve_{40}/Vt_{spont}</td>
<td>96</td>
<td>95</td>
<td>96</td>
<td>85</td>
</tr>
<tr>
<td>Sassoon, et al (1993)</td>
<td>P_{0.1} x f/Vt</td>
<td>97</td>
<td>60</td>
<td>89</td>
<td>86</td>
</tr>
<tr>
<td>Present study (2013)</td>
<td>WI</td>
<td>87</td>
<td>78</td>
<td>95</td>
<td>94</td>
</tr>
</tbody>
</table>

Pti=pressure-time index; Ve_{40} (Ve required for PaCO2=40); Vt_{spont} = spontaneous Vt

**Conclusions:** more specific that RSBI; easier than using P_{0.1} or PTI faster than a spontaneous breathing trial.....but......
Inspiratory Muscle Training Did Not Accelerate Weaning from MVS

◊ Methods

- Inspiratory loading device set at 40% MIP
  - 5 sets x 10 breaths bid; clinicians blinded to intervention

◊ Results

<table>
<thead>
<tr>
<th></th>
<th>Experimental (n=45)</th>
<th>Control (n=47)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>64</td>
<td>65</td>
</tr>
<tr>
<td>Apache II</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>GCS</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>MIP change*</td>
<td>7</td>
<td>-3</td>
</tr>
<tr>
<td>Vt change (ml)*</td>
<td>56</td>
<td>-16</td>
</tr>
<tr>
<td>RSBI</td>
<td>-21</td>
<td>-7</td>
</tr>
<tr>
<td>Duration MV (hrs)</td>
<td>219</td>
<td>220</td>
</tr>
<tr>
<td>Weaning (hrs)</td>
<td>53</td>
<td>61</td>
</tr>
</tbody>
</table>

*p < 0.05
## Comparison of Weaning Methods

Prospective, Randomized with 29-37 in Each Group

<table>
<thead>
<tr>
<th>Method</th>
<th>Days to Wean</th>
<th>Weaned</th>
<th>Re-intubated</th>
<th>&gt;13 days of MVS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMV</td>
<td>5</td>
<td>69%</td>
<td>14%</td>
<td>17%</td>
</tr>
<tr>
<td>PSV</td>
<td>4</td>
<td>62%</td>
<td>19%</td>
<td>11%</td>
</tr>
<tr>
<td>OneDaily SB Trial</td>
<td>3</td>
<td>71%</td>
<td>23%</td>
<td>3%</td>
</tr>
<tr>
<td>Multiple SB Trials</td>
<td>3</td>
<td>82%</td>
<td>15%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Esteban, Frutos, Tobin et al. NEJM 1995;332:345-50
Pooled data from 15 trials (1143 adults, 30 kids)

- **Weaning duration decreased** 32% (CI 19-46, p=0.002)
  - However, heterogeneity substantial
  - Significant only for mixed or MICU populations, not SICU
  - Significant for Smartcare/PS system only (p=0.02)

- **MVS duration reduced** 17% (CI 8-26, p<0.05)

- **ICU LOS reduced 11%** (CI 0-21, p < 0.05)

- Mortality & Hospital LOS **not** significantly improved

- Need multi-center randomized controlled trials
### Wean Earlier & Automatically

**Canadian Study, 9 ICU’s**

Burns KE et al. AJRCCM 2013;187:1203-1211

<table>
<thead>
<tr>
<th></th>
<th>Automatic Wean N = 49</th>
<th>Protocolized Wean N = 43</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline characteristics</td>
<td>Age, Dx, etc</td>
<td>MVS days prior</td>
<td>&gt;0.13</td>
</tr>
<tr>
<td>Time to 1st successful SBT (d)*</td>
<td>1.0</td>
<td>4.0</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Duration of MVS (days)</td>
<td>10.5</td>
<td>11.0</td>
<td>0.13</td>
</tr>
<tr>
<td>Time to successful extubation (d)*</td>
<td>4.0</td>
<td>5.0</td>
<td>0.01</td>
</tr>
<tr>
<td>ICU mortality</td>
<td>18.4%</td>
<td>20.4%</td>
<td>0.8</td>
</tr>
<tr>
<td>Hospital mortality</td>
<td>26.55</td>
<td>25.6%</td>
<td>0.9</td>
</tr>
<tr>
<td>Re-intubation</td>
<td>18.8%</td>
<td>25.6%</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Automated Weaning via SmartCare (Evita, Draeger)**
- adjusts PS via f, Vt, and PetCO2

**Protocolized Weaning via written protocol for RTs**
- q 4-6 hr evaluations to adjust PS (24 hr/day)
Wean Earlier & Automatically

Burns KE et al. AJRCCM 2013;187:1203-1211

% Successfully Extubated

Days to Successful Extubation

P = 0.0178
The Decision to Extubate in the ICU

<table>
<thead>
<tr>
<th>Study (Reference)</th>
<th>Number of Extubations</th>
<th>Rate of Extubation Failure [% (n)]</th>
<th>ICU Mortality in Reintubated Patients [% (n)]</th>
<th>ICU Mortality in Nonreintubated Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esteban et al., 1997 (1)</td>
<td></td>
<td>19 (74)</td>
<td>27 (20)</td>
<td>3</td>
</tr>
<tr>
<td>Esteban et al., 1999 (2)</td>
<td></td>
<td>13 (61)</td>
<td>33 (20)</td>
<td>5</td>
</tr>
<tr>
<td>Epstein et al., 1997 (4)</td>
<td></td>
<td>14 (40)</td>
<td>43 (17)</td>
<td>12</td>
</tr>
<tr>
<td>Vallverdu et al., 1998 (3)</td>
<td></td>
<td>15.5 (23)</td>
<td>35 (8)</td>
<td>5.6</td>
</tr>
<tr>
<td>Thille et al., 2011 (6)</td>
<td></td>
<td>15 (26)</td>
<td>50 (13)</td>
<td>5</td>
</tr>
<tr>
<td>Frutos-Vivar et al., 2011 (14)</td>
<td></td>
<td>16 (180)</td>
<td>28 (50)</td>
<td>7</td>
</tr>
<tr>
<td>Funk et al., 2009 (38)</td>
<td></td>
<td>10 (26)</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Tonnelier et al., 2011 (39)</td>
<td></td>
<td>10 (12)</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Sellares et al., 2011 (34)</td>
<td></td>
<td>20 (36)</td>
<td>Not available</td>
<td>Not available</td>
</tr>
<tr>
<td>Peñuelas et al., 2011 (40)</td>
<td></td>
<td>10 (278)</td>
<td>26 (72)</td>
<td>5</td>
</tr>
</tbody>
</table>

◊ Extubation facts: 10-20% failure rate despite meeting all criteria

Associated with a 25-50% mortality rate
Extubation & the Myth of “Minimal Ventilator Settings”
Tobin M. Am J Respir Crit Care Med. 2012;185:349-350

◊ Tobin still recommends 30 min T-Piece trials

➢ Alternative: Flow-by with no PS nor PEEP

◊ What you see is what you get:

➢ The breathing pattern before extubation (no PS, ZEEP) was the same as after extubation (n=50)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Extubation</th>
<th>Post-extubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Rate</td>
<td>23.3 (5.3)</td>
<td>24.3 (5.5)</td>
</tr>
<tr>
<td>Vt (ml)</td>
<td>423 (139)</td>
<td>435 (169)</td>
</tr>
<tr>
<td>V_t (liters)</td>
<td>9.32 (3.26)</td>
<td>9.74 (3.83)</td>
</tr>
<tr>
<td>% Rib Cage</td>
<td>52.1 (1.6)</td>
<td>51.0 (1.4)</td>
</tr>
</tbody>
</table>

Work of Breathing (WOB)
Before & After Extubation from a T-Piece

Pressure Support (PS) vs Trache Collar (TC) in Patients Requiring Prolonged Mechanical Ventilation

Jubran A...Tobin. JAMA 2013;309:671-677

◊ Methods - single LTACH from 2000-2010

- 500 screened (200-2010) via 5 day TC trial
  - 316 failed were randomly assigned
- PS group: PS decreased by 2 at 0800, 1400, 2000
  - PS titrated for RR <30; initial PS 14
  - Once PS 6 reached, trache collar for 5 days
- TC group
  - TC for up to 12 hrs qd
  - Once 3 successful 12 hr periods reached, TC for 5 days
- 5 days of TC considered successful wean
Definition of Weaning Failure

Criteria A
- HR > (220-age) x 0.8 beats/min
- BP sys < 80
- SpO2 , 90%
- Patient request

Criteria B
- RR > 35
- BP sys > 180
- Agitation
- Diaphoresis
PS vs Trache Collar in LTACH Wean

Jubran A...Tobin. JAMA 2013;309:671-677

% Remaining on MVS

Log-rank $P = .016$

No. of patients at risk
- Pressure support 152
- Tracheostomy collar 160
Effect of Vent Mode on Sleep Quality in Critically Ill Patients

Parthasarathy & Tobin. A J Respir Crit Care Med 2002;166:1423-1429

◊ 11 patients
◊ AC with $V_t = 8 \text{ ml/kg}$ vs CPAP with PS set to achieve 8 ml/kg
  ➢ AC RR 4 below awake RR
◊ Sleep fragmentation more in PS (79+/−7) vs AC (54+/−7)
  ➢ $P=0.02$

CPAP + PS induced more central apneas
Sleep Quality in Tracheostomized Patients
CPAP/PS (MV) vs T-piece/Trache Collar

◊ Single institution study; n=16
  • No sedation > 48 hrs; able to tolerate T-p or TC > 5 hrs
  • Single night study (5 hrs CPAP + PS and 5 hrs T-p or TC)
    – PS adjusted for RR 25 & Vt 6 ml/kg

◊ Results

<table>
<thead>
<tr>
<th></th>
<th>Spontaneous</th>
<th>MV</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Sleep Time</td>
<td>132 mi</td>
<td>183 min</td>
<td><strong>0.04</strong></td>
</tr>
<tr>
<td>Stages 1-2</td>
<td>68%</td>
<td>67%</td>
<td>0.36</td>
</tr>
<tr>
<td>Stages 3-4</td>
<td>16%</td>
<td>27%</td>
<td>0.57</td>
</tr>
<tr>
<td>REM</td>
<td>2%</td>
<td>9%</td>
<td>0.14</td>
</tr>
<tr>
<td>Fragmentation</td>
<td>23/hr</td>
<td>25/hr</td>
<td>0.65</td>
</tr>
</tbody>
</table>

◊ Conclusions
  ➢ MV improved sleep duration but not quality
  • Suggest using MV qhs at least in the beginning of weaning
Reference textbook of Sleep Disorders Medicine

Dr. Seuss's SLEEP BOOK
Which ventilatory strategy often worsens the PaO2/FiO2 ratio in patients with ARDS?

a) Pressure controlled–inverse ratio ventilation
b) Prone position
c) Vt (6 ml/kg IBW) strategy
d) Nitric Oxide
e) High-frequency oscillatory jet vent
# ARDS Network - Outcomes

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lower Vt</th>
<th>Traditional</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>31%</td>
<td>40%</td>
<td>0.007</td>
</tr>
<tr>
<td>No MVS @ day 28</td>
<td>66%</td>
<td>55%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Baro-trauma</td>
<td>10%</td>
<td>11%</td>
<td>0.43</td>
</tr>
<tr>
<td>Days with no MSOF</td>
<td>15</td>
<td>12</td>
<td>0.006</td>
</tr>
<tr>
<td>Interleukin 6, day 3</td>
<td>2.0 pg/ml</td>
<td>2.3 pg/ml</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

NEJM 2000;342:1301-8
High-Frequency Ventilation
The “Ultimate” Lung Protective Strategy
High Frequency Oscillatory Ventilation

No Statistical Effect on Survival

<table>
<thead>
<tr>
<th></th>
<th>HFOV</th>
<th>CV MVS</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>75</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td><strong>Alive off MVS</strong></td>
<td>27</td>
<td>23</td>
<td>0.686</td>
</tr>
<tr>
<td></td>
<td>(36%)</td>
<td>(31%)</td>
<td></td>
</tr>
<tr>
<td><strong>Alive on MVS</strong></td>
<td>20</td>
<td>12</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td>(26%)</td>
<td>(16%)</td>
<td></td>
</tr>
<tr>
<td><strong>Dead</strong></td>
<td>28</td>
<td>38</td>
<td>0.102</td>
</tr>
<tr>
<td></td>
<td>(37%)</td>
<td>(52%)</td>
<td></td>
</tr>
</tbody>
</table>
Hospital or 30 day mortality in patients with acute lung injury/acute respiratory distress syndrome allocated to high frequency oscillation or conventional MVS

Sud S et al. BMJ 2010;340:bmj.c2327 (5/18/10)

Reviewed 2,995 citations; only 8 met criteria (total n=431)

*20% of patients were children*

Derdak & Bollen study started HFO in < 2 days

<table>
<thead>
<tr>
<th></th>
<th>High frequency oscillation</th>
<th>Conventional mechanical ventilation</th>
<th>Risk ratio (95% CI)</th>
<th>Weight (%)</th>
<th>Risk ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnold 1994</td>
<td>10/29</td>
<td>12/29</td>
<td></td>
<td>13.0</td>
<td>0.83 (0.43 to 1.62)</td>
</tr>
<tr>
<td>Derdak 2002</td>
<td>28/75</td>
<td>38/73</td>
<td></td>
<td>42.6</td>
<td>0.72 (0.50 to 1.03)</td>
</tr>
<tr>
<td>Shah 2004</td>
<td>6/15</td>
<td>6/13</td>
<td></td>
<td>7.9</td>
<td>0.87 (0.37 to 20.4)</td>
</tr>
<tr>
<td>Bollen 2005</td>
<td>16/37</td>
<td>8/24</td>
<td></td>
<td>12.5</td>
<td>1.30 (0.66 to 2.55)</td>
</tr>
<tr>
<td>Mentzelopoulos 2007</td>
<td>11/27</td>
<td>18/27</td>
<td></td>
<td>20.6</td>
<td>0.61 (0.36 to 1.04)</td>
</tr>
<tr>
<td>Samransamruajkit 2005*</td>
<td>2/6</td>
<td>5/10</td>
<td></td>
<td>3.4</td>
<td>0.67 (0.18 to 2.42)</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>73/189</td>
<td>87/176</td>
<td></td>
<td>100.0</td>
<td>0.77 (0.61 to 0.98)</td>
</tr>
</tbody>
</table>

Test for heterogeneity: $\tau^2=0.00$, $\chi^2=3.36$, df=5, $P=0.64$, $I^2=0$

Test for overall effect: $z=2.12$, $P=0.03$
High-Frequency Oscillation in Early ARDS

“OSCILLATE” Trial Investigators

◊ Randomized-controlled trial in 39 ICUs
   ➢ Canada & US > Mexico, Saudi Arabia, India
   ➢ Initial goal: 1200 patients
   ➢ Terminated after interim analysis of 500 patients
     • Increased mortality in HFOV group (47% vs 35%, p=0.005)

◊ Methods
   ➢ Goals: PaO2: 55-80 mmHg; pH > 7.25
   ➢ Control Vt 6 ml/kg; Pplateau <35; high PEEP 20

# High-Frequency Oscillation in Early ARDS

**“OSCILLATE” Trial Investigators**

## Physiology at Time of Randomization

<table>
<thead>
<tr>
<th></th>
<th>HFOV</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>FiO2</td>
<td>0.75</td>
<td>0.73</td>
</tr>
<tr>
<td>pH</td>
<td>7.31</td>
<td>7.30</td>
</tr>
<tr>
<td>P : F ratio</td>
<td>116</td>
<td>113</td>
</tr>
<tr>
<td>PEEP</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

## Mortality - Multivariate Analysis

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HFOV Use</strong></td>
<td>1.66 (1.12 - 2.46)</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>1.42 (1.24 - 1.63)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Acute Physiology Score</strong></td>
<td>1.49 (1.26 - 1.76)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Days Prior to Trial</strong></td>
<td>1.10 (1.06 - 1.10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Sepsis</strong></td>
<td>1.17 (0.66 – 2.06)</td>
<td>0.59</td>
</tr>
</tbody>
</table>
Prone Positioning in ARDS

Stocker et al. Chest 1997; 111:1008-17; 25 trauma ARDS pts
Prone Positioning in ARDS

**Rationale, Indications, and Limits**

*CT Scans  Supine and Prone*

Gattinoni L, Marini JJ, et al. AJRCCM 2013;188:1286-1293
Prone Positioning in ARDS

Rationale, Indications, and Limits

Gattinoni L, Marini JJ, et al. AJRCCM 2013;188:1286-1293
Effects of Prone Positioning

- Increase in FRC
  - volume recruited in the posterior lung (which receives the greatest proportion of perfusion)
- Regional V & V/Q more uniform
  - diaphragm & chest wall mechanics aided
  - less distortion from heart, mediastinum & diaphragm
- Dorsal-to-ventral orientation allows better drainage
- Results in improved oxygenation & possibly reduced incidence of VALI

Messerole, Peine, Wittkopp, Marini, Albert. AJRCCM 2002;165:1359-63
Randomized Prone (≥20 hrs/d) vs Supine Trial in ARDS

**Physiology (p<0.05)**

- **mmHg**
  - Supine: 350, Prone: 300, p=0.001
  - Supine: 300, Prone: 250, p=0.001
  - Supine: 250, Prone: 200, p=0.07

- **PaO2/FiO2**
  - Supine: 200, Prone: 150, p=0.74

- **PaCO2**
  - Supine: 7.5, Prone: 7.4, p=0.007

- **pH**
  - Supine: 7.4, Prone: 7.3, p=0.304

- **Respiratory Rate**
  - Supine: 25, Prone: 20, p=0.043

**Survival (p=0.27)**

Number of patients at risk:
- Supine group: 40, 31, 28, 28, 28, 28, 28
- Prone group: 55, 47, 46, 44, 44, 44

Survival probability graph:
- Prone: 100, 90, 80, 70, 60, 50, 40, 30, 20, 10
- Supine: 100, 80, 60, 40, 20, 10

Mancebo J…Albert RK. AJRCC 2006;173;1233-39
**Prone - Supine II Study**

◊ **Methods**
  - Randomized, multi-institutional study of 342 adults
  - 23 Italian and 2 Spanish ICU’s
  - 168 prone for 20 hrs/d; 174 supine

◊ **Results**
  - Mortality at 28 days: 31.0 vs 32.8%
    - RR 0.97; 95% CI 0.84-1.13;   p=0.72
  - Mortality at 6 months: 47.0 vs 52.3%
    - RR 0.90; 95% CI 0.73-1.11;   p=0.33
Prone Positioning in Severe Acute Respiratory Distress Syndrome

Guerin C, et al for the PROSEVA Study Group
(Proning Severe ARDS Patients)

◊ Methods

◊ ARDS criteria (after 12-24 hrs MVS stabilization)

   ➢ PaO2:FiO2<150 with FiO2>0.59 & PEEP >4
     • Vt ~6ml/kg IBW
   ➢ 26 French ICUs and 1 in Spain

◊ Prone group turned within 1 hr of randomization

   ➢ > 16 hrs prone, then supine for up to 4 hrs
   ➢ Criteria to stop prone position (met for 4 hrs supine)
     • P:F ratio>149 with PEEP<11 & FiO2<0.61
   ➢ Daily trials continued for up to 28 days
### PROSEVA Trial

**Parameters at the Time of Inclusion in Study**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Supine Group (N = 229)</th>
<th>Prone Group (N = 237)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume (ml)</td>
<td>381 ± 66</td>
<td>384 ± 63</td>
</tr>
<tr>
<td>Tidal volume (ml per kg of PBW)</td>
<td>6.1 ± 0.6</td>
<td>6.1 ± 0.6</td>
</tr>
<tr>
<td>Respiratory frequency (breaths per min)</td>
<td>27 ± 5</td>
<td>27 ± 5</td>
</tr>
<tr>
<td>PEEP (cm of water)</td>
<td>10 ± 4</td>
<td>10 ± 3</td>
</tr>
<tr>
<td>Fio₂</td>
<td>0.79 ± 0.16</td>
<td>0.79 ± 0.16</td>
</tr>
<tr>
<td>Pplat&lt;sub&gt;RS&lt;/sub&gt; (cm of water)</td>
<td>23 ± 5</td>
<td>24 ± 5</td>
</tr>
<tr>
<td>Cst&lt;sub&gt;RS&lt;/sub&gt; (ml per cm of water)</td>
<td>35 ± 15</td>
<td>36 ± 23</td>
</tr>
<tr>
<td>Pao₂ (mm Hg)</td>
<td>80 ± 18</td>
<td>80 ± 19</td>
</tr>
<tr>
<td>Pao₂:Fio₂ (mm Hg)</td>
<td>100 ± 20</td>
<td>100 ± 30</td>
</tr>
<tr>
<td>Paco₂ (mm Hg)</td>
<td>52 ± 32</td>
<td>50 ± 14</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>7.30 ± 0.10</td>
<td>7.30 ± 0.10</td>
</tr>
<tr>
<td>Plasma bicarbonate (mmol per liter)</td>
<td>25 ± 5</td>
<td>25 ± 5</td>
</tr>
</tbody>
</table>

PROSEVA Trial

Cumulative Probability of Survival

**PROSEVA Study**

Why It Was So Successful

**PROSEVAS Trial**

**Previous Prone Trials**

![Graphs showing cumulative probability of survival over time for prone and supine groups.](image)

Log-rank test results:
- Log-rank < 0.001 for PROSEVAS Trial
- Log-rank = 0.03 for Previous Prone Trials

<table>
<thead>
<tr>
<th>No. at Risk</th>
<th>Time (Days since randomization)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prone</td>
<td>237 202 191 186 182</td>
</tr>
<tr>
<td>Supine</td>
<td>229 163 150 139 136</td>
</tr>
<tr>
<td>Prone</td>
<td>260 128 140 93 55</td>
</tr>
<tr>
<td>Supine</td>
<td>226 98 80 71 41</td>
</tr>
</tbody>
</table>

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For a detailed analysis of the trial and its implications, please refer to the comprehensive report available online.
PROSEVA Study
Why It Was So Successful

◊ Avoided pitfalls of previous ARDS studies
  ➢ Used as a preventative strategy, not as salvage mode
    • Started within 36 hours of ARDS
  ➢ Used only in the most severe ARDS patients
  ➢ Control group was “amazingly” well-matched
    • Almost too good to be real
  ➢ Control group MVS well done (low Vt strategy)

◊ Putting study in perspective of clinical ICUs
  ➢ Each ICU averaged 6.7 eligible ARDS patients / year
    • Each ICU averaged 49 ARDS patients / year

◊ Conclusions: Use It Early in Only the Most Severe


Second Opinion

By Rob Rogers

Do you recommend a triple bypass, Doctor?

Yes... I recommend you bypass KFC, Wendy's and McDonald's!