UPSIDE DOWN YOU TURN ME: THE WHEN, THE WHY AND THE HOW OF PRONE POSITIONING WITH ARDS PATIENTS

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Disclosures for Kathleen Vollman

- Consultant-Michigan Hospital Association Keystone Center
- Consultant/Faculty for CUSP for MVP—AHRQ funded national study
- Subject matter expert CAUTI, CLABSI, HAPU, Sepsis, Safety culture
- Consultant and speaker bureau for Sage Products LLC
- Consultant and speaker bureau for Eloquest Healthcare
Objectives

• Discuss the physiologic rationale for the improvement in oxygenation and reduce lung injury with the prone position in patients with ARDS.

• Review the evidence to help determine whether to use the position in ARDS as front line therapy.

• Identify evidence based strategies for determining when to turn, how long to remain prone and preventing airway and skin complications.

• Compare and contrast patient and staff advantages and disadvantages of various methods to position patients prone.
Low Tidal Volume Ventilation

APPRV

HFOV

ECMO

Neuromuscular Blockade
Why Prone Positioning in ARDS

- To improve oxygenation during prone positioning and after repositioning supine (Langer, Chest 1988; Gattinoni, NEJM 2001)
- To improve the response to recruitment maneuvers during prone positioning (Pelosi, AJRCCM 2003, Oczenski, CCM 2005)
- To improve respiratory mechanics after repositioning supine (Pelosi, AJRCCM 1998)
- To improve drainage of secretions (Pelosi, Eur Respir J 2002; Reignier, Intensive Care Med 2005)
Major Factors Influencing Distribution of Ventilation

- Gravity/weight of the lung
- Compliance
- Heterogeneous lung disease
Air Goes To Area of Least Resistance
Distribution of Regional Volumes

- Regional pleural pressures
- Local lung compliance
Lung Weight Theory
Supine Position:

- Distribution becomes more uniform from apex to base
- Dependent lung ventilation > non-dependent
- Reduction in FRC

Amis et al. Respiratory Physiology 1984 56;145
Kaneko et al. J of Applied Physiology 1966 21;767
Reduction in FRC in the Supine Position

- Influence of the abdominal contents on the diaphragm
- Position of the heart and relationship of the supporting structures to the lung and its influence on pleural pressure gradients
Reduction in FRC

Position of the heart and supporting structures alters pleural pressure gradients.
SUPINE POSITION

Cardiac Structures

Pressure

Lungs

Spine

Result: More \( \oplus \) Pleural Pressure

Collapsed Alveoli
PRONE POSITION

Cardiac Structures

Lungs

Sternum

Lungs

Result: More \( \bigcirc \) Pleural Pressure

Open Alveoli
Major Factors Influencing Distribution of Ventilation

- Gravity/weight of the lung
- Compliance
- Heterogeneous lung disease
Heterogeneous Lung Disease

A1  Supine  A2  Prone
Summary

Supine:
- Marked reduction in lung volumes
- Alteration in lung mechanics (low compliance/high resistance)
- Compression atelectasis
- Hypoxemia

Prone:
- Increased FRC & improved compliance
- Shifting of lung water & densities
- More homogenous aeration of the lung in ARDS from dorsal lung recruitment
- Increased oxygenation
PERFUSION
Factors Influencing Regional Distribution of Perfusion

- Cardiac output
- Pulmonary vascular resistance
- Gravity/body position
Distribution of Perfusion

Upright Position:

Blood flow decreases as it moves from base to apex with virtually little or no flow at the apices
Blood Flow Changes with Position

Supine position: Distribution becomes more uniform. Zone 3 maintained throughout the lung. Greater vertical perfusion gradient.

Lateral position: Similar to supine except lung transforms to zone 2 approximately 18 cm above the most dependent part of the chest.

Prone position: No major impact on regional distribution of pulmonary blood flow
Lung Protection in the Prone Position

- Attenuate mechanical lung injury
  - Improves dependent aeration recruiting alveoli
  - Non-dependant regions shows dramatic reduction in hyperinflation
  - Results in more homogenous lung aeration which reduces regional shear strain…less VILI
  - Also decrease barotrauma and atelectrauma by recruiting and reducing over distension that occurs with higher PEEP
  - Potential reduction in infection from drainage

Prone Positioning Clinical Research
2000’s Prone Positioning Research

Methodology

- Study Period: 1996-1999
- 304 patients with Acute Lung Injury/Acute Respiratory Distress Syndrome randomized to receive 6 hours of prone positioning q 24 for 10 days or supine position with q 2 hour lateral positioning
- Entrance criteria: modified ALI/ARDS definitions
- Measured:
  - Measured: Primary endpoints: mortality at 10 days, hospital D/C & 6 months
  - Secondary endpoints: PaO₂/FiO₂, ratio reduction, organ failure & incidence of complications

2000’s Prone Positioning Research

Results

- 10 day mortality: 21% vs. 25% (RR 0.84 CI 0.56 to 1.27)
- Hospital d/c mortality: 50.7% vs. 48% (RR 1.05 CI 0.84 to 1.32)
- 6 months mortality: 62.5% vs. 58.6% (RR 1.06 CI 0.88 to 1.28)
- Significant increase in PaO2/FiO2 ratio in the prone group
- No difference in organ dysfunction
- % of patients with new or worsening pressure ulcers per patient was worse in the prone group

Study Concerns

- Was the study methodology relevant?
  - Testing an intervention using 1996-1999 ventilator management
    - TV: 10.3/ml/kg ± 2.9 (s)
    - TV: 10.3/ml/kg ± 2.7 (p)
    - Average PEEP: <10cm
  - Majority of patients entered into the study were primary respiratory pathology vs. secondary

- Were the patients in the prone position a sufficient period of time?
  - Average time prone: 7.0 ± 1.8

- Was the study powered sufficiently?
  - Stopped early with recruitment problems
  - Deviations from the protocol/41 patients
Mortality Benefit in the Most Severely Ill

Mortality rate

Quartiles SAPS II

2000’s Prone Positioning Research

Methodology

• Study conducted: Dec 1998-2002
• 791 ARF patients, multicenter trial, unblinded, randomized
• 413 prone, 378 supine (8 hours per day)
• Patient in supine group could cross over to prone if P/F ratio < 100 for > 12 hours, or < 60 for 1 hr or on 100% FiO2
• P/F ratio < 300, hemodynamically stable & no contraindications to the prone position
• Measured 28 day all cause mortality, duration of mechanical ventilation, incidence of VAP & oxygenation

Guerin C. et al JAMA 2004;292:2379-2387
2000’s Prone Positioning Research

Results

- No difference in mortality
- No difference in ventilation days
- Reduction in VAP in the prone group*
- Significantly higher P/F ratio for 28 days in the prone group

Limitations

- Most patient’s in supine group crossed over
- Mechanical ventilation was not performed using a pre-determined algorithm (Tidal volume 8 ml/kg & tidal volume in pressure control 11ml/kg)
- Only in prone position for 8.6 hours for total of 4.6 days

*P < 0.045

Guerin C. et al JAMA 2004;292:2379-2387
**Pediatric Prone Position**

**Methodology**
- Multicenter, randomized controlled clinical trial measuring ventilator free days to day 28
- 7 Pediatric ICU’s (age 2 weeks to 18 years)
- Randomized to supine or prone within 48 hrs of **ALI** criteria
- Prone position for **20 hours** each day during acute phase of illness
- Both groups tx with lung protective strategy, sedation protocols, extubation readiness and hemodynamic & skin care guidelines

**Results**
- Stopped for lack of efficacy: no difference in VFD, mortality, OFD, hospital discharge

Prolonged Prone Ventilation Study

Methodology

- Multicenter trial: 13 ICU’s accruing 136 ARDS patients randomized within 48hrs of tracheal intubation (Between 1998-2002)
- 60 to supine, 76 to prone (20h/d)
- Guidelines for ventilation & weaning were established

Results

- Mortality: Supine 58% vs. Prone 43% p=0.12
- Simplified APACHE II score higher in prone group
- Independent risk factors for mortality: APACHE score at inclusion, days elapsed prior to inclusion & randomization to supine position
- Minimal complications and rapidly reversible (prone avg. 17hrs for 10 days)

Prone Positioning in Patients with Mod & Severe ARDS: RCT

- Multicenter, unblended RCT, 23 centers in Italy & 2 Spain
- 324 adults with ARDS (192 mod & 150 severe hypoxemia)
- Supine or prone 20hrs per day
- Entrance P/F ratio < 200 with ARDS dx & btwn 5-10 PEEP, <72 hrs
- Upon enrollment assessed O2 with PEEP 5-10 (potential derecruitment)
- Ventilation: \( \leq 8\text{ml/kg (IBW)} \) \( T_v \) & 30 cm H2O PP
- Did not control weaning or sedation

Results
- No difference in mortality
- Trend towards a reduced mortality in the subgroup of severe hypoxemia
- Prone group had higher overall complication rates (3x) higher than shorter prone times

PROSEVA Trail: Proning Severe ARDS Patients

- RCT 466 patients with severe ARDS (26 ICU’s in France/1 Spain)
  - Severe ARDS P/F ratio < 150 mm Hg, with Fio2 0.6, PEEP of at least 5 cm of water, & a Vₜ of 6 ml per kg of PBW
  - Initiation 12-24hrs

- Prone-positioning 16hrs/or supine position/ (proned within 1hr of randomization)

- NMB used 5 days

- Stopping prone treatment
  - After 4hrs in supine meeting oxygenation criteria
  - ↓ in PaO2/FiO2 ratio of 20% (after 2 consecutive prone positions)
  - Complications leading to immediate interruption

- Applied for 28 days, then clinician discretion

Results: Guerin C, et. al. Prone Study

- Baseline characteristics similar except for, vasopressors (S), sepsis related SOFA score (S) & use of NMB’s (P)
- Prone 16% mortality, supine 32.8% p< 0.0001
- Prone group ↓ ICU LOS (2 days, & ↑ VFD (4 days) (NS)
- No differences in complications except > cardiac arrest in supine position (31 S vs. 16 P)

Prone Positioning in ARDS: A Systematic Review and Meta-analysis

Meta-analysis:
- 11 RCT’s (n=2341)
- 6 trials used lung protective strategies
- Difference seen with > 16hrs in the position

2014 Meta-Analysis: Sub-Groups

- Benefit of lung protective ventilation
- Benefit of longer time in the prone position

<table>
<thead>
<tr>
<th>Statistical Model</th>
<th>No. of Trials</th>
<th>No. of Patients</th>
<th>Odds Ratio (95% CI) for Mortality</th>
<th>Interaction P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed effects</td>
<td>11</td>
<td>2,246</td>
<td>0.82 (0.69-0.97)</td>
<td></td>
</tr>
<tr>
<td>Random Effects</td>
<td>11</td>
<td>2,246</td>
<td>0.77 (0.59-0.99)</td>
<td></td>
</tr>
<tr>
<td>Lung Protective Ventilation</td>
<td></td>
<td></td>
<td></td>
<td>0.015</td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>1,100</td>
<td>0.62 (0.48-0.79)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>1,146</td>
<td>1.04 (0.80-1.36)</td>
<td></td>
</tr>
<tr>
<td>Duration of Prone Positioning</td>
<td></td>
<td></td>
<td></td>
<td>0.015</td>
</tr>
<tr>
<td>≥ 10 hours/session</td>
<td>8</td>
<td>1,100</td>
<td>0.62 (0.48-0.79)</td>
<td></td>
</tr>
<tr>
<td>&lt; 10 hours/session</td>
<td>3</td>
<td>1,146</td>
<td>1.04 (0.80-1.36)</td>
<td></td>
</tr>
<tr>
<td>Patient Population</td>
<td></td>
<td></td>
<td></td>
<td>0.021</td>
</tr>
<tr>
<td>ARDS only</td>
<td>7</td>
<td>1,060</td>
<td>0.62 (0.48-0.80)</td>
<td></td>
</tr>
<tr>
<td>ALI/ARDS</td>
<td>4</td>
<td>1,186</td>
<td>1.02 (0.76-1.36)</td>
<td></td>
</tr>
<tr>
<td>Severe ARDS population (PaO2/FiO2 ratio)</td>
<td></td>
<td></td>
<td></td>
<td>0.635</td>
</tr>
<tr>
<td>≤ 150 mmHg</td>
<td>8</td>
<td>1,364</td>
<td>0.72 (0.55-0.95)</td>
<td></td>
</tr>
<tr>
<td>&gt; 150 mmHg</td>
<td>3</td>
<td>882</td>
<td>0.77 (0.38-1.55)</td>
<td></td>
</tr>
<tr>
<td>HFOV were used with positioning</td>
<td></td>
<td></td>
<td></td>
<td>0.661</td>
</tr>
<tr>
<td>Yes</td>
<td>2</td>
<td>54</td>
<td>0.57 (0.18-1.82)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9</td>
<td>2,192</td>
<td>0.77 (0.58-1.02)</td>
<td></td>
</tr>
<tr>
<td>Adequate concealment of allocation</td>
<td></td>
<td></td>
<td></td>
<td>0.764</td>
</tr>
<tr>
<td>Yes</td>
<td>10</td>
<td>2,224</td>
<td>0.76 (0.58-0.99)</td>
<td></td>
</tr>
<tr>
<td>No/unclear</td>
<td>1</td>
<td>22</td>
<td>1.00 (0.18-5.68)</td>
<td></td>
</tr>
</tbody>
</table>

Pressure ulcer, dislodgement of the ET tube and thoracotomy tube higher in prone position

### Table 4: Physiologic, clinical and safety outcomes associated with prone positioning during mechanical ventilation

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No. of patients or events</th>
<th>Measure of effect*</th>
<th>$R^2$ value, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygenation (PaO$_2$/FiO$_2$ ratio)†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>1283</td>
<td>1.36 (1.25–1.47)</td>
<td>49</td>
</tr>
<tr>
<td>Day 2</td>
<td>1171</td>
<td>1.29 (1.21–1.37)</td>
<td>27</td>
</tr>
<tr>
<td>Day 3</td>
<td>933</td>
<td>1.25 (1.18–1.31)</td>
<td>0</td>
</tr>
<tr>
<td>Clinical and safety outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilator-associated pneumonia</td>
<td>368/1561</td>
<td>0.89 (0.71–1.13)</td>
<td>0</td>
</tr>
<tr>
<td>Pressure ulcers</td>
<td>818/1765</td>
<td>1.27 (1.16–1.40)</td>
<td>0</td>
</tr>
<tr>
<td>Obstruction of endotracheal tube</td>
<td>200/1847</td>
<td>1.60 (1.27–2.02)</td>
<td>0</td>
</tr>
<tr>
<td>Unplanned extubation or dislodgement of endotracheal tube†</td>
<td>211/2309</td>
<td>1.08 (0.78–1.48)</td>
<td>16</td>
</tr>
<tr>
<td>Unplanned removal of central or arterial lines</td>
<td>59/886</td>
<td>1.49 (0.42–5.27)</td>
<td>67</td>
</tr>
<tr>
<td>Dislodgement of thoracostomy tube</td>
<td>17/886</td>
<td>3.14 (1.02–9.69)</td>
<td>0</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>95/1663</td>
<td>0.84 (0.57–1.25)</td>
<td>0</td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>211/1527</td>
<td>0.73 (0.39–1.38)</td>
<td>76</td>
</tr>
</tbody>
</table>

Note: CI = confidence interval, PaO$_2$/FiO$_2$ ratio = ratio of partial pressure of arterial oxygen to fraction of inspired oxygen.
*Random-effects models were used for all analyses.
†We measured effect on oxygenation by comparing the mean PaO$_2$/FiO$_2$ ratio in the prone group to the closest available recorded measurement in the supine group. If more than one measurement was taken, we chose the measurement closest to the end of the session of prone positioning on that day.
‡One trial included all dislodgements of endotracheal tubes, not just unplanned extubations. When we excluded the results of this trial from the meta-analysis, the risk ratio for unplanned extubation was 0.86 (95% CI 0.62–1.20; $R^2 = 0$; 9 trials, 1471 patients, 129 events).

Comparison of the Major Prone Trials

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gattinoni et al&lt;sup&gt;10&lt;/sup&gt;</th>
<th>Guérin et al&lt;sup&gt;8&lt;/sup&gt;</th>
<th>Mancuso et al&lt;sup&gt;7&lt;/sup&gt;</th>
<th>Taccone et al&lt;sup&gt;11&lt;/sup&gt;</th>
<th>Guérin et al&lt;sup&gt;8&lt;/sup&gt; (PROSEVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prone group mortality, %</td>
<td>50.7 (ICU mortality)</td>
<td>32.4 (28 d)</td>
<td>43 (ICU mortality)</td>
<td>31 (28 d)</td>
<td>16 (28 d)</td>
</tr>
<tr>
<td>Control group mortality, %</td>
<td>48 (ICU mortality)</td>
<td>31.5 (28 d)</td>
<td>58 (ICU mortality)</td>
<td>32.8 (28 d)</td>
<td>32.8 (28 d)</td>
</tr>
<tr>
<td>RR of mortality (prone/control)</td>
<td>1.05 (P = .65)</td>
<td>1.02 (P = .77)</td>
<td>0.74 (P = .12)</td>
<td>0.97 (P = .72)</td>
<td>0.48 (P &lt; .001)</td>
</tr>
<tr>
<td>Patients, No</td>
<td>802</td>
<td>142</td>
<td>342</td>
<td>466</td>
<td></td>
</tr>
<tr>
<td>Targeted disease</td>
<td>ALI&lt;sup&gt;a&lt;/sup&gt; and ARDS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Respiratory failure with Pao&lt;sub&gt;2&lt;/sub&gt;/Fio&lt;sub&gt;2&lt;/sub&gt; &lt; 300 mm Hg</td>
<td>ARDS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ARDS&lt;sup&gt;a&lt;/sup&gt;</td>
<td>ARDS&lt;sup&gt;a&lt;/sup&gt; with Pao&lt;sub&gt;2&lt;/sub&gt;/Fio&lt;sub&gt;2&lt;/sub&gt; &lt; 150 mm Hg</td>
</tr>
<tr>
<td>Pao&lt;sub&gt;2&lt;/sub&gt;/Fio&lt;sub&gt;2&lt;/sub&gt; at enrollment, mm Hg</td>
<td>128</td>
<td>153</td>
<td>139</td>
<td>113</td>
<td>100</td>
</tr>
<tr>
<td>Enrollment early in disease course?</td>
<td>No</td>
<td>No</td>
<td>Yes, &lt; 2 d of intubation</td>
<td>Yes, &lt; 3 d</td>
<td>Yes, &lt; 1.5 d</td>
</tr>
<tr>
<td>SAPS II</td>
<td>40</td>
<td>46</td>
<td>43</td>
<td>41</td>
<td>46</td>
</tr>
<tr>
<td>V&lt;sub&gt;T&lt;/sub&gt; delivered, mL/kg</td>
<td>10.3</td>
<td>7.9</td>
<td>8.5</td>
<td>8</td>
<td>6.1</td>
</tr>
<tr>
<td>Patients paralyzed, %</td>
<td>Not reported</td>
<td></td>
<td>21</td>
<td>45</td>
<td>Not reported</td>
</tr>
<tr>
<td>Mean increase in Pao&lt;sub&gt;2&lt;/sub&gt;/Fio&lt;sub&gt;2&lt;/sub&gt; on prone positioning, mm Hg</td>
<td>19</td>
<td>18</td>
<td>32&lt;sup&gt;d&lt;/sup&gt;</td>
<td>44</td>
<td>59</td>
</tr>
<tr>
<td>Average time prone, hr/d</td>
<td>7</td>
<td>8</td>
<td>17</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Average days prone</td>
<td>10</td>
<td>4</td>
<td>10</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Significant reduction in ventilator days?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Difficulty enrolling?</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Crossover (supine to prone), %</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

PROSEVA benefited from limitations of previous trials; limited sample size, sign treatment crossover, unstandardized vent management with higher Vt, mild ARDS, short prone times per 24hrs, stop times arbitrary, enrollment late in Dx

Prone positioning was used in 16.4% of patients with severe ARDS

Gattinoni L, et al. JAMA, 2016;315(8):788-800
What’s the Challenge?
Indications for Use
Who to Place in Prone Position?

- Patients with severe ARDS (PaO2/FiO2 < 150 mm Hg)
- Early in the course (ideally within 48 hr)
- Best outcomes reported when prone positioning is used in combination with both low tidal volume ventilation (6 cc/kg) and neuromuscular blockade (48 hrs)
- “Unless otherwise contraindicated prone positioning should be applied as first line therapy to any patient with moderate or severe ARDS and applied as early as possible after identification of hypoxemic ARDS

# The Berlin ARDS Definition

<table>
<thead>
<tr>
<th>Timing</th>
<th>Within 1 week of a known clinical insult or new/worsening respiratory symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Imaging (X-ray or CAT scan)</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 factors present</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygenation</td>
<td>$&lt; 200 \text{ PaO}_2/\text{FiO}_2$ or $&lt; 300$ with PEEP/CPAP $\geq 5 \text{ cm H}_2\text{O}$</td>
<td>$&lt; 100 \text{ PaO}_2/\text{FiO}_2$ or $&lt; 200$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
<td>$&lt; 100 \text{ PaO}_2/\text{FiO}_2$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
<tr>
<td>Mortality</td>
<td>27% (24% to 30%)</td>
<td>32% (29% to 34%)</td>
<td>45% (42% to 48%)</td>
</tr>
</tbody>
</table>

French Trial Entrance Criteria

- Severe ARDS P/F ratio < 150 mm Hg, with Fio2 0.6, PEEP of at least 5 cm of water, and a Tv to 6 ml per kg of PBW
- Initiation 12-24hrs

Berlin ARDS Definition Oxygenation Criteria

<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygenation</td>
<td>&lt; 200 PaO₂/FiO₂ or &lt; 300 with PEEP/CPAP ≥ 5 cm H₂O</td>
<td>&lt; 100 PaO₂/FiO₂ or &lt; 200 with PEEP ≥ 5 cm H₂O</td>
</tr>
</tbody>
</table>
Indications for Use

Contraindications
Who Not to Place in Prone Position?

- Patients with facial/neck trauma or spinal instability
- Patients with recent sternotomy or large ventral surface burn
- Patients with elevated intracranial pressure
- Patients with massive hemoptysis
- Patients at high risk of requiring CPR or defibrillation

Decision Making Factors in Positioning Patients Prone

- Time interval from injury to position change
  - < 48 hrs

- Hemodynamic status
Challenges to Mobilizing Critically Ill Patients

Potential Modifiable Barriers

- Patient-related barriers (50%)
  - Hemodynamic instability
  - ICU devices
  - Physical & neuropysch

- Structural (18%)
  - Human or Technological Resources

- ICU culture (18%)
  - Knowledge/Priority/Habits

- Process related (14%)
  - Service delivery/lack of coordination
  - Clinician function

How Well Are We Really Doing?

Every-2-Hour Turning
Body Position: Clinical Practice vs. Standard

- Multicenter study: 74 patients/566 total hours of observation
  - Change in body position recorded every 15 minutes for 8hrs
  - 2.7% had a q 2 hour body position change
  - 49.3% of observed time no body position change
- Prospectively recorded, 2 days, 40 ICU’s in the UK
  - Analysis on 393 sets of observations
  - Average time between turns 4.85 hrs (3.3 SD)

Krishnagopalan S. Crit Care Med 2002;30:2588-2592
Goldhill DR et al. Anaesthesia 2008;63:509-515
Hemodynamic Instability

Is it a Barrier to Positioning?
The Role of Hemodynamic Instability in Positioning$^{1,2}$

- Lateral turn results in a 3%-9% decrease in SVO$_2$, which takes 5-10 minutes to return to baseline
- Appears the act of turning has the greatest impact on any instability seen
- Minimize factors that contribute to imbalances in oxygen supply and demand
- Factors that put patients at risk for intolerance to positioning:$^3$
  - Elderly
  - Diabetes with neuropathy
  - Prolonged bed rest
  - Low hemoglobin and cardiovascular reserve
  - Prolonged gravitational equilibrium

Decision-Making Tree for Patients Who Are Hemodynamically Unstable With Movement\textsuperscript{1,2}

Screen for mobility readiness within 8 hrs of admission to ICU & daily initiate in-bed mobility strategies as soon as possible

- Is the patient hemodynamically unstable with manual turning?
  - O\textsubscript{2} saturation < 90%
  - New onset cardiac arrhythmias or ischemia
  - HR < 60 <120
  - MAP < 55 >140
  - SPB < 90 >180
  - New or increasing vasopressor infusion

  - No
    - Begin in-bed mobility techniques and progress out-of-bed mobility as the patient tolerates

  - Yes
    - Is the patient still hemodynamically unstable after allowing 5-10 minutes' adaption post-position change before determining tolerance?
      - No
        - Begin in-bed mobility techniques and progress out-of-bed mobility as the patient tolerates
      - Yes
        - Screen for mobility readiness within 8 hrs of admission to ICU & daily initiate in-bed mobility strategies as soon as possible
          - No
            - Allow the patient a minimum of 10 minutes of rest between activities, then try again to determine tolerance
          - Yes
            - Has the manual position turn or HOB elevation been performed slowly?
              - No
                - Try the position turn or HOB maneuver slowly to allow adaption of cardiovascular response to the inner ear position change
              - Yes
                - Initiate continuous lateral rotation therapy via a protocol to train the patient to tolerate turning

HOB=head of bed; HR=heart rate; MAP=mean arterial pressure; SPB=systolic blood pressure.

Decision Making Factors in Positioning Patients Prone

- Time interval from injury to position change
- Hemodynamic status
- Mentation-PAD guidelines

Neuromuscular Blockade in Early ARDS: Not Ready For Front Line Therapy

- Multicenter, double blind trial
- 340 patients with ARDS within 48hrs of admitted to ICU
- ARDS defined as P/F ratio of < 150 ≥ PEEP 5cm & Vt of 6-8 ml/kg PBW
- Randomized to receive 48hrs of cisatracurium or placebo
- Study did not use train of 4
- Results:
  - After risk adjustment NMB group showed improved mortality at 90 days (31.6% vs. 40.7%)
  - Also significant at 28 days
  - ↑time off vent
  - No difference in muscle weakness


NNT 10-11
Neuromuscular Blocking Agents in ARDS: Systematic Review and Meta-analysis

- 3 trials (431 patients; 20 centers; all from the same research group in France)
- All trials assessed 48-hour infusions of cisatracurium besylate.
- Lower risk of barotrauma
- No increase in vents days or risk of ICU acquired weakness

Consider use in patients with Severe ARDS and patient ventilator asynchrony

Gattinoni L, Marini JJ. ICM, 2015;41:2201-2203

Alhazzani W, et al. Critical Care, 2013;17:R43
Challenges to Mobilizing Critically Ill Patients

Potentially Modifiable Barriers

- Patient-related barriers (50%)
  - Hemodynamic instability, ICU devices, physical & neuropysch
- Structural (18%)
  - Human or Technological Resources
- ICU culture (18%)
  - Knowledge/Priority/Habits
- Process related (14%)
  - Service delivery/lack of coordination
  - Clinician function

<table>
<thead>
<tr>
<th>Adverse Events</th>
<th>No. of Trials Reporting the Outcome</th>
<th>Events/Prone</th>
<th>Events/Supine</th>
<th>OR (95% CI)</th>
<th>p</th>
<th>Number Needed to Treat/Number Needed to Harm</th>
<th>Heterogeneity</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>Ventilator-associated pneumonia</td>
<td>6</td>
<td>120/567</td>
<td>128/513</td>
<td>0.76 (0.44–1.33)</td>
<td>0.343</td>
<td>26</td>
<td>34.4</td>
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<tr>
<td>Pressure ulcers</td>
<td>6</td>
<td>294/698</td>
<td>218/646</td>
<td>1.49 (1.18–1.89)</td>
<td>0.001</td>
<td>12</td>
<td>0.0</td>
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<tr>
<td>Major airway problem&lt;sup&gt;*&lt;/sup&gt;</td>
<td>9</td>
<td>255/1,104</td>
<td>180/1,063</td>
<td>1.55 (1.10–2.17)</td>
<td>0.012</td>
<td>16</td>
<td>32.7</td>
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<td>Unplanned extubation</td>
<td>7</td>
<td>113/1,091</td>
<td>98/1,050</td>
<td>1.17 (0.80–1.73)</td>
<td>0.421</td>
<td>98</td>
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<td>Selective intubation</td>
<td>2</td>
<td>12/642</td>
<td>5/615</td>
<td>2.73 (0.29–25.46)</td>
<td>0.378</td>
<td>95</td>
<td>55.9</td>
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<td>Endotracheal tube obstruction</td>
<td>4</td>
<td>130/823</td>
<td>77/802</td>
<td>2.16 (1.53–3.05)</td>
<td>&lt;0.001</td>
<td>16</td>
<td>0.0</td>
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<tr>
<td>Loss of venous or arterial access</td>
<td>4</td>
<td>36/407</td>
<td>22/397</td>
<td>1.34 (0.29–6.26)</td>
<td>0.712</td>
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<td>75.5</td>
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<tr>
<td>Thoracostomy tube dislodgement or kinking</td>
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<td>14/397</td>
<td>1.14 (0.35–3.75)</td>
<td>0.827</td>
<td>1,154</td>
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<tr>
<td>Pneumothorax</td>
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<td>0.77 (0.46–1.30)</td>
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<td>Cardiac arrest</td>
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<td>119/675</td>
<td>0.74 (0.47–1.17)</td>
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<tr>
<td>Tachyarrhythmia or bradyarrhythmia</td>
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<td>102/634</td>
<td>1.08 (0.78–1.50)</td>
<td>0.643</td>
<td>80</td>
<td>8.8</td>
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</table>
Decision Making Factors in Positioning Patients Prone

- Time interval from injury to position change
- Hemodynamic status
- Mentation-PAD guidelines/NMB
- Patient Size

### The How

<table>
<thead>
<tr>
<th>Indications for Use</th>
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<tbody>
<tr>
<td>Contraindications</td>
<td>✓</td>
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<tr>
<td>Pre-Proning Prep</td>
<td>✓</td>
</tr>
</tbody>
</table>
Pre-Prone Position Requirements for Safe Prone Positioning Checklist

- Pre-oxygenate the patient with FiO2 1.0
- Secure the endotracheal tube and lines
- Tubes inserted above the waist/Top of the Bed
- Tubes inserted below the waist/Foot of the Bed (Except Chest Tubes)
- Correct number of staff to assist in the turn, and monitor the turn
- Adequate number supplies to turn (pads for bed, sheet, protection for the patient or specialty bed)
- Experienced staff with working knowledge of how to perform the turn and how to supine the patient in the event of an emergency

Pre-Prone Position Requirements for Safe Prone Positioning Checklist

• Requires 3-5 people, close attention to endotracheal tube (ETT) and central lines
• Preparation: preoxygenation, empty stomach, suction ETT/oral cavity, remove ECG leads and reattach to back, repeated zeroing of hemodynamic transducers
• Consider placement of 5 layer silicone dressings in high pressure/shear risk areas (forehead, chest, knee’s)
• Ensure the tongue is inside patients mouth
• Empty ileostomy/colostomy bags before the turn

The How
Prone Positioning: The How

Step 1: With a flat sheet, pull the patient to side of bed opposite the ventilator using 4 staff.

Step 2: Place the flat sheet around the arm that will pull through, (side you are turning toward). Turn towards the ventilator.
Prone Positioning: The How

Step 3: A second flat sheet is placed on the bed and tucked under the patient. This sheet will pull through as you are turning the patient.

Step 4: Using the sheet turn the patient over toward the ventilator and position them prone. The arm and sheet will pull across the bed.
Prone Positioning: The How

Step 5: Pull and center the patient. Discard the sheet that was used to supine patient. Straighten lines and tubes.

Chest and/or pelvic support can be done by placing a pillow at the abdomen before completing the turn.
Returning to Supine: The How

Step 1: Using a flat sheet, pull the patient to one side of the bed.

Step 2: Place the flat sheet around the arm that will pull through, (side you are turning toward).

Step 3: A second flat sheet is placed on the bed and tucked under the patient. This sheet will pull through as you are turning the patient.
Returning to Supine: The How

Step 4: Using the sheet turn the patient over and position them supine. The arm and sheet will pull across the bed.

Step 5: Discard the sheet that was used to supine patient (A). Straighten lines and tubes (B).
When to Stop Prone Positioning?

- In PROSEVA, prone positioning was stopped when PaO2/FiO2 remained > 150 mm Hg 4 h after supinating (with PEEP < 10 cm H2O and FiO2 < 0.6)
- Optimal strategy is unclear: consider continuing prone positioning until clear improvement in gas exchange, mechanics, and overall clinical course.

Positioning Schedule & Maintenance Care

- Consider every 16hrs uninterrupted (more freq turn back may cause decruitment)
- Maintain gain, laterally rotated/q2 turning until gas exchange decreases or no more than 2 hrs
- Loose gain, provide necessary care and return to the prone position
- Move head slightly every hour or q 2
- If hemodynamic monitoring, level the zero reference point at the right atrium

Positioning Schedule & Maintenance Care

- ROM of arms every 2 hours/change position of the arms
- Support feet in correct anatomical alignment
- Double secure endotracheal tube
- Eye care-if taping preform horizontal
- Turn off tube feeding 1hr prior to position change
- Consider time periods in reverse trendelenburg to address facial edema and reduce risk of vomiting

Potential Complications

- Temporary increase in oral and tracheal secretions occluding airway
- ETT migration or kinking
- Vascular catheter kinking
- Elevated intraabdominal pressure
- Increased gastric residuals
- Facial pressure ulcers, facial edema, lip trauma from ETT
- Brachial plexus injury (arm extension)

Care Concerns

- Hemodynamic monitoring:
  - In studies that communicated landmarks for zero reference, no difference in HR, SBP or CI

- Feeding:
  - The patient is at most risk for aspiration during the turning process
  - If reverse Trendelenburg position is used to reduce facial edema, must weigh risk-benefit of micro aspiration
  - Tubes placed past the pyloric valve may also reduce the risk of aspiration

- Patients have been placed in the prone position successfully;
  - open abdomens, intra-cranial pressure monitoring, hemodynamic instability, pelvic fractures, external fixators, multiple traumatic injuries, use of extracorporeal membrane oxygenation (ECMO), and continuous renal replacement therapy (CRRT)

Goettler CE. Et al Critical Care 2002,6:452-455
Questions That Remain

• Optimal PEEP management in prone position
• Does effective prone positioning necessitate neuromuscular blockades for several days?
• What impact does that have on ICU acquired weakness?
• What is the learning curve and associated risk for inexperience centers adopting the practice

Definition of Progressive Mobility

• Early Progressive Mobility definition:
  – Planned movement in a sequential manner beginning at a patient’s current mobility status and returning the patient to baseline

• Early mobility includes:
  – Head elevation
  – Manual turning
  – Passive and active range of motion
  – Continuous lateral rotation therapy/prone positioning
  – Movement against gravity
  – Physiologic adaptation to an upright/leg down position (Tilt Table, bed egress)
  – Chair position
  – Dangling
  – Ambulation

Outcomes of Early Mobility Program

- ↓ incidence of skin injury
- ↓ time on the ventilator
- ↓ incidence of VAP
- ↓ days of sedation
- ↓ delirium
- ↑ ambulatory distance
- Improved function

Thomsen GE, et al. *CCM* 2008;36;1119-1124
Winkelman C et al, *CCN*,2010;30:36-60
TO PRONE OR NOT TO PRONE?

Base Your Decision on Research & Clinical Experience
"HAPPY TURNING"