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What's *New* About Proning?

J. Brady Scott, MSc, RRT-ACCS, FAARC

Director of Clinical Education and Assistant Professor

Department of Cardiopulmonary Sciences

Division of Respiratory Care

Rush University

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Conflict of Interest

I have no real or perceived conflict of interest that relates to this presentation. Any use of brand names is not in any way meant to be an endorsement of a specific product, but to merely illustrate a point of emphasis.

Objectives

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- Review the rationale and current literature support for prone positioning in hypoxemic respiratory failure
- Discuss the process of prone positioning
- Describe common challenges with prone positioning

What is prone positioning?

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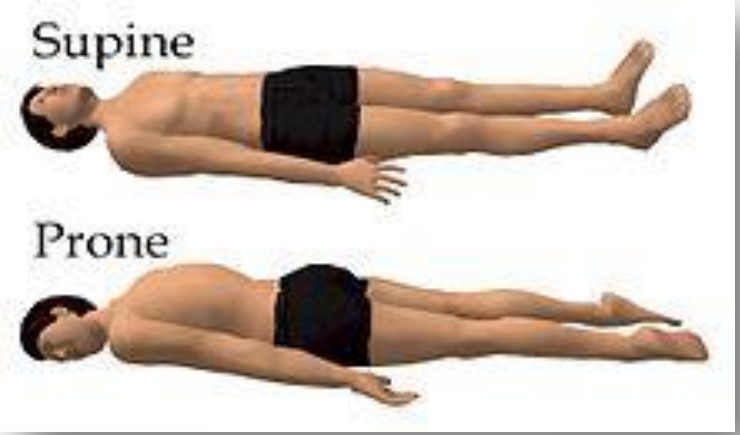
- Prone position is a term that indicates the body position is *face-down*



Prone Position Mechanical Ventilation

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- Mechanical ventilation is usually delivered to patients in supine or Semi-Fowlers (head of bed ~30°)
  - ***"Yes, I am aware… duh?"***
- Prone position mechanical ventilation is not new!
  - Papers date back to the late 1970's
- Sound physiologic rationale

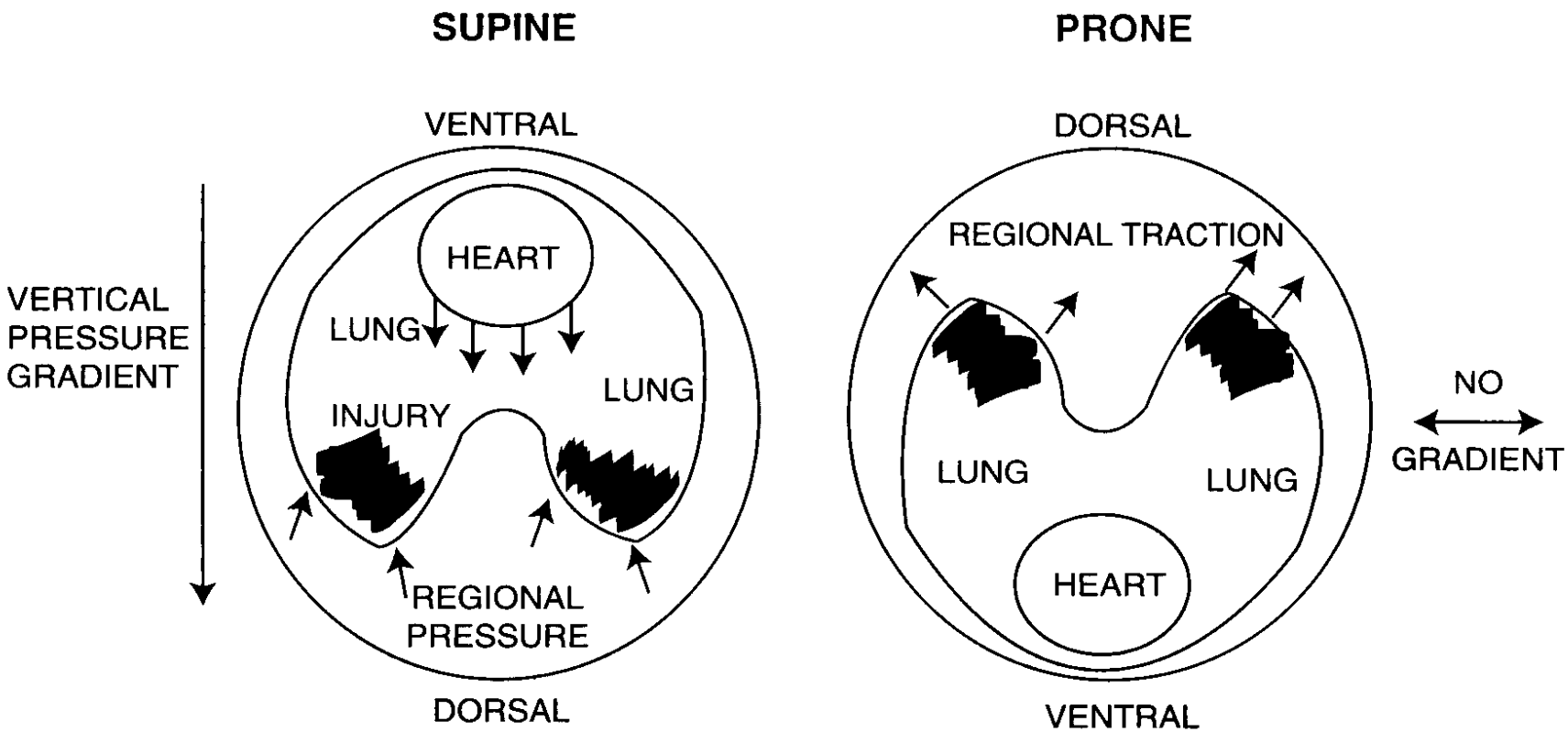
Prone Position Mechanical Ventilation

- How does it work?
  - Alters mechanics and physiology of gas exchange
  - Improves the ventral-dorsal transpulmonary pressure difference
  - Improves lung perfusion
  - Reduces dorsal lung compression

Mechanism of Action

- Supine Position
  - Increased regional pressure at the "bottom" due to vertical pressure
  - Heart is superior to lung injury -- compresses lung tissue
  - Close of gravity-dependent dorsal lung regions
  - Low V/Q and increased shunt -- ↓ PaO_2
  - Increased possibility of opening - closing injury

Proposed Mechanisms for Effectiveness of Prone Ventilation



1. Weight of heart upon lungs
2. Perfusion is dorsal
3. Higher compressive pressure due to vertical pressure gradient in dorsal region

1. Heart below lungs
2. Perfusion persists dorsal
3. Tractive pressure in dorsal region

Mechanism of Action

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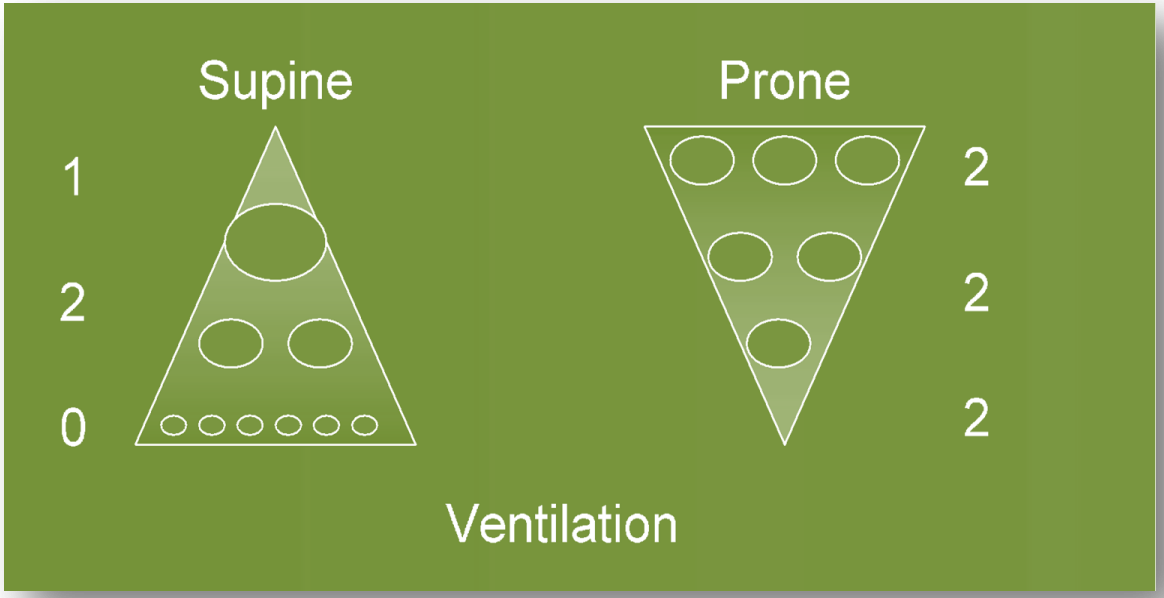
Prone Position

- Reduces difference between dorsal and ventral transpulmonary pressure
  - Ventilation becomes more homogeneous



Mechanism of Action

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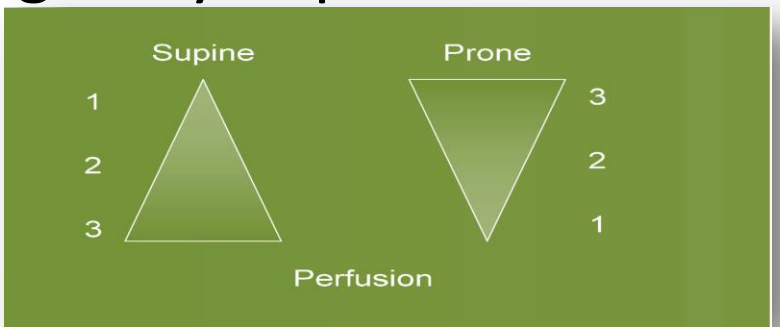
- Decreases alveolar overinflation and dorsal alveolar collapse
  - Resultant decrease in alveolar overdistention and cyclic atelectasis ***(injury)***
- Promotes lung recruitment
- V/Q improves -- ↑ PaO_2
- FRC may increase
  - May change distribution of extravascular lung water
  - May change distribution of secretions
- Perfusion becomes less gravity dependent and tends to persist dorsally



Mechanism of Action

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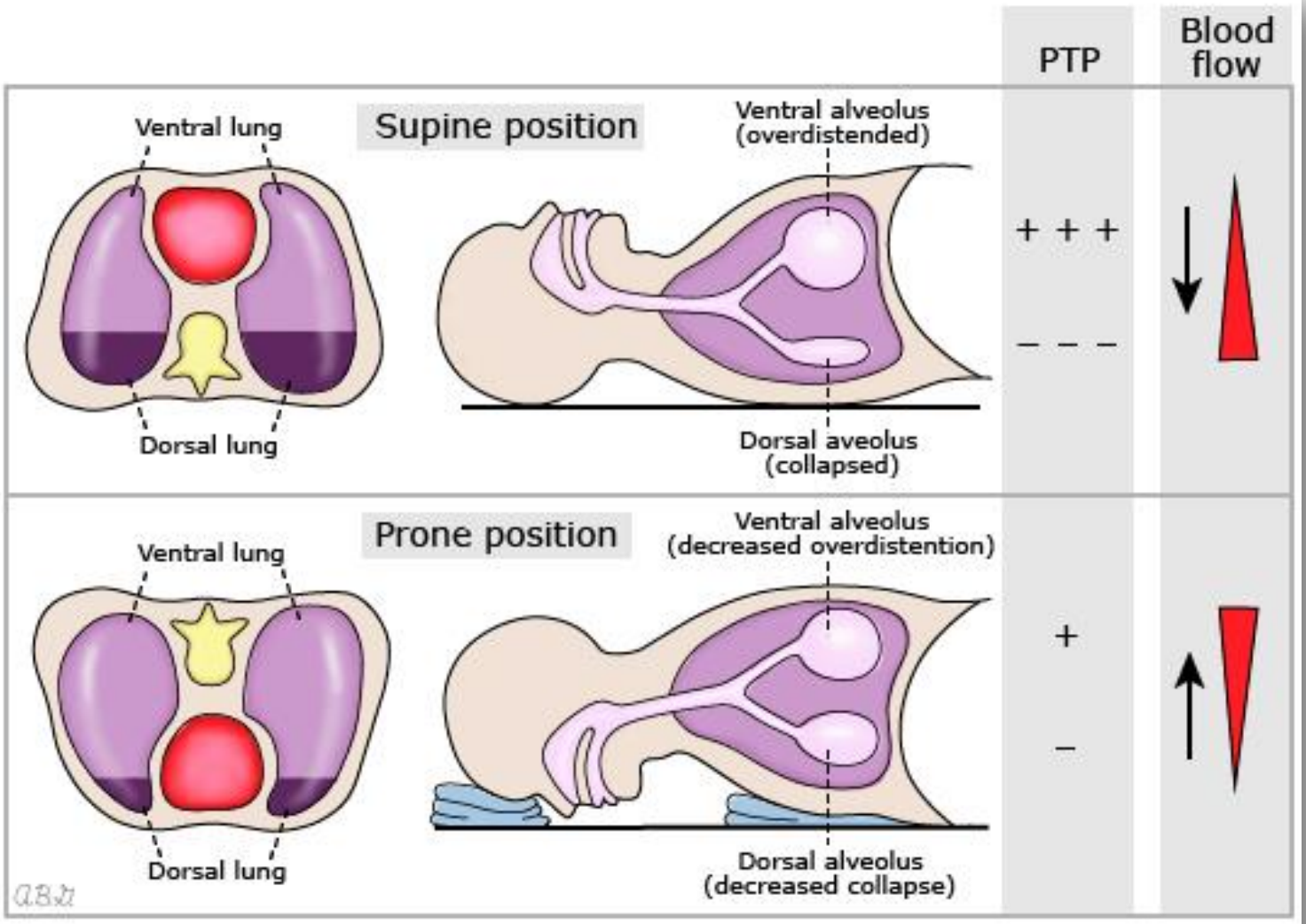

Image from UptoDate® 2017

Prone Position Mechanical Ventilation

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- Several past studies (RCTs) have shown ↑↑ in oxygenation
  - Up to 70% of patients respond with improvement in oxygenation
    - Allows for reduction in F_IO_2

Prone Position Mechanical Ventilation

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- Patient factors that predict improved oxygenation w/prone positioning
  - Diffuse pulmonary edema and dependent alveolar collapse→ better than predominately anterior abnormalities, marked consolidation, and fibrosis
  - Extrapulmonary causes of ARDS
  - Elevated intra-abdominal pressure vs. normal
  - Patients with chest wall compliance decrease from supine to prone

So… why aren't we doing it?

- Several past studies have shown prone **can prevent** ventilator-induced lung injury (VILI)

But…

- In most trials, the physiologic benefits did not mean better patient outcomes
- No improvement in survival/mortality

But wait!

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Prone positioning improves survival in severe ARDS: a pathophysiologic review and individual patient meta-analysis

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ABSTRACT

Prone positioning has been used for over 30 years in the management of patients with acute respiratory distress syndrome (ARDS). This maneuver has consistently proven capable of improving oxygenation in patients with acute respiratory failure. Several mechanisms can explain this observation, including possible intervening net recruitment and more homogeneously distributed alveolar inflation. It is also progressively becoming clear that prone positioning may reduce the nonphysiological stress and strain associated with mechanical ventilation, thus decreasing the risk of ventilator-induced lung injury, which is known to adversely impact patient survival. The available randomized clinical trials, however, have failed to demonstrate that prone positioning improves the outcomes of patients with ARDS overall. In contrast, the individual patient meta-analysis of the four major clinical trials available clearly shows that with prone positioning, the absolute mortality of severely hypoxemic ARDS patients may be reduced by approximately 10%. On the other hand, all data suggest that long-term prone positioning may expose patients with less severe ARDS to unnecessary complications.

(Minerva Anestesiol 2010;76:448-54)

Key words: Respiratory distress syndrome, adult - Prone position - Respiration, artificial - Ventilator-induced lung injury.

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Intensive Care Med (2010) 36:585–599
DOI 10.1007/s00134-009-1748-1

REVIEW

Sachin Sud
Jan O. Friedrich
Paolo Taccone
Federico Polli
Neill K. J. Adhikari
Roberto Latini
Antonio Pesenti
Claude Guérin
Jordi Mancebo
Martha A. Q. Curley
Rafael Fernandez
Ming-Cheng Chan
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Gregor Voggenreiter
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Prone ventilation reduces mortality in patients with acute respiratory failure and severe hypoxemia: systematic review and meta-analysis

between-trial heterogeneity for most clinical outcomes. *Conclusions:* Prone ventilation reduces mortality in patients with severe hypoxemia. Given associated risks, this approach should not be routine in all patients with AHRF, but may be considered for severely hypoxemic patients.

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Abroug *et al. Critical Care* 2011, **15**:R6
http://ccforum.com/content/15/1/R6

CRITICAL CARE

RESEARCH Open Access

An updated study-level meta-analysis of randomised controlled trials on proning in ARDS and acute lung injury

Fekri Abroug[1*], Lamia Ouanes-Besbes[1], Fahmi Dachraoui[1], Islem Ouanes[1], Laurent Brochard[2,3,4]

Abstract

Introduction: In patients with acute lung injury (ALI) and/or acute respiratory distress syndrome (ARDS), recent randomised controlled trials (RCTs) showed a consistent trend of mortality reduction with prone ventilation. We updated a meta-analysis on this topic.

Methods: RCTs that compared ventilation of adult patients with ALI/ARDS in prone versus supine position were included in this study-level meta-analysis. Analysis was made by a random-effects model. The effect size on intensive care unit (ICU) mortality was computed in the overall included studies and in two subgroups of studies: those that included all ALI or hypoxemic patients, and those that restricted inclusion to only ARDS patients. A relationship between studies' effect size and daily prone duration was sought with meta-regression. We also computed the effects of prone positioning on major adverse airway complications.

Results: Seven RCTs (including 1,675 adult patients, of whom 862 were ventilated in the prone position) were included. The four most recent trials included only ARDS patients, and also applied the longest proning durations and used lung-protective ventilation. The effects of prone positioning differed according to the type of study. Overall, prone ventilation did not reduce ICU mortality (odds ratio = 0.91, 95% confidence interval = 0.75 to 1.2; $P = 0.39$), but it significantly reduced the ICU mortality in the four recent studies that enrolled only patients with ARDS (odds ratio = 0.71; 95% confidence interval = 0.5 to 0.99; $P = 0.048$; number needed to treat = 11). Meta-regression on all studies disclosed only a trend to explain effect variation by prone duration ($P = 0.06$). Prone positioning was not associated with a statistical increase in major airway complications.

Conclusions: Long duration of ventilation in prone position significantly reduces ICU mortality when only ARDS patients are considered.

2013

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The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 6, 2013 VOL. 368 NO. 23

Prone Positioning in Severe Acute Respiratory Distress Syndrome

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Background

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- What is known?
  - Use for over 3 decades to treat hypoxic respiratory failure
  - Ventilation/perfusion matching may improve, pleural pressure gradients are more uniform, and compression of lung volume from the heart and abdomen is reduced
  - Several studies have shown improvements in oxygenation and reductions in ventilator-induced lung injury
- Why was the study done?
  - Physiologic improvements were seen, but prone positioning failed to show mortality benefits

Hypothesis

- The early application of prone positioning will improve survival among patients with ARDS who, at the time of enrollment, were receiving mechanical ventilation with a PEEP of at least 5 cm H_2O and in whom the P/F ratio was < 150 mm Hg

Objectives

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- Primary end point
  - Mortality at day 28
- Secondary end points
  - Mortality at day 90
  - The rate of successful extubation
    - Defined as no reintubation or use of NIV in the 48 hours after extubation
  - The time to successful extubation
  - Length of stay in the ICU
  - Complications
  - Use of noninvasive ventilation
  - Tracheostomy rate
  - Number of days free from organ dysfunction
  - Ventilator settings
  - ABGs
  - Respiratory system mechanics

❖ In trach'd patients, successful weaning was defined as the ability to breath unassisted through a tracheostomy tube for at least 24 hours

Methods: Design

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- What type of study was done?
  - Prospective, multicenter, randomized controlled trial
- Randomization was computer-generated and stratified according to ICU
  - Patients randomly assigned to the prone group or supine group
  - A web-based management system (Clininfo) used to help for randomization

Methods: Setting

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- 26 ICUs in France/1 ICU in Spain
- All ICUs had at least **5 years of prone positioning experience**
- Adult patients meeting the following criteria:
  - Diagnosed with ARDS (using American-European Consensus Conference criteria)
  - Endotracheal intubation and MV for ARDS for < 36 hours
  - Severe ARDS (P/F ratio < 150 mm Hg, $F_IO_2 \geq 0.60$, PEEP ≥ 5 cm H_2O, on tidal volumes of 6 ml/kg of PBW)

Methods: Interventions

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- Prone group
  - Placed completely prone for at least 16 consecutive hours
  - Standard ICU beds were used for all patients
- Supine group
  - Remained in a semirecumbent position

❖ Mechanical ventilation was VCV with volume target of 6 ml/kg PBW

❖ PEEP selected from PEEP/F_IO_2 table

❖ Goals: Pplat < 30 cm H_2O

❖ pH 7.20-7.45

Results

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- The two groups were similar at inclusion except: SOFA scores and use of neuromuscular blockers and vasopressors
- Ventilator settings, respiratory mechanics, and ABG measurements were similar in the two groups
- On average, prone group patients were prone positioned 4 times/patient
  - Mean duration 17±3 hours
  - ❖Prone group patients were ventilated 73% of the 22,334 patient-hours spent in the ICU from the start of the first session to the end of the last

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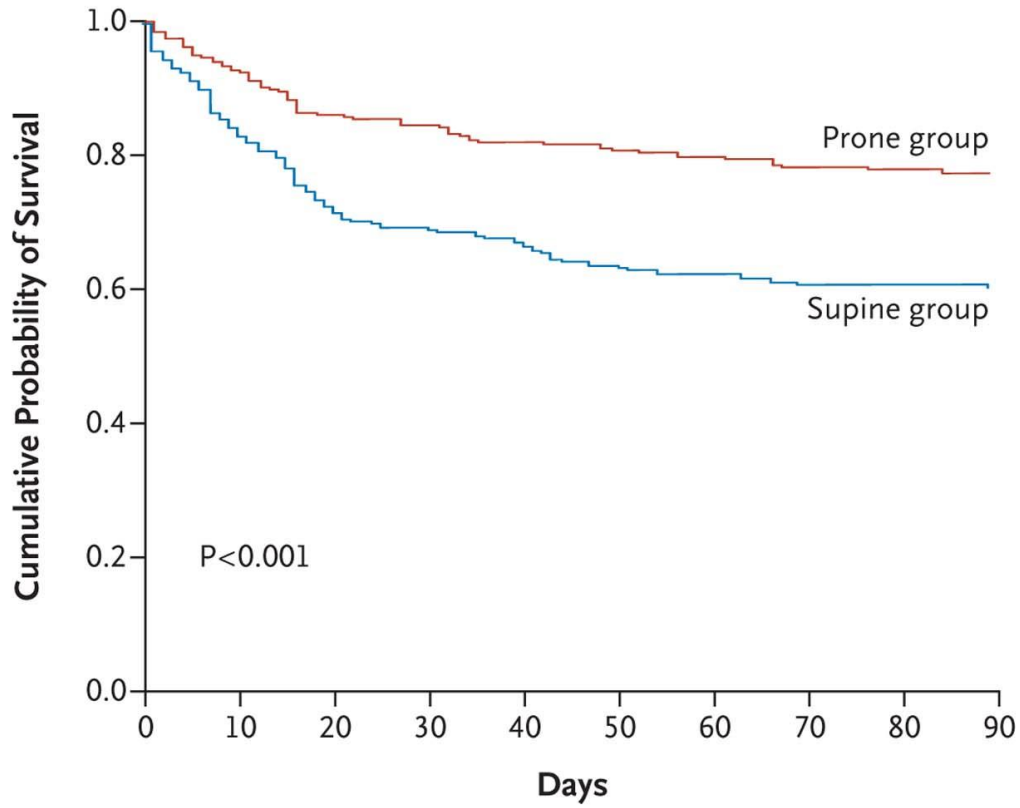
Table 3. Primary and Secondary Outcomes According to Study Group.*

	Supine Group	Prone Group	Hazard Ratio or Odds Ratio with the Prone	
Mortality — no. (% [95% CI])				
At day 28				
Not adjusted	75 (32.8 [26.4–38.6])	38 (16.0 [11.3–20.7])	0.39 (0.25–0.63)	<0.001
Adjusted for SOFA score†			0.42 (0.26–0.66)	<0.001
Not adjusted	94 (41.0 [34.6–47.4])	56 (23.6 [18.2–29.0])	0.44 (0.29–0.67)	<0.001
Adjusted for SOFA score†			0.48 (0.32–0.72)	<0.001
Successful extubation at day 90 — no./total no. (% [95% CI])	145/223 (65.0 [58.7–71.3])	186/231 (80.5 [75.4–85.6])	0.45 (0.29–0.70)	<0.001
Time to successful extubation, assessed at day 90 — days				
Survivors	19±21	17±16		0.87
Nonsurvivors	16±11	18±14		
Length of ICU stay, assessed at day 90 — days				
Survivors	26±27	24±22		0.05
Nonsurvivors	18±15	21±20		
Ventilation-free days				
At day 28	10±10	14±9		<0.001
At day 90	43±38	57±34		<0.001
Pneumothorax — no. (% [95% CI])	13 (5.7 [3.9–7.5])	15 (6.3 [4.9–7.7])	0.89 (0.39–2.02)	0.85
Noninvasive ventilation — no./total no. (% [95% CI])				
At day 28	10/212 (4.7 [1.9–7.5])	4/228 (1.8 [0.1–3.5])	0.36 (0.07–3.50)	0.11
At day 90	3/206 (1.5 [0.2–3.2])	4/225 (1.8 [0.1–3.5])	1.22 (0.23–6.97)	1.00
Tracheotomy — no./total no. (% [95% CI])				
At day 28	12/229 (5.2 [2.3–8.1])	9/237 (3.8 [1.4–6.0])	0.71 (0.27–1.86)	0.37
At day 90	18/223 (8.1 [4.5–11.7])	15/235 (6.4 [3.3–9.5])	0.78 (0.36–1.67)	0.59

* Plus–minus values are means ±SD. Hazard ratios are shown for mortality and successful extubation; odds ratios are shown for other outcomes. CI denotes confidence interval.

† There were no significant differences between the groups in organ dysfunction as assessed from the SOFA score (Table S4 in the Supplementary Appendix).

Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.



No. at Risk

Prone group	237	202	191	186	182
Supine group	229	163	150	139	136

Conclusions

- Patients with ARDS and severe hypoxemia can benefit from prone treatment when used early and in relatively long sessions

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CHEST

[Contemporary Reviews in Critical Care Medicine]

Treatment of ARDS With Prone Positioning

CrossMark

Eric L. Scholten, MD; Jeremy R. Beitler, MD, MPH; G. Kim Prisk, PhD, DSc; and Atul Malhotra, MD

CHEST 2017; 151(1):215-224

In summary, clinical trial evidence suggests that to achieve improved survival with prone positioning, one needs patients with severe ARDS treated early in their course, a long duration of prone positioning (> 16 h/d), physiologically driven criteria for cessation of daily prone positioning (eg, minimal ventilator requirements), the concurrent use of lung-protective therapies for ARDS, and experienced staff able to minimize procedural risks. Interested readers may review other

TABLE 2] Summary Recommendations for Prone Ventilation

Who to place in prone position? Patients with severe ARDS ($Pa_{O_2}/Fi_{O_2} < 150$ mm Hg) Early in the course (ideally within 48 h) Best outcomes reported when prone positioning is used in combination with *both* low tidal volume ventilation (6 cc/kg) and neuromuscular blockade	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
How to place patient in prone position? Requires 3-5 people, close attention to endotracheal tube (ETT) and central lines; a demonstration video and checklist are available[9,73] Preparation: preoxygenation, empty stomach, suction ETT/oral cavity, remove ECG leads and reattach to back, repeated zeroing of hemodynamic transducers Support and frequently reposition pressure points: face, shoulder, anterior pelvis	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)
How long to have patient in prone position each day? Successful trials use at least 16 hours of daily proning Long prone positioning sessions likely avoid derecruitment	When to stop? In PROSEVA, prone positioning was stopped when Pa_{O_2}/Fi_{O_2} remained > 150 mm Hg 4 h after supinating (with PEEP < 10 cm H_2O and $Fi_{O_2} < 0.6$) Optimal strategy is unclear: consider continuing prone positioning until clear improvement in gas exchange, mechanics, and overall clinical course.

CPR = cardiopulmonary resuscitation; PEEP = positive end-expiratory pressure. See Table 1 legend for expansion of other abbreviation.

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Chertoff *Journal of Intensive Care* (2016) 4:70
DOI 10.1186/s40560-016-0194-8

Journal of Intensive Care

COMMENTARY

Open Access

Why is prone positioning so unpopular?

Jason Chertoff

Why so unpopular?

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- Burdensome
- Cumbersome
- Additional human resources
- Adverse events
  - Accidental extubation
  - Pressure ulcers
  - Losing lines/drains, etc

Real evidence or just anecdotal evidence?

How do we do it?

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- Two ways:
  - Manual
  - Specialized bed
    - RotoProne®

Manual Proning

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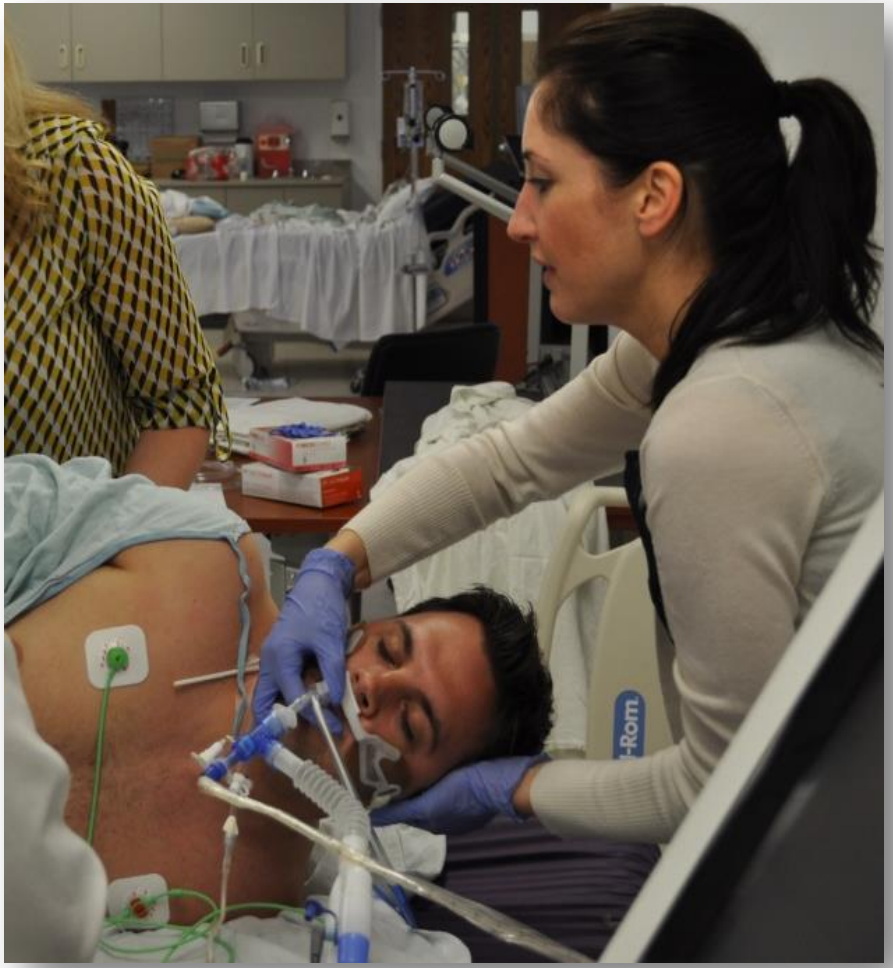

Evaluation of a Training Method to Improve Knowledge, Skills and Increase the Clinical Use of Prone Positioning

Adel Aljoaid BS RRT, J. Brady Scott MSc RRT-ACCS, Sara H. Mirza MD MSc, Meagan N. Dubosky MSc RRT-ACCS NPS AE-C, David L. Vines MHS RRT FAARC

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Introduction

Patients with moderate to severe acute respiratory distress syndrome (ARDS) are typically managed by low tidal volume, lung protective mechanical ventilation. Several methods have been evaluated in an attempt to better understand best practices in the care of patients with severe ARDS but none have shown a mortality benefit. In June of 2013, a multicenter, prospective, randomized, controlled trial demonstrated that the early use of prolonged prone-positioning sessions significantly decreased mortality in cases of severe ARDS.[1] Because of this, our institution sought to establish guidelines and training to support the implementation of prone positioning for the treatment of severe ARDS.

Purpose

The primary aim of this study is to determine if discussion, video, and human simulation laboratory exercises improves knowledge, confidence, and skill associated with prone positioning which may result in an increase in its clinical use.

Methods

Critical care respiratory therapists, nurses, and physicians were invited to participate in an educational interventional study that was approved by the IRB. This study included written cognitive examinations to assess knowledge and affective evaluations to assess self-confidence that were administered before and after the educational intervention. The participants received instructions on prone positioning procedure through three methods: reviewing/discussing printed guidelines and protocols outlining the associated policy and procedure, video demonstration of a correct method to place a patient in the prone position, and hands-on human simulation until competency was achieved.

Results

Twenty-three subjects were enrolled in the study that completed all activities. Of these, 12 were physicians, 5 were nurses, and 6 were respiratory therapists; 12 men and 11 women. The pre-affective survey revealed that 22% of the participants had prone positioning experience. Significant improvements were observed in participant confidence (Figure 1) and cognitive scores (Figure 2) for all disciplines. The cumulative knowledge score on written pre-test was 61%. Knowledge increased following the education intervention by 23 % with post-training written test score of 84%, ($p<0.05$).

Figure 1: Self-assessed Confidence on a 5-point Likert scale.

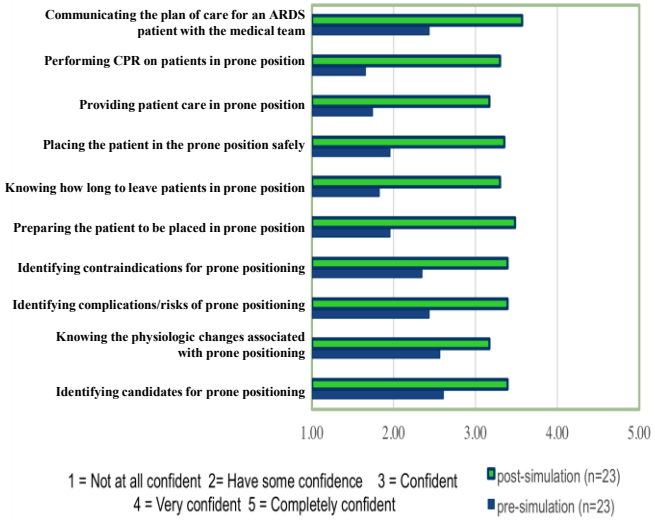
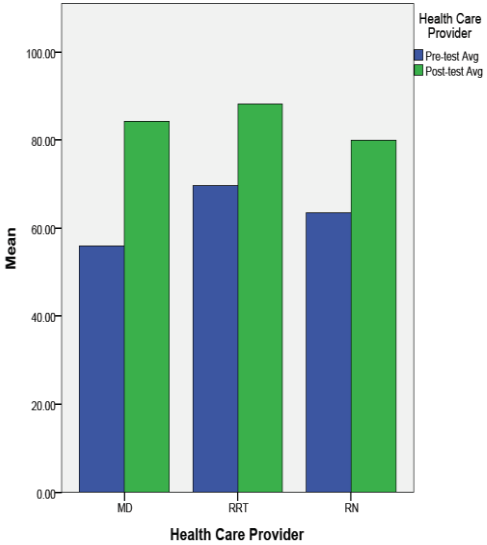


Figure 2: Overall Average Knowledge Scores before and after educational intervention.



Conclusion

Our study was able to show

- A significant improvement in knowledge and confidence following our educational intervention.
- This improvement was seen across all disciplines of health care.
- Improvement was seen even in the group claiming to have had prior experience with proning.

Early data is suggestive of increased utilization of this modality at our institution following educational intervention.

Reference:

1. Guerin C, Reigneir J, Richard JC, et al. Prone Positioning in Severe Acute Respiratory Distress Syndrome. N Engl J Med 2013;368:2159-2168.

Procedure for prone positioning

Preparation
1. Check for contraindications.
a. Facial or pelvic fractures
b. Burns or open wounds on the ventral body surface
c. Conditions associated with spinal instability (eg, rheumatoid arthritis, trauma)
d. Conditions associated with increased intracranial pressure
e. Life-threatening arrhythmias
2. Consider possible adverse effects of prone positioning on chest tube drainage.
3. Whenever possible, explain the maneuver to the patient and/or their family.
4. Confirm from a recent chest roentgenogram that the tip of the endotracheal tube is located 2 to 4 cm above the main carina.
5. Inspect and confirm that the endotracheal tube and all central and large bore peripheral catheters are firmly secured.
6. Consider exactly how the patient's head, neck, and shoulder girdle will be supported after they are turned prone.
7. Stop tube feeding, check for residual, fully evacuate the stomach, and cap or clamp the feeding and gastric tubes.
8. Prepare endotracheal suctioning equipment, and review what the process will be if copious airway secretions abruptly interfere with ventilation.
9. Decide whether the turn will be rightward or leftward.
10. Prepare all intravenous tubing and other catheters and tubing for connection when the patient is prone.
a. Assure sufficient tubing length
b. Relocate all drainage bags on the opposite side of the bed
c. Move chest tube drains between the legs
d. Reposition intravenous tubing toward the patient's head, on the opposite side of the bed
Turning procedure
1. Place one (or more) people on both sides of the bed (to be responsible for the turning processes) and another at the head of the bed (to assure the central lines and the endotracheal tube do not become dislodged or kinked).
2. Increase the FiO_2 to 1 and note the mode of ventilation, the tidal volume, the minute ventilation, and the peak and plateau airway pressures.
3. Pull the patient to the edge of the bed furthest from whichever lateral decubitus position will be used while turning.
4. Place a new draw sheet on the side of the bed that the patient will face when in this lateral decubitus position. Leave most of the sheet hanging.
5. Turn the patient to the lateral decubitus position with the dependent arm tucked slightly under the thorax. As the turning progresses the nondependent arm can be raised in a cocked position over the patient's head. Alternatively, the turn can progress using a log-rolling procedure.
6. Remove ECG leads and patches. Suction the airway, mouth, and nasal passages if necessary.
7. Continue turning to the prone position.
8. Reposition in the center of the bed using the new draw sheet.
9. If the patient is on a standard hospital bed, turn his/her face toward the ventilator. Assure that the airway is not kinked and has not migrated during the turning process. Suction the airway if necessary.
10. Support the face and shoulders appropriately avoiding any contact of the supporting padding with the orbits or the eyes.
11. Position the arms for patient comfort. If the patient cannot communicate, avoid any type of arm extension that might result in a brachial plexus injury.
12. Auscultate the chest to check for right mainstem intubation. Reassess the tidal volume and minute ventilation.
13. Adjust all tubing and reassess connections and function.
14. Reattach ECG patches and leads to the back.
15. Tilt the patient into reverse Trendelenburg. Slight, intermittent lateral repositioning (20 to 30°) should also be used, changing sides at least every two hours.
16. Document a thorough skin assessment every shift, specifically inspecting weight bearing, ventral surfaces.

FiO_2: fraction of inspired oxygen.

Reproduced with permission from: Messerole E, Peine P, Wittkopp W, et al. The pragmatics of prone positioning. Am J Respir Crit Care Med 2002; 165:1359. Official Journal of the American Thoracic Society © American Thoracic Society.

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http://jfrie.blogspot.com/2010/09/running-saved-my-life.html

Prone Position Mechanical Ventilation

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- Ventilation strategy similar to ARDSnet
- Optimal PEEP setting is unknown
- **Note:**
  - **Peak and plateau pressures may increase immediately!**
    - Likely related to decreased chest wall compliance
    - Mobilization of secretions

➢ The subsequent decrease probably related to progressive alveolar recruitment

Prone Position: Assessing Response

- Improvement in gas exchange (>10 mm Hg increase in PaO_2)
- Evidence of lung recruitment (decrease in plateau pressure for given tidal volume)
- Can be noted in first hour, but may take longer

Prone position: Contraindications and complications

Contraindications
Shock (eg, persistent mean aterial pressure <65 mmHg)
Acute bleeding (eg, hemorrhagic shock, massive hemoptysis)
Multiple fractures or trauma (eg, unstable fractures of femur, pelvis, face)
Spinal instability
Pregnancy
Raised intracranial pressure >30 mmHg or cerebral perfusion pressure <60 mmHg
Tracheal surgery or sternotomy within two weeks
Relative contraindictions
Recent DVT treated for <2 days*
Anterior chest tube(s) with air leaks*
Major abdominal surgery
Recent pacemaker*
Clinical conditions limiting life expectancy* (eg, oxygen or ventilator-dependent respiratory failure)
Severe burns*
Lung transplant recipient*
Prior use of rescue therapies*¶

Complications
Nerve compression (eg, brachial plexus injury)
Crush injury
Venous stasis (eg, facial edema)
Dislodging endotracheal tube
Diaphragm limitation
Pressure sores (eg, facial)
Dislodging vascular catheters or drainage tubes
Retinal damage
Transient reduction in arterial oxygen saturation
Vomiting
Transient arrhythmias

DVT: deep vein thrombosis.
* Based upon exclusion criteria from the Prone Postioning in Severe ARDS trial (PROSEVA).
¶ Patients in whom benefit is not assured include: patients on inhaled nitric oxide, on almitrine bimesyalte, extracorporeal membrane oxygeneation (ECMO), or noninvasive ventilation (NIV) prior to intubation.

Data from:

1. *Ryan DW, Pelosi P. The prone position in acute respiratory distress syndrome. BMJ 1996; 312:860.*
2. *Guérin C, Reignier J, Richard JC, et al. Prone positioning in severe acute respiratory distress syndrome. N Engl J Med 2013; 368:2159.*

References available upon request

Thank You!

Questions/Discussion

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