

Benefits of Prone Positioning and Kinetic Therapy in Acute Respiratory Failure


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Acute Lung Injury/ Acute Respiratory Distress Syndrome

- Severe lung injury characterized by noncardiogenic pulmonary edema, decreased lung compliance, and refractory hypoxemia
- 3-criteria definition, with formal diagnosis established by chest radiograph, oxygenation score, and exclusion of cardiogenic causes¹
 - Acute onset (<2 weeks)
 - Bilateral infiltrates on chest radiography
 - Pulmonary-artery wedge pressure ≤ 18 mm Hg or lack of evidence of left atrial hypertension

Acute Lung Injury (ALI) $PaO_2/FiO_2 \leq 300$	Acute Respiratory Distress Syndrome (ARDS) $PaO_2/FiO_2 \leq 200$
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PaO₂ = partial pressure of arterial oxygen; FiO₂ = fraction of inspired oxygen

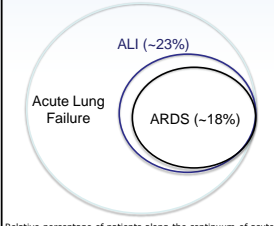
1. Bernard G, et al. The American-European Consensus Conference on ARDS: Definitions, Mechanisms, Relevant Outcomes, and Clinical Trial Coordination. *Am J Respir Crit Care Med*. 1998;158:1830-47.



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ARDS — One of the Most Challenging Acute Clinical Processes to Treat

Acute Respiratory Failure Spectrum



Relative percentage of patients along the continuum of acute respiratory failure (intubation and mechanical ventilation >24h). Acute lung failure (ALF) = PaO₂/FIO₂ >300 mm Hg.

- ALI and ARDS
 - Acute onset
 - Persistent
 - Associated with one or more known risk factors
 - Characterized by arterial hypoxemia resistant to oxygen therapy alone¹
- ALI represents a small fraction of ALF patients
- ARDS makes up most of the ALI population

1. Bernard GR, et al. Acute Respiratory Distress Syndrome: A Historical Perspective. *Am J Respir Crit Care Med.* 2005; 172: 798-806.
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Risk Factors for ALI and ARDS

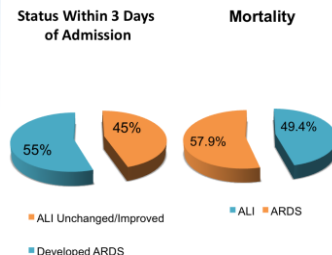
- The most common **risk factors** are
 - Pneumonia
 - Aspiration
 - Sepsis
 - Severe trauma with multiple transfusions (>15 units)
- Other **risk factors** include
 - Pulmonary contusion
 - Smoke/toxic gas inhalation
 - Fat embolism
 - Major surgery
 - Pancreatitis
 - Drug reaction or overdose
 - Reperfusion pulmonary edema after lung transplantation or
 - Neurogenic pulmonary edema due to stroke, seizure, head trauma

Ware LB, et al. The Acute Respiratory Distress Syndrome. *N Engl J Med.* 2000; 342(18): 1334-1349
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ALI Often Evolves into ARDS

ALI is frequently observed in the ICU

- 7.1% (n = 463) of 6,522 admissions
- 16.1% of all mechanically ventilated patients
- 65.4% cases occurred on ICU admission



Brun-Buisson C, et al. Epidemiology and outcome of acute lung injury in European intensive care units. *Intensive Care Med.* 2004; 30: 51-61
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Measures of Long-term Disability Indicate Slow and Incomplete Recovery from ARDS (cont.)

- Functionally
- Survivors' perception of health was <70% of normal in
 - Physical role: extent to which health limits physical activity
 - Physical functioning: extent to which health limits work
 - Vitality: degree of energy
 - 6-minute walk remained low
 - Only 49% had returned to work

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Improved Outcomes Are Needed for Patients with ALI/ARDS

- Mechanical ventilation contributes to the high mortality level in ARDS¹
- Research continues to fine-tune lung-protective strategies to respiratory mechanics while reducing ventilator injury
- An increase in oxygenation has been demonstrated in patients ventilated in the prone position²⁻⁴
- For patients at imminent risk of death from hypoxemia, **prone ventilation intervention can make sense¹**

1. Slutsky AS, et al. Incurring Outcomes in Critically Ill Patients: The Seduction of Physiology. *JAMA*. 2009;302(18):2030-2032
 2. Taccone P, et al. Prone Positioning in Patients With Moderate and Severe Acute Respiratory Distress Syndrome. *JAMA*. 2009; 302(18): 1977-1984
 3. Sola S, et al. Effect of mechanical ventilation in the prone position on clinical outcomes in patients with acute hypoxemic respiratory failure: a systematic review and meta-analysis. *CMAJ*. 2008; 178(9): 1153-1161
 4. Albert RK, et al. Prone Ventilation. *Clinics in Chest Med*. 2000; 21(3): 511-517

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Multiple Benefits of Prone Positioning for ARDS Patients

- Improved respiratory mechanics¹
 - Homogenize pleural pressure gradient, alveolar inflation, and ventilation distribution
 - Increase lung volume and reduce atelectasis
- Improved oxygenation^{2,3}
- Facilitation of secretion drainage¹
- Reduced ventilator-associated lung injury^{1,4}

1. Pezzi P, et al. Prone position in acute respiratory distress syndrome. *Eur Respir J*. 2002; 20(4):1017-1028
 2. Gattinoni L, et al. Effect of Prone Positioning on the Survival of Patients with Acute Respiratory Failure. *N Engl J Med*. 2001; 345(8): 868-873
 3. Gattinoni L, et al. Decrease in Pao2 with prone position is predictive of improved outcome in acute respiratory distress syndrome. *Crit Care Med*. 2003; 31(12): 2727-2733
 4. Papazian L, et al. Comparison of prone positioning and high-frequency oscillatory ventilation in patients with acute respiratory distress syndrome. *Crit Care Med*. 2005; 33(10): 2162-2171

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Effect of Prone Positioning on the Survival of Patients with Acute Respiratory Failure 16

Design

- Prospective, randomized study of 304 ARDS/ALI patients in 28 intensive care units (ICUs)


Methods

- Patients placed in prone position 6 or more hours daily for 10 days
- Respiratory, biochemical, and skin care assessed daily while supine
- Change to the prone position was triggered each day if PaO₂/FiO₂ ratio met AECC-defined ARDS/ALI criteria

Endpoints

- Primary = Death at 10 days, at ICU discharge, and at 6 months
- Secondary = Improvements in respiratory and organ function

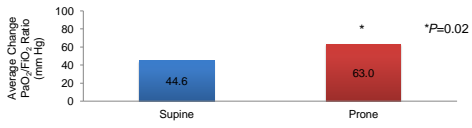
AECC = American European Consensus Conference
Gattinoni L, et al. Effect of Prone Positioning on the Survival of Patients with Acute Respiratory Failure. *N Engl J Med.* 2001; 345(8): 668-673
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Prone Positioning Improves Oxygenation in Patients with Acute Respiratory Failure 17

Oxygenation was improved in 73.2% of the pronation procedures

69.9% of the improved oxygenation was seen within the first hour of pronation




Position	Average Change PaO ₂ /FiO ₂ ratio (mm Hg)
Supine	44.6
Prone	63.0

**P=0.02*

Incidence of complications was similar in the two groups


Gattinoni L, et al. Effect of Prone Positioning on the Survival of Patients with Acute Respiratory Failure. *N Engl J Med.* 2001; 345(8): 668-673
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Prone Positioning of Patients at Highest Risk Suggested a Survival Advantage 18

- Improved 10-day survival in patient quartile with the highest risk of mortality
- PaO₂/FiO₂ ratio <88 [prone = 23.1% vs. supine = 47.2%; RR of death 0.49; 95% CI, 0.25-0.95]
- Simplified Acute Physiology Score II >49 [prone = 19.4% vs. supine 48.5%; RR of death, 0.40; 95% CI, 0.19-0.85]
- Tidal volume >12 mL per kilogram predicted body weight [prone = 18.2% vs. supine = 41.0%; RR of death 0.44; 95% CI 0.20-1.00]

Gattinoni L, et al. Effect of Prone Positioning on the Survival of Patients with Acute Respiratory Failure. *N Engl J Med.* 2001; 345(8): 668-673
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Kinetic Therapy 31

Kinetic Therapy beds continuously rotate the patient from side to side to:

- Mobilize secretions
- Redistribute pressure in the lung
- Re-expand areas of atelectasis
- Improve blood flow, gas exchange, and oxygenation

Davis JW, et al. Prone Ventilation in Trauma or Surgical Patients with Acute Lung Injury and Adult Respiratory Distress Syndrome: is it Beneficial? J Trauma. 2007; 62(5): 1201-1206
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Kinetic Therapy Improved Outcomes in Critically Ill Blunt-Trauma Patients 32

Outcome	Conventional Bed (%)	RotoRest Kinetic Treatment Table Bed (%)	P-value
Lower Respiratory Tract Infection	58.3	25.5	P=0.0011
Pneumonia	39.6	13.7	P=0.0056
Length of Hospital Stay	37	20	P=0.0138
Days Intubated	7	4	P=0.0501

Fink MP, et al. The efficacy of an oscillating bed in the prevention of lower respiratory tract infection in critically ill victims of blunt trauma: a prospective study. Chest. 1999; 91: 132-137
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Improvement in Oxygenation and Resolution of Atelectasis with Kinetic Therapy 33



Outcome	Manual Repositioning (%)	TriaDyne Kinetic Therapy System (%)	P-value
Partial or Complete Resolution of Atelectasis	14.3	82.3	P=0.004

Days	Manual Repositioning (PaO ₂ /FiO ₂ Ratio)	TriaDyne Kinetic Therapy System (PaO ₂ /FiO ₂ Ratio)
0	~180	~200
3	~140	~250
7	~100	~300
14	~110	~320

* Baseline PaO₂/FiO₂ in TriaDyne group was different from all other time points (3, 7, and 14 days) in the TriaDyne group (P=.05).
 ** Manual and TriaDyne groups different at 3, 7, and 14 days (P=0.03).
 Raouf S, et al. Effect of combined kinetic therapy and percussion therapy on the resolution of atelectasis in critically ill patients. Chest. 1999; 115: 1658-1666
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Options for Prone Positioning

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Manual Prone Positioning Kinetic Therapy™ Surface	Automated Prone Positioning Kinetic Therapy™ Surface
	
Triadyne™ II Kinetic Therapy System	RotoProne™ Therapy System

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Features of the RotoProne™ Therapy System

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CPR

- Returns patient from prone to supine in <40 seconds in the event of a code

Rotation programmable in 1° increments

- Allows customization of therapy

Pause and hold functions

- Facilitates nursing care or medical procedures

Tube-management system

- Helps prevent line and tube dislodgement

Electronically monitored buckles

- Ceases rotation and alarms if buckles not secured

Intuitive touch-screen control panel

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RotoProne™ Therapy System

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Prone positioning is an aggressive noninvasive therapy that can be used adjunctively with other modes of ventilation

<ul style="list-style-type: none">Kinetic Therapy<ul style="list-style-type: none">Reduces VAPReduces ICU stayReduces and resolves atelectasis	<ul style="list-style-type: none">RotoProne™ Therapy System<ul style="list-style-type: none">Quickly improves oxygenationEffective lung-protective therapyReduces ICU stayReduces ventilation timeReduces barotraumaMobilizes secretions
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1. Picher P, et al. Prone position in acute respiratory distress syndrome. *Sur Respir J*. 2002; 20(4): 1011-1020.
2. Davis DJ, et al. Prone Ventilation in Trauma or Surgical Patients with Acute Lung Injury and Acute Respiratory Distress Syndrome: Is it Beneficial? *J Trauma*. 2007; 62(5): 1201-1206.
3. Martin JL, et al. Ventilatory management of acute respiratory distress syndrome: a consensus of the. *Crit Care Med*. 2004; 32(1): 290-295.
4. Marabito J, et al. A multicenter trial of prolonged prone ventilation in severe acute respiratory distress syndrome. *Am J Respir Crit Care Med*. 2006; 173: 1233-1239.
5. Watanabe I, et al. Beneficial Effect of a Prone Position for Patients with Severe Hypoxemia after Intubation and Mechanical Ventilation. *Crit Care Med*. 2002; 30(9): 1759-1802.
6. Akbulut FN, et al. The prone position eliminates compression of the lungs by the heart. *Am J Respir Crit Care Med*. 2000; 161: 1650-1655.
7. Gattinoni L, et al. Decrease in Pao2 with prone position is predictive of improved outcome in acute respiratory distress syndrome. *Crit Care Med*. 2003; 31(12): 2727-2733.

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RotoProne™ Therapy System



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The image shows the RotoProne Therapy System, a specialized medical bed designed for prone positioning and kinetic therapy. It features a white head and foot section, a blue and grey central body, and a blue base with wheels. The bed is shown in a prone position, with a patient lying face down. The system includes various adjustment mechanisms and safety features.

Introduction

- Advanced patient care system for treatment and prevention of pulmonary complications associated with immobility
- Rotation up to 62° in both prone and supine positions
 - Kinetic Therapy: Gentle side-to-side rotation of a patient ≥ 40°
 - Mobilizes pulmonary secretions
 - Improve ventilation/perfusion matching
 - Resolution of atelectasis
 - Reduction in incidence of nosocomial pneumonia
 - Prone Therapy:
 - Improves oxygenation in patients with ARDS
 - Aids in recruitment of collapsed alveoli
 - Enhances drainage of airway secretions
 - Improves ventilation/perfusion matching
 - RotoProne™ Therapy System:
 - Allows immobile patient with respiratory complications to be moved from supine to prone position
 - Most aggressive form of positioning therapy for treatment of pulmonary complications

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Indications

Patient conditions for which the application of RotoProne™ Therapy is indicated include:

- Treatment and prevention of pulmonary complications associated with immobility
 - Acute Respiratory Distress Syndrome (ARDS)
 - Acute Lung Injury (ALI)
 - Ventilator Associated Pneumonia (VAP)
 - **Ventilator Induced Lung Injury (VILI)**

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Contraindications 43

Patient conditions for which the application of RotoProne™ Therapy is contraindicated include:

- Unstable cervical, thoracic, lumbar, pelvic, skull or facial fractures
- Cervical and/or skeletal traction
- Uncontrolled Intracranial Pressure (ICP)
- Patient weight below 40 kilograms (88 lbs.)
- Patient weight above 159 kilograms (350 lbs.)
- Patient height in excess of 6 feet 6 inches

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Precautions 44

Precautions may also need to be taken when using this product with certain patient conditions, including, but not limited to:

Hemodynamic Instability	Wounds at risk of dehiscence while in prone position
Severe Agitation	Patients in prone position with open sternal wound or thoracic post-surgical incision
Uncontrollable Claustrophobia or fear of confinement	Patient in the prone position with open abdomen
Uncontrollable Diarrhea	Any implant potentially increases risk of skin breakdown including but not limited to breast implants or penile prosthesis
Intolerance to face down position	Pregnancy

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Risks 45


Use of the RotoProne™ Therapy System is typically prescribed for patients at high risk of mortality. While some studies have demonstrated that proning improves mortality, there are inherent risks with proning itself. For instance, some studies and caregiver experience have suggested or reported risks of the following in relation to proning in general.

Skin breakdown and/or pressure necrosis	Corneal Abrasion
Wound dehiscence	Myositis Ossification
Cardiac Arrest	Venous Air Embolism
Loss of invasive lines or tubes; extubation (endotracheal & oral)	Increased Intraorbital Pressure
Edema and/or swelling	Central Retinal Artery Occlusion
Splenic rupture	Pain and Discomfort
Blindness and other consequences of damage to the ocular nerve	Difficulty performing CPR

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Prone Protocols 46


- Early intervention
- Longer prone times
- No standard protocol in the literature
 - Manual prone procedures usually proned for 6 – 12 hrs then supine for 6 – 12 hrs
- KCI Protocol:
 - 3 hrs and 15 min in the prone position with Kinetic Therapy (min of 40° and max of 62°)
 - 45 min supine
 - Provides for approximately 19 – 20 hrs of prone time per 24 hrs
 - Timing designed to allow for every 4 hr complete assessment by nursing staff
 - No real science to back up the "4 hr" protocol



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Prone Protocols 47


- Reverse Trendelenburg
 - Reduces facial swelling
- Open exterior hatches
 - Provides visibility and access to patient by nursing staff
 - Provides cooler environment
 - Prevents pressure against back of heels
- Kinetic Therapy
 - Minimum of 40°
 - Mobilizes secretions
 - Needed to prevent skin breakdown from immobility



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Features of the RotoProne™ Therapy System 48


- Rotation programmable in 1° increments
 - Allows customization of therapy
- Acclimation mode
 - Slow increase in degree of turn allows unstable patients to gradually become accustomed to therapy
- Pause and Hold Functions
 - Facilitates nursing care
- Tube Management System
 - Helps prevent line and tube dislodgement
- Electronically Monitored Buckles
 - Ceases rotation and alarms if buckles not secured
- Ergonomically Designed Head Positioning System
 - Adjustable for size and shape of patient
- CPR
 - Returns patient from prone to supine in < 40 seconds in the event of a code



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Pulmonary Assessment 55


- Section would include
 - Ventilatory and gas-exchange values
 - Chest radiography
 - Hemodynamics



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Case Considerations 56


- Discussion of findings
 - Patient risk factors
 - Challenge associated with this specific case
- Factors considered in determination of prone positioning for this patient



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Clinical Course 57

- Section would include overview of care provided and outcomes achieved during treatment



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Case Pearls 58

- Discuss why this case demonstrates the clinical benefits of prone positioning, or
- Why this patient was an ideal candidate for prone therapy, or
- How prone therapy improved long-term outcomes for the patient



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