Prone Positioning of Patients With Acute Respiratory Distress Syndrome

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Effectively treating critically ill patients with acute respiratory distress syndrome (ARDS) is a challenge for many intensive care nurses. Multiple disease processes and injuries contribute to the complexity of ARDS and often complicate therapy. As a means of supportive care for ARDS, practitioners resort to rescue therapies to improve oxygenation and salvage the patient. The pathophysiology of ARDS and the use of prone positioning to improve pulmonary ventilation and oxygenation in ARDS patients are described. Educating nursing and medical staff on the use of prone positioning allows ease of patient placement with an emphasis on safety of both patients and staff. Scrupulous assessment of patients coupled with judicious timing of prone positioning expedites weaning from ventilatory support and contributes to positive outcomes for patients. (Critical Care Nurse. 2015;35[6]:29-37)

Critical care nurses work diligently day and night to manage intensely ill patients who are in unstable condition. The added strain of watching a patient’s condition deteriorate despite constant care and intervention often leaves nurses feeling helpless. Acute respiratory distress syndrome (ARDS) is not a primary disease, but rather reflects failure of the respiratory system resulting from inflammatory processes in the body. The inflammatory process derives from a variety of pathological triggers; therefore, ARDS has no boundaries and is often observed in various acute and intensive care settings. According to the National Heart, Lung, and Blood Institute, about 190,000 Americans are affected by ARDS annually. Physical findings are often nonspecific, and diversity in signs and symptoms complicates the diagnosis of ARDS and leads to reported mortality rates varying from 20% to 40%.

In 2011, the combined efforts of the European Society of Intensive Care Medicine, the American Thoracic Society, and the Society of Critical Care Medicine produced the Berlin definition of ARDS. The objectives for this initiative were to use epidemiological, physiological, and clinical trials to address the limitations of the American European Consensus Conference definition of ARDS. Specifically addressed...
were missing or poorly defined components of the American European Consensus Conference's definition, including (a) timing of onset, (b) sensitivity of the ratio of $P_{aO_2}$ to fraction of inspired oxygen ($P_{aO_2}$/$FIO_2$ or $P/F$ ratio) to varied ventilator settings, (c) reliability of radiographic criteria, and (d) hydrostatic edema. Under the new definition, ARDS is diagnosed if symptom onset is within 1 week of clinical injury or worsening symptoms.\(^5\) Three categories of ARDS were described in the Berlin definition of ARDS, based on degree of hypoxemia as evidenced by the calculated $P/F$ ratio: mild, moderate, and severe (Table 1).\(^6\) The $P/F$ ratio is a useful measure of efficiency of oxygen transfer across the lung. Lower $P/F$ ratios indicate poor gas exchange in the lungs (Table 1).

An additional resource available as a result of the Berlin definition of ARDS work group is a chest radiograph reference set, which provides a visual aid to assist practitioners with diagnosing ARDS. With the new definition, the criteria for pulmonary artery wedge pressure for hydrostatic edema (for diagnosis of ARDS) were removed.\(^5\) Development, dissemination, and periodic expert review of definitions of syndromes such as ARDS is imperative for continued research and to support positive outcomes for patients. Costa and Amato\(^8\) showed that the reassessment of the criteria at 24 hours was better for predicting mortality across the 3 ARDS groups. Villar et al\(^9\) reported that mortality was better described by assignment of the ARDS criteria (in terms of $P/F$ ratio) at a given positive end-expiratory pressure (PEEP) and $FIO_2$ at 24 hours. Hernu et al,\(^10\) in a prospective survey, did not find any difference in mortality between patients with mild versus moderate ARDS.

ARDS is manifested acutely and progresses rapidly. Recognition and treatment of the underlying cause with concurrent mechanical ventilatory support is the multimodal approach to combat the damaging effects of ARDS. Interventions used supportively to decrease ventilator-induced lung injury and to maximize oxygenation include lung-protective (low-tidal-volume) ventilation, use of PEEP, and fluid management to maintain cardiac output.\(^11,12\) A National Heart, Lung, and Blood Institute clinical trial reports strong evidence that low tidal volume (6 mL/kg vs 12 mL/kg) results in lower mortality than does higher tidal volume.\(^1,13,14\)

Other therapies termed rescue or salvage therapies (because of when these therapies are initiated) are used in combination with the measures noted. These therapies may include inhaled pulmonary vasodilators (nitric oxide or prostacyclin), partial liquid ventilation (perfluorocarbon liquids), alternative ventilation (high-frequency oscillatory, jet, airway pressure release, or pressure control-inverse ratio), neuromuscular blocking agents, exogenous surfactant, intravascular oxygenation, extracorporeal membrane oxygenation, and prone ventilation.\(^13,15\)

According to Taber's Cyclopedic Medical Dictionary,\(^16\) prone is defined as “horizontal with the face downward”

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Table 1 The Berlin definition of acute respiratory distress syndrome\(^a\)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Timing</td>
<td>Within 1 week of injury or new/worsening respiratory symptoms</td>
</tr>
<tr>
<td>Chest imaging</td>
<td>Bilateral opacities</td>
</tr>
<tr>
<td>Origin of edema</td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment to exclude hydrostatic edema, if no risk factors</td>
</tr>
<tr>
<td>Oxygenation</td>
<td></td>
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<tr>
<td>Mild</td>
<td>$P_{aO_2}$/$FIO_2$ ≤200 mm Hg with PEEP or CPAP ≥5 cm $H_2O$</td>
</tr>
<tr>
<td>Moderate</td>
<td>$P_{aO_2}$/$FIO_2$ ≤200 mm Hg with PEEP ≥5 cm $H_2O$</td>
</tr>
<tr>
<td>Severe</td>
<td>$P_{aO_2}$/$FIO_2$ ≤100 mm Hg with PEEP ≥5 cm $H_2O$</td>
</tr>
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</table>

How to calculate the $P_{aO_2}$/$FIO_2$ ($P/F$) ratio: \(^7\)

1. Obtain most recent $P_{aO_2}$ value in mm Hg
2. Convert $FIO_2$ (%) value into decimal $FIO_2$ (%) / 100 = $FIO_2$ decimal
3. Calculate the $P/F$ ratio taking numbers from steps 1 and 2

Abbreviations: CPAP, continuous positive airway pressure; $FIO_2$, fraction of inspired oxygen; $P_{aO_2}$, partial pressure of arterial oxygenation; PEEP, positive end-expiratory pressure.\(^a\) Based on information from The ARDS Definition Task Force.\(^4\)
or the opposite of supine, and pronation is defined as “the act of lying prone or face downward.” Patients are placed prone for surgery, procedures, dressing changes, and to improve pulmonary complications of ARDS. Potential benefits of prone positioning include improved oxygenation, improved lymphatic drainage and secretion removal, and reinflation of collapsed pulmonary alveoli.11,15,17,18

A variety of techniques or devices can be employed to achieve prone position; namely, manual proning maneuvers, positioning devices, and automated beds.11 The decision regarding which technique or device to use is multifactorial and should take into consideration facility resources, nurses’ education level, and equipment availability. In this article, we briefly introduce and review each approach to achieving the prone position for treatment of patients with ARDS.

**ARDS Pathophysiology Review (in Relation to Prone Positioning)**

A brief review of the pathophysiology of ARDS provides a basis for understanding the utility of prone positioning as a treatment technique to improve oxygenation and facilitate weaning of patients off of ventilatory support. ARDS develops as a result of direct (pulmonary) or indirect (extrapulmonary) lung injury11,19 (Table 2). Specifically in extrapulmonary ARDS, injury of the alveolar epithelium and pulmonary vasculature leads to increased alveolar capillary permeability, causing alveolar and interstitial edema.12,17,19 Damage of type II alveolar cells renders surfactant inactive, which contributes to atelectasis and decreased lung compliance and ultimately results in refractory hypoxia and respiratory failure.12,17,19 Furthermore, edematous alveoli compress alveoli in dependent regions and the weight of the heart and abdominal contents of the sedated, often chemically paralyzed, patient contributes to the alveolar collapse.11,20 Impairment of oxygenation ensues, and bilateral infiltrates, unrelated to cardiac cause, are seen on chest radiographs.11

**Evidence to Support Prone Positioning of Patients With ARDS**

In the 1970s, positive effects on arterial oxygenation as a result of prone positioning were hypothesized to promote dorsal lung reexpansion, oxygenation, and alveolar recruitment in patients with ARDS.2,17 Prone positioning benefits the patient by improving regional ventilation and perfusion, aiding in secretion and redistribution of extravascular lung water, and unweighting the soft tissues.15,17 Additional physiological benefits of prone position include improved lung recruitment and oxygenation.17 The prone position allows a greater percentage of open alveoli (greater recruitment) and therefore potentially causes less ventilator-induced lung injury or delays such injury by allowing a lower FIO2 and lower airway pressures to achieve adequate oxygenation.11,21 Sud et al14 reported that prone positioning during mechanical ventilation reduces mortality in ARDS patients receiving protective lung ventilation (tidal volume < 8 mL/kg of predicted body weight). The effects of PEEP, recruitment maneuvers, and prone positioning are greater in patients with ARDS that has not resulted from direct lung injury.22

Prone positioning within 72 hours of diagnosis with the patient kept prone up to 20 hours per day yield the most benefit.15,18 In a meta-analysis, Lee et al23 reported that sufficient duration of mechanical ventilation of prone patients significantly reduced overall mortality in patients with severe ARDS. In a randomized controlled trial for positioning patients with severe ARDS prone, Guerin et al24 demonstrated that early prone positioning (patient placed prone within 1 hour after randomization) reduced mortality (28 and 90 days later) and increased the rate of successful extubation. Improvement in gas exchange is often used to indicate successful prone positioning; therefore, prescribing the duration of prone positioning is patient specific.25

When the patient is prone, alveolar recruitment is hypothesized to result from the pleural gradient being

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**Table 2 Causes of acute respiratory distress syndrome**

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
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<tbody>
<tr>
<td>Pneumonia</td>
<td>Sepsis</td>
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<tr>
<td>Aspiration</td>
<td>Transfusion of blood products</td>
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<tr>
<td>Inhalation injury</td>
<td>Shock</td>
</tr>
<tr>
<td>Fat emboli</td>
<td>Burns19</td>
</tr>
<tr>
<td>High-pressure mechanical ventilation20</td>
<td>Drug overdose</td>
</tr>
<tr>
<td>Pulmonary contusion</td>
<td>Cardiopulmonary bypass</td>
</tr>
<tr>
<td>Near drowning</td>
<td>Acute pancreatitis</td>
</tr>
<tr>
<td>Reperfusion pulmonary edema9</td>
<td>Severe trauma</td>
</tr>
<tr>
<td></td>
<td>Head injury20</td>
</tr>
<tr>
<td></td>
<td>Disseminated intravascular coagulation20</td>
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</tbody>
</table>

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**References**

2. http://ccn.aacnjournals.org/ Downloaded from by AACN on January 12, 2018
Prone positioning in life-threatening hypoxemia may prevent imminent death. The heart rests mostly on the sternum when the patient is prone, thus exerting less pressure on the pleura and lung. In addition, intra-abdominal pressure may be reduced when the patient is prone. Positive-pressure ventilation amplifies this effect while the patient is prone by directing the pulmonary blood flow to the more ventilated regions. Postural drainage of water and exudates and accelerated removal of secretions are also noted clinical benefits of positioning patients prone. Prone positioning improves oxygenation in 70% to 80% of patients with ARDS. Use of the reverse Trendelenburg position while the patient is prone may serve to decrease abdominal pressure and prevent displacement of stomach contents.

Procedure for Achieving Prone Positioning

Patients may be positioned prone manually, with the use of assistive devices, or with the use of an automated bed. Manual positioning refers to placing the patient prone without the use of equipment or specialized beds to achieve the position. When positioning a patient manually, ensure that a sufficient number of staff help to turn the patient safely. Prone positioning may also be achieved with the Vollman Prone Positioner, a padded metal frame with belt buckles that secure and protect the patient’s head, chest, and abdomen during the procedure. Last, prone positioning may be achieved via use of an automated bed.

Prone positioning in life-threatening hypoxemia may prevent imminent death.

Such devices assist critical care nurses by mechanically assisting the nurse in positioning the patient prone and providing lateral rotation while allowing Trendelenburg and reverse Trendelenburg positioning. Automated beds provide a mechanism to position the patient supine rapidly in the event of a cardiac arrest or hemodynamic instability.

Regardless of the method used to achieve the prone position, only trained teams who have completed staff education and demonstrated competency (Table 3) should be permitted to attempt this intervention. Positioning a patient prone is labor intensive and physically challenging for nursing staff. Protocols and an algorithmic approach to prone positioning should be used to meet specific needs of the unit and the population of patients.

Indications

Research demonstrates the importance of early prone positioning and indicates that sufficient duration of prone positioning can lead to better outcomes for patients. Knowledge of the physiological benefits of prone therapy in select ARDS patients (particularly those with extrapulmonary ARDS) supports advocacy for the procedure. The basis for initiating prone positioning begins with assessment of the patient, a key activity of acute and critical care nurses. Well-sedated patients receiving mechanical ventilation should be placed prone with the following inclusion criteria in mind: inadequate oxygenation at greater than 50% F<sub>io2</sub> despite PEEP levels higher than 10 cm H<sub>2</sub>O, and the presence of bilateral infiltrates on chest radiograph. These criteria may differ between institutions, individual practitioners, and from patient to patient.

Risks of prone positioning are often offset by the need to provide adequate oxygenation and should be weighed on an individual basis. Table 4 lists absolute and relative contraindications for placing a patient prone. The P/F ratio can be used to guide timing for initiating prone positioning. Prone positioning as a rescue maneuver in cases of life-threatening hypoxemia in patients undergoing mechanical ventilation (Pao<sub>2</sub> ≤ 55 mm Hg at F<sub>io2</sub> = 1.00 and PEEP ≥ 15 cm H<sub>2</sub>O) may prevent imminent death and allow time for other treatments. Patients with severe ARDS as evidenced by a P/F ratio less than 100 have shown the most benefit from prone positioning, with reduced mortality. Regardless, prone positioning should be implemented as early as possible in patients with ARDS rather than using it as rescue intervention. In the PROSEVA trial, Guérin et al reported decreased mortality at 28 and 90 days and demonstrated the importance of using prone positioning as a first-line intervention rather than a rescue maneuver.

Nursing Implications

ARDS patients who are placed prone are critically ill. Critical care nurses must be vigilant when caring for such patients. Frequent assessments of all body systems
are important nursing actions. Furthermore, anticipating adverse effects is an important function of the critical care nurses caring for prone patients. Pressure ulcers, obstruction of the endotracheal tube, and dislodgement of thoracostomy tubes are particularly high-risk complications for these patients.14

Ensuring a Patent Airway

Anticipation of complications must be ensured to prevent dislodgement of the airway and critical tubes or catheters in prone patients.12 Use of specialized securement devices may decrease the risk of catheter or airway loss when used in conjunction with careful monitoring.2 Additionally, having a respiratory therapist in the room for the procedure in the event of airway or ventilator complications may prove useful. Nursing or respiratory staff should securely tie and double tape the endotracheal or tracheostomy tube, as secretions may increase with the patient prone and may loosen adhesive, dislodging the tubes and causing airway compromise. A bite block may be used to prevent the patient’s tongue from protruding and becoming injured.

Ongoing Respiratory Assessment

Other complications may include transient oxygen desaturation and hypotension.32 Nurses caring for the
In-depth training and in-service training serve as a foundation for the success of prone positioning. Changes in baseline values are important to determine patients’ tolerance of prone positioning. Assessing improvements in the P/F ratio is one means of assessing the patient’s response to being positioned prone, and it is recommended that arterial blood gases be measured 30 minutes after the patient is initially positioned prone. Improvements in gas exchange during prone positioning may be caused by an increase in functional residual capacity (volume of air present in the lungs at the end of passive expiration), similar to the effects of PEEP. A PaO₂ increase of at least 10 mm Hg or an increase in P/F ratio by 20 mm Hg or more indicates a positive response to prone positioning. Additionally, improvement in oxygenation with prone therapy was described in the PROSEVA trial as a P/F ratio of at least 150 mm Hg with a PEEP of 10 cm H₂O or less and an FIO₂ of 0.6 or less.

Integumentary Concerns
Eye and skin care should be included in the plan of care to minimize complications from prone positioning. To prevent corneal drying and abrasions, nurses should cover the eyes and apply lubricant as ordered. Routine eye care should be performed to reduce the patient’s risk for ophthalmic infection. Recent recommendations suggest that polyethylene-film eye covers may be more effective than instilling drops or ointment to prevent corneal abrasions. Nurses should also ensure that padding is not causing direct pressure on the eyes once the patient is positioned prone.

Any dressings or drainage tubes present on the anterior part of the patient’s body should be changed and emptied before positioning the patient prone to reduce the risk of skin breakdown from oozing secretions. Nurses should assess and document skin condition before turning the patient prone because skin breakdown may occur with prone positioning. Once the patient is prone, considerable pressure is placed on the forehead and cheeks. Measures should be taken to prevent or minimize skin breakdown; for example, removing electrocardiography leads from the anterior chest wall and repositioning them posteriorly or toward the shoulders and sides, avoiding pressure areas. The Figure shows an example of high-risk breakdown areas that may be padded with foam dressings.

Neurological Considerations
The nurse should assess neurological status frequently, as adequate sedation is imperative for all ARDS patients being treated with prone therapy. Some patients may require sedation with the addition of neuromuscular blocking agents. Turning can be a frightening experience for a patient if he or she is not adequately sedated. Pain assessment should be performed per agency policy, and the potential need for a bolus dose of sedative before positioning the patient prone should be considered.

Gastrointestinal Considerations
In order to prevent aspiration, enteral feedings should be withheld at least 1 hour before positioning a patient prone. In 2009, Schneider et al. reported that best practice guidelines for withholding enteral feeding from intubated patients before scheduled procedures need to be developed jointly by the critical care specialties. Adequate patient nutrition supports recovery and can be achieved with enteral feedings via the postpyloric or parenteral route. If the patient requires neuromuscular blocking agents to sustain prone positioning, enteral feedings should be discontinued and replaced with parenteral nutrition.
Anticipating Adverse Effects of Prone Positioning

Patient who are turned prone are at risk for many complications. These complications include, but are not limited to, adverse airway events, displacement of the endotracheal tube, selective intubation or accidental extubation, obstruction of the endotracheal tube, pressure sores or facial edema, and dislodgement of catheters or tubes.25,26,32,36 Hemodynamic instability, worsening gas exchange, patients’ intolerance owing to inadequate sedation, cardiac dysrhythmia, and inadequate enteral nutrition also may occur.37 Difficulty in monitoring the patient and performing cardiopulmonary resuscitation are additional complications of prone positioning. As mentioned earlier, facial, orbital, and ocular edema, peripheral nerve injuries, skin necrosis, corneal ulceration, and abdominal wound dehiscence may occur.12,32 The complications that may occur with prone positioning, coupled with the patient’s critically ill status, necessitate frequent assessment and adjustment of the nurse to patient ratio.

Education

Providing ongoing education to the patient’s family is an important function of the critical care nurse. Additionally, to ensure the patient’s safety while he or she is prone, ongoing staff education, development, and competency are all necessary.

Staff Education

Nurses are primarily responsible for placing the patient prone and for the ongoing assessment of the patient. In-depth training and in-service training serve as a foundation for the success of prone positioning. A medical skills learning center or simulation laboratory may serve as an integral component for educating and maintaining staff competency with use of prone positioning. Detailed instruction, including demonstration, followed by guided hands-on placement is important to form a solid foundation for competency. Use of simulation mannequins or peer volunteers for placement in the prone position provides a realistic environment and contributes to a nurse’s comfort level.

Nursing policy including an algorithmic approach to assessing, diagnosing, and use of prone ventilation should be clear and available to all members of the health care team. Education including return demonstration can strengthen competency and enhance comfort with positioning patients prone, especially when recent experience is lacking or absent. Patients’ complications decrease with increased experience gained by nurses with frequent use of prone positioning, regardless of the technique used.32

Family Education

A patient’s family can feel helpless when a loved one is critically ill. An important component of caring for the patient involves care for the patient’s family as well. Inclusion of the family in decision making and caregiving during the course of illness can empower the family and give them hope and purpose. Family members can become overwhelmed with the complexity of equipment that monitors and supports their loved one. Concerns regarding prone positioning may include fear for their loved one’s safety. Providing a rationale for prone positioning and explaining the expected benefits may help alleviate doubts. The nurse should also prepare the patient’s family for facial edema and the possibility of skin breakdown. Educational brochures may be offered to patients and their families and may aid in alleviating fears. Allowing family members to be present while the patient is turned prone may also alleviate their fear of the patient being injured. According to the American Association of Critical-Care Nurses practice alert38 (from 2011), evidence shows that the unrestricted presence and participation of a support person can enhance satisfaction of both patients and their families.

Summary

As the incidence of ARDS continues to contribute to patients’ mortality, critical care nurses must understand the pathophysiology of ARDS, indications for prone positioning, and nursing interventions for patients who are positioned prone. Prone positioning of a patient with ARDS may result in a greater proportion of alveoli being aerated at equivalent delivered volumes and should be considered as an early supportive therapy rather than a rescue maneuver.33 Future research should focus on timing, duration, and effectiveness of prone positioning in the treatment of patients with ARDS. CCN

References
Prone Positioning of Patients With Acute Respiratory Distress Syndrome


Facts

Acute respiratory distress syndrome (ARDS) is manifested acutely and progresses rapidly. Interventions used supportively to decrease ventilator-induced lung injury and to maximize oxygenation include lung-protective ventilation, use of positive end-expiratory pressure, and fluid management to maintain cardiac output. Other therapies used in combination with the measures noted may include inhaled pulmonary vasodilators, partial liquid ventilation alternative ventilation, neuromuscular blocking agents, exogenous surfactant, intravascular oxygenation, extracorporeal membrane oxygenation, and prone ventilation.

- Research demonstrates the importance of early prone positioning and indicates that sufficient duration of prone positioning can lead to better outcomes for patients.
- A variety of techniques or devices can be employed to achieve prone position; namely, manual proning maneuvers, positioning devices, and automated beds. The decision regarding which technique or device to use is multifactorial and should take into consideration facility resources, nurses’ education level, and equipment availability.
- The basis for initiating prone positioning begins with assessment of the patient, a key activity of acute and critical care nurses.
- Well-sedated patients receiving mechanical ventilation should be placed prone with the following inclusion criteria in mind: inadequate oxygenation at greater than 50% FIO2 despite positive end-expiratory pressure levels higher than 10 cm H2O, and the presence of bilateral infiltrates on chest radiograph.
- Any dressings or drainage tubes present on the anterior part of the patient’s body should be changed and emptied before positioning the patient prone to reduce the risk of skin breakdown from oozing secretions.
- Nurses should assess skin condition before turning the patient prone because skin breakdown may occur with prone positioning. Once the patient is prone, considerable pressure is placed on the forehead and cheeks. Measures should be taken to prevent or minimize skin breakdown; for example, removing electrocardiography leads from the anterior chest wall and repositioning them posteriorly or toward the shoulders and sides, avoiding pressure areas.
- Critical care nurses must be vigilant when caring for patients who are placed prone. Frequent assessments of all body systems are important nursing actions. Pressure ulcers, obstruction of the endotracheal tube, and dislodgement of thoracostomy tubes are particularly high-risk complications for these patients. CCN