Implementing Prone Positioning in Your Unit: What Do You Need to Know?

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Prone positioning for patients with acute respiratory distress syndrome (ARDS) has been occurring for over 30 years. A recent randomized control trial showing significant impact on 30- and 90-day mortality has placed it into international guidelines as a strongly recommended therapy. The current coronavirus pandemic shined a light on prone positioning as a lifesaving technique to improve oxygenation. This has resulted in worldwide implementation in intensive care units (ICUs). To incorporate prone positioning into moderate and severe ARDS patients' routine practice, the multiprofessional team must address many factors. They include:

- *Understanding why prone positioning works and the evidence to supports its use with moderate to severe ARDS patients.*
- *Identify screening strategies to determine which patients the position should be initiated early in the course of their disease.*
- *Multiprofessional development of a protocol is required to address indications for use, methods, frequency of prone positioning, contraindications, equipment needed, preparation of the patient to prevent injury, and care of the patient while in the prone position as indications for stopping the procedure.*
- *Development of education and implementation plans to ensure the successful integration of the new practice.*

Keywords: prone position, ARDS, complications, pressure injuries, mechanical ventilation

INTRODUCTION

Prone positioning is utilized to recruit alveoli to improve oxygenation while preventing ventilator-induced lung injury complications in patients with acute respiratory distress syndrome (ARDS) for over 30 years. Recently with new studies, prone positioning is now considered front-line therapy, and utilization of the technique has increased significantly since COVID 19. With the ARDS patient's mortality rate remaining at 40%, we need to implement evidence-based practices that work. The journey to implement and incorporate the practice of prone positioning within a unit starts by gathering a multiprofessional team to evaluate the science and understand the prone position's physiological mechanisms for reducing lung trauma and improving oxygenation. The team then builds a protocol that details indications for use, length of time in the position, methods, people, and resources to perform the procedure safely. Evidence-based strategies for turning and providing care while the patient is in the prone position are critical in preventing patient and staff complications. Lastly, designing staff education, competency assessment, and a plan for ease of implementation will allow the intensive care unit (ICU) to successfully integrate prone position as part of a standard of care for moderate to severe ARDS patients.

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UNDERSTANDING THE WHY

Prone positioning is used as an adjunct short-term supportive therapy to recruit alveoli to improve gas exchange and reduce ventilator injury in critically ill patients with severe hypoxemia ARDS. Understanding the beneficial effects of prone positioning is aided by examining the impact of position change on physiological and structural areas: pressure gradient changes, lung compliance, and the change in perfusion with altering a patient's position (Gattinoni et al., 2019; Johnson et al., 2017; Malhotra & Kacmarek, 2020).

Pressure Difference

The pressure difference between the airway and pleural space creates a gradient (Pelosi et al., 2002). This gradient results in the dorsal or posterior portions of the lung/alveoli in the supine position to expand less. This is worsened in ARDS because of the weight of the lung caused by non-cardiogenic edema (Gattinoni et al., 1991; Gattinoni et al., 1988). In the prone position, the pressure gradient is less steep, making ventilation more even or homogenous (Lai-Fook & Rodarte, 1991). There is a reduction in the overdistension of the upper part of the lungs (ventral) and a decrease in posterior alveolar collapse (Chatte et al., 1997; Douglas et al., 1977; Fridrich et al., 1996; Henderson et al., 2013; Pappert et al., 1994). This results in less ventilator-induced lung injury from the overdistension and the cyclical opening and closing of the alveoli, reducing shear stress in the dependent regions (Gattinoni et al., 2019).

Changes in Chest Wall/Lung Compliance/Perfusion

In the ARDS patient, lung compliance is determined by the number of alveoli open to ventilation (Guérin et al., 2020). How does the body's position affect chest wall and lung compliance? Regarding chest wall compliance, in the supine position, the heart compresses the posterior part of the lung against a rigid spine, and the diaphragm pushes into the most posterior part of the lung, impacting expansion. In healthy subjects, the diaphragm acts as a shield against the forces created by the abdominal contents (Froese & Bryan, 1974). The abdominal contents play a larger role when the shielding function is lost by reducing tone caused by sedation, paralytics, or increased abdominal pressure in patients with ARDS (Malbouisson et al., 2000). In the prone position, the heart rests against the sternum versus the rigid spine, decreasing posterior lung compression, opening previously closed alveoli again, making ventilation more evenly distributed. If the abdomen is free from restriction, the contents do not push up on the diagram resulting in fewer compression forces on the lower lung unit (Douglas et al., 1977; Pelosi et al., 1996). Lung compliance is determined by the number of alveoli available for ventilation. With the pressure changes and the change in the chest wall compliance in the prone position, alveoli are recruited, resulting in overall improvement in lung compliance. This in turn causes a more homogenous distribution of ventilation, reducing the impact of volutrauma (Guérin et al., 2020).

When the ARDS patient is supine, lung perfusion is gravity dependent and is directed towards collapse alveoli creating a significant ventilation/perfusion mismatch (West, 1985). When prone, perfusion is remarkably similar to the supine position (Albert and Hubmayr, 2000; Albert et al., 1987; Glenny et al., 1991; Lai-Fook & Rodarte, 1991; Pappert et al., 1994). Therefore, the improved ventilation and perfusion in the prone position is attributed to the greater recruit of alveoli and regional ventilation than any perfusion changes (Guérin et al., 2020).

Clinical Evidence

Research on the impact of prone position spans over 40 years. Each study helps us learn more about the targeted patient for best response, when to use it, how long to use it, and likely patient response. There are numerous studies, metanalysis, and the largest prospective randomized controlled trial (RCT) demonstrating that patients with ARDS and severe hypoxemia, when placed in the prone position, significantly increase PaO2/FiO2 ratio compared with the supine position. The most significant effect is seen within the first few days, with continuing benefits up to 8 days (Fridrich et al., 1996; Gattinoni et al., 2001; Guerin et al., 2004; Guérin et al., 2013; Lee et al., 2014; Mancebo et al., 2006; Munshi et al., 2017; Voggenreiter et al., 2005; Vollman & Bander, 1996). Guérin et al. (2013), in the PROSEVA studied a total of 466 ARDS patients with severe hypoxemia, with 237 in the prone group and 229 in the supine group. Patients were randomly assigned to undergo prone or supine positioning. The patient met eligibility criteria with ARDS and severe hypoxemia defined as a PaO2/FiO2 ratio <150 mm Hg, with a FiO2 >60% with at least 5 cm of Positive End Expiratory Pressure (PEEP). Those in the prone group were turned within 1 hour of randomization and spent at least 16 consecutive hours in the prone position per day. The 28-day mortality was significantly reduced in the prone group. The mortality of the prone group was 16% compared with the supine group at 32.8%. This benefit held out to 90 days (Guérin et al., 2013). In examining the Guérin et al. (2013) trial data, it appears that the improvement in gas exchange did not predict survival. It is suggested that improved survival occurred by reducing ventilator-induced lung injury.

With an established benefit in oxygenation and reduced mortality, an international guideline for ventilation of the ARDS patient created by the American Thoracic Society, the European Society of Intensive Care Medicine, and the Society of Critical Care Medicine gave a strong recommendation for using prone therapy for greater than 12 hours per day for patients with severe ARDS (Fan et al., 2017). The adoption has been slow worldwide and is often used as a last attempt to save an ARDS patient's life. Two prevalence trials, the LUNG SAFE & APRONET, demonstrate low utilization in ARDS patients (Bellani et al., 2016; Guérin et al., 2018). The lung safe trial was a 4-week international observation prevalence study in 50 countries examining the incidence, recognition, and management of ARDS patients. Prone positioning was only used in ARDS 16.9% of the time (Bellani et al., 2016). In a more recent European prevalence study called APRONET, 32% of the respondents used prone positioning for severe ARDS patients (Guérin et al., 2018). The landscape changes with the recent COVID pandemic and prone positioning should be used early as front-line therapy for moderate to severe ARDS patients (Chiumello et al., 2018). There are several prospective observational studies that have been published on mechanically ventilated COVID patients that have used prone positioning successfully as part of overall ARDS management (COVID-ICU Group, 2020; Thomson et al., 2020). Prone positioning has also been used in awake nonintubated COVID patients with some success in improving oxygenation, however there are no RCTs published and it is beyond the scope of this article to address awake nonintubated prone positioning (Weatherald et al., 2020)

SCREENING FOR EARLY USE

For successful integration into practice, there is a need to determine a type of screen that would allow the clinician to evaluate hypoxemia severity once the ARDS diagnosis is made. The newer Berlin Definition for ARDS grades severity of hypoxemia in ARDS to be mild, moderate, and severe based on PaO2/FiO2 (P/F ratio) ratio and amount of PEEP (Figure 1; Ranieri et al., 2012). P/F ratio is calculated by having the partial pressure of oxygen measurement in the blood obtained by an arterial blood gas (PaO2) divided by the fraction of inspired oxygen concentration (FiO2) the patient is currently receiving. For example, if the ARDS patients have a PaO2 of 70 torr and are on 60% FiO2, their P/F ratio would be 116. In the Proseva trial, patients were placed into the prone position when they met the following criteria: PaO2/FiO2 ratio <150 mm Hg, with a FiO2 >60% with at least 5 cm of PEEP (Guérin et al., 2013). Using the P/F ratio as a screening tool and PEEP settings frequently in patients diagnosed with ARDS or COVID ARDS can help determine prone positioning's timely initiation. If a blood gas is not readily available, studies have shown that using oxygen saturation (SPO2) to

Figure 1. Berlin definition of acute respiratory distress syndrome (ARDS).

TIMING	Within 1 week of a known clinical insult or new / worsening respiratory symptoms		
CHEST IMAGING (X-RAY OR CAT SCAN)	Bilateral opacities-not fully explained by a fusions, lobar / lung collapse, or nodules		
ORIGIN OF EDEMA	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		
	MILD	**MODERATE**	**SEVERE**
OXYGNEATION	< 200 PaO_2/FiO_2 or $\leq$ 300 with PEEP/CPAP $\geq$ 5 cm H_2O	< 100 PaO_2/FiO_2 or $\leq$ 200 with PEEP/CPAP $\geq$ 5 cm H_2O	< 100 PaO_2/FiO_2 with PEEP $\geq$ 5 cm H_2O

perform the equation is comparable (Rice et al., 2007).

PROTOCOL DEVELOPMENT

The development of a protocol/guideline starts with gathering the stakeholders of the process. At a minimum, this should include a critical care intensivist/provider, nursing unit manager, a critical care nurse, a respiratory therapist/chest physiotherapist, and a pharmacist. Additional group members to consider for consultation include a wound or tissue viability specialist, dietary, and a safe patient handling expert (Mitchell & Seckel, 2018). After reviewing the literature, the group's goal is to determine inclusion and exclusion criteria, methods for proning, equipment required, the number and type of staff needed to perform the procedure, duration, and unique care practices while prone. After the protocol is created, sending it out to additional stakeholders for feedback will help create buy-in upfront. Finally, the group is tasked with creating the education and roll-out plan.

Inclusion and Exclusion Criteria

In an expert consensus formal guideline recently published, they recommend a series of management steps for ARDS patients before prone positioning (Papazian et al., 2019). When the patient is suspected of developing ARDS, initiation of low tidal volume ventilation at 6 mL/kg of predicted body weight in the absence of severe metabolic acidosis and sedation as needed is applied. Once the diagnosis is confirmed, the objective is to maintain low tidal volume ventilation, plateau pressures < 30 cm H2O pressure and 5 cm H2O of PEEP, and monitor for hypercapnia. If the P/F ratio drops below 200, then an incremental application of higher PEEP levels to improve oxygenation should occur. Once increases in PEEP no longer demonstrate improvement in oxygenation and the P/F ratio drops below 150, it is time to consider prone positioning (Papazian et al., 2019). Target prone positioning in ARDS patients less than 48 hours into their diagnosis if they met the following criteria; PaO2/FiO2 ratio < 150 mm Hg, FiO2 > 0.60 mm Hg, and minimum of PEEP > 5 cm H2O (Guérin et al., 2013; Scholten et al., 2017). The goal is early in the course to prevent ventilator-induced lung injury (Guérin et al., 2020). Absolute contraindications to the prone position are patients with unstable spines, uncontrolled intracranial pressure, and care goals to allow for a natural death (Guérin et al., 2020; Malhotra & Kacmarek, 2020; Table 1).

TABLE 1. Absolute and Relative Contraindications for Prone Positioning

Absolute Contraindications	Relative Contraindications
Unstable spine	Hemodynamic instability (as defined by a systolic blood pressure <90 mm Hg or MAP <60) with fluid and vasoactive support in place
Uncontrolled intracranial pressure	Unstable pelvic or long bone fractures
Goals of care to allow for a natural death	Unstable chest wall and open abdomen
	Third trimester pregnancy
	Rheumatoid arthritis (ensure neck collar is in place prior to use of prone position)
	Weight 160 kg or greater (weigh the risk/benefit ratio for the patient and staff)
	Cardiac abnormalities: life threatening arrhythmias, ventricular assist devices, intra-aortic balloon pump, ECMO, fresh pacemaker
	Burns >20% of the ventral body surface

Note. ECMO = extracorporeal membrane oxygenation; MAP = mean arterial pressure.

Relative contraindications include hemodynamic instability (as defined by a systolic blood pressure <90 mm Hg or MAP < 60) with fluid and vasoactive support in place, unstable pelvic or long bone fractures, unstable chest wall, and an open abdomen (Guérin et al., 2020; Malhotra & Kacmarek, 2020; Mitchell & Seckel, 2018). Open abdomen patients have been successfully prone using an iodoform band and abdominal binder to protect and maintain placement of the abdominal contents (Murray & Patterson, 2002). Third-trimester pregnancy has been viewed as a contraindication. However, correct positioning with padding above and below the gravis uterus and fetal monitoring is safe (Tolcher et al., 2020). Relative contraindication should be discussed with the multiprofessional team to weigh the risk and benefits.

Prone positioning is discontinued when the patient no longer shows a positive response to the position change or mechanical ventilation support is optimized. It is defined as a P/F ratio > 150 mmHg with FiO2 of < 60%, < 10 PEEP after 4 hours in the supine position (Guérin et al., 2013).

Timing, Methods for Prone Positioning, Equipment, and Human Resources

Research supports the patient to be maintained in the prone position anywhere from 12 to 16 hours consecutively (Fan et al., 2017; Guérin et al., 2013). Consider the timing of the position change based on available resources. Many units have chosen to prone in the late afternoon, have the patient remain in the position through the night, and return supine in the morning when greater resources are present.

There are a variety of methods to turn a mechanically ventilated patients prone. Specialized beds have been employed but require training, are costly, and the resource is limited (Vollman, 2004). If available, consider placing the patient on a pressure reducing surface if not already on one to help with pressure redistribution. The remaining methods are manual with some degree of safe patient handling depending on the equipment used, which can include bed sheets, disposable shear, and friction-reducing sheet, air-powered turn and position systems, and ceiling lifts (Guérin et al., 2013; Vollman et al., 2017; Wiggermann et al., 2020). Regardless of the equipment used for manual pronation, the steps are the same. It requires anywhere from three staff if using a ceiling lift to five staff with the bed linen.

There are usually two clinicians on each side of the bed and one at the head of the bed to protect the patient's airway during the turn. A clinician from the group should be designated as a team leader to help coordinate the steps (Mitchell & Seckel, 2018; Vollman, 2004). There are care practices to perform before initiating the turn to prevent any complications (Table 2). Perform eye care with lubrication and consider horizontal taping of the eyes if possible. Ensure the patient's tongue is in the mouth. If using a commercial ET holder, consider switching to tape or twill ties to reduce the risk of facial pressure injuries while still maintaining a secure airway (Gomaa & Branson, 2015; National Pressure Injury Advisory Panel, 2020). If a wound or line? dressing on the anterior body is scheduled for change during the prone session, perform the dressing change before the turn. If the patient has an ileostomy or colostomy, empty the bag before the turn. To address shear and pressure injury to the skin during the turn and while in the prone position, consider applying soft silicone multi-layer prophylactic foam dressings to all boney prominences and other areas that may be affected by pressure during prone position, that is, face, shoulders, chest, breasts, penis, elbows, pelvic bones, knees, anterior feet (Davis and Beeson, 2020; NPIAP, 2020; Vollman et al., 2017). Apply a nongreasy skin barrier to areas of the face likely to be exposed to moisture for oral and nasal drainage. Ensure that invasive lines inserted from the waist up or at the head of the bed in lines inserted below the waist or at the foot of the bed. The exception is chest tubes, ECMO, and continuous renal replacement therapy (CRRT) lines, which should be placed at the foot of the bed unless internal jugular access is used (Vollman, 2004; Vollman et al., 2017).

Whichever manual method is used, the patient should ideally turn towards the ventilator into the prone position. This prevents disconnection of the ventilator tubing or kinking of the endotracheal tube. The pancake or burrito method strategy uses two sheets/positioning aids with the patient sandwich between them to accomplish the turn. This method helps distribute the weight evenly between four staff members and allows the individual to be free at the head of the bed. It also allows the placement of wedges or pillows to support the chest and pelvic region if desired. The five-step method includes a bottom positioning aid to move the patient to the side of the bed opposite the ventilator. A second positioning sheet is rolled and placed around the patient's arm and rolled under the patient. When using either method, it is recommended when turning lateral prior to moving into the prone position to stop, assess the lines and tubes, consider the placement of new electrodes, and then complete the turn by pulling through the second positioning sheet. A similar process is followed to return the patient to the supine position (Vollman et al., 2017; Wiggermann et al., 2020). If there is concern about the airway, having an intubation tray and a critical care provider nearby should be considered. Several prone procedures with similar steps have been published by professional associations including the American Association of Critical Care Nurses and UK Faculty of Intensive Care Medicine (Faculty of Intensive Care Medicine, 2019; Vollman et al., 2017).

Patient Care in the Prone Position

Once in the prone position, certain care practices need to be incorporated to prevent complications. The most frequent complications seen with prone positioning include major airway complications and pressure injuries (Lee et al., 2014; Munshi et al., 2017). Major airway complications are defined as unplanned extubation or endotracheal tube obstruction. The most significant risk for pressure injuries in the prone patient in the face, including the chin and cheeks (Lucchini et al., 2020). Other complications noted are peripheral nerve injuries, crush injury, dislodging of tubes and lines, vomiting, and transient arrhythmias (Guérin et al., 2018; Guérin et al., 2013; Malhotra & Kacmarek, 2020).

TABLE 2. Prone Preparation Checklist

1. Preprone oxygen and hemodynamic measurements
2. Consider removal of commercial (ET)/replace with tape or twill
3. Remove ECG electrodes and leads from the chest
4. Eye care-lubrication and horizontal taping if able
5. Ensure the tongue is inside the patient's mouth if able
6. Apply nongreasy skin barrier to areas around the mouth and nose
7. Placement of soft silicone protective dressings on high risk pressure points(forehead, chin, cheeks, shoulders, chest, elbows, pelvic bone, knees, and anterior feet)
8. Placement of the line and tubes at head of bed or foot of the bed based on location in the body
9. Empty any ileostomy or colostomy bags
10. Consider turning off tube feeding 1 hour before to allow gastric emptying
11. Maxi-inflate the bed surface if needed
12. Ensure tubes and lines are secure, disconnect nonessential tubing (feeding, NG, etc.)

Note. ET = endotracheal tube holder; NG = nasogastric tube.

Proper anatomic support and body alignment are necessary to prevent skin injury, reduce nerve and joint complications, potential eye damage, and endotracheal tube obstruction. If using pillows or foam supports on the upper chest and pelvic region, ensure they are spaced to prevent overextension or cervical spine flexion. The potential for foot drop and ankle pressure injuries exist. Therefore supporting the legs to prevent external rotation or shortening of the Achilles tendon is critical. This is accomplished by placing a pillow under the shins to flex the knees allowing the feet to be at a 90-degree angle (Vollman, 2004; Vollman et al., 2017). To reduce the risk of brachial plexus injuries is recommended to position one arm up and one arm alongside the body while turning the patient's head in the upper arm's direction. This is called the swimmers' position. When in this position, keep the shoulder in a neutral position and the elbow at 90 degrees. The position change of the limbs and head are performed every 2-hours to shift pressure on at-risk areas. Different head supports are available to enable head movement and clear access to the endotracheal tube. Upon returning to the supine position, a thorough examination of the skin, including under protective dressings, should happen to identify potential at-risk areas (NPIAP, 2020).

Consider the use of 10–25-degree reverse Trendelenburg to minimize facial edema and reduce aspiration risk (Boullata et al., 2017; Saez de la Fuente et al., 2016; Savio et al., 2020). It is recommended to continue to enterally fed the patient while in the prone position, whether using a gastric or postpyloric tube. Prokinetic agents or transpyloric feedings can help prevent complications associated with vomiting or high gastric residuals (Boullata et al., 2017). Additional care activities while supine, such as assessing the patient's response to a position change, assessment of pain, anxiety, and delirium, hemodynamic monitoring, suctioning, and oral hygiene, should continue while the patient is in the prone position. Neuromuscular blocking agents should be used in the prone or supine position only when ventilator asynchrony cannot be managed with analgesia and sedation (Guérin et al., 2020).

Education Plan and Implementation

The development of a new practice within the environment is not complete without a comprehensive education and implementation plan. The education plan should consider the targeted audience, critical knowledge and skill development, competency check off, and incorporation into critical care classes or orientation program. The implementation plan should consider the launch date of the new practice based on education and skill completion. If the environment wants to move the practice in rapidly, consider training super users. Tools to make implementation easier included, bedside checklist of the procedure steps, an online video with easy access, a prone kit that may include EKG leads, dressings for pressure injury reduction, tape or twill ties, along with a procedural checklist (Mitchell & Seckel, 2018). The frequency of prone positioning occurring in the ICU will determine whether annual competencies are necessary for the staff.

SUMMARY

Understanding the physiology and evidence to support oxygenation and morality improvements with prone positioning will allow the team to commit to protocol development and education for success in introducing a new practice safely. The critical care nurse plays a pivotal role in identifying ARDS patients that might benefit from prone positioning and initiating a discussion with the team to use the therapy. Prone positioning is beneficial and should be considered frontline therapy to manage moderate to severe ARDS patients.

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