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Acute Respiratory Distress Syndrome and Prone Positioning

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ABSTRACT

Acute respiratory distress syndrome continues to have high morbidity and mortality despite more than 50 years of research. The Berlin definition in 2012 established risk stratification based on degree of hypoxemia and the use of positive end-expiratory pressure. The use of prone positioning as a treatment modality has been studied for more than 40 years, with recent studies showing an improvement in oxygenation and decreased mortality. The studies also provide evidence to support the methodology and length of treatment time. Recent guidelines include several ventilator strategies for acute respiratory distress syndrome, including prone positioning. Protocols and procedures discussed in this article ensure successful prone repositioning and prevention of complications related to the procedure itself.

Keywords: acute respiratory distress syndrome, ARDS, prone positioning, mechanical ventilation, evidence-based practice

In 1967, Ashbaugh et al[1] published a report describing the acute onset of tachypnea, hypoxemia, and decreased compliance as respiratory distress syndrome in 12 adult patients who did not respond to conventional therapy at the time. The patients had signs and symptoms similar to respiratory distress in infants, and thus the syndrome was termed *adult respiratory distress syndrome*.[1] Eventually, *adult respiratory distress syndrome* was changed to *acute respiratory distress syndrome* (ARDS).[2-4]

The first consensus definition of ARDS was determined at the 1994 American-European Consensus Conference, later revised to the *2012 Berlin definition*.[5,6] The Berlin definition outlines timing of symptom onset, details chest imaging and edema findings, stratifies ARDS into 3 main categories based on specified oxygenation criteria (mild, moderate, severe), and removes the term *acute lung injury* from the original definition (Table 1).[6,7]

Typical development of ARDS is within 7 days of a known risk factor, with pneumonia, aspiration of gastric contents, and sepsis leading to nearly 85% of cases.[2,4] The mortality rate for ARDS has decreased in the last decade, from a reported hospital mortality of up to 90% down to a reported 46%; intensive care unit (ICU) mortality currently is reported at 38%.[5,8] Annually, nearly 200 000 patients in the United States are diagnosed with ARDS; worldwide, the syndrome is responsible for 10% of all ICU admissions and occurs in 23% of patients undergoing mechanical ventilation.[9,10] The long-term morbidity of critical illness coupled with ARDS is extensive, with substantial physical, neuropsychiatric, and neurocognitive impairment reported in patients

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Table 1: Berlin Criteria for Acute Respiratory Distress Syndrome

Timing	Within 1 week of clinical insult or new or worsening symptoms
Chest imaging	Bilateral opacities that are not explained by effusions, collapse, or nodules
Edema	Respiratory failure not explained by cardiac failure of fluid overload
Oxygenation	
Mild	PaO_2/FIO_2 200 mm Hg to) 300 mm Hg with PEEP/CPAP * 5 cm H_2O
Moderate	PaO_2/FIO_2 100 mm Hg to) 200 mm Hg with PEEP * 5 cm H_2O
Severe	PaO_2/FIO_2) 100 mm Hg with PEEP * 5 cm H_2O

Abbreviations: CPAP, continuous positive airway pressure; FIO_2, fraction of inspired oxygen; PaO_2, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure.
Adapted from the ARDS Definition Task Force.[6]

for as long as 5 years after recovery.[11] Cognitive impairment has been reported in up to 100% of patients at discharge and in nearly 20% of patients after 5 years.[12] Compromised quality of life including depression and posttraumatic stress disorders has been reported in patients and their families.[12]

In this article, we describe ARDS and options for management of the syndrome. We also provide evidence in support of prone positioning for ARDS and discuss our health system's guidelines for using the prone position.

Acute Respiratory Distress Syndrome

Pathogenesis

The pathogenesis of ARDS typically is described in 3 phases: (1) exudative, (2) proliferative, and (3) fibrotic. The *exudative* phase is the initial response to the lung injury. In this phase, damage occurs to both the endothelial and epithelial walls of the alveoli. The resulting increased capillary permeability leads to impaired fluid drainage from the alveolar space and increased protein-rich fluid inside the alveoli, leading to further alveolar damage and the release of pro-inflammatory cytokines.[4,7] Neutrophils and macrophages then are recruited by the lungs and toxic mediators are released, resulting in further cell damage, inflammation, and pulmonary edema. Intrapulmonary shunting increases, leading to severe hypoxemia.[4,7]

During the *proliferative* phase, the patient's lung begins its repair processes; the epithelial integrity is reestablished, the alveolar fluid is reabsorbed, and the alveolar structure and function is restored. The *fibrotic* phase, which may not occur in all patients, is due to inadequate or delayed epithelialization and the formation of interstitial and alveolar fibrosis. This phase can lead to increased ventilator days and mortality.[4]

Mechanical Ventilation Strategies

Much of the current ARDS research focuses on mechanical ventilation as a supportive strategy that also prevents injuries caused by the ventilator (ventilator-induced lung injuries [VILI]), which include volutrauma from alveolar overdistention and atelectrauma from alveolar nonheterogeneous recruitment and derecruitment.[7] The 2017 clinical practice guidelines from the American Thoracic Society, the European Society of Intensive Care Medicine, and the Society of Critical Care Medicine recommend evidence-based treatment strategies for adult patients with ARDS.[13] Supportive strategies to limit lung damage are known as *lung-protective ventilation* and include low tidal volume and inspiratory pressure, positive end-expiratory pressure (PEEP), lung recruitment maneuvers (LRMs), extracorporeal membrane oxygenation (ECMO), and high-frequency oscillatory (HFO) ventilation.

Low Tidal Volume and Inspiratory Pressure. The use of low tidal volume strategies (4-8 mL/kg of predicted body weight combined with limited inspiratory pressure or plateau pressure < 30 cm H_2O) reduce mortality of patients with ARDS by preventing volutrauma and barotrauma.[13,14] Alveolar pressure can be estimated during an inspiratory pause by measuring plateau pressure; during that inspiratory pause, flow is at zero and the plateau pressure should reflect inspiratory alveolar pressure.

Positive End-Expiratory Pressure. Positive end-expiratory pressure has been a treatment strategy for patients with ARDS for more than 50 years. Positive end-expiratory pressure reflects the pressure in the alveoli at end expiration; an increased PEEP may improve alveolar recruitment and reduce the effects of atelectrauma. Patients with moderate to severe ARDS and larger amounts of potentially recruitable lung benefit the greatest from high PEEP

Table 2: High Positive End-Expiratory Pressure Recommendations

FIO_2, mm Hg	0.3	0.4	0.5	0.5-0.8	0.8	0.9	1.0
PEEP, cm H_2O	12-14	14-16	16-18	20	22	22	22-24

Abbreviations: FIO_2, fraction of inspired oxygen; PEEP, positive end-expiratory pressure.
Adapted from Brower RG, et al.[15]

(Table 2).[15] High PEEP should not be used for all patients with ARDS because of the lack of mortality benefit and risk of alveolar injury, increased shunt, and dead space, along with the hemodynamic effects of increased pulmonary vascular resistance.[13,16]

Lung Recruitment Maneuvers. An LRM consists of a brief application of high (30-40 cm H_2O) continuous positive airway pressure, incremental PEEP increases at a constant driving pressure, or a high driving pressure.[13,17] The physiologic benefits of an LRM include decreased VILI and decreased mortality. The LRM, however, may lead to hemodynamic instability and barotrauma. Lung recruitment maneuvers done in conjunction with a higher PEEP strategy makes it difficult to isolate the direct benefits of the LRM. The guidelines suggest caution using LRM in patients who have concurrent hypovolemia or shock.[13]

Extracorporeal Membrane Oxygenation. The use of ECMO for severe refractory ARDS has increased since 2009.[18] Extracorporeal membrane oxygenation uses a mechanical artificial lung to provide oxygenation and removal of carbon dioxide. This strategy may allow recovery from the primary lung injury and minimize VILI.[18-20] The patient's respiratory system may contribute to ventilation during ECMO. Because of the complexity of ECMO and limited availability of centers that provide this treatment, the amount of literature is limited. The guidelines suggest that additional research is needed on whether to recommend the use of ECMO for managing ARDS.[13] Several studies including a large international randomized controlled trial are in process.[8,18-20]

High-Frequency Oscillatory Ventilation. High-frequency oscillatory ventilation delivers very small tidal volumes at higher mean airway pressures with a rapid oscillatory respiratory rate of up to 900 breaths per minute.[21] This ventilator strategy has not been shown to be beneficial in adult patients with ARDS; in contrast, studies have shown patients are significantly harmed with routine HFO use.[13,21,22] Although not recommended for routine use, HFO ventilation is an adjunctive rescue mode for refractory hypoxemia.[23]

Prone Positioning

History of Prone Positioning

Prone positioning has been used as a treatment modality for patients with ARDS for more than 40 years. One of the first mentions of prone positioning was made in 1974 by Froese and Bryan.[24] In that same year, Bryan[25] noted that the supine position—despite various ventilation modes and increased end-expiratory pressure—left the dependent areas of the lungs without adequate ventilation. Bryan believed that placing the patient in the prone position improved expansion of dependent areas of the lung and that this position should be used as a strategy in the treatment of ARDS.[25] In 1976, Piehl and Brown[26] used the terminology of *extreme position* to review the positive effects of prone positioning, including an increase in oxygenation and pulmonary hygiene. Because of the dramatic positive results in some patients in the study, placement in the prone position was used as a rescue mode after other ventilator strategies proved unsuccessful.[26]

Pathophysiology

The physiologic mechanism for the change and the resulting improvement in patients' oxygenation while in the prone position led to further investigations.[27-30] With the patient in the prone position, the once dependent (dorsal) lung fields were well ventilated and perfusion was improved with a decrease in intrapulmonary shunting.[27] Researchers believed this change was due to recruitment of the well-perfused dorsal lung that overshadowed the derecruitment of the ventral lung fields.[27,28] Additionally, researchers noted that patients treated with mechanical ventilation and placed in the prone position had decreases in lung strain; this effect was due to the more even distribution of inflation and ventilation throughout the dorsal lung fields, minimizing the occurrence of VILI.[29,30]

Early randomized controlled studies showed improvement in oxygenation that helped build the case for the prone position; however, these studies did not demonstrate reduced mortality.[31-33] The Proning Severe ARDS Patients (PROSEVA) trial in 2013, however, demonstrated a significant decrease in mortality of patients with ARDS and established the methodology for a longer prone position (16 hours) before returning to supine position.[34] A subsequent meta-analysis pooled results from 8 randomized controlled trials, with a subgroup analysis showing that patients with severe ARDS had a mortality benefit when prone positioning was used for a minimum of 12 hours per day.[35] The use of prone positioning for more than 12 hours per day in patients with severe ARDS is strongly recommended in the 2017 clinical practice guidelines.[13]

Prone Positioning Techniques

In early considerations for placing patients in the prone position, clinicians were concerned about logistics.[25] The prone position was used for patients with severe ARDS but often as a late rescue strategy due to a lack of clinicians' expertise with performance of the procedure, concern with complications, and uncertainty regarding the evidence.[19] Multiple techniques have been used to place patients in the prone position; all techniques focus on patient safety while also easing the physical burden on clinicians performing the procedure.[26-29]

Manual prone positioning is the first methodology described in the literature.[32,33,36] This technique is still used today as researchers work to improve safety and ease of performing manual prone positioning.[36] Assistive turning devices have been designed specifically to assist with manually positioning the patient in the correct prone position or to assist with repositioning.[37-39] Specialty beds that mechanically rotate the patient into the correct position are also used.[37,39,40]

Challenges with all the prone positioning techniques include a lack of knowledge and familiarity of the procedure, the number of staff members needed to safely place critically ill patients in the prone position, prevention of complications from the turning procedure, and the ability to maintain the patient in the position for the recommended length of time. Complications of prone positioning that also occur with supine positioning include, but are not limited to, tube dislodgement (endotracheal, chest, central access, and urinary catheters), hemodynamic compromise, eye injuries, and pressure injuries.[34,39]

When placing a patient in the prone position, the clinicians must pay attention to devices being used to care for the patient, such as airway management and other invasive lines. In preparation for and maintenance during prone positioning, the clinician must thoroughly assess the patient and provide care that mitigates some of the known complications.[38]

Updating Interprofessional Prone Positioning Guidelines

With the recognized benefits of using the prone position in patients with ARDS, emphasis is being placed on having a well-trained team that follows a streamlined process to produce the desired effects of and minimize potential complications of prone positioning. What follows is a description of how we updated our procedures and guidelines in our health care system.

Within the 2 hospitals in our 1100-bed health care system, prone positioning is being used as a lung-protective strategy for patients with ARDS because of the recent research noting reduced mortality with the maneuver.[13,34,35] The health care system had previously developed a nurse-driven guideline for prone positioning. However, with our increased and earlier use of prone positioning, the gaps and opportunities for improvement were highlighted.

Our original 2010 guideline was outdated and lacked interdisciplinary input. In this outdated guideline, the physician determined if a patient required prone positioning and the nursing team would develop a plan for when repositioning could happen, leaving physicians out of the process. In general, the medical team was unfamiliar with the guideline and processes. The prone positioning plan was based on the number of staff required to place a patient in the prone position, also taking into account the availability of the respiratory therapist and the time taken to gather supplies and wait for delivery of protective devices. Across the ICUs there was a lack of standardization and communication regarding the prone positioning procedure, including when the procedure would occur, which varied depending on day of the week and time of day.

Development and Planning

Our health care system's critical care stakeholders, recognizing the need to create best practice within like units and across all ICUs, invited an interdisciplinary team led by a pulmonary critical care intensivist and critical care clinical nurse specialists to discuss prone positioning in the institution. Team members included providers (physicians, physician assistants, and nurse practitioners), clinical nurses, respiratory care providers, physical therapists, and wound ostomy continence nurses. The team's goal was 2-fold: to review the latest evidence for using prone positioning including methodology, equipment, and staffing, and to create a new guideline. Initial dialogue focused on gaps in current practice and current evidence as well as knowledge deficits of all stakeholders regarding the prone positioning process. The clinical nurse specialist played a key role as content expert in the early phase of the guideline development, educating the team on current practice and collecting input from team members.

As part of planning of the new protocol, many efforts were made to ensure that all team members in all adult ICUs had an opportunity to communicate their needs related to prone positioning. The guideline was reviewed by all stakeholders and their feedback was incorporated in the final guideline, particularly feedback related to inclusion and exclusion criteria for cardiovascular surgery and neurosurgical patients. Because each stakeholder had an active role in the development of the new process, the completed guideline became the Inaugural Interprofessional Clinical Practice Guideline.

Features and Procedures

The interdisciplinary guideline, adapted from the stepwise process introduced by Guérin et al[34] in 2013, was implemented in the system in 2014 and revised in 2018 (Table 3). A key feature included in the guideline was the interdisciplinary component, which ensures that all team members are involved in the procedure from planning to procedure and recovery.

Within the guidelines, inclusion and exclusion criteria for placing a patient in prone positioning have been based on a review of the literature and have become the standard of care for all ICUs in the system (Table 4).[28,34,41] We also included in the guidelines that 16 hours was the recommended length for a patient to be in the prone position. Team members can now plan maintenance interventions and prepare for the return to the supine position at the 16th hour. The updated procedures in the guidelines have improved teamwork and efficiency, changing the process from a purely nursing one to one that is interdisciplinary.

The guidelines require a team huddle, which is led by the nurse caring for the patient, before the prone positioning procedure. This short meeting reinforces communication of procedures, orders, and other care requirements needed before placing the patient in the prone position and the time needed to perform those tasks. One important procedural step that we added to our guidelines is the use of the side-lying position in the middle of turning the patient. The side-lying position allows the team to pause, assess the patient and the initial response to the position change, and change the monitor leads from the ventral to dorsal chest. While a patient is in the prone position, nurses must be vigilant in monitoring the patient's vital signs and response to medications.[38] Therefore, in our health care system, the clinical nurse is a key member of the team coordinating the care of patients prior to placement in the prone position and while in the position. The nurse assesses any changes that may occur due to the prone position.

Case Study

A 52-year-old woman is admitted to the intensive care unit with septic shock due to pneumonia. On day 2 she is intubated for ARDS with progressive hypoxemic failure. Her chest x-ray shows bilateral patchy opacities and her bedside ultrasound shows a normal ejection fraction. Several hours after being intubated, she is asynchronous with the ventilator, her arterial blood gas pH is 7.01, and her partial pressure of arterial oxygen/fraction inspired oxygen (PaO_2/FIO_2) ratio is 89 mm Hg. The patient is started on paralytic agents with her sedation and analgesia to maintain a tidal volume of 5.6 mL/kg based on ideal body weight. After a team huddle and a consultation with the night intensivist, the nurse-led team (3 nurses, 2 respiratory care providers, and a resident) place the patient

Table 3: Prone Positioning Interdisciplinary Guideline

Step 1. Pre–Prone Positioning Preparation

Staff Member	*Responsibilities*
Physician, advanced practice provider	• Consult with team before repositioning patient • Order for prone position must come from attending physician; use order set for determined time of prone position • Explain purpose and procedure to the patient and family • Consider the need for: o Central venous catheter, arterial line, or urinary catheter o NMBA o Bolus narcotics for repositioning o Sedation goal based on RASS o Prokinetic agent o Ophthalmic ointment • Confirm radiographic positioning of the endotracheal and orogastric tubes • Place a Wound Ostomy Care Consult on all patients upon protocol initiation
Respiratory care provider	• Consult with team before repositioning patient; decide which direction to turn the patient; priority given to moving patient toward the ventilator • Document: o 1-hour preprone arterial blood gas value and ventilator settings o Endotracheal tube position at the lip and confirm secure position o Airway pressure and end-tidal carbon dioxide concentration • Pre-oxygenate to 100% FIO_2 • Suction oropharynx and endotracheal tube • Validate pulse oximetry and correct length of cable • Ensure that intubation equipment is immediately accessible • Move the ventilator as close to the patient's bed as possible
Registered nurse (designated team leader)	• Facilitate consultation with team before repositioning patient • Ensure team, patient, and family have been educated on the process and what to expect • Gather all supplies necessary for the move (eg, gown, sheets, pads, electrodes, hydrocolloid dressings, pillows) • Monitor the following before, during, and after implementation of the prone position: o Heart rate o Cardiac rhythm o SpO_2 o Respiratory rate o RASS or BIS monitoring for patients on NMBA o TOF for patients on NMBA o Blood pressure o Skin assessment o Any other hemodynamic parameters (as applicable) • Tube feeding: Turn off 1 hour before prone positioning or aspirate gastric contents • Invasive lines: ensure they are secured, not kinked, and are long enough for the turn o All lines in the lower torso aligned and placed at the foot of the bed o All lines in the upper torso aligned over the right or left shoulder o Chest tubes: place at the foot of the bed • Skin: o Assess and change any dressing on anterior body; empty any drains or ostomies o Place hydrocolloid dressing over areas where shearing and friction injuries are likely to occur (ie, forehead, chin, chest, shoulders, pelvis, elbows, and knees) o Consult with respiratory therapy regarding need for evaluation of oral endotracheal tube position and placement of hydrocolloid on additional potential pressure points o Maximally inflate bed during repositioning o Remove the patient's gown

Continued

Table 3: *Continued*

Step 2A. Prone Positioning: The Horizontal Move

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube
Registered nurse	• The nurse closest to the patient always maintains body contact with the bed to ensure a safe environment • Move the patient horizontally away from the ventilator • After moving the patient horizontally, place the patient's hand on the rotating side under the buttock • Place new linen under the patient as old linen is removed

Step 2B. Prone Positioning: The Side-Lying Position

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube.
Registered nurse	• The nurse closest to the patient always maintains body contact with the bed to ensure a safe environment • The patient is rotated laterally in a full side lying position toward the ventilator • One nurse places new electrodes on the back while another removes the old electrodes from the anterior chest wall, minimizing time patient is off monitor

Step 2C. Prone Positioning: Complete Positioning

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube while completing the proning process
Registered nurse	• The person closest to the patient always maintains body contact with the bed to ensure a safe environment • The new pad or sheet is used to move patient into the final complete prone position • The patient is placed in a horizontal position at 180 degrees

Step 3. Postprone Positioning

Staff Member	*Responsibilities*
Physician, advanced practice provider	• Suggested duration of prone session: 12-16 hours per protocol
Respiratory care provider	• Monitor the stability and position of the endotracheal tube; remain with the patient until members of the team are assured that the patient is maintaining airway and adequate oxygenation, and is stable hemodynamically • Reposition the ventilator tubing at the head of the bed • Endotracheal tube must be easily accessible at all times • Document patient's position and end-tidal carbon dioxide concentration
Registered nurse	• Perform frequent oral care and suctioning of the airway as needed • Lines and tubes: ensure they are easily accessible and are not kinked • Tube feeding: resume at prior rate 1 hour after patient is positioned • Body positioning ◦ Care should be taken to close the eyelids and avoid pressure on the ear ◦ Arrange arms either in a side-lying position or swimmer's position (one arm at the side of the body and the other extended above the head) ◦ Place feet in the anatomically correct position, maintaining flexion by elevating shins on pillows or positioning feet off the end of the bed ◦ Place pillows/cushions under patient's head, chest, and pelvic region ◦ Replace the patient's gown. ◦ Change positions every 2 hours placing patient's limbs in alternating positions ◦ With respiratory care provider, reposition patient's head to the side ◦ Consider percussion and vibration therapy and continuous lateral rotation therapy

Continued

Step 3A. Preparation: Returning to Supine Position

Staff Member	*Responsibilities*

Respiratory care provider	• Consult with team about which direction to turn the patient
	• Document:
	  ○ 1 hour presupine arterial blood gas value and ventilator settings, if ordered
	  ○ Endotracheal tube position at the lip and confirm secure position
	  ○ Airway pressures and end-tidal carbon dioxide concentration
	• Pre-oxygenate to 100% F_{IO_2}
	• Suction oropharynx and endotracheal tube
	• Validate pulse oximetry and correct length of cable
	• Ensure that intubation equipment is immediately accessible
	• Move the ventilator as close to the patient's bed as possible

Registered nurse	• Facilitate consultation with team before repositioning; designated team leader
	• Remove support pillows and gown
	• Monitor the following before, during, and after implementation of the supine position:
	  ○ Heart rate
	  ○ Cardiac rhythm
	  ○ SpO_2
	  ○ Respiratory rate
	  ○ RASS or BIS monitoring for patients on NMBA
	  ○ TOF for patients on NMBA
	  ○ Blood pressure
	  ○ Skin assessment
	  ○ Any other hemodynamic parameters (as applicable)
	• Tube feeding: Turn off 1 hour before supine positioning or aspirate gastric contents
	• Invasive lines: ensure they are secured, not kinked, and are long enough for the turn
	  ○ All lines in the lower torso aligned and placed at the foot of the bed
	  ○ All lines in the upper torso aligned over the right or left shoulder
	  ○ Chest tubes: place at the foot of the bed

Step 3B. Returning to Supine Position: Horizontal Move

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube
Registered nurse	• Place patient's hands underneath his or her anterior thigh • Move the patient horizontally toward the side of the bed away from the ventilator

Step 3C. Returning to Supine Position: Side-Lying Position

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube
Registered nurse	• Rotate the patient laterally in a full side-lying position • Place electrodes on chest and remove from back • Prepare new linen and sling along the length of the bed

Step 3D. Returning to Supine Position: Complete Position

Staff Member	*Responsibilities*
Respiratory care provider	• Monitor the stability and position of the endotracheal tube; remain with the patient until members of the team are assured that the patient is maintaining airway and adequate oxygenation, and is stable hemodynamically • Document patient's position and end-tidal carbon dioxide concentration
Registered nurse	• New linen is used to move the patient into the final and complete supine position • Dress the patient in a new gown • Full physical assessment of patient once supine

Abbreviations: BIS, bespectral index; F_{IO_2}, fraction inspired oxygen; NMBA, neuromuscular blocking agent; RASS, Richmond Agitation Sedation scale; SpO_2, blood oxygen saturation; TOF, train of four.

Table 4: Criteria and Considerations for Prone Positioning in ARDS

Inclusion criteria	• < 48 hours after onset of ARDS and meets all the following criteria: a. PaO_2/FIO_2 ratio) 150 mm Hg b. FIO_2 * 0.60 mm Hg c. PEEP * 10 cm H_2O • Mean arterial pressure > 65 mm Hg (with or without medications)
Possible complications resulting in immediate termination of prone position	• Cardiac arrest • SpO_2 < 85% or PaO_2 < 55 mm Hg for > 5 minutes • Heart rate < 30 beats per minute for > 1 minute • Systolic blood pressure < 60 mm Hg for > 5 minutes
Exclusion criteria (absolute)	• Trauma: unstable cervical, thoracic, lumbar, pelvic, skull, or facial fractures • Neurologic: uncontrolled intracranial pressure, cerebral edema, or frequent seizures • Hematologic: venous thromboembolism treated < 48 hours • Goals of care: allow natural death (do not resuscitate) with treatment limitations
Exclusion criteria (relative)	• ENT: raised intraocular pressure or recent ophthalmic surgery, facial trauma, or recent oral maxillofacial surgery in last 15 days • Cardiac: severe hemodynamic instability, unstable cardiac rhythms, ventricular assist device, intra-aortic balloon pump, recent sternotomy, new pacemaker < 48 hours • Pulmonary: hemoptysis, unstable airway (double lumen endotracheal tube), new tracheostomy < 15 days, bronchopleural fistula, lung transplant • Abdomen: second or third trimester pregnancy, grossly distended abdomen, ischemic bowel, abdominal compartment syndrome, recent abdominal surgery or stoma, extensive inguinal or abdominal soft tissue injury • Musculoskeletal: chest wall abnormalities, kyphoscoliosis, or advanced arthritis • Skin: burns on more than 20% body surface • Other underlying disease with a life expectancy of less than a year
Considerations	• Cardiovascular: o Prone positioning can increase cardiac index in patients with preload reserve and reduce right ventricular afterload o Concurrent ECMO for difficulty oxygenating or weaning from veno-venous EMCO has been shown to be safe • Abdomen: o Morbid obesity is not a contraindication and these patients may experience a mortality benefit o Recent abdominal surgery is not associated with an increased rate in postsurgical complications or revision surgery • Renal: o Sustained low efficiency dialysis has been performed safely

Abbreviations: ARDS, acute respiratory distress syndrome; ECMO, extracorporeal membrane oxygention; ENT, ear-nose-throat; FIO_2, fraction inspired oxygen; PaO_2, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure; SpO_2, blood oxygen saturation.
Adapted from Fistler and Mitchell.[41]

in the prone position for 16 hours. Over the course of the next 3 days, the patient's position is alternated between a minimum of 16 hours daily of prone positioning and approximately 8 hours of supine position. The health care team discusses the patient daily in morning and afternoon rounds to ensure continuity of the care plan. Prone positioning is discontinued on day 4, when the PaO_2/FIO_2 ratio is 263 mm Hg, the FIO_2 is 60%, and PEEP is 10 cm H_2O.

Guideline Outcomes

During the implementation of the guideline, several strategies were used to meet education needs of the staff, including face-to-face education sessions, a video of the entire process developed by the ICU team, a quick reference sheet for the step-by-step process, and web-based education that provided details for each discipline. After implementation of the new guideline, simulation sessions have been conducted to maintain competence and incorporate unit-based champions who

can guide the staff through the process in real-time.

Over time, the number of patients placed in the prone position has increased in our health care system. In 2016, members of the team implemented data collection through electronic medical records. Before that time, no direct means had been available to capture data related to prone positioning. In 2017, the first full year of data collection, 48 patients with ARDS had been placed in the prone position across the 5 adult ICUs in the system, with most cases occurring in the 2 medical ICUs. Comparison of the first 6 months of calendar years 2017 and 2018 revealed that 28 patients were placed in the prone position during that time in 2017, compared with 33 in 2018.

The team continues working to expand the information gathered through the process to evaluate the care of patients with ARDS as well as the proning procedure itself. Nurses at our health care system have acknowledged and appreciated the interdisciplinary focus on the prone positioning and the stepwise process and have found that the guidelines help in minimizing previous anxieties that often accompanied the prone order.

Advanced Practice Nurse Role

The advanced practice nurse (APN) is well positioned as a leader in the development of a prone positioning guideline and in the guiding and reinforcing of the process with all disciplines once use of prone positioning is initiated for patients with ARDS. The APN can facilitate the communication of the plan, ensure proper orders are written, and mentor the clinical nurse in the role of team leader for planning and caring for the patient in the prone position. Additionally, the APN can ensure that team members are prepared for adverse events that may occur related to placing a patient in the prone position.

Conclusions

Acute respiratory distress syndrome continues to be a frequent diagnosis in ICUs. Even with the many treatment modalities used over the last 50 years, more research still is needed for improved outcomes. Recent research efforts have focused on preventive measures to mitigate or minimize the long-term detrimental effects of ARDS on both patients and their families. Early recognition and treatment should continue to be a focused strategy, along with research into preventing complications related to the disease and treatment modalities. Using the prone position as an effective therapy to reduce mortality for patients with ARDS is recommended for moderate to severe cases and for those who meet inclusion criteria. Critical care clinicians are encouraged to explore the use of prone positioning as an early treatment option. We highly encourage establishing a prone-positioning guideline, including interdisciplinary involvement throughout the procedure, and providing staff training to achieve the best results for patients.

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