Prone positioning

Improving oxygenation in patients with ARDS

Learn about a therapy that can help turn ARDS outcomes around. By Monica Kennison, RN, EdD, and Wilbert Yost III, RN, BSN

Prone positioning, or proning, can improve oxygenation in up to 70% of patients with acute respiratory distress syndrome (ARDS) or acute lung injury (ALI).[1] Although not standard treatment, prone positioning is indicated when mechanical ventilation fails to reverse severe hypoxemia.

Proning lets the lungs, particularly their dependent areas, expand, resulting in improved oxygenation that occurs primarily within the first hour. In the prone position, lung compression is decreased, secretions drain better, and collapsed alveoli reopen.

In this article, we'll describe ALI and ARDS, prone positioning, and how you'd use it to care for a patient with respiratory failure following pneumonia.

Reviewing ALI and ARDS

ALI and ARDS can be caused by direct injuries, such as pneumonia, aspiration, and pulmonary contusion, and indirect injuries such as sepsis, severe nonthoracic trauma, and cardiopulmonary bypass. Signs and symptoms develop 24 to 48 hours after the initial injury.[2] In both syndromes, you'll see the acute onset of hypoxemia and diffuse bilateral infiltrates on chest X-ray in the absence of left atrial hypertension (indicated by a pulmonary capillary wedge pressure less than 18 mm Hg). Patients will have poor oxygenation, as indicated by a P/F ratio of less than 300 mm Hg in ALI and less than 200 in ARDS (normal is about 500 mm Hg). The P/F ratio compares the partial pressure of arterial oxygen (PaO_2) to the fraction of inspired oxygen (F_IO_2), or the amount of oxygen the patient is receiving via mechanical ventilation.[3] In a patient with ARDS, the most serious form of ALI, the P/F ratio typically will be below 200, reflecting even poorer oxygenation than in ALI.[4]

Although mortality rates for ALI and ARDS have decreased over the last decade, the current overall mortality rate is 43%.[5] Death typically occurs from

sepsis-related multisystem organ failure rather than respiratory failure.[6]

ALI and ARDS progress in three phases:

- In the *acute exudative phase*, the inflammatory response is activated, targeting the lungs. Alveolar endothelial and pulmonary vascular endothelial damage leads to increased permeability, causing alveolar and interstitial edema. Surfactant becomes inactivated. The resultant atelectasis and decreased compliance lead to refractory hypoxia and respiratory failure.[7]
- In the *proliferative phase*, patients may improve if inflammation abates and alveoli and capillary damage can be repaired.
- In the *fibrotic phase*, which can rapidly follow the proliferative phase, progressive vascular occlusion and pulmonary hypertension occur, and the patient will need long-term ventilation or oxygen support.[7]

The earliest signs of ALI or ARDS are progressively worsening dyspnea and tachypnea despite maximum supplemental oxygen. As the disease progresses, diminished breath sounds, pulmonary crackles, and wheezes may occur with signs of consolidation on chest X-ray. The patient's skin may be mottled or cyanotic, particularly in the nailbeds and the circumoral area. Tachycardia commonly occurs. The patient's SpO_2 and PaO_2 indicate moderate to severe hypoxemia.[7]

Even without arterial blood gas results, you may be able to detect ALI and ARDS early by using the SpO_2/F_IO_2 ratio as a surrogate for the P/F ratio. In healthy individuals, changes in PaO_2 correlate well with changes in SpO_2 for oxygen saturation in the range of 80% to 100%.[8] Researchers with the National Institutes of Health's ARDS network found that in patients participating in ALI/ARDS clinical trials, SpO_2/F_IO_2 ratios of 235 and 315 were appropriate surrogates for P/F ratios of 200 and 300 mm Hg, respectively.[8]

Treating ALI and ARDS

The primary treatment for ALI and ARDS includes aggressive treatment of the underlying cause, as well as mechanical ventilation to maximize oxygenation. Conventional lung protective ventilation strategies (aimed at decreasing ventilator-associated lung injury) including low tidal volumes, low to moderate positive end-expiratory pressure (PEEP), and low plateau pressures have been found to reduce ventilator days and hospital mortality.[9] As prescribed, maintain chemical paralysis and sedation to optimize oxygenation, and administer positive inotropes and vasopressors for circulatory support, crystalloids and colloids to increase preload, and glucocorticoids to treat local and systemic inflammation.

Although glucocorticoids aren't commonly used, increasing evidence points to including them as part of the standard treatment.[10] In a recent randomized controlled trial, patients treated with early and prolonged low-dose methylprednisolone had lower infection rates and shorter duration of mechanical ventilation and ICU stay. ICU mortality rate in the treatment group declined to 20.6% compared with 42.9% in the control group.[11]

About complications

The most common complications of ALI/ARDS are deep vein thrombosis, pressure ulcers, poor nutritional status, and VAP.[3] Specialized nursing care is required to achieve optimum outcomes for ALI/ARDS patients. When patients present with ALI, especially those with additional risk factors such as smoking and advanced age, preventing respiratory failure is the priority. Nurses need to report early signs of hypoxemia, including change in mental status, shortness of breath, tachypnea, adventitious breath sounds, and decreased oxygen saturation as evidenced by pulse oximetry and arterial blood gas analysis.[12]

Refractory hypoxemia, or low oxygen saturation despite increasing supplemental oxygen, indicates the patient is progressing from ALI to ARDS and will need endotracheal intubation and mechanical ventilation.[3] Standard oxygen administration is the lowest concentration that results in a PaO_2 equal to or greater than 60 mm Hg. An F_IO_2 higher than 0.6 for more than 48 hours put patients at risk for oxygen toxicity.[13] To promote maximum oxygenation, maintain airway patency, monitor oxygenation, and airway pressures, and provide sedation and analgesia.

Because changes are occurring so rapidly, emotional support and teaching are essential for the patient and family.

Hemodynamic monitoring is indicated along with enteral nutrition and fluid replacement. No consensus exists on using crystalloids versus colloids for fluid replacement. To prevent pulmonary edema, nurses should carefully monitor the

pulmonary capillary wedge pressure and cardiac output to guide volume replacement.[13]

Why use proning?

Prone positioning may be ordered as an early trial to increase the patient's P/F ratio and treat or prevent pulmonary complications associated with ARDS. Not all patients are candidates for this therapy, so consult the manufacturer's guidelines for the proning device you're using. For example, the Vollman Proner isn't recommended for patients weighing more than 300 pounds, and the RotoProne system is contraindicated in patients with unstable cervical, thoracic, lumbar, pelvic, skull, or facial fractures.[14,15]

An optimal length of proning hasn't been established, although 4 to 6 hours at a time is commonly used. In a recent systematic review and meta-analysis of the effects of proning for ventilator-assisted patients with ALI/ARDS, proning was associated with improved oxygenation and a decreased incidence of ventilator-associated pneumonia (VAP).[16] However, neither mortality rate nor length of mechanical ventilation decreased with proning, and the prone position increased the incidence of pressure ulcers.[3] Proning also can cause tube dislodgement, oxygen desaturation, facial edema, peripheral nerve injuries, skin necrosis, corneal ulceration, and abdominal wound dehiscence.[17]

Rotational therapy, a less-aggressive form of turning, is recommended in conjunction with proning to improve oxygenation in patients with ALI or ARDS.[3] Also called continuous lateral rotation therapy, this therapy consists of using a programmable bed to turn the patient (intermittently or continuously) from side-to-side on an arc of 40 degrees or less. If the degree of turn is greater than 40 degrees to each side (or more than 80 degrees total arc), the treatment is referred to as kinetic therapy.[18]

Two systematic reviews and meta-analyses of critically ill patients with respiratory complications suggest that compared to standard manual turning, rotational and kinetic therapy decrease the incidence of healthcare-associated pneumonia, but have no effect on duration of mechanical ventilation, length of stay in intensive care, or mortality.[18,19] No consistent or optimal rotation parameters (for example, degree, pause time, and amount of time per day) were found. Because patients can be awake during rotational therapy, intolerance may preclude therapy or require premedication for agitation and nausea.

PHOTO COURTESY OF KCI.

The RotoProne therapy system from KCI of San Antonio, Texas, is an automated proning bed with special openings for monitoring cables and invasive lines.

Preparing your patient

Patients and their families are understandably anxious about the critical nature of the patient's clinical status. Explain proning therapy, why it's being used, and the expected benefits. Assess the patient's mental status, assess anxiety level using the Faces Anxiety Scale, in which 1 is neutral and 5 is extreme fear.[20] Also assess the patient's hemodynamic status, as well as pulse oximetry and arterial blood gases to help determine tolerance before, during, and after proning.[21]

Before proning a patient, take these steps to prevent complications:

- Stop tube feedings at least 1 hour before proning, to prevent aspiration.
- Change dressings on the anterior body and empty ostomy bags to reduce the risk of skin breakdown from oozing secretions.
- Remove ECG leads from the anterior chest wall and reposition them toward the shoulders and sides, avoiding pressure areas and any equipment. (The patient shouldn't rest on any electrodes.)[21]
- Securely tie and double tape the endotracheal or tracheostomy tube because secretions increase in the prone position and may loosen adhesive, dislodging the tubes and causing airway compromise.

- Use a bite block to prevent the patient's tongue from protruding and becoming injured.[21]
- Perform routine eye care to reduce the patient's risk for dry eye with possible corneal abrasion or infection. Recent recommendations suggest that polyethylene-film eye covers are significantly better than instilling drops or ointment to prevent corneal abrasions.[22]

Turning the patient

Proning can be performed manually with or without assistive devices, although the process is time- and labor-intensive, requiring three to six staff. Regardless of method, patients should be sedated beforehand and closely monitored via a pulmonary artery catheter and arterial line. If the patient rests on a kinetic or continuous lateral rotation surface with or without an accessory prone kit (an additional air cushion), it should be fully inflated before proning for ease of movement.[21]

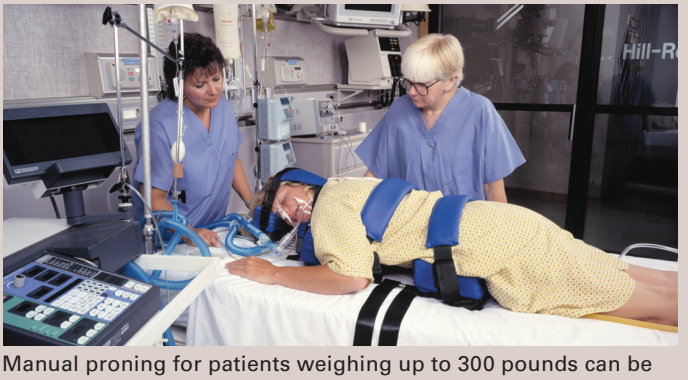
Manual proning. One method involves placing the patient between two lift sheets and rolling the sheets tightly toward the patient. Four to six staff members position the patient to the side of the bed away from the ventilator and turn him laterally toward the ventilator. For optimal airway maintenance the person at the head is responsible for securing the endotracheal (ET) tube, I.V. lines, and ventilator tubing as well as holding the ET tube during turning. Once airway, tubing, and patient tolerance are deemed satisfactory, the prone position is established.[23]

For manual proning, a pillow, pads, or foam blocks are needed to maintain an open and quick access to the airway/ET tube, and face. The P3 Prone Positioning Pillow, developed by a surgeon, supports the head while maintaining straight alignment of the neck without pressure on the eyes, nose and ears. Sandbags and additional pads maintain alignment of extremities and prevent edema and pressure ulcers. Elevate the patient's feet with ankle rolls to prevent skin breakdown.[23]

Manual proning for patients up to 300 pounds may be assisted with the Vollman Proner. The proner has adjustable head and pelvic cushion supports, a stationary chest support cushion, woven securing straps and turning straps attached to stainless steel support rods. In the prone position, the patient's abdomen is freely suspended and you can access the patient from all sides. Using this device, three nurses may successfully perform proning.[24]

Proning beds. The RotoProne is an automated proning bed with a halo-type opening at the head for I.V. lines, monitor cables, and ventilator tubing, and an opening at the bottom for catheters such as an indwelling urinary catheter. Extension tubing is required for I.V. lines when using this bed.[25]

PHOTO COURTESY OF HILL-ROM.



Manual proning for patients weighing up to 300 pounds can be accomplished with the Vollman Proner from Hill-Rom of Batesville, Ind.

Saving the skin

Regardless of method, with proning a primary concern is preventing pressure ulcers, primarily on the face and anterior shoulders. Thorough regular skin assessment is an essential component of any position therapy; pay special attention to all bony prominences. Nonblanchable erythema of intact skin is an early indication that the skin is becoming less tolerant of the therapy.[26] To protect the patient's skin, apply lotion after bathing, use moisturizers to prevent dryness, pad the skin to avoid direct contact with devices, and avoid massaging bony prominences.[27]

Proning in action

Let's look at how you'd use proning to care for Jim Haynes, 49. A week after being diagnosed with pneumonia, Mr. Haynes arrived in the ED with persistent dyspnea and substernal chest pain. Other than smoking for 20 years, his past medical history was unremarkable. An emergency cardiac catheterization demonstrated significant three-vessel disease.

Mr. Haynes needs coronary artery bypass graft surgery as soon as his pneumonia has been treated aggressively to optimize pulmonary function. He's receiving I.V. antibiotics and his latest chest X-ray revealed bilateral infiltrates, an early sign of ALI or ARDS.

About 3 hours post-cardiac catheterization, Mr. Haynes' oxygen saturation progressively decreased despite 100% continuous oxygen administration with a nonrebreather mask. He became tachypneic and increasingly dyspneic. The cardiac monitor showed sinus tachycardia. Arterial blood gas analysis revealed severe hypoxemia with a PaO_2 of 39 mm Hg and SaO_2 of 74%.

Mr. Haynes was placed on a mechanical ventilator using a volume control synchronized intermittent mandatory ventilation mode, a ventilation rate of 10 breaths/minute, tidal volume of 600 mL (appropriate for a patient with an ideal body weight of 85 kg [187.4 pounds]), PEEP of 10 cm H_2O, pressure support of 20 cm H_2O, and F_IO_2 of 1.0 (100% oxygen). He was sedated with propofol. His hemodynamic parameters indicated adequate cardiac function, with cardiac output of 7.2 L/minute (normal range, 4 to 8 L/minute) and a cardiac index of 3.4 L/minute/m^2 (normal range, 2.6 to 4.2 L/minute/m^2). However, repeat ABGs showed further decline in oxygenation, with a PaO_2 of 36 mm Hg.

Because mechanical ventilation wasn't reversing Mr. Haynes' respiratory failure, the healthcare provider ordered prone positioning. Before prone positioning, Mr. Haynes received premedication of I.V. midazolam along with propofol titrated for agitation. Within an hour of the turn, Mr. Haynes showed remarkable signs of improved ventilation. Oxygen saturations rose to 100% without ventilator changes, respirations decreased to 12 to 14 per minute with ventilator assistance, and he was now in normal sinus rhythm.

Pulmonary function continued to improve over the next few days. He was transferred to a tertiary care center for successful coronary artery bypass graft surgery with an uneventful recovery. For Mr. Haynes, prone positioning was an effective therapy to reverse acute respiratory failure. ❖

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