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Review

Featured Applications in Intensive Care Units in the COVID-19 Pandemic: Prone Position

Ayşegül ÖZTÜRK BİRGE, Sevinç KUTLUTÜRKAN
Department of Nursing, Ankara University, Faculty of Nursing, Ankara, Turkey

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ABSTRACT

The effectiveness of prone positioning in the management of hypoxic respiratory failure has come to the fore again with the coronavirus disease-2019 pandemic. Intensive care nurses, together with the intensive care team, have considerable responsibilities for the implementation of the position, the follow-up of the patient, obtaining effective results, and the prevention of possible complications. In this direction, it is important to establish valid and reliable protocols prepared by the relevant authoritative institutions regarding the prone position. In order to follow these protocols, it is necessary to train the nurses together with the members of the intensive care team and to inform the patients and their relatives that the prone position will be applied. In this review, the physiological effect of prone positioning, its use in intubated and non-intubated intensive care patients, its indications and contraindications, care recommendations about the implementation, monitoring, and termination of the positioning, the duration of the use of the position, barriers to its use, and recommendations to increase the effectiveness of its clinical use was discussed.

Keywords: COVID-19, intensive care nursing, position, prone

Introduction

"Proning" or moving a patient from a supine to a prone position is a treatment approach used to increase the likelihood of survival in individuals with coronavirus disease 2019 (COVID-19).[1,2] It is recommended that high-flow nasal cannula (HFNC) oxygenation with oxygen saturation (SpO_2) > 92% and prone position to be used in the management of COVID-19-induced hypoxia. When these approaches are inadequate, the use of extracorporeal membrane oxygenation (ECMO) is recommended.[3]

Patients are admitted to intensive care units (ICU) and monitored due to severe pneumonia, sepsis, septic shock, myocarditis, arrhythmia, cardiogenic shock or multiple organ failure, and acute respiratory distress syndrome (ARDS), which are severe forms of COVID-19 disease.[4] In the literature, it has been shown that the prevalence of ARDS is 17% in patients with COVID-19 and that maintaining oxygenation is an important problem.[5]

The prone position was first defined as a treatment method that was used in ARDS, and its beneficial effects were first studied in 1976.[6] The procedure was initially used as a last resort when all other treatments failed, but recent findings suggest that the use of the prone position should be included as part of the early management of severe ARDS.[7] It has been shown that in the presence of respiratory failure and severe hypoxemia developing in COVID-19 pneumonia, the prone position used in ARDS treatment can also be used as an adjuvant treatment approach to improve oxygenation.[5]

In this review, the physiological effect of the prone position, its use in intubated and non-intubated patients, its indications and contraindications, application, monitoring and termination protocols of the position, the duration of application, barriers to its use, and recommendations for its clinical use was discussed.

In addition, the review was discussed as a Panel issue in the Nursing Program at the 21st National Congress of Internal Medicine held in Cyprus on 6-10 October 2021. However, the content of the speech was not published in the congress book.

Corresponding author: Ayşegül ÖZTÜRK BİRGE, e-mail: birge@ankara.edu.tr

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Physiological Effect of the Prone Position

Prone positioning increases local ventilation/perfusion compliance with changes in alveolar ventilation and distribution of blood flow and improves oxygenation by reducing areas with low ventilation/perfusion rates (pulmonary areas open to ventilation increase in this position and show a homogeneous distribution).[8] The basic mechanism in prone positioning is the result of the difference between ventral and dorsal pleural pressure. Ventilation and pulmonary blood flow in the dorsal region increase with the decrease of intra-abdominal pressure in the diaphragm in the prone position.[9] The prone position is a maneuver that facilitates the redistribution of pulmonary blood flow rather than inflating the deflated alveoli, thereby reducing shunt formation.[4] In addition to these effects, the prone position can reduce the risk of ventilator-induced lung injury, prevent atelectasis by reducing alveolar overstrain, hyperinflammation, and regional shear stress of small airways, and improve pulmonary parenchyma tissue with secretion mobilization.[8] As a result, the application of prone positioning has positive effects on hypoxemia in intubated/non-intubated COVID-19 patients with lung involvement.

The Use of Prone Positioning in Intubated and Non-intubated Patients

According to ARDS management guidelines in intubated patients, the use of prone positioning in consecutive sessions of at least 16 hours is recommended to reduce mortality in patients with a PaO_2/FiO_2 ratio <150 mmHg (Grade 1, strong recommendation). To increase the safety of prone positioning, each unit must have a written procedure, and special training for nurses is required.[8,10] In the Prone Positioning in Severe Acute Respiratory Distress Syndrome (PROSEVA) study conducted in 27 different ICUs, the 28-day mortality rate was found as 16% in patients with ARDS (n = 466), who were placed in prone position early and for a long time (>16 hours), and this rate was 33% in the control group in the supine position ($P < .05$).[11]

It is assumed that the prone position may be more beneficial in improving oxygenation in non-intubated patients than in intubated patients and preventing both ICU admissions and intubation and that possible complications of mechanical ventilation support can be avoided.[5,12] However, studies on the applicability of prone positioning and patient outcomes in non-intubated patients are limited.[13] In a randomized–controlled study evaluating the effect of prone positioning in non-intubated patients with hypoxemic respiratory failure due to COVID-19, it was determined that the intubation rate did not change in the experimental and control groups.[14] In a meta-analysis evaluation, it was stated that the awake prone positioning improved the PaO_2/FiO_2 ratio and decreased the respiratory rate.[15]

It is stated that there are positive results in awake patients who are not intubated, especially in those who are placed in prone position, together with HFNC or non-invasive ventilation (NIV) treatments.[9,15] Jayakumar et al[16] (2021) evaluated the effect of the awake prone positioning in 60 non-intubated patients with acute hypoxic respiratory failure secondary to COVID-19 pneumonia who required 4 L or more oxygen to maintain 92% saturation. Accordingly, in the prone group, 43% (13 out of 30) of the patients were able to maintain their position for 6 hours or more per day. In the supine group, 47% (14 out of 30) of the patients in the supine position and 53% in the prone position spent several hours, but none of the patients were able to maintain their position for more than 6 hours. The PaO_2/FiO_2 ratio was 201.4 ± 118.8 in randomized patients who remained in the prone position, and it was 185.6 ± 126.1 in patients who received standard care ($P > .05$). There was no significant difference between the groups in terms of fluid balance, length of stay in the unit, increased respiration, or mortality.[16] According to all these research results, it can be said that the use of the prone position in intubated and non-intubated patients is beneficial.

Indications and Contraindications of Prone Positioning in Intubated Patients

The indications and contraindications of prone positioning in intubated patients are given below.[8,17]

Indications

- $PaO_2/FiO_2 < 150$ mmHg,
- Decrease in oxygen saturation ($SpO_2 < 92\%$),
- Decreased in respiratory rate (<30/min).[8,17]

Contraindications

- Spine or pelvic fractures,
- In patients with open chest or abdomen, central cannulation of ECMO or ventricular assist devices,
- In pregnant women in the second and third trimesters.[8,17]

Relative contraindications

- High intracranial or intraocular pressure,
- Uncontrollable seizures,
- Cardiac arrhythmias in a short time,
- Hemodynamic instability or significant coagulopathy.[8,17]

Recommendations for the Application of Prone Positioning, Patient Follow-up, and Termination of the Application in Intubated Patients

Working with maintenance algorithms/protocols in intubated patients in the initiation, monitoring, and termination of prone positioning has critical importance in terms of the benefit of patients. For this purpose, the recommendations of the Turkish Nurses Association and the Turkish Intensive Care Nurses Association in our country for prone positioning, patient monitoring, and termination of the position in intubated patients were compiled and tabulated (Table 1).[18,19] To benefit from the physiological effect of the prone position, it is necessary to maintain the position for at least 12-16 hours. Working with a care protocol will guide nurses and other health professionals in preventing possible complications, protecting employee and patient safety, and providing comfort.

It is necessary to make patient-specific decisions to determine the optimal timing to terminate the prone position. If $PaO_2/FiO_2 \geq 150$ mmHg, $FiO_2 \leq 0.6$, and Positive end-expiratory pressure (PEEP) ≤ 10 cmH_2O and these results continue for at least 4 hours after the initiation of prone positioning, the position can be terminated.[20]

Indications and Contraindications of the Prone Positioning in Non-Intubated Patients

The indications and contraindications of the prone positioning in non-intubated patients are given below.[16,21-24] Since the patient must consciously initiate and maintain the position in non-intubated patients, this position is also called the awake prone positioning.[24]

Indications

- Patients with mild to moderate ARDS but not requiring emergency intubation,
- Patients who can maintain SpO_2 level at 92% with 4 L/min of nasal oxygen and above,
- $PaO_2/FiO_2 < 200$ mmHg,
- Respiratory rate < 30/min,
- Not using the sternocleidomastoid muscles for breathing,
- Conscious patients who can communicate and follow instructions.[16,21-24]

Contraindications

- Patients requiring emergency mechanical intubation,
- Changed mental status,

Table 1. Recommendations for Implementation, Monitoring, and Termination of Prone Positioning in Intubated Patients[18,19]

Before Prone Positioning	While Prone Positioning	Patent Care and Monitoring	Termination
✓ At least 5 health personnel are required. ✓ Attention is paid to the safety of the endotracheal/tracheostomy tube. Tube level is checked before application. ✓ All intubation materials are kept ready against the risk of extubation. ✓ Before changing the position, endotracheal/tracheal aspiration is performed. ✓ Unnecessary connections and lines are removed. ✓ The location and length of the infusion pumps are adjusted accordingly to avoid straining the catheters. ✓ Attention is paid to tube-fixing bands and cuff pressure. ✓ The patient is oxygenated with 100% FiO_2 for 10 minutes before the application. ✓ Eyes are covered with protectors. ✓ Whether arterial and venous catheters and enteral or gastric tubes are securely fixed is checked. ✓ The nasogastric tube is aspirated by interrupting the feeding at least 1 hour before the application. ✓ The need for sedation or muscle relaxant is evaluated according to the level of sedation-agitation.	✓ A clean sheet is placed under the patient while he/she is in the supine position. ✓ The patient's arm close to the ventilator is placed under the hip with the palm facing forward. ✓ Anterior ECG electrodes are removed ✓ A pillow is placed on the patient's chest, iliac crests, and knees. ✓ A clean sheet is placed over the patient, leaving only the head and neck exposed. ✓ The edges of the upper and lower sheets are tightly wrapped together and the patient is fixed between the 2. ✓ The sheets are tightly stretched and the patient is pulled to the side of the bed against the direction to be turned. ✓ With the command of the person at the patient's bedside, the patient is turned 90° sideways. ✓ Without distorting the tension of the sheet, hands are changed with the other person in accordance with the direction of rotation. ✓ With the command of the person leading the team, the patient is turned to the prone position, and his/her head is placed to face the ventilator. ✓ It is ensured that the ETT is not folded. ✓ Ventilator settings are checked, and ECG electrodes are placed on the patient's back. ✓ The patient is relieved by positioning his/her arms on either side of his/her head.	✓ The ETT level is measured and recorded. ✓ The position of the head and arms is changed every 2-4 hours to change pressure points. ✓ The patient is placed in a reverse Trendelenburg position with the head elevated to 10°-25°C. ✓ The development of facial edema is prevented. ✓ Oral care is applied. ✓ Aspiration of nasogastric tube contents into the airway is observed/prevented. ✓ Pressure on the eye is prevented by the reverse Trendelenburg position (follow-up every 2-4 hours). ✓ Vasopressor medicines are kept ready against the development of hemodynamic hypotension. ✓ Medical device-related pressure injuries are monitored/prevented. ✓ All catheters and drains are monitored for folding and dislocation.	✓ All vital parameters (blood pressure, heart rate, respiration, etc.) are checked. ✓ Monitorization is continued by attaching monitor connections and ECG electrodes. ✓ Eye, mouth, and body care are done properly. ✓ Body areas under pressure are checked. ✓ Respiratory parameters (SpO_2, blood gas values, compliance with the ventilator, ventilator alarms, etc.) are closely monitored. ✓ Pain–sedation–agitation levels are evaluated. ✓ If there is a negative change in respiratory parameters (SpO_2: <88-90%, etc.), the team is contacted.

ECG, electrocardiogram; ETT, endotracheal tube.

- SpO_2/FiO_2 < 140 mmHg,
- Patients with severe respiratory distress requiring invasive intervention (Rr > 40/min),
- Hemodynamic instability (pulse > 100/min and systolic blood pressure<100 mmHg) and presence of cardiac arrhythmia,
- Patients with spinal instability secondary to severe rheumatoid arthritis,
- Women with pregnancy (second and third trimester),
- Facial trauma, clinical conditions due to increased intra-abdominal pressure,
- Patients with fractures.[16,21-24]

The Application and Monitoring of the Prone Positioning in Non-intubated Patients

Patients who meet the indication criteria for the awake prone positioning in non-intubated patients are identified, and a slight reverse Trendelenburg position is given. The comfort of the patients should be supported during the positioning.[24] It is important to develop a relationship of trust between the patient and health professionals to increase the education and compliance of patients with the position on issues, such as the benefit of the position, the method, and the duration of the application.[25] Oxygenation is monitored for the first 30 minutes after the patient is placed in the prone position, and if SpO_2 > 94, the position is maintained. To benefit from the awake prone positioning at the maximum level, it is necessary to maintain the position at least 3 times a day and for 2-3 hours if possible.[22] After the position is given, the patient's vital signs and oxygenation should be closely monitored. If the patient needs aspiration, it should be met, and if necessary, mild sedation or anxiolytic therapy should be applied.[25] Patients should rotate from the prone position to the right lateral, left lateral, and sitting positions, respectively, and change positions every 30 minutes as tolerated.[24]

The Duration of the Prone Positioning in Intubated and Non-intubated Patients

The American Thoracic Society and the European Society of Intensive Care Medicine recommend the use of prone positioning for 12-16 hours each day for patients with ARDS.[26] It is recommended to rotate the head and neck laterally every 2 hours during this time to relieve pressure. The oxygen index should be evaluated by measuring blood gas 2 hours after the patient is positioned. Patients with a 20 mmHg increase in PaO_2/FiO_2 ratio or PaO_2 > 10 mmHg in their blood gas results are considered sensitive to prone positioning.[27]

Unlike patients with sedated ARDS on invasive mechanical ventilation, the duration of prone positioning in non-intubated patients depends on patient tolerance and comfort. Although there is no consensus yet on the reported time, it is stated in the published reports that it varies between 30 minutes and 8 hours. In addition, according to these reports, each session is applied 2-3 times or more during the day.[9] As a matter of fact, in a study examining the effect of early prone positioning in COVID-19-positive patients with severe hypoxia, it was determined that The respiratory rate-oxygenation (ROX) index (SpO_2/FiO_2(%)/respiratory rate) of the patients increased from 3.35 ± 0.46 to 3.96 ± 0.45 after 30 minutes of prone positioning (P < .01).[28] In another study evaluating hypoxemic patients (n = 50) with COVID-19 admitted to an emergency room in New York, it was determined that the median SpO_2 of the patients was 80% and increased to 84% after oxygen support in room conditions and that it increased to 94% after 5 minutes of prone positioning (P = .001). Oxygen saturation did not improve in 24% of the patients, and endotracheal intubation was required.[23] Although some studies have shown the effectiveness of short-term applications of prone positioning, it is predicted that longer application of the position may increase the success rate of the treatment.[9] Prone position time appears to be an important factor affecting patient outcomes.

For this reason, it is important to take nursing interventions that will increase the adaptation of the patients to the position.

Complications of Prone Positioning

Prone positioning has potential complications. The most common complications are accidental extubation (78%), pressure injury (50%), and facial edema (50%).[17] In systematic reviews, it has been shown that there is an increased incidence of higher pressure injuries, tracheal tube occlusion, and dislocation of thoracostomy tubes in the prone position.[8] In addition, hemodynamic instability and brachial plexus injury can be seen in these patients.[4]

The direct pressure on the orbits along with vascular changes in prone positioning causes extraocular muscle damage, which can potentially result in conjunctival edema, bleeding, and even corneal injury. Ten minutes after prone positioning, patients have been reported to show a greater risk of corneal ulcers as well as elevated intraocular pressure. Although evidence suggests that corneal abrasions and scleral scars caused by prone positioning are usually self-limiting, such damage can compromise eye function and require lifelong eye care.[17]

Gastric bloating, gastroesophageal reflux, and vomiting can be seen in patients in the prone position.[29] In a systematic review examining the nursing problems in enteral nutrition in prone positioning in critically ill patients, it was determined that the need to stop enteral nutrition and vomiting attacks are higher in prone positioning but that the high stomach volume ratio was similar in supine and prone positions.[30] It was found that ventilator-associated pneumonia, length of stay, and mortality rates were similar in supine and prone positions. In only 1 study, patients who received full-day enteral nutrition had lower mortality compared to an 18-hour administration protocol.[30]

Barriers to the Application of Prone Positioning in Intensive Care Units

The prone position is a life-saving therapy for some patients with COVID-19,[1,7] but the difficulty of prone positioning often limits its application.[7] Turning patients face down while they are lying on their side is the most physically demanding task.[7] Prone positioning is typically accomplished using manual techniques that require 5-7 caregivers, depending on the patient's weight and method of rotation. Education of care teams on the positioning procedure and how to manage potential problems is a barrier to its implementation. In addition, gathering such highly trained personnel in the ICU is very challenging and causes a significant interruption in the workflow. Particularly, under COVID-19 pandemic conditions, gathering so many healthcare professionals around patients is difficult due to the shortage of personnel and personal protective equipment (PPE), putting many healthcare workers at risk for exposure to infectious agents.[31]

Manual prone positioning techniques include pushing, pulling, and lifting the patient. Manual prone positioning may put healthcare workers at greater risk than common patient transport tasks because it involves lifting or holding the patient against gravity and carefully positioning them to avoid adverse safety events.[2] While prone positioning methods are evaluated, weight limit, cost, and availability of equipment, as well as the safety of patients and healthcare workers, should be considered. Availability of equipment is a potential barrier to some prone positioning methods. Manual techniques require little or no specialized equipment, whereas lifting-assisted techniques require lifting equipment.[7] Prone positioning may also prevent performing procedures such as intubation and chest compressions quickly.[8] Despite all these results, the dominance of the intensive care team in the positioning process is an important factor that reduces the obstacles.

Recommendations for the Efficiency of Prone Positioning Application in Intensive Care Units

This section includes recommendations to achieve the effectiveness of the prone positioning application in ICUs, such as the education of nurses and all health professionals, close monitoring and monitorization of the patient, patient education, support for comfort, and chest compression and enteral nutrition support in the patient who is placed in the prone position and who develops an arrest.

Education of healthcare professionals: Prone positioning requires several positioning cycles that will increase the potential workload of nurses. Therefore, in addition to certain institutional protocols, an appropriate number of educated nurses are needed to achieve patient and employee safety.[17] Although the clinical benefits of prone positioning outweigh the possible adverse events,[32] nurses should take precautions against endotracheal tube dislocation, hemodynamic deterioration, disconnection, eye injuries, and pressure injuries.[31]

Patient monitorization: Prone positioning is an application that has beneficial effects, especially when it is initiated early and applied for a long time.[33] Patient tolerance and monitoring are key factors for treatment success during prone positioning. Monitoring parameters are not well defined for treatment success. Ng et al[21] (2020) recommended that when the combination of prone positioning and HFNC therapy is evaluated, if the patient cannot tolerate prone positioning in the presence of clinical deterioration and if the ROX index is <4.88 despite optimal HFNC therapy, then the prone positioning should be terminated.

Patient education and comfort: Patient comfort and positioning education are very important for the success of prone positioning in non-intubated patients. Anxiety is associated with any form of respiratory illness but is exacerbated due to uncertainty about the treatment and prognosis of COVID-19 today. Also, the majority of hospitals have very restricted visitor policies, reducing the availability of family support and further increasing anxiety. Early evaluation of low-dose anxiolytics can reduce the patient's anxiety and increase compliance with prone positioning.[13] In the monitoring of prone positioning in non-intubated patients, after providing the use of the toilet, patients should be supported with a pillow and made comfortable as much as possible. A call bell should be placed in a suitable place where patients can reach it. Patients should be adequately oxygenated with conventional oxygen, HFNC, or NIV and monitored on a continuous respiratory monitor. Patients should be provided with a visual educational brochure explaining the position. They should be reassessed by nurses every 30 minutes for the first hour and every hour for the next 2 hours.[24]

Chest compressions: In case of cardiac arrest in the non-intubated patient who is in the prone position, the patient should be supine positioned immediately before starting chest compressions while wearing the PPE appropriately.[34] In intubated patients who develop cardiac arrest, it is possible to perform chest compressions by pressing the patient's back. Thus, the perfusion of vital organs can be achieved until the team is ready to put the patient in the supine position. If compressions are ineffective (if diastolic pressure is less than 25 mmHg in invasive arterial blood pressure measurement), if something requiring intervention such as airway problems has occurred, if circulation has not recovered within minutes, then the patient should be put in the supine position. A shock should be given if the rhythm is ventricular fibrillation/pulseless ventricular tachycardia. If the patient remains in a shockable rhythm and PPE is used, chest compressions are initiated. If PPE is not available, 2 additional shocks can be given while other healthcare professionals are wearing their PPEs.[34]

Enteral nutrition: Deep sedation, septic shock, hemodynamic disorder, high intra-abdominal pressures, and mechanical ventilation are common in patients with ARDS who are in the prone position. These factors can alter gastric motility and delay emptying, leading to high residual gastric volume, regurgitation, or episodes of vomiting.[30] Therefore, the evaluation and monitoring of enteral nutrition in these patients are very important.[35] According to the latest guidelines published by the European Society for Clinical Nutrition and Metabolism, enteral nutrition should be initiated as early as possible (within the first 48 hours of ICU) if there are no contraindications, even in those treated in the prone position.[30] In addition, the European Society of Intensive Care Medicine recommends that early enteral nutrition not be delayed simply because of the prone position. It is stated that early enteral nutrition reduces ICU and hospital mortality, length of stay, and infections.[30] It is recommended that enteral nutrition should be initiated early in critically ill patients in the prone position, the height of the head of the bed (reverse Trendelenburg) should be kept at 10°-25°, and risk factors should be assessed and managed individually.[29] In addition, the efficiency of fluid resuscitation in critically ill patients with ARDS who are in the prone position can be reliably evaluated with the Trendelenburg maneuver (Central venous pressure increases significantly, while the pulse does not change).[36]

Conclusion

With the COVID-19 pandemic in ICUs, the frequency of prone position use in the management of hypoxia has increased. Knowledge of the recommendations for prone positioning in intubated and non-intubated patients and the physiological effect of the position, patient monitoring, and termination of the position will be beneficial in preventing complications that may develop in patient care or in controlling them when they develop. In addition, for the effectiveness of prone positioning, especially in ICUs, education and counseling of healthcare professionals about patient monitorization (a), patient education and comfort (b), chest compression (c), and enteral nutrition (d) will contribute to the increase in the quality of patient care.

For the intensive care team to benefit from the positive effects of prone positioning at the highest level, it is very important that they are aware of the results of the studies at the evidence level and follows the recommendations of the relevant authorized institutions. In this review article, the latest studies in the literature were reviewed, and the awareness of health professionals working in ICUs was tried to be raised.

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