# Proning Patients With COVID-19: A Review of Equipment and Methods

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**Objective:** To identify and critically evaluate methods for proning patients with COVID-19 in the intensive care unit (ICU).

**Background:** Acute respiratory distress syndrome (ARDS) is common in hospitalized patients with COVID-19. Proning improves blood oxygenation and survival rates in these patients but is not commonly performed due to the difficulty of the procedure.

**Methods:** An academic literature review, internet video search, and consultation with five subject-matter experts was performed to identify known methods for proning. Evaluation of each method considered the number of healthcare workers required, physical stresses on staff, risk of adverse events to patients, and equipment cost and availability.

**Results:** Several variations of manual techniques and-lift assisted techniques were identified in addition to a specialized proning bed. Manual methods require more healthcare workers, higher physical stresses, and greater risk of adverse events than lift-assisted methods or the proning bed.

**Conclusion:** Both the specialized proning bed and a lift-assisted method using straps largely eliminated manual forces required for proning while allowing for a controlled lowering and positioning of the patient.

**Application:** This review will guide practitioners to the most suitable methods for proning patients in the ICU.

**Keywords:** patient handling, prone positioning, proning, medical devices and technologies, nursing and nursing systems

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## INTRODUCTION

"Proning," or moving a patient from lying on the back to lying face down, is a therapy used to increase the likelihood of survival in patients with coronavirus disease 2019 (COVID-19). Proning was first described as a treatment for acute respiratory distress syndrome (ARDS) in the medical literature over 40 years ago. The procedure was initially used as a last resort when all other treatments failed, but recent findings suggest the use of prone positioning should be included as a part of the early management of severe ARDS (Koulouras et al., 2016; Mitchell & Seckel, 2018).

### Proning to Treat ARDS

ARDS was first recognized during the Vietnam War in the 1960s and is characterized by poor gas exchange as a result of alveolar damage and excess fluid in the lungs that prevents oxygen from reaching vital organs. ARDS is a disease state that can result from pneumonia, aspiration of gastric contents, sepsis, and COVID-19. Nearly 200,000 patients are diagnosed with ARDS in the United States annually. ARDS is responsible for 10% of all intensive care unit (ICU) admissions worldwide and occurs in 23% of patients who are mechanically ventilated. The hospital mortality rate for patients with ARDS is 46% and the ICU mortality rate is 38% (Mitchell & Seckel, 2018). The characteristics of ARDS in patients with COVID-19 are similar to that of ARDS in patients with other underlying causes although some physiological differences have been observed and details are still emerging (Gattinoni et al., 2020). In hospitalized patients with COVID-19, 42% developed ARDS, and those patients had a mortality rate of 52% (Wu et al., 2020).

Prone positioning has demonstrated effectiveness for treating ARDS: the 28-day mortality was 16% of for ARDS patients receiving prone positioning compared to 33% in a supine control group (Guérin et al., 2013). The Society of Critical Care Medicine, the American Thoracic Society, and the European Society of Intensive Care Medicine all recommend the use of prone positioning for 12–16 hr each day for patients with ARDS (Alhazzani et al., 2020; American Thoracic Society, 2020; Mitchell & Seckel, 2018). Placing a patient in prone position allows gravity to aid in mobilizing secretions from the posterior aspect of the lung field. Alveolar recruitment occurs as a result of drainage of secretions, allowing improved ventilator performance and blood oxygenation (Koulouras et al., 2016). Proning benefits patients with COVID-19 who have developed ARDS in largely the same manner as for other ARDS patients. Proning for COVID-19 is being widely adopted and recommended for patients who have developed ARDS, and is even being prescribed by some clinicians for patients who are not ventilated (Bamford et al., 2020; US National Library of Medicine, 2020).

### Barriers to Proning

Although the clinical benefits of proning far outweigh any possible adverse events (Park et al., 2015), healthcare workers must safeguard against endotracheal tube dislodgement, hemodynamic compromise, disconnecting lines, eye injuries, and pressure injuries while maintaining access to the chest, central lines, arterial lines, and urinary catheters.

Prone positioning is typically accomplished using manual techniques that require five to seven care team members depending on the method and size of the patient. Training care teams on the procedure for proning and how to safeguard against adverse events is a barrier to implementation. Moreover, gathering these many trained staff in a typical ICU is very challenging and a considerable disruption to workflow. Specific to COVID-19, gathering so many healthcare workers around the patient is particularly difficult due to staff and personal protective equipment shortages, and places many staff at risk of exposure.

Manual proning techniques include pushing, pulling, and lifting the patient. Although physical stresses during proning have not been studied, manual patient handling is associated with musculoskeletal injury (Davis & Kotowski, 2015). Manual proning may put healthcare workers at even greater risk than common patient handling tasks because proning involves lifting or holding the patient against gravity, and carefully positioning the patient to prevent adverse safety events.

Despite the benefits of prone positioning for treating ARDS, the adoption of proning is limited (Guérin et al., 2018) and is partially due to the barriers of implementation. The COVID-19 pandemic has refocused the medical community on the need for proning and interest is high for identifying appropriate techniques for moving a patient between supine and prone.

Clinicians and vendors have proposed several techniques and even developed specialized devices to facilitate proning. The objective of this review is to identify and critically evaluate known methods for proning patients in the ICU setting. This analysis will focus on the feasibility of different techniques and the associated safety risks for patients and healthcare workers.

## METHODS

A combination of academic literature review, internet search, and expert consultation was employed to describe current proning practice and identify available proning techniques.

### Academic Literature Search

An extensive academic literature search was performed to identify proning methods documented in previous studies. Articles describing proning published between 1980 and April 15, 2020 were extracted. Studies were included if the prone positioning was performed in ICU or MedSurg environments, and details on the prone positioning technique were described. Studies were excluded if prone positioning was conducted specifically in the operating room for spine surgery, or for first responders rescuing traumatic patients.

### Internet Search

An internet video search was performed specifically to identify proning methods and to supplement the literature search. A video search was performed between April 13 and April 17, 2020 in Google and Bing using the terms "prone positioning," "proning ARDS," and "proning ICU." The private browsing mode of the browser was used to avoid personalized recommendations. The top 20 results for each term for each search engine were examined for relevance.

### Expert Consultation

The identified proning methods from the literature and video search were documented. Five clinical experts were consulted to (1) review and verify the details of the proning methods, (2) confirm that no additional methods were missed, and (3) verify or recommend strong representative videos of each proning method. This team included three registered nurses, one physical therapist, and one occupational therapist who all had experience mobilizing patients in ICU environments. Each proning method was assessed for attributes that affected ease of implementation, equipment required, patient safety concerns, and exposure or injury risks to the healthcare worker.

## RESULTS AND DISCUSSION

The academic literature search identified manual proning methods using draw sheets (Messerole et al., 2002; Rowe, 2004), manual proning using a portable frame positioner (i.e., Vollman Prone Positioner; Vollman & Bander, 1996; Wiegand, 2016), and mechanical proning using a specially designed proning bed (i.e., RotoProne; Dickinson et al., 2011; Dirkes et al., 2012).

The internet search and expert consultation revealed variants of proning methods that fit into three distinct categories: manual, mechanical lift-assisted, and the specialized proning bed. Manual proning was by far the most common and had the most variants such as the use of air-assisted lateral transfer devices, friction-reducing devices, and systems that include friction-reducing devices and patient positioners. Lift-assisted techniques used mechanical lifts together with repositioning sheets or lifting straps. Table 1 lists the proning methods identified in the review with key characteristics and considerations listed for each method. The main process steps for different methods are illustrated in Figure 1. When returning to supine, the methods described in Figure 1 follow essentially the same steps as for moving to prone.

### Patient Safety

The manual proning methods and lift-assisted methods with a repositioning sheet require healthcare workers to catch and lower patients as they are rolling to prone. This manual lowering increases the risk of extubation or line removal. The RotoProne and the lift-assisted method with straps both allow mechanical lowering, providing more control for managing the endotracheal tube and lines. Pressure injury is a risk for all patients in prone position, but the RotoProne may provide additional challenges to pressure injury prevention because patients on the bed are not as easily accessible for repositioning as compared to a standard hospital bed. The RotoProne alarms after 3 hr and 15 min to prompt healthcare workers to bring the patient back to supine (ArjoHuntleigh, 2019). This may be undesirable for clinicians attempting to follow recommendations that patients remain prone for 12–20 hr, while being repositioned as frequently as every 2 hr (Guérin et al., 2018; McKenna & Meehan, 2018).

### Staff Safety: Exposure

Minimizing the number of healthcare workers needed to prone the patient is beneficial not just for workflow and staffing, but also to limit the number of staff exposed to a patient with COVID-19. Manual techniques of repositioning patients all require five to seven healthcare workers present. A minimum of two healthcare workers are needed on each side of the bed to rotate the patient and more may be needed for wider, heavier, or more medically complex patients. An additional worker, usually a respiratory therapist, is needed at the head of the bed to hold the head of the patient and manage the airway. The lift-assisted techniques with repositioning sheets do not substantially reduce the number of healthcare workers needed because of the substantial pushing and lifting forces required to physically rotate and lower the patient to prone. The lift-assisted technique using straps and the

**TABLE 1:** Proning Methods Identified and Key Characteristics

| Category | Method | Equipment Required | Estimated Staff Required | Physical Exposure Concern | | | Patient Descent | Comments | Source |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Lateral Repo. | Lift/Rotate | Lowering | | | |
| Manual | Manual technique: Draw sheet | Draw sheet and flat sheet | 5 to 7 | Y | Y | Y | Manual | Sometimes referred to as the "Burrito" technique | https://youtu.be/yb1ppe8Y-70 https://youtu.be/qx2z26IL6g8 |
| | Manual technique: Friction-reducing device | Friction-reducing sheet and flat sheet | 5 to 7 | N | Y | Y | Manual | Some vendors include foam or fluidized prone positioners | https://youtu.be/lcBPaHQUvXY https://youtu.be/wxCnTsZeKxo |
| | Manual technique: Air-assisted lateral transfer device | Flat sheet and 2x air-assisted sheets | 5 to 7 | N | N | Y | Manual | Device assists with lateral repositioning and may also be inflated for patient rotation. Rotation may be less controlled | https://www.linkedin.com/feed/update/urn:li:activity:6651526505816031232/ |
| | Volman prone positioner | Volman prone positioner | 5 to 7 | Y | Y | Y | Manual | No longer commercially available | Vollman and Bander (1996) |
| Lift-assisted | Repositioning sheet for rotation | Mechanical lift and 1x or 2x sheets | 5 | N | N | Y | Manual | The 2nd sheet is used to reposition back to supine. Video shows fewer caregivers than required in clinical environment | https://youtu.be/0ksD7B64T7A |
| | Repositioning sheet and positioning sling | Mechanical lift, 2x sheets, positioning sling | 5 | N | N | Y | Manual | Positioning sling can also be used for repositioning for skin | https://youtu.be/Gh9JDmETtyI |
| | Lift straps for rotation | Mechanical lift and 2x straps | 3 | N | N | N | Mechanically controlled | It may be possible to feed straps under patient without turning | https://youtu.be/72QO3X9_Lus |
| Specialized bed | RotoProne | RotoProne Bed | 2 to 3 | N | N | N | Mechanically controlled | 350 lb weight limit. Requires a transfer to the bed | |

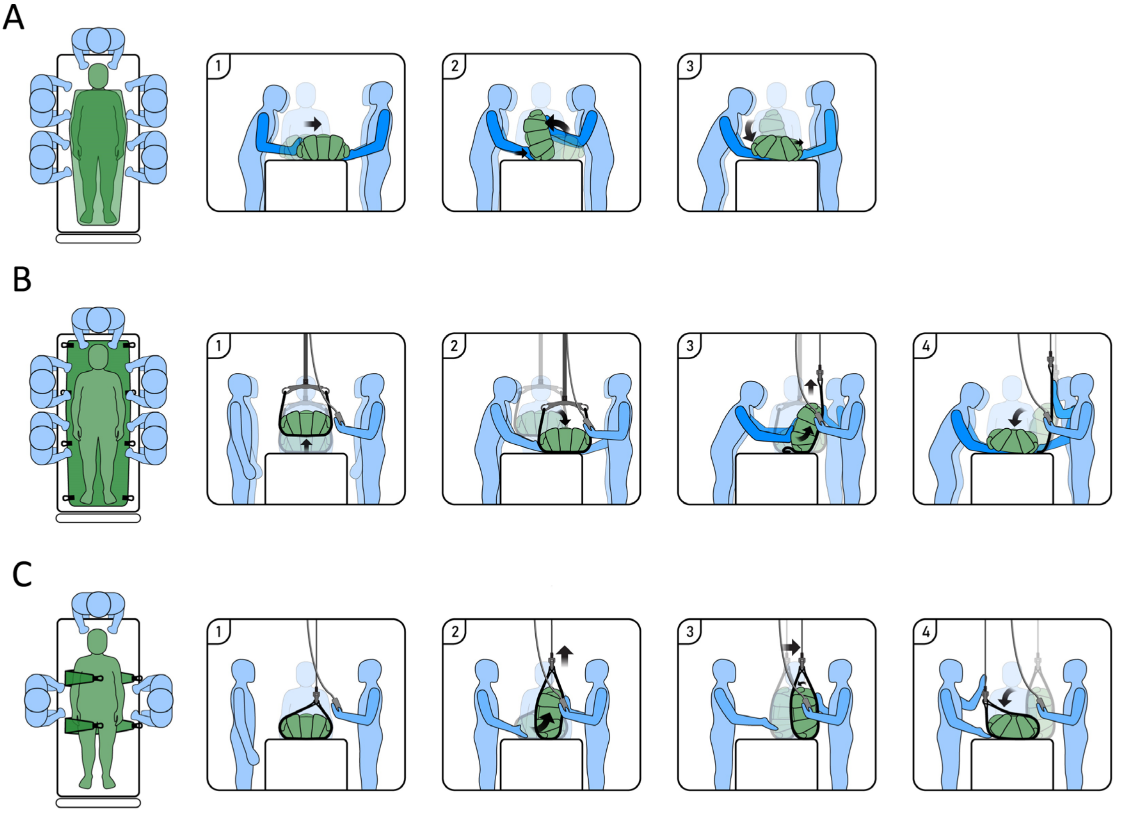


*Figure 1.* Process steps for the proning methods. *Manual proning* (A). The patient is laterally repositioned (1), lifted and rotated (2), and lowered (3). All steps are manual but friction-reducing sheets may be used to assist with (1). *Lift-assisted proning with repositioning sheet* (B). The patient is laterally repositioned (1 & 2), lifted and rotated (3), and lowered (4). The lift assists with all steps except lowering (4). *Lift-assisted proning with straps* (C). The patient is lifted and rotated (1 & 2), laterally repositioned with most of the weight supported by the lift (3), and lowered (4). All steps are mechanically assisted by the lift.

RotoProne require fewer healthcare workers because they eliminate the manual lowering activity as well as all other manual elements of proning.

## Staff Safety: Musculoskeletal Injury

Although no studies have assessed the biomechanical stresses on healthcare workers when proning patients, inferences can be made based on published research. Regardless of the method used to prone patients, the movement contains three common elements: lateral repositioning, rotating from supine to side lying, and lowering from side lying to prone. These subtasks are illustrated in Figure 1.

Laterally repositioning a 50-kg by a single healthcare worker using a draw sheet was associated with pull forces that exceed recommended guidelines (Wiggermann et al., 2020), whereas forces for laterally repositioning a 77-kg patient using friction-reducing devices were acceptable. Assuming lateral repositioning is performed by at least four healthcare workers, friction-reducing devices appear to sufficiently reduce the forces required for repositioning, whereas the draw sheet could have resulted in unacceptable forces for heavier patients. These estimated risks are listed in Table 1.

Lifting and rotating the patient to side lying is most similar to turning a patient away from the healthcare worker. Budarick et al. (2020) found that turning an 82-kg patient sometimes exceeded recommended hand forces. As compared to the simple turning task, during proning healthcare workers may also apply an upward lift force to rotate the patient in place and additional horizontal force to push against the workers on the opposite side of the patient. Although this force may be divided among two or three healthcare workers, it is likely to be physically demanding, especially for heavier patients. The lift-assisted techniques or RotoProne eliminate the manual forces associated with this rotation.

Lowering a patient from side lying to prone is likely the most physically demanding element of proning. The patient must be decelerated against gravity out of concern for the endotracheal tube, lines, and skin tears. Mannion et al. (2000) showed that receiving an anticipated sudden load increases spine compression by up to 30% compared to the same static load. This lowering may even require lifting and sliding to properly place the patient and positioning devices. Furthermore, the element of lowering the patient requires substantial trunk flexion as healthcare workers stoop to lower the patient and the worker closest to the patient center of mass is likely to take much more load than adjacent workers. Using lift straps or the RotoProne to control the patient rotation eliminates the manual forces and provides mechanical control when lowering the patient.

In addition to proning the patient, care must be taken to inspect and reposition the patient every 2–4 hr to avoid pressure injury (Capasso et al., 2020). Placing sheets, slings, or repositioning devices under the patient can often be accomplished by turning the patient, which has not generally been associated with a high risk of injury (Budarick et al., 2020; Wiggermann, 2016; Wiggermann et al., 2020). Nagavarapu et al. (2017) identified spine compression loads that exceeded 3400 N in healthcare workers placing slings under patients, but only for a 100-kg patient at a 56-cm bed height. Repositioning activities that require lifting the limbs or torso are more likely to have a high risk of musculoskeletal injury (Waters, 2007), and lift equipment or repositioning aids should be considered to reduce the stresses of this task.

## Other Considerations

In addition to the safety of patients and healthcare workers, considerations such as weight limit, cost, and equipment availability are important when evaluating methods for proning. The patient weight limit of the RotoProne bed is listed as 159 kg (350 lbs; ArjoHuntleigh, 2019), and the weight capacities of slings and lifts are generally at least 200 kg (440 lbs), with higher capacity options and larger slings and straps available. Although there is no strict discreet weight limit for manual methods, the strength limitations of staff provide a practical limitation. For patients heavier than 159 kg, the lift assisted proning method with straps may be the only feasible option because it eliminates manual forces on workers.

Equipment availability is an important consideration and potential barrier for some proning methods. Manual techniques require little to no specialized equipment, whereas lift-assisted techniques obviously require lift equipment. Ceiling lifts are ideal for use in the ICU, but the lift-assisted methods can also be accomplished with mobile lifts. The sliding sheets, lift sheets, and lift straps used in these different methods are relatively inexpensive and come in both launderable and single patient use options. Lift equipment requires an initial capital investment but can be used for all patient handling and mobilization activities. Lift equipment has a demonstrated return on investment ranging from 1.25 years (Garg & Kapellusch, 2012) to 3.75 years (Nelson et al., 2006) and is recommended for all nursing units (Matz, 2019). The RotoProne bed can only be rented, starting at US$1000 or more per day (George, 2009), and supplies are limited in the United States.

## Recommendations

Of the proning methods identified, the lift-assisted method with lift strap appears to have the best outcomes for patients and healthcare workers, and should particularly be considered in ICUs with ceiling lifts. The RotoProne bed also appears to be a good solution for patients below 350 pounds (159 kg) if available. For facilities that do not have ceiling lifts and choose not to use mobile lifts, repositioning aids like friction reducing sheets can help with some of the physical aspects of the proning maneuver, but they do not address the rotation and lowering components that have the greatest risk to patients and healthcare workers.

### Limitations and Future Work

This analysis includes informal methods of review, but identified proning methods not described in the academic literature. The evaluation of patient and healthcare worker safety is based on criteria believed to be associated with outcomes for patients and healthcare workers. However, clinical evaluation is needed to verify the assumptions that manually lowering patients is associated with greater risk of adverse events. Similarly, biomechanical studies are needed to comprehensively evaluate the different methods of proning.

The current review did not consider proning between two surfaces which may be common in the operating room. The biomechanical thresholds for injury assumed in this analysis may not be sufficiently conservative for the population of healthcare workers which skews older, is more female, and works longer shifts than the general working population (US Department of Health and Human Services, & US Health Resources and Services Administration, 2013).

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## KEY POINTS

- Prone positioning is a lifesaving therapy for some patients with COVID-19 but the difficulty of proning often limits its practice.
- A review and critical evaluation of methods for proning patients is provided. Key considerations include number of healthcare workers required, risk of adverse events to the patient, and risk of injury to staff.
- A proning method using a mechanical lift with lift straps may be the most suitable for many patients and environments.

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