Pressure Injury Outcomes of a Prone-Positioning Protocol in Patients With COVID and ARDS

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Background During the COVID-19 outbreak, standard methods for treating acute respiratory distress syndrome (ARDS) were used for patients presenting with ARDS. One such treatment method involves placing patients prone to improve oxygenation and reduce mortality risk. Challenges in preventing pressure injuries in patients placed prone have been reported, and no studies have explored the effects of including a certified wound and skin care nurse as part of the care team on the incidence of pressure injuries in SARS-CoV-2–infected patients with ARDS.

Objectives To evaluate the association between including a certified wound and skin care nurse on a multiprofessional pronation team and prevention of pressure injuries in SARS-CoV-2–infected patients with ARDS.

Methods This multicenter observational cohort study used retrospective data from the electronic health record. The intervention group consisted of SARS-CoV-2–infected patients diagnosed with ARDS who were treated by a multidisciplinary prone-positioning team that included a certified wound and skin care nurse specialist. The comparison group of SARS-CoV-2–infected patients with ARDS was treated by a multidisciplinary prone-positioning team that did not include a certified wound and skin care nurse specialist.

Results As shown by multivariable logistic regression mixed-effect modeling, patients in the intervention group had a 97% lower adjusted odds ratio of a pressure injury developing than did patients in the comparison group (0.03 [95% CI, 0.01-0.14]; $P<.001$).

Conclusion The inclusion of a certified wound and skin care nurse on a multiprofessional prone-positioning team significantly reduced the odds of pressure injuries developing in patients infected with SARS-CoV-2. (*American Journal of Critical Care.* 2022;31:34-41)

CE 1.0 Hour

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During the initial outbreak of COVID-19, hospitalized patients in severe respiratory distress with low blood oxygen levels required intensive care and respiratory support. As the care and management of patients with SARS-CoV-2 infection evolved and patients' condition continued to deteriorate, care teams put standard methods for the treatment of acute respiratory distress syndrome (ARDS) into place. For example, early in their respiratory decline, patients received high-flow oxygen therapy advancing to bilevel positive airway pressure and ultimately endotracheal intubation.

Another method used to improve oxygenation and ventilation associated with ARDS is to turn the patient from supine to prone. A recent systematic review and meta-analysis explored the mortality of patients with ARDS who received mechanical ventilation in the prone position compared with conventional ventilation with the patient supine.[1] The results of the analysis showed lower mortality in patients placed prone for longer than 12 hours.[1] However, the results also showed higher than normal rates of pressure injuries the longer a patient was placed prone.[1]

Pressure injuries are injuries of the skin and underlying tissue that develop as a result of prolonged pressure on areas of the body. In hospitals, patients are at higher risk of pressure injuries developing when they are immobile or are exposed to moisture, poor nutrition, or poor oxygenation. A patient's risk increases with the severity of their illness. When we reviewed the existing literature further, we found that the development of pressure injuries is a significant complication of placing patients prone. In multiple systematic reviews, meta-analyses, and retrospective reviews exploring the effects of prone positioning on oxygenation in patients with ARDS, it was established that prolonged positioning of a patient prone is associated with higher rates of new pressure injuries, specifically on the face, cheekbones, and thorax and over bony prominences.[1-8]

Although many studies have reported the development of new pressure injuries in patients with ARDS who are placed prone for prolonged periods, we are aware of no studies that have explored the effects of having a nurse who is specially trained and certified in the prevention of pressure injuries as a key member of the multiprofessional team treating patients who require prone positioning. Overall, treatment-related strategies for preventing pressure injuries in this highly critically ill patient population remain unknown.

> Many studies have reported the development of new pressure injuries in patients with ARDS who are placed prone.

We conducted this study to evaluate the effectiveness of a multiprofessional pronation team that included a certified wound and skin care nurse for reducing pressure injuries in patients infected with SARS-CoV-2 and diagnosed with ARDS. We hypothesized that having a certified wound and skin care nurse lead the pressure injury prevention component of the prone-positioning protocol would reduce the development of pressure injuries in this population.

Methods

Study Design

This observational cohort study was guided by a patient- and family-centered care model. We evaluated retrospective existing data from the electronic health record (EHR) of a large 6-hospital academic health system to evaluate the effectiveness of a new standard of care for patients diagnosed with ARDS and infected with SARS-CoV-2.[9] We studied 2 groups: an intervention group and a comparison group. The intervention

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group included SARS-CoV-2–infected patients diagnosed with ARDS who were treated by a multiprofessional prone-positioning team that included a certified wound and skin care nurse. The comparison group of SARS-CoV-2–infected patients diagnosed with ARDS was treated by a prone-positioning team that used the National Pressure Injury Advisory Panel's prone guidelines but did not include a certified wound and skin care nurse leading the pressure injury prevention strategies.[10] We collected data retrospectively from the EHR of patients who met the inclusion criteria during the study period (from February 1, 2020, to August 30, 2020).

Study Population

Inclusion Criteria. We studied the EHRs of patients who were (1) admitted to the critical care units of the Penn Medicine Health System, a large multicenter academic health system in the mid-Atlantic region of the United States; (2) were aged 21 years or older; (3) were intubated and had a diagnosis of ARDS; and (4) were infected with SARS-CoV-2.

Clearly defined multiprofessional team roles in prone positioning and pressure injury prevention were critical to preventing pressure injuries.

Exclusion Criteria. We excluded the EHRs of patients who (1) were aged less than 21 years, (2) were not placed prone, and (3) were unable to be positioned prone for longer than 1 hour.

Human Subject Protection

This multicenter observational cohort study was approved by the health system's institutional review board and was carried out with the ethical standards set forth in the Helsinki Declaration.

The Intervention

Multiprofessional Team Roles in Prone Positioning and Pressure Injury Prevention. During the COVID-19 pandemic, we formed a multiprofessional team focused on ensuring the safe pronation of critically ill SARS-CoV-2–infected patients with ARDS. Specific considerations were needed to care for and manage these patients. These considerations included assembling the right team with the specialized expertise needed to ensure the safe transition of critically ill patients from supine to prone.

The specific roles and expertise of the core pronation team were geared toward preventing the additional complications typically associated with prone positions, such as pressure injuries, accidental extubations, and loss of intravenous catheters. Equally important were the safe handling of patients during the action of pronation and ensuring the tolerance of patients to pronation. Thus, the team included (1) a certified wound and skin care nurse specialist, (2) a critical care physician, (3) an anesthesiologist or respiratory therapist (or both), (4) a critical care nurse, and (5) persons who move and position patients regularly, such as surgical technicians. In total, we determined that 10 people with specific and specialized expertise were needed to successfully place a critically ill patient prone and avoid the complications well established in the literature.

We first developed a prone-positioning protocol and assigned roles to the team members. Before placing any patient prone, the team tried out different prone-positioning techniques on volunteer staff members and ultimately created a refined systematic and smooth method with step-by-step visual aids.

Owing to the life-threatening nature of the COVID-19 disease process, the critical care physician and anesthesiologist regularly collaborated and reviewed the hemodynamic and respiratory status of the patients under consideration for pronation. The criterion used to select appropriate patients for pronation was a ratio of the partial pressure of arterial oxygen to the fraction of inspired oxygen (Pa_{O_2}/F_{IO_2}) of less than 150 along with discussions of additional medications needed to ensure the patient's tolerance of pronation.[11] Once the critical care physician and anesthesiologist determined that the patient was a candidate for prone positioning, the next step was to ensure that the most appropriate personnel were assembled to perform the pronation procedure.

Role of the Certified Wound and Skin Care Nurse. A certified wound and skin care nurse led the team in strategies for pressure injury prevention. During the pronation session, the certified wound and skin care nurse team leader administered ophthalmic lubricant to protect the sclera and secured the patient's eyes in the closed position with flexible soft silicone. This was done to reduce the potential for shearing of the eyelid skin should orbital edema occur. Although the certified wound and skin care nurse trained the team to care for the patient's skin, the nurse had direct supervision and oversight of all skin preparation procedures.

Prone-Positioning Procedure. With the patient supine, the electrocardiographic leads were removed, the skin was cleaned and moisturized, and soft silicone multilayered foam prophylactic dressings were applied on the skin over any bony prominence. To ensure that the skin did not shear during pronation, a protective layer and cushioning device was used to roll the patient during the pronation procedure. Before the patient was moved, the anesthesia and respiratory therapy team members secured the endotracheal tube using a device that keeps the tube from touching the lips, while the critical care nurse secured any central or peripheral intravenous catheters. The surgical technicians were experienced in moving patients from supine to prone and back in the operating room setting. Thus, their expertise on the pronation team was focused on appropriate positioning of the patient's limbs and strategic placement of supportive devices such as pillows to ensure that the patient's body was properly aligned and the patient's limbs were protected during the procedure.

Next, the patient was moved slowly to the edge of the bed, brought up onto their side, and repositioned slowly in the prone position. Patients were placed in a "swim position" with a foam headrest protecting the skin of the face from resting directly on the endotracheal tube or any other tubes. Additional fluidized pillows were used to cushion high-risk body regions from the bed surface and to alleviate any areas of pressure. Overall, the patient was positioned to ensure optimal offloading of all bony prominences to achieve redistribution of pressure. Once the patient was in the proper prone position, the certified wound and skin care nurse assessed for any pressure-causing elements, such as wrinkles in sheets, or any tubing that may have been inadvertently left under the patient. Finally, the patient was placed into a reverse Trendelenburg position of 10°.

The critical care nurse, critical care physician, and respiratory therapists closely monitored prone patients for any changes in physiological condition. The respiratory therapist assisted the critical care nurse every 4 hours in repositioning the head and "swim position" of the patient's arms while monitoring for any facial skin precursors of pressure injuries of the face and head. The importance of repositioning the head every 4 hours addresses pressure redistribution to the face, which prevents facial pressure injury, ear pressure injuries, and eye injury. Ideally, patients who tolerated the prone position remained in that position for 16 to 18 hours and were then returned to a supine position. Once the patient was supine, the head of the bed was elevated 30°, the patient's skin was inspected, prophylactic dressings were reapplied, and oral care was performed.

Data Analysis

We first calculated descriptive statistics (eg, median, interquartile ranges, frequencies) to characterize the sample. We then compared demographics and clinical characteristics between groups using the Mann-Whitney *U* test and χ^2 tests. We constructed logistic regression models to examine the association between each exploratory demographic and clinical variable and the outcome of interest (ie, a pressure injury developing during hospitalization in the intensive care unit [ICU]). Last, we constructed a multivariable logistic regression mixed-effects model to examine the adjusted odds ratio (AOR) of a pressure injury developing in the intervention group relative to the comparison group while accounting for relevant demographic and clinical characteristics.

The construction of the multivariable mixed-effects model was stepwise and systematic. A multivariable model was constructed by using an exhaustive machine learning–based approach, with the fit of each subsequent model assessed by using the Akaike information criterion (AIC). Each model included a random effect for the facility to account for correlation between patients seen at the same hospital in the health system. The final sample size achieved sufficient power (98%) to detect a difference as small as 0.1 in the AOR of the outcome occurring across intervention and comparison groups at an alpha of .05 using χ^2 tests.[12] Statistical significance was set to $P<.05$. All analyses were conducted in R 3.5.1.[13]

> Patients in the intervention group had a 97% lower AOR of pressure injury development than the comparison group had.

Results

A total of 130 patients met the inclusion criteria for this cross-sectional analysis, 40% of whom were in the intervention group (Table 1). Some clinical characteristics and demographics differed significantly between the intervention and comparison groups. A larger proportion of patients in the comparison group were Black (58% compared with 17% in the intervention group; $P<.001$). However, a larger proportion of patients in the intervention group identified as Latino or Hispanic (40% compared with 14% in the comparison group; $P=.001$).

Acuity also differed between the intervention and comparison groups. For example, patients in the comparison group had a higher median number of comorbidities, as evidenced by Elixhauser Comorbidity Index scores ($P<.001$). Median length of hospitalization (19 days) and median ICU length of stay (13 days) were shorter in the intervention group than in the comparison group (28 and 21 days, respectively; $P=.002$ and $P<.001$, respectively). Additionally,

Table 1
Sample characteristics

Variable	Intervention group (n=52)	Comparison group (n=78)	*P*
Age, median (IQR), y	63 (56-69)	60 (51-67)	.11
Sex, No. (%)			.21
Female	13 (25)	29 (37)	
Male	39 (75)	49 (63)	
Race, No. (%)			<.001
Asian	6 (12)	5 (6)	
Black	9 (17)	45 (58)	
Other	27 (52)	17 (22)	
White	10 (19)	11 (14)	
Ethnicity, No. (%)			.001
Hispanic/Latino	21 (40)	11 (14)	
Not Hispanic/Latino	31 (60)	67 (86)	
Discharge status, No. (%)			.01
Other facility	5 (10)	25 (32)	
Died	32 (62)	34 (44)	
Home	15 (29)	19 (24)	
Elixhauser Comorbidity Index, median (IQR)	0 (0-9)	9 (2-15)	<.001
Hospital length of stay, median (IQR), d	19 (13-31)	28 (19-51)	.002
ICU length of stay, median (IQR), d	13.0 (8.5-18.3)	21.0 (16.0-37.0)	<.001
No. of prone days, median (IQR)	2.5 (1.0-5.0)	3.0 (1.0-9.0)	.29
Pressure injury, No. (%)			<.001
Yes	4 (8)	47 (60)	
None	48 (92)	31 (40)	
Pressure injury location,[a] No. (%)			.86
Extremity	1 (25)	11 (23)	
Head/neck	2 (50)	18 (38)	
Pelvic/abdominal	1 (25)	18 (38)	
Braden score, median (IQR)			
Initial	20 (18-21)	16 (12-20)	<.001
Last	10 (10-16)	12 (10-18)	.17
Change	−2 (−7 to 2)	−8 (−11 to −3)	<.001
Specialty surface or bed during hospitalization, No. (%)			.03
Yes	40 (77)	44 (56)	
No	12 (23)	34 (44)	

Abbreviations: ICU, intensive care unit; IQR, interquartile range.
[a] Percentages are based on numbers of pressure injuries listed in preceding entry.

a larger proportion of patients in the intervention group died (62% compared with 44% in the comparison group; *P*=.01). A higher proportion of patients in the intervention group (77%) than in the comparison group (56%) used a specialty surface or a specialty bed type, such as a weight-based pressure redistribution surface, during hospitalization (*P*=.03).

A χ^2 test indicated that significantly fewer patients in the intervention group had pressure injuries develop (8% compared with 60% in the comparison group; *P*<.001). Among patients in the comparison group who had pressure injuries develop, the most frequent location was the head/neck region (38%), followed by the pelvic/abdominal region (38%) and the extremities (23%). No significant differences were observed between groups in the total number of days patients were prone. Although the median Braden score was significantly higher (*P*<.001) in the intervention group than in the comparison group at the time of initial documentation, the median scores did not differ significantly at the time of discharge.

The results of the multivariable logistic regression mixed-effect modeling showed that patients in the intervention group had a significantly lower AOR of a pressure injury developing, even with adjustment for race, discharge status, Elixhauser Comorbidity Index score, length of hospitalization, Braden score at time of discharge, and choice of ICU bed (Table 2). After adjustment for relevant factors, patients in the intervention group had a 97% lower AOR of a pressure injury developing compared with the comparison group, which did not have a certified wound and skin care nurse leading the intervention (AOR, 0.03 [95% CI, 0.01-0.14]; *P*<.001). Compared with White patients, Black patients had an 81% lower AOR of a pressure injury developing (0.19 [95% CI, 0.04-0.95]; *P*=.04). Importantly, each additional day spent in the hospital was associated with a 7% increase in AOR of a pressure injury developing (1.07 [95% CI, 1.04-1.11]; *P*<.001). Each additional point on the Braden scale at time of discharge was associated with a 23% decrease in the AOR of a pressure injury developing (0.77 [95% CI, 0.60-0.98]; *P*=.03). The use of a specialty surface such as a weight-based pressure-redistribution surface during hospitalization, compared with a standard ICU bed, was associated with a 69% decrease in the AOR of a pressure injury developing (0.31 [95% CI, 0.10-0.93]; *P*=.04). Although not statistically significant, the inclusion of discharge status and Elixhauser Comorbidity Index score improved overall model fit (AIC 114.6).

Discussion

The literature supports that oxygenation is improved and mortality risk is reduced when patients with ARDS are placed prone. Yet, the literature equally identifies the development of pressure injuries as a common and significant complication necessitating strategies for prevention. In the past 5 years, the literature has continued to stress the challenges associated with preventing pressure injuries in patients with ARDS who are placed prone. Interestingly, medical journals have published best practices for treating facial pressure injuries associated with pronation, yet strategies for preventing pressure injuries in this population are sparse and those that are published have had minimal success.[2,14,15] In the present study, the active presence of a certified and specialized nurse with expertise in pressure injury prevention and skin preservation significantly reduced the odds of patients having pressure injuries develop when they were placed prone for prolonged periods.

Four of 52 patients (8%) in the intervention group had pressure injuries develop. The identified pressure injuries in these patients were distributed across the head/neck region, pelvic/abdominal region, and extremities. In the course of several months of placing patients prone, we recorded 1 deep-tissue pressure injury of the chin; however, we classified this particular pressure injury as unavoidable per the specific criteria from the National Pressure Injury Advisory Panel guidelines and the prevention methods in place.[16-18] We also noted skin tears of the cheek in the intervention group related to adherence of the endotracheal tube holder, which resulted from diaphoresis. All skin tears were treated and resolved. To prevent such tears from occurring in the future, the respiratory therapist replaced the endotracheal tube holders every 5 days or as often as needed.

In the comparison group, a majority of the pressure injuries were located on the anterior surfaces of the head/neck and pelvic regions. Pressure injuries in these areas are common because the skin lies close to the bony prominences of the cheeks and hips and the cartilage of the ears. To ensure that those areas in particular had a consistent focus, in the intervention group, the certified wound and skin care nurse educated the critical care nurses and respiratory therapists in the consistent rotation of the patient's head from side to side every hour to relieve any potential pressure.

Although no patients in the intervention group exhibited the purple toes classically reported with COVID-19, a few patients did experience complications due to microvascular occlusion from stroke and pulmonary embolism.[15] According to Black and Cuddigan, skin manifestations with COVID-19, such as purple skin and toes, may not indicate deep-tissue pressure injury.[16] Nonetheless, the clotting process innate in the COVID-19 disease process seems to compound the challenges associated with preventing pressure injuries in patients placed prone.

A predictable finding in this study was related to the association between pressure injuries and the type of bed or bed surface used. The type of bed used was a significant factor in ensuring skin health and preventing pressure injuries. The type of bed to prevent pressure injuries is best determined by a certified wound and skin care nurse, who is the most skilled in aligning the specific needs of the patients with the most appropriate bed type. Also as expected, the odds of patients having a pressure injury develop decreased as the Braden score improved. Likewise, the longer the patient remained hospitalized, the higher the odds of a pressure injury developing.

Table 2
Multivariable logistic regression mixed-effect model

Variable	Adjusted odds ratio	95% CI	*P*
Intervention	0.03	0.01-0.14	<.001
Race			
White (reference)			
Asian	1.48	0.17-13.31	.72
Black	0.19	0.04-0.95	.04
Other	0.49	0.09-2.80	.42
Discharge status			
Other facility (reference)			
Died	0.75	0.13-4.33	.74
Home	3.48	0.56-21.70	.18
Elixhauser Comorbidity Index	1.02	0.95-1.09	.63
Hospital length of stay	1.07	1.04-1.11	<.001
Last Braden score	0.77	0.60-0.98	.03
Specialty surface or bed during hospitalization	0.31	0.10-0.93	.04

Interestingly, the results related to ethnicity and the odds of pressure injuries developing are incongruent with the published literature. The literature indicates that persons with darker skin tones have a higher prevalence of pressure injuries.[19,20] We surmise that this increased prevalence is a direct result of the difficulty in detecting early acute changes in skin in patients with darker skin tones, thus making early intervention more difficult.[19,20]

Ultimately, this comprehensive, multipronged patient-centered intervention led by a certified wound and skin care nurse was associated with a 97% lower AOR of pressure injuries developing in patients infected with the SARS-CoV-2 virus who were placed prone.

Limitations

The observational nature of this study has inherent limitations. For example, the use of EHR data limits the granularity of the detail collected and documented on pressure injuries, including staging and nurses' qualitative descriptions of the pressure injuries. Additionally, our findings are associative in nature, not causal, thereby making it difficult to isolate the impact on subsequent care outcomes of having a certified wound and skin care nurse as part of the pronation team. Future prospective research studies are needed to overcome these limitations. Despite the use of a mixed-effects model to account for potential collinearity within facilities, the rapidly evolving nature of the ongoing COVID-19 pandemic and the geographic differences in the timing of when hospitals within the health system, which serves several large and diversely populated regions, experienced surges in admissions could have affected our findings. Even with these limitations, the multicenter nature of this study and the use of multivariable statistical modeling help to advance current understanding of how best to mitigate the development of pressure injuries among SARS-CoV-2–infected patients who require prone positioning.

Conclusion

Having a certified wound and skin care nurse lead pressure injury prevention on a multiprofessional prone-positioning team was significantly associated with a lower odds of pressure injuries developing in patients infected with SARS-CoV-2. This study has implications for expanding the evidence and redefining the strategies used to prevent pressure injuries in patients with ARDS who are placed prone. The results of this systematic and team-based approach led by a certified wound and skin care clinical nurse specialist were significant and should be implemented and tested further in other settings.

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FINANCIAL DISCLOSURES
None reported.

SEE ALSO

For more about prone positioning and pressure injuries in patients with COVID, visit the *AACN Advanced Critical Care* website, **www.aacnacconline.org**, and read the article by Miguel et al, "Development of a Prone Team and Exploration of Staff Perceptions During COVID-19" (Summer 2021).

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