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. Published online September 13, 2021.)
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. The results of the analysis showed lower mortality in patients placed prone for longer than 12 hours. However, the results also showed higher than normal rates of pressure injuries the longer a patient was placed prone.

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.

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

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.

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. We studied 2 groups: an

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intervention group and a comparison group. The intervention 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.  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.

**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 extrusions, 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 (PaO₂/FIO₂) of less than 150 along with discussions of additional medications needed to ensure the patient’s tolerance of pronation.  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...
Patients in the intervention group had a 97% lower AOR of pressure injury development than the comparison group had.
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, 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 $\chi^2$ 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 pelvis/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, 0.04 [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

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**Table 1** Sample characteristics

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

Abbreviations: ICU, intensive care unit; IQR, interquartile range. a Percentages are based on numbers of pressure injuries listed in preceding entry.
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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{15} According to Black and Cuddigan, skin manifestations with COVID-19, such as purple skin and toes, may not indicate deep-tissue pressure injury.\textsuperscript{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.

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.\textsuperscript{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.\textsuperscript{19,20}

\begin{table}[h]
\centering
\caption{Multivariable logistic regression mixed-effect model}
\begin{tabular}{|l|c|c|c|c|}
\hline
Variable & Adjusted odds ratio & 95\% CI & \(P\) \\
\hline
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 \\
\hline
\end{tabular}
\end{table}
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 realigning 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.

ACKNOWLEDGMENTS

The COVID-19 pandemic has changed the lives of so many, including those caring for patients. We acknowledge the tireless work of all those who participated in the prone-positioning team and unselfishly shared expertise to develop cutting-edge patient care. Clearly, the results of this study are the true testament to the dedication of all our health care heroes.

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).

REFERENCES

17. European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel, and Pan Pacific Pressure Injury


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