COVID-19 Lessons Learned: Prone Positioning With and Without Invasive Ventilation

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Summary

Prone positioning (PP) has been used extensively for patients requiring invasive mechanical ventilation for hypoxemic respiratory failure during the COVID-19 pandemic. Evidence suggests that PP was beneficial during the pandemic, as it improves oxygenation and might improve chances of survival, especially in those with a continuum of positive oxygenation responses to the procedure. Additionally, the pandemic drove innovation regarding PP, as it brought attention to awake PP (APP) and the value of an interdisciplinary team approach to PP during a pandemic. APP appears to be safe and effective at improving oxygenation; APP may also reduce the need for intubation in patients requiring advanced respiratory support like high-flow nasal cannula or noninvasive ventilation. Teams specifically assembled for PP during a pandemic also appear useful and can provide needed assistance to bedside clinicians in the time of crisis. Complications associated with PP can be mitigated, and a multidisciplinary approach to reduce the incidence of complications is recommended. *Key words: coronavirus disease 2019; COVID-19; prone position; awake prone positioning; prone team.* [Respir Care 2022;67(8):1011–1021. © 2022 Daedalus Enterprises]

Introduction

Prone positioning (PP) for the treatment of hypoxemic respiratory failure was first described in the literature over 40 years ago.[1-3] Until 2013, many studies demonstrated that PP improved oxygenation and prevented ventilator-induced lung injury but failed to show significant improvements in mortality for patients with ARDS.[4-7] It was not until Guérin et al[8] published the Proning Severe ARDS Patients (PROSEVA) study in 2013 that clinicians had convincing evidence that PP was useful in treating severe ARDS beyond ARDS Network guidelines.[9] After the PROSEVA study, in combination with results from numerous studies, systematic reviews, and meta-analyses,[5,10-13] PP was added to formal guidelines on the management of patients with ARDS.[14,15] As the global COVID-19 pandemic evolved, PP was also recommended for patients with COVID-19–induced severe hypoxemic respiratory failure.

Organizations such as the American Association for Respiratory Care[16] and the Society of Critical Care Medicine published online recommendations that included the use of PP for patients with severe ARDS. According to Kharat et al,[17] the use of PP in intubated patients increased substantially over the pandemic, as the rate of PP use was $< 20\%$ prepandemic and increased to as high as 70% during the pandemic. The pandemic also quasi-introduced awake PP (APP)—or PP used in patients who did not require invasive mechanical ventilation.[18]

With the accelerated use of PP came numerous lessons learned. This paper aims to review many of the lessons learned about the use of PP with and without the use of invasive mechanical ventilation for patients with COVID-19.

Prone Positioning With and Without Invasive Ventilation

As with other aspects of COVID-19, numerous studies have been published evaluating the effects of PP. Researchers have reported various types of retrospective and prospective studies on clinical outcomes such as physiological responses (eg, P_{aO_2}/F_{IO_2}, P_{aO_2}, S_{pO_2}, breathing frequency, ROX index [S_{pO_2}/F_{IO_2}/breathing frequency]), intubation rate, and mortality.[17] Additionally, several reviews, systematic reviews, and meta-analyses have been published on the topic of PP for patients who did and did not require invasive mechanical ventilation for COVID-19. Interestingly, more reviews have been published regarding the use of PP without invasive mechanical ventilation. The relative novelty of PP for non-intubated patients, or APP, and APP impact on the need for intubation and mechanical ventilation, given the increased demand for mechanical ventilation during the pandemic, probably explain this proliferation of papers covering the topic.[19]

With Invasive Ventilation

In 2021 (first available online June 22, 2021), Chua et al[19] reported their findings after conducting a systematic review and meta-analysis on the effect of PP versus supine position (SP) in subjects with COVID-19. The authors included 35 cohort studies, as no randomized controlled trials (RCTs) were published at the time of study implementation. Of the 35 studies, 14 included subjects that were intubated. Eight of those studies demonstrated improved P_{aO_2}/F_{IO_2} in prone position compared to supine position ($n = 579$; mean difference [MD] 46.74 mm Hg [95% CI 33.34–60.15], $P < .001$). Three studies showed an improvement in S_{pO_2} in the prone position compared to the supine position ($n = 432$; MD 1.67% [95% CI 1.08–2.26], $P < .001$). Further subgroup analyses revealed no difference in P_{aCO_2}, mortality, and the number of subjects discharged alive between prone position and supine position groups.[19] Given the nature of retrospective studies, the small sample size of the included studies, and the substantial heterogeneity of measured outcomes, the clinical implication of the study findings is limited. Additionally, improvement in oxygenation does not always translate to improved patient outcomes, such as survival benefit. Particularly, most ARDS deaths are attributable to multi-organ dysfunction syndrome rather than refractory hypoxemia.[20]

A more recent review (published February 2022) included a total of 24 studies on PP in patients intubated for COVID-19.[17] Three studies found no significant difference in mortality between PP and supine position groups (odds ratio 0.45 [95% CI 0.09–2.18]). The authors noted considerable heterogeneity ($I^2 = 91\%$), making it hard to interpret the effect of PP. Regarding the physiological responses to PP, 15 studies included in the review reported an increase in P_{aO_2}/F_{IO_2} by an average of 52 mm Hg (38–66, $P < .01$). All but 2 studies showed a mean increase in P_{aO_2}/F_{IO_2} by 20 mm Hg. The authors noted a significant increase in static compliance from pre-PP to PP (2 mL/cm H_2O, $P < .001$). Notably, subjects that responded to PP in terms of oxygenation were found to have better outcomes in regard to mortality compared to nonresponders (odds ratio 0.44 [0.27–0.71], $P < .001$).[17]

In all, study results demonstrate that PP for patients intubated for COVID-19 improves oxygenation and might improve chances of survival. The survival benefit may only be in those that show significant oxygenation improvements when placed into the prone position. Given that the impact of PP on survival was inconsistent across studies, more studies are needed to definitively determine if PP has a survival benefit for intubated patients with COVID-19. Further investigation is needed to better understand outcomes associated with oxygenation responses after the initial PP session and subsequent PP sessions. In our own analysis of data collected early in the pandemic (between March 18, 2020–March 31, 2020), we noted no significant differences in oxygenation response to the first PP session between subjects who survived to discharge and those who died or were placed on extracorporeal membrane oxygenation (ECMO). Interestingly, on the second and third PP cycles, subjects who survived to discharge continued to respond to PP in terms of oxygenation compared to a negligible oxygenation response in those who died or were placed on ECMO.[21] It appears that oxygenation responses to PP might offer a prognostic insight into patient outcomes—or at least the trajectory toward the outcome. Future studies should assess how ongoing assessments of oxygenation responses can guide timely

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decisions for escalation of care to modalities such as ECMO. Additionally, studies are warranted to explore the mechanism of patient responses to PP and how the responses translate to clinical outcomes. Recent studies have suggested that computed tomography and electrical impedance tomography can provide evidence of clinical changes leading to improved oxygenation, like the recruitment of the dorsal aspect of the lungs.[22-24] It remains unclear how knowing the response to PP will change important outcomes like mortality, but clinicians might use this information to guide decisions regarding additional interventions in the future.

Without Invasive Ventilation

To date, there have been 13 systematic reviews and meta-analyses published pooling data from trials investigating outcomes associated with APP in COVID-19 (Table 1).[17-19,25-34] Outcomes assessed in these papers differ, and the results varied over time as the first group of publications did not include any RCTs.[25-28,30,31]

Eight of the systematic reviews and/or meta-analyses found consistent improvement with APP in oxygenation compared to supine position.[18,19,25,26,31-34] When assessing the impact of APP on mortality, some of the results varied based on studies available at the time. Beran et al[32] conducted a systematic review and meta-analysis of trials published prior to August 30, 2021. Fourteen studies were included in their analysis, 13 of which reported mortality. When analyzed together, the risk of death for the APP group was 17.9% compared to 25.7% in the control group (relative risk 0.68 [95% CI 0.51–0.90], $P = .008$; $I^2 = 52\%$).[32] The review by Kharat et al[17] also noted a lower risk of death at the latest time recorded in the APP compared to the supine position group (odds ratio 0.44 [0.35–0.55]). They also noted that the mortality benefit was seen in subjects managed in an ICU. Importantly, the authors noted that their analysis did not include results from a meta-trial that pooled results from several RCTs evaluating the effect of APP on intubation rates and mortality.[17,35]

Fazzini et al[18] also conducted a systematic review and meta-analysis to assess oxygenation, mortality, and intubation rates associated with APP compared to supine position in all patients—not only those with COVID-19. They searched for papers published from 2010–August 2021 and found 14 studies that met their criteria. The vast majority of subjects included in their analysis, however, did have COVID-19 (2,332/2,352). Like many of the COVID-19 exclusive studies, they found an improvement in P_{aO_2}/F_{IO_2} after APP (MD −23.10 [95% CI −34.80 to 11.39], $P < .001$; $I^2 = 26\%$). In subjects with COVID-19, they found that APP was associated with a lower mortality when compared to supine position (odds ratio 0.51 [95% CI 0.32–0.80], $P = .003$; $I^2 = 48\%$). Interestingly, they did not find that APP changed the risk of intubation when compared to SP. However, the authors noted that significant heterogeneities exist in the included studies for intubation ($I^2 = 75\%$) and moderate heterogeneities in the included studies for mortality ($I^2 = 48\%$), suggesting the results be interpreted cautiously.

Most recently, Li et al[34] conducted a systematic review and meta-analysis that included studies from January 2020–November 2021, using APP to treat subjects with COVID-19 with SP as the control group. Different from other aforementioned systematic reviews and meta-analyses, they included 7 RCTs and also searched ClinicalTrials.gov and contacted the authors with completed, but as yet unpublished, RCTs to obtain their aggregated results. Twenty-nine studies were finally included in their analysis, 10 of which were RCTs (3 were unpublished RCTs). As such, their study provided a comprehensive assessment of studies investigating APP for subjects with COVID-19 and provided robust evidence regarding the practice. The pooled data from the 10 RCTs show that APP significantly reduced the need for intubation in the overall population compared to SP (relative risk 0.84 [95% CI 0.72–0.97]). In a subgroup analysis, APP appears to reduce intubation rates in those subjects on advanced respiratory support, such as high-flow nasal cannula (HFNC) or noninvasive ventilation (NIV) (relative risk 0.83 [95% CI 0.71–0.97]), and those treated in ICUs (relative risk 0.83 [95% CI 0.71–0.97]). For those receiving conventional oxygen support and those treated in general care wards, APP did not appear to affect intubation rates, nor did it appear to reduce mortality.[34] Whereas it is not entirely clear why less severely ill subjects (conventional oxygen support/treated in general care wards) benefited less from APP, it can probably be explained by the lower event rate, lower adherence to APP from less intense monitoring, and disease severity differences.[34] Interestingly, improvements in mortality were noted in 17 non-RCTs (relative risk 0.56 [95% CI 0.48–0.65]), which was similar to the findings in other meta-analyses in which most of the included studies were non-RCTs. The authors explained the discrepancy between the findings in RCTs and non-RCTs might be due to the publication bias of non-RCTs or might be attributed to the lack of power for the outcome in the RCTs, as mortality was a secondary objective in all the RCTs.[34] Their findings also emphasize the importance of RCT implementation.

In all, APP appears to have a net-positive impact on patients with COVID-19. APP improves oxygenation and reduces the need for intubation in patients requiring advanced respiratory support and admission to an ICU. It does appear to be beneficial in patients who require advanced respiratory support. Additionally, APP appears to be safe, as no serious adverse effects of APP were reported. Moving forward, efforts need to be made to better understand the timing of APP, specifically about when a patient (based on oxygenation support) should be

Table 1. Chronology and Outcomes of Reviews, Systematic Reviews, and/or Meta-Analyses of Clinical Trials of Awake Prone Positioning for COVID-19

Date Published	Authors	Study Type	Studies Included in analysis, no.	Study Types Included in Analysis (no.)	Total Subjects Included in Review or Analysis, *n*	Outcomes Assessed	Primary Findings Associated With APP
April 2021	Tan et al[25]	Meta-analysis	16	Cohort (6) Case series (10) 5/16 were non-COVID-19 studies	243	Intubation rate Mortality Improvement in P_{aO_2}/F_{IO_2} Improvement in S_{pO_2} Change in breathing frequency Intolerance	Improvement in oxygenation Reduced breathing frequency Intubation rate: 33% Mortality: 4% Intolerance rate: 7%
April 2021	Pb S et al[26]	Systematic review and meta-analysis	16	Prospective (6) Retrospective (6) Before and after (4)	316	Intubation rate Oxygenation indices P_{aO_2}/F_{IO_2} $P_{aO_2}S_{pO_2}$ Breathing frequency ROX index Mortality and LOS	Improvement in oxygenation
May 2021	Cardona et al[27]	Meta-analysis	18	Prospective, cohort (3) Prospective, case series (2) Retrospective, cohort (2) Retrospective, case series (11)	364	Prevalence of intubation Intubation within 24 h of presentation Mortality	Intubation rate in COVID-19 subjects who underwent APP: 28% Mortality: 14%
August 2021	Chilkoti et al[29]	Systematic review	36	17 original articles Prospective (5) Retrospective (6) Before and after (2) Pilot (2) Cluster randomized controlled (1) Nested case matched-control analysis (1) Case series (9) Case reports (10)	1,385	Mode of oxygen therapy Duration of proning	Improvement in oxygenation
August 2021	Parashar et al[30]	Systematic review	21	Prospective, cohort (14) Retrospective, cohort (6) Pilot (1)	698	Duration of proning session Intubation rate Mortality	Duration: 1 to 8 hr/d Intubation rate: 27.1% Mortality: 13.3% Overall improvement in oxygenation

(Continued)

Table 1. Continued

Date Published	Authors	Study Type	Studies Included in analysis, no.	Study Types Included in Analysis (no.)	Total Subjects Included in Review or Analysis, *n*	Outcomes Assessed	Primary Findings Associated With APP
October 2021	Ponnapa Reddy et al[31]	Systematic review and meta-analysis	25	Observational (25)	758	Improvement in physiologic variables (P_{aO_2}/F_{IO_2}, P_{aO_2}, S_{pO_2}) before and after APP Intubation rate Mortality Adverse events Breathing frequency Location of APP Duration of proning	APP appeared safe and feasible Improvement in oxygenation
November 2021	Chua et al[19]	Systematic review and meta-analysis	35	Cohort or observational studies (prospective or retrospective) for intubated or non-intubated patients 35 (cohort studies)	1,712	Oxygenation parameters (P_{aO_2}/F_{IO_2}, S_{pO_2}) P_{aCO_2} Intubation rate Mortality Number of subjects discharged alive	Improvement in oxygenation Lower risk of death No significant difference was noted in the risk of intubation
January 2022	Pavlov et al[28]	Systematic review of proportional outcomes	25	Prospective (15) Retrospective (9) Case report (1)	2,994	Physiologic response to APP Probability of intubation with APP Probability of death with APP Tolerability and comfort of APP	Improvement in oxygenation No significant differences of the risk were found in intubation and death
January 2022	Schmid et al[33]	Systematic review and meta-analysis	2	Randomized controlled (2)	1,196	Need for intubation Mortality	Compared to standard care, APP likely decreases need for intubation APP appears advantageous for subjects with COVID-19
February 2022	Kharat et al[17]	Review	17	Prospective (3) Retrospective (9) Randomized controlled (5)	2,301	Need for intubation Mortality	APP might be associated with lower mortality
February 2022	Fazzini et al[18]	Systematic review and meta-analysis	14	Prospective, cohort (8) Retrospective, cohort (4) Randomized controlled (2)	2,352	Change in oxygenation (P_{aO_2}/F_{IO_2} or S_{pO_2}/F_{IO_2}) Rate of intubation Mortality ICU admission Adverse events	Improvement in oxygenation when applied for at least 4 h over repeated daily episodes APP appears to be safe Effect on rate of intubation and mortality unknown

(Continued)

Table 1. Continued

Date Published	Authors	Study Type	Studies Included in analysis, no.	Study Types Included in Analysis (no.)	Total Subjects Included in Review or Analysis, *n*	Outcomes Assessed	Primary Findings Associated With APP
March 2022 (published online ahead of print)	Li et al[34]	Systematic review and meta-analysis	29	Randomized controlled (10) Nonrandomized controlled (19) Prospective (7) Retrospective (12)	4,654	Need for intubation Mortality Need for escalation of respiratory support ICU and hospital LOS Safety	APP reduces the need for intubation Does not reduce mortality, need for escalation of respiratory support, ICU admissions or stay, or hospital length of stay
April 2022	Beran et al[32]	Comparative systematic review and meta-analysis	14	Randomized controlled (5) Observational (9)	3,324	Need for intubation Mortality Hospital LOS	Significant reduction in mortality No significant effect on intubation across all studies Intubation rate lower in APP group in subgroup analysis

APP = awake prone positioning
LOS = length of stay

placed in the APP. So far, one post hoc analysis of an RCT found that early initiation (< 24 h on HFNC) of APP in subjects with COVID-19–induced hypoxemic respiratory failure had improved 28-d survival.[36] Whereas these results are interesting and suggest early APP may be advantageous, they are limited by the post hoc study design.

In the meta-trial conducted by Ehrmann et al,[35] it was noted that longer APP sessions were associated with a lower risk of treatment failure, which was defined as intubation or death within 28 d of study enrollment. Treatment failure occurred in 25 of 151 (17%) subjects that stayed in APP for > 8 h/d. For those that remained in APP < 8 h/d, 198 of 413 (48%) experienced treatment failure. Based on these findings, it appears that longer APP sessions confer a benefit on treatment success; thus, long sessions of APP should be encouraged. That said, patients have reported musculoskeletal pain, general discomfort, and delirium as reasons why they could not tolerate APP for extended periods of time.[37] Future studies specifically evaluating factors that enhance tolerability and promote compliance with APP are needed.[35]

Prone Positioning Training and Team Development

Despite considerable evidence supporting PP for severe ARDS, before the COVID-19 pandemic, PP was underutilized.[38-40] The underutilization of PP is attributed to several factors including clinicians' judgment of hypoxemia severity, concern for hemodynamic instability, concern for obesity, and misconceptions of high risk of adverse events (AEs), among others.[38,40] However, information gained from the initial Italian and Chinese experiences with COVID-19, along with the expected rapid influx of patients in hypoxemic respiratory failure, forced many teams to quickly begin PP training in preparation for the pandemic.[21,38]

PP training is largely an institution-developed process, and several teams have reported the use of simulation to prepare for manual PP.[38,41-43] Some have also reported utilizing the material provided by the authors of the PROSEVA study,[8] which includes a video demonstrating the procedure.[38,43] In our own experience, we utilized a process based on our previous research to prepare for manual PP,[44] which consisted of using a healthy volunteer to simulate an intubated patient to practice the process of manual PP. We also established institutional guidelines on COVID-19 treatment including PP based on the PROSEVA study[8] and consensus among respiratory therapists (RTs), nurses, and physicians at our institution.[21,44] Training efforts

Fig. 1. Front (A) and side view (B) of a prone cart used by a prone positioning team. Top-level contents: gloves, N95 masks, disinfectant wipes, hand sanitizer, soft endotracheal tube holders, chlorohexidine wipes, zinc oxide waterproof tape, various sizes of bordered self-adhesive foam dressings, electrocardiogram leads, moisture-wicking antimicrobial fabric for skin folds, face shields (hanging on cart); middle-level contents: absorbent pads, towels, flat sheets; bottom-level contents: foam positioning wedge, slide sheets, air seat cushions (used to support head while in the prone position).

improved knowledge and confidence of the manual PP procedure, but the pandemic prompted inventive solutions to manage large patient loads and pandemic-related stress.

Multidisciplinary PP teams emerged as an innovative strategy to facilitate the PP process safely, effectively, and efficiently. PP teams consisted of various professionals, including RTs, nurses, certified registered nurse anesthetists, occupational therapists, physical therapists, and technologists.[38,41-43,45,46] The overall goals of PP teams were to provide support to the bedside RTs and nurses, standardize the PP process, and to reduce AEs related to PP.[38,41]

Whereas publications regarding the use of PP teams primarily describe the development and experiences related to their implementation, some patterns have consistently emerged with the use of PP teams. First, the use of health care professionals who are not typically involved in the PP process for critically ill patients (eg, occupational therapists, physical therapists, non-ICU nurses, and technologists) is feasible and safe when adequate training is provided. Second, PP teams resulted in a considerable benefit to bedside staff and patients, as they off-loaded the work of PP from the bedside staff, allowing them to focus on other tasks. Third, PP teams provide needed efficiencies, like having someone dedicated to supplying materials from outside the room, and staff satisfaction during a pandemic surge. Finally, perhaps due to the nature of multidisciplinary care, imaginative ideas like the use of prone team carts (Fig. 1) were used to improve efficiency.[38,41-43,45] PP teams may not be necessary during non-pandemic times. Still, their concept illustrates how institutions can use training, standardization, and resource re-allocation to provide essential services during patient surge situations (pandemic or other disasters).

Complications Associated With Prone Positioning

Whereas PP has shown to be beneficial in patients with severe ARDS induced by COVID-19 or non-COVID-19 pneumonia, it is not without complications.[47-52] In 2021, Gonzalez-Sequel et al[53] conducted a scoping review to identify AEs related to PP in subjects with ARDS requiring mechanical ventilation. Of the 41 studies included in their review, 15 (36.6%) included subjects with COVID-19 ARDS. The authors identified > 40 individual AEs. Of those, severe desaturation (37.9%), followed by barotrauma (30.5%), pressure sores (29.7%), ventilation-associated pneumonia (28.2%), facial edema (16.7%), arrhythmia (15.4%), hypotension (10.2%), and peripheral nerve injuries (8.1%) were reported as the highest-pooled occurrence rates.[53]

Also, in 2021, Binda et al[47] reported results from a cross-sectional study aimed at assessing complications associated with PP during the COVID-19 pandemic. They included 63 subjects that were intubated and treated with PP, of whom 32 had at least one complication. Bleeding occurred in 25% of subjects, most commonly at the site of the nose and mouth secondary to medical devices (nasogastric and endotracheal tubes), but only one case of bleeding led to PP interruption for bleeding control. The prevalence of pressure injuries related to PP was 30.2% (95% CI 18.8–41.5). The face was the most commonly affected site of all observed pressure injuries.[47] Other studies reporting prevalence data pressure ulcers vary from 44–77%.[54-56] The high prevalence rates reported in these COVID-19-related

Table 2. Summary of Recommendations Made to Prevent Pressure Injuries Associated With Prone Positioning

Author	Recommendations
Moore et al[57]	Frequently assess common risk areas for pressure injuries
	Keep skin clean and moisturized
	Utilize pressure redistribution devices to off-load pressure points on the face and body
	Make simple adjustments to posture and device position to minimize pressure and shear
	Use protective coverings such as hydrocolloids, transparent film, and silicone
Parhar et al[59]	Frequent (every 2 h) repositioning of pressure points
	Use gel or foam face cushions
Team et al[60]	Prior to PP:
	Conduct a skin assessment
	Utilize pressure redistribution devices
	Select an appropriate overlay or mattress
	Remove commercial endotracheal tube securing device; use tape instead
	Use liquid film-forming dressing
	Lubricate eyes and tape closed.
	During PP:
	Use swimmer's position
	Reposition patient every 2 h when possible
	Keep skin clean
	Conduct regular skin checks
	Confirm proper nutrition and hydration.
	After PP (supine position):
	Conduct and document pressure point assessment
	Promote early mobilization
Capasso et al[61]	Consider impact of oxygen deficits on the risk of pressure injuries
	Determine repositioning frequency, with consideration of patient factors
	Reposition to off-load bony prominences and redistribute pressure
	Use soft-silicone multilayered foam dressings
	Use prophylactic dressings beneath medical devices

PP = prone positioning

studies are probably explained by the overwhelming nature of the pandemic, requiring teams to place an unprecedented number of patients in the PP simultaneously.[56] Pressure injuries have been reported in other non-COVID-19 studies as a complication associated with PP.[57,58] In a secondary analysis of the PROSEVA study, Girard et al[58] reported that subjects in the PP group had a higher frequency of pressure ulcers than those in the SP group. The prevalence of pressure ulcers from randomization to ICU discharge was 13.92/1,000 and 7.72/1,000 ICU d ($P = .002$) in the prone versus supine groups. Unsurprisingly, pressure injuries are common during PP, especially since the evidence supports the need to place patients in the prone position for long periods of time (~16 h).[8] Given the data that support PP for severe ARDS, it is incumbent for clinicians to find ways to mitigate pressure injuries during its use.

Several papers have been published on strategies to reduce pressure injuries associated with PP for subjects with COVID-19.[57,59-61] Common recommendations include the frequent assessments of skin for pressure injuries, keeping the skin clean, repositioning and use of pressure redistribution devices to off-load pressure points, and the use of protective dressing (Table 2). Utilizing the expertise of a certified wound and skin care nurse may also help reduce the incidence and severity of pressure-related injuries.[46]

In addition to pressure injuries, brachial plexus injuries have also been reported from PP during the COVID-19 pandemic.[49,62] The brachial plexus is a network of nerves arising from the cervical spine that aid in sensory and movement function to the arms and hands.[49,62,63] When the brachial plexus is injured, a resultant loss of sensation and/or paralysis to the arm can occur. Injury to closed nerves is caused by hypoxic injury to neurons caused by compression and traction. During PP, patients are at risk for this type of injury due to the nature of body placement during the procedure. A common practice during PP is to position one arm abducted and one arm adducted with the head facing the abducted arm. The intent of this so-called swimmer's position is to reduce facial pressure injuries, provide access to intravenous lines, and allow for visual assessments.[52]

Acknowledging the importance of PP, but the reality that injury is likely to occur, Simpson et al[49] provided a set of concise recommendations to reduce brachial plexus injury based on findings from the available literature. For patients placed in the prone position, they suggest (1) slide the scapulae up the back with a slight shoulder shrug to avoid depression of the shoulder girdle, (2) maintain straight spine alignment to avoid excessive rotation, (3) avoid extension of the shoulder or subluxation of the shoulder joint dorsally, (4) avoid abduction of the arm beyond 70° with elbow extension and external rotation of the shoulder more than 60°, (5) avoid neck extension, and (6) reduce venous pressure in the thoracic outlet and neck by avoiding abdominal compression.[49] To account for institution-specific needs, we suggest that those charged with developing and implementing PP practices in their respective institutions seek the input of physical therapists regarding optimal limb and body alignment. In our own pandemic experience, we found physical therapists to be invaluable in educating our team on the best practices to reduce nerve damage and contractures during PP.[41] In fact, a physical therapist is automatically consulted for each patient placed in the prone position to mitigate AEs related to the procedure in our institution.

Summary

Prior to the COVID-19 pandemic, PP was suggested for patients with severe ARDS based on high levels of evidence. Now, more than 2 years after the start of the pandemic, it is evident that PP is a feasible and clinically useful treatment for patients intubated due to hypoxemic respiratory failure from COVID-19. For non-intubated patients, APP is also a worthwhile therapeutic option, as it has shown to be feasible and safe, and can improve oxygenation. APP can also reduce the need for intubation in patients who require advanced respiratory support like HFNC oxygen therapy and NIV. Whereas PP teams might not be necessary during normal hospital operations, they are helpful during a pandemic or other patient surge situations. Steps to mitigate complications from PP can be taken—and an interdisciplinary approach to reduce complications is probably best. Finally, more research is needed to determine if APP should be used in patients without COVID-19.

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