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# Critical Analysis of an Awake Prone Positioning Protocol at a Community Hospital

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**Acknowledgments**

This project is dedicated to the frontline healthcare workers of the COVID-19 pandemic. I would like to express gratitude to my family, classmates, and mentor for support and encouragement throughout this rigorous academic journey. Thank you to every clinical mentor who has encouraged my critical thinking, independence and growth on an academic and personal level. Your leadership has shaped my perception of the kind-hearted and skilled provider I hope to be in order to make a meaningful impact in patients' and families' lives.

**Abstract**

**Background:** Prone positioning has traditionally been implemented in the ICU as a last resort measure to treat ventilator-induced lung injury (VILI) and acute respiratory distress syndrome (ARDS). With the COVID-19 pandemic, awake prone positioning (APP) in non-intubated patients emerged as an intervention on general medical wards to prevent respiratory decompensation and transfer to the ICU as these patients frequently developed acute hypoxemic respiratory failure (AHRF) and ARDS. **Methods:** A critical analysis of a local community APP protocol was performed with updated recommendations from a comprehensive review of literature and feedback from stakeholders. **Results:** Early initiation and longer duration of APP is associated with improved patient outcomes, with periods of 30 minutes to 2 hours having immediate improvement on oxygenation and periods of >8 hours reducing intubation and mortality rates. Few adverse side effects have been identified. Barriers to implementation include adequate equipment and staffing resources, consideration of relative and absolute contraindications, and awareness of APP as an existent, nurse-initiated protocol. **Conclusion:** APP is a non-invasive, feasible, nurse-driven intervention that may be applied in both ICU and non-ICU settings to decrease the risk of respiratory decompensation. APP may be considered outside of the context of the COVID-19 pandemic in cases of future respiratory illnesses in which physiological effects of APP may have similar outcomes.

*Keywords*: *Awake prone positioning (APP), COVID-19, acute respiratory distress syndrome (ARDS), acute hypoxemic respiratory failure (AHRF), high flow nasal cannula (HFNC), non-invasive ventilation (NIV), intensive care unit (ICU)*

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**Critical Analysis of an Awake Prone Positioning Protocol at a Community Hospital**

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), spread globally during the pandemic, resulting in mild to severe symptoms of Coronavirus disease 2019 (COVID-19) with complications of acute hypoxemic respiratory failure (AHRF) and acute respiratory distress syndrome (ARDS). As of April 1, 2023, the national prevalence of COVID-19 reached approximately 104 million cases, 6 million hospitalizations, and 1.1 million deaths (Centers for Disease Control and Prevention [CDC], 2023a). In Washington state, the first state to identify the virus in the United States, there have been 1.9 million reported cases resulting in more than 83 thousand hospitalizations and 16 thousand deaths (Washington State Department of Health, 2023).

The severity of COVID-19 led to high intubation and mortality rates - often overwhelming the capacity for care in intensive care units (ICU) and subsequently leading to higher patient acuity in general hospital wards (Douin et al., 2020). Risk factors and interventions were identified and implemented rapidly as patients presented with ranging levels of disease severity. Individuals with comorbidities such as advancing age, cancer, chronic kidney disease, chronic liver disease, chronic lung disease, diabetes, cardiovascular disease, and immunocompromised states were identified as risk factors for developing severe disease (CDC, 2023b).

Prior to the COVID-19 pandemic, morbidity and mortality from cases of ARDS were nonetheless high. ICU and hospital mortality rates were estimated to be 42.7% and 47.8% in the ICU and the general hospital setting respectively (Villar et al., 2011). Approximately 190 thousand cases of ARDS were estimated in the United States each year (Rubenfeld et al., 2005). The majority of these patients (85%) required mechanical ventilation (Bellani et al., 2016). Up to 10% of admitted ICU patients and up to 23% of patients who were mechanically ventilated met criteria for ARDS (Rubenfeld et al., 2005). Despite the significant morbidity and mortality of ARDS, clinical recognition ranged from 51.3% (95% CI [47.5-55.0])

in mild to 78.5% (95% CI, [74.8-81.8]) in severe cases, while prone positioning (a non-invasive intervention shown to improve treatment of ARDS) was only used in 16.3% (95% CI, [13.7-19.2]) of patients with severe forms (Bellani et al., 2016). With the pandemic, high patient acuity and lack of bed capacity resulted in the need for a novel approach to the care of patients at extreme risk of ARDS with awake prone positioning (APP) as an intervention to reduce the risk of respiratory decompensation.

**Non-Cardiac Pulmonary Edema (ARDS) Pathophysiology**

A direct or indirect lung insult, such as pneumonia or sepsis, initiates the exudative phase of ARDS with release of neutrophils and proinflammatory cytokines resulting in progressive alveolar-capillary damage, accumulation of protein-rich fluid in the alveolar spaces, and malfunctioning pneumocytes with diminished surfactant production resulting in the collapse of alveoli. The fibroproliferative phase presents with early fibrotic changes and thickening of damaged alveolar capillaries progressing to increased collagen deposition, ventilation-perfusion (V/Q) mismatching, and diminished lung compliance (Walkey et al., 2012).

The Berlin criteria for diagnosis includes acute onset, bilateral non-cardiogenic lung infiltrates on chest radiography or computed tomography, and a $PaO_2/FiO_2$ (P/F ratio) <300 mmHg with positive end-expiratory pressure (PEEP) $\geq$5 (ARDS Definition Taskforce et al., 2012). Increasing severity is inversely correlated to the $PaO_2/FiO_2$ ratio. The Kigali modification of identifying ARDS in resource-limited settings includes ultrasonography over radiography for identification of infiltrates and an $SpO_2/FiO_2$ <315 without a PEEP requirement (Riviello et al., 2016). When applying $SpO_2/FiO_2$ ratios to assess improvement in oxygenation, arterial blood gases should be used to correlate $SpO_2$ readings as they may be overestimated in patients with darker skin which can lead to ethnic disparities (Fawzy et al., 2022).

**COVID-19 Pathophysiology**

A valuable hypothesis presented by Gattinoni et al. (2020) proposed the severity of COVID-19 patterns being affected by "(1) the severity of the infection, the host response, physiological reserve and comorbidities, (2) the ventilatory responsiveness of the patient to hypoxemia, and (3) the time elapsed between the onset of the disease and the observation in the hospital" (p. 1099). Gattinoni et al. (2020) proposed two phenotypes of COVID-19 based on the progressive course of the disease from an atypical presentation of ARDS with a highly compliant state, no V/Q mismatch, and low lung recruitability to a more typical presentation with decreased lung compliance, a V/Q mismatch, and high lung recruitability: Type L and Type H respectively.

The physiology of these two phenotypes may illuminate the efficacy of prone positioning at different time points of COVID-19. In type L, for example, the focus may be on reversing hypoxemia and relieving dyspnea by increasing the fraction of inspired oxygen ($FiO_2$) through conventional oxygen therapy or noninvasive ventilation (NIV) instead of recruitment maneuvers, which would be futile at this point, whereas in type H, recruitment maneuvers such as mechanical ventilation and use of prone positioning could improve the V/Q mismatch.

**Physiology of Prone Positioning for ARDS**

Prone positioning has been utilized in ICUs as early as the 1970s for the prevention of ventilator-induced lung injury (VILI) and treatment of ARDS (Piehl & Brown, 1976). Physiologically, prone positioning improves the V/Q mismatch (Henderson et al., 2013). As pressure is relieved from the dorsal surfaces of the lungs and trans-pulmonary pressures become more homogenous, dorsal alveoli are recruited and ventilation is more evenly distributed to functional lung spaces with minimal change in perfusion (Guérin et al., 2020). Clearance of secretions may further enhance ventilation and oxygenation.

**Awake Prone Positioning (APP) Definition**

Improved mortality rates were identified in mechanically ventilated patients with severe ARDS undergoing traditional prone positioning for at least 16 hrs (Guérin et al., 2013). With the emergence of COVID-19, a trend in prone positioning in non-intubated patients in the emergency department and general medical floors appeared and was defined as awake prone positioning (APP) (Touchon et al., 2021). Limited evidence exists on the benefits of APP with regard to escalation of oxygen therapy, transfers to higher levels of care, intubation and mortality rates, and length of hospital stay as well as a lack in standardized protocols of initiation, duration, and termination of therapy.

**Lung Ultrasound Score and ROX Index**

Various lung ultrasound score (LUS) calculations exist to determine lung aeration and extravascular lung water reflecting high density tissue. The most common scoring system ranges from 0 to 36 with higher scores indicative of poor aeration and greater consolidation (Mojoli et al., 2019). The score is calculated in six regions of the hemithorax based off ultrasound findings of 1) A or B-lines and 2) tissue-like pattern (representing consolidation) and is strongly correlated to tissue density findings on computed tomography and extravascular lung water assessed by transpulmonary thermodilution. LUS has been used in prediction of extubation distress and monitoring of conditions such as ventilator-associated pneumonia and ARDS. Findings such as multiple anterior diffuse B lines with lung sliding can be 97% sensitive and 95% specific for pulmonary edema (Lichtenstein & Mezière, 2008). However, ultrasound is operator-dependent and requires training.

The ROX index is another score in the management of pneumonia and ARDS that predicts failure of high flow nasal cannula (HFNC) treatment in patients with COVID-19 AHRF (Prakash et al., 2021). It is calculated by dividing the $SpO_2/FiO_2$ by the respiratory rate. Lower scores are indicative of higher risk of intubation with sensitivity of 0.70 (95% CI, 0.59–0.80) and specificity of 0.79 (95% CI, 0.67–0.88)

**Research Question**

Given ongoing limited resources and a predicted healthcare workforce shortage, research begs the question of how healthcare personnel can learn from this historical event to prevent respiratory decompensation in patients with future respiratory illnesses in general medical wards. The aim of the project is to critically appraise an existing protocol of APP in non-intubated patients in non-ICU settings at a local community hospital through a comprehensive literature review of current evidence supplemented with feedback from stakeholders.

**Theoretical Framework**

The theoretical framework used for this project is Stetler's Model of Evidence-Based Practice to guide the translation of research into clinical practice (Christenbery, 2018). The initial step involves preparation, identifying the purpose of the research, considering influential factors, and searching and sorting through the research. This step includes identifying the appropriate key terms used to guide research and obtain relevant literature that will answer the question addressed by the project. The step of validation is key in assessing evidence for level of quality, which involves verifying credibility, evaluating levels of evidence based on study design, addressing methodological strengths and weaknesses of studies, and considering potential clinical practice implications versus statistical significance. Some studies may have high statistical significance but may not be applicable in a clinical setting whereas others may have low statistical significance but a lack of adverse outcomes leading to potential for clinical impact.

Next, the comparative evaluation and decision-making steps involve an overall synthesis of literature with comparisons and differences amongst studies in order to draw final conclusions. Last of all, translation into clinical practice focuses on how research will be implemented at an individual, group, and organizational level and disseminated to appropriate audiences and stakeholders, with emphasis on those involved in the care of patients and education of staff. The outcomes and the degree

to which change in practice is implemented is the final evaluation of the project. This will rely on the organization's interest in accepting or rejecting the updated protocol.

## Review of Relevant Literature

A search was conducted through PubMed, CINAHL, and Cochrane databases with focus on relevant literature from 2017 to April 2023 with the key term: APP. Reference lists of meta-analyses were reviewed. APP studies in most recent years have centered specifically around patients with COVID-19 combined with ARDS or AHRF. A table of identified articles was created with identified research design, sample size, inclusion and exclusion criteria, final outcomes and conclusions of studies for processing and evaluating the strengths of the studies.

### Systematic Reviews & Meta-Analyses

Overall, meta-analyses had great heterogeneity amongst studies in terms of outcomes measured, duration of prone positioning, and uses with various modes of oxygen delivery. Common clinical outcome measurements included intubation and mortality rates, while measures of oxygenation and ventilation included $PaO_2$, $PaO_2/FiO_2$ ratio, $SpO_2$, and respiratory rates. Meta-analysis interpretations were limited by small sample sizes and scarcity of randomized control trials (RCTs) compared to large numbers of observational cohort studies. Most studies recommended the need for additional large-scale RCTs.

In sum, significant improvements in oxygenation were identified in APP groups compared to standard care. Studies showed mixed results in intubation and mortality rates with either significant or no change. No change is, however, meaningful to note as not contributing to worse intubation rates or harm. Furthermore, improvement in the work of breathing and inspiratory effort results in a reduced risk of patient self-inflicted lung injury (Damiani et al., 2022). Overall, intubation should not be delayed in clinically deteriorating patients and non-responders to therapy.

Several meta-analyses were identified in 2021 identifying significant improvements in oxygenation in terms of $PaO_2/FiO_2$ and $SpO_2$ (Chua et al., 2021; Pavlov et al., 2021; Pb et al., 2021; Tan et al., 2021). Pb et al. (2021) identified an average mean difference of $PaO_2/FiO_2$ 51.29 mmHg (95% CI

[13.91-88.67]), $PaO_2$ 27.94 mmHg (95% CI [15.2-40.69]), and $SpO_2$ 5.39% (95% CI [1.53-9.25]) amongst studies and differences in timing of initiation of APP between responders (2.7 days) versus non-responders to therapy (4.6 days) in a study by Coppo et al. (2020), indicating need for early implementation of APP.

Chua et al. (2021) and Tan et al. (2021) identified similar findings with improvements of $PaO_2/FiO_2$ and $SpO_2$. Chua et al. (2021) analyzed combined APP and traditional prone positioning (TPP) in mechanically ventilated patients in a meta-analysis identifying 35 cohort studies which showed an associated lower incidence of mortality but no significance in intubation rates. Tan et al. (2021), on the other hand, identified reduced respiratory rates and lower intubation and mortality rates particularly with longer duration of APP (>5 hrs/day).

As the COVID-19 pandemic progressed and the role of APP became more evident in 2022, increased numbers of meta-analyses regarding oxygenation, mortality, and intubation were published but continued to consist of a greater portion of observational studies. Like Tan et al. (2021), Ashra et al. (2022) compared APP and TPP in patients with COVID-19 ARDS. Statistically significant improvements in $PaO_2/FiO_2$, $SpO_2$, and $PaO_2$ were identified in both groups without significant difference between the two groups, exhibiting equal effectiveness of APP compared to TPP. Improvement in $PaO_2/FiO_2$ was further confirmed by Fazzini et al. (2022) and Kollias et al. (2022) who estimated a 50-60 mmHg improvement on average. Patients with higher body mass index and longer duration of APP per day (>12 hours) were associated with larger standardized mean differences of $PaO_2/FiO_2$ with prone positioning (Ashra et al., 2022). Longer APP durations were associated with greater treatment success (Schmid et al., 2022). However, median tolerance of positions tended to settle at approximately 4 hrs in some cases (Fazzini et al., 2022).

Overall, evidence tends to show possible reductions in mortality rates, particularly in sub-analyses of observational studies with less significant findings coming from RCTs (Beran et al., 2022;

Fazzini et al., 2022; Kang et al., 2022; Li et al., 2022). Significant reductions occurred particularly in patients receiving oxygen via HFNC or NIV or patients in the ICU with no significant reduction in patients in non-ICU settings or receiving conventional oxygen therapy (Li et al., 2022; Siddiquie et al., 2023). Reductions in intubation rates were confirmed by Kang et al. (2022) and Weatherhald et al. (2022) but discounted by Fazzini et al. (2022) who identified no significant change. Beran et al. (2022) identified a significant reduction in a sub-group analysis of RCTs. Explanations for different conclusions come from lack of randomization in trials, low power sizes, and low adherence to prone positioning.

Although most meta-analyses consisted of a mix of observational and RCT studies, two meta-analyses focused on RCTs solely. Chong et al. (2022) analyzed three studies with patients on HFNC and NIV and five with patients requiring supplemental oxygen and non-rebreather. The analysis revealed that the APP group had less invasive mechanical ventilation requirement (26.5% vs. 30.9%; OR 0.77; P=0.03) than the standard care group with greater benefit in groups requiring HFNC and NIV (32.5% vs. 39.1%; OR 0.75; P=0.02). All-cause hospital mortality, hospital and ICU length of stay, and adverse events were comparable. A meta-analysis of 10 RCTs by Huang et al. (2022) further distinguished reduced intubation rates in patients who were older (≥60 years), obese, came from a high mortality risk population (>20%), received HFNC or NIV, had lower beginning $SpO_2/FiO_2$ (<150 mmHg), or had undergone longer durations of APP (≥8 hrs).

The most recent meta-analysis by Godoy et al. (2023) identified varying recommendations for duration of APP being as long as tolerated (Ehrmann et al., 2021; Ibarra-Estrada, Li et al., 2022; Kaur et al., 2021), > 16 hrs per day (Ferrando et al., 2020; Rosén et al., 2021; Xu et al., 2020), 12 hrs for 1–2 times per day, or 2–6 hrs or more than 6 hrs for 1–5 times per day (Jouffroy et al., 2021; Kucukdemirci-Kaya et al., 2022; Tu et al., 2020; Yang et al., 2020). The decision to discontinue therapy may be based off clinical judgment according to improvements in $FiO_2$, $PaO_2/FiO_2$, $SpO_2$, ROX index (predictive value for HFNC failure and intubation risk), and general respiratory status (Godoy et al., 2023).

Few side effects were noted during the APP intervention. Back pain was noted as the most common side effect (Fazzini et al., 2022; Pb et al., 2022) with additional mild complications such as pressure injury, central venous or arterial line dislodgment, vomiting, bloating, and general discomfort (Fusi et al., 2023; Li et al., 2022). Overall, APP was found to be feasible with no differences in significant adverse events identified between groups receiving APP versus standard care (Chilkoti et al., 2022; Kang et al., 2022).

Caveats to why conventional oxygen or general ward settings have seen varied outcomes compared to TPP in the ICU were addressed in a narrative review by Long & Gottlieb (2022). Several hypotheses included higher patient to nurse ratios, less intensive monitoring, lower disease severity, and lower adherence to APP with insufficient sample sizes as well as lack of data on modified prone positions to enhance adherence. Modified positions, such as Rodin's thinker, Dolphin, and Reverse Trendelenberg, as shown in Figure A1, could promote comfort and further improve patient outcomes (Chen et al., 2022).

**Clinical Trials**

In an international meta-trial including Canada, France, Ireland, Mexico, the United States, and Spain, Ehrmann et al. (2021) investigated the effect of APP in adults requiring HFNC for AHRF due to COVID-19. The primary outcome of treatment failure (defined as intubation or death) within 28 days was 40% and 46% in the APP and standard care group respectively with HR 0.75 (0.62-0.91) for intubation. Patients in the APP group were more likely to be weaned from HFNC. $SpO_2/FiO_2$, respiratory rates, and the ROX index all significantly improved during the first APP session. Although the study was not designed to measure duration of APP, a mean duration of 5 hrs and longer was reported in association with lower treatment failure rates. Mortality and the risk of adverse events such as skin breakdown, vomiting, and central or arterial line dislodgement was similar among the groups with feasibility and lack of adverse outcomes confirmed by Jayakumar et al. (2021).

An RCT of 430 patients with COVID-19-induced AHRF requiring HFNC identified lower intubation rates (30% vs 43%, RR 0.70; CI 95% [0.54-0.90], P = 0.006) and a shorter length of hospital stay (11 [IQR, 9-14] vs. 13 [IQR, 10-17] days, P = 0.001) in the APP group (Ibarra-Estrada, Li et al., 2022). In a sub-group analysis, longer duration of APP (>8 hours/day), an increase in ROX index >1.25 after the first APP session, and a decrease in the lung ultrasound score ≥ 2 within the first 3 days, indicating improvement in aeration, were identified as factors significantly associated with lower intubation rates. Patients who received early APP (defined as within 24 hrs of initiation of HFNC) as compared to after 24 hrs, had a significantly lower mortality rate (26% vs. 45%, p = 0.039) without a significant difference in intubation rate in supplementary studies (Kaur et al., 2021; Agarwal & Martin, 2022). Alhazzani et al. (2021) failed to establish any statistically significant impact on intubation but recommended not to exclude the potential effect on clinical impact given a small decrease in intubation rates in the APP group. Predictors of treatment failure in a separate study included daily duration of APP <7.7 hrs, respiratory rate at enrollment ≥25, and a decrease in respiratory rate <3 after the first session of APP (Ibarra-Estrada, Vargas-Obieta et al., 2022).

Taylor et al. (2021) studied 40 patients with oxygen requirements of 3 liters or greater. The median $SaO_2/FiO_2$ ratio after a 48-hour period was 253 (95% CI [197–267]) in the APP group versus 216 (95% CI [95–303]) in the control. Barriers to the trial included low adherence to prone positioning, large differences between physician-recommended and patient-tolerated prone durations, and diffusion of prone positioning into the control group.

Several studies identified benefits with shorter periods of APP. Mirza et al. (2022) assessed patients with HFNC receiving APP for at least 30 minutes. Identified predictors of treatment success included higher $SpO_2/FIO_2$ and ROX index before APP and a lower risk of intubation identified with $SpO_2/FiO_2$ >150. Othman et al. (2022) further confirmed improvement in oxygenation parameters of

$SpO_2$, $PaO_2/FiO_2$, ROX index, $PaO_2$, and $SaO_2$ values after 1 hr of APP with use of nonrebreather or CPAP in 82 patients equally distributed between standard and APP care.

Two studies identified no significant benefits with APP durations of 4 hrs. In a study of 257 of 502 patients assigned to APP, total 4 hr duration of 2hr APP cycles failed to improve survival or need for mechanical ventilation in patients requiring oxygen by nasal cannula or face mask (Gopalakrishnan et al., 2022). In a non-randomized trial of 501 patients equally distributed between control and APP groups with a median of 4.2 hrs (IQR, 1.8-6.7 hrs) spent in APP, patients showed worse clinical outcomes according to increased $FiO_2$ needs and discharge vs death with theories of APP improving oxygenation but obscuring progression of disease and delaying treatment (Qian et al., 2022).

Additional RCTs lacked significance. Intubation rates, mortality, or length of stay at the 30-day mark showed no difference by Rosén et al. (2021). In this study, APP was discouraged in the control group. However, an APP duration of 3.4 hrs overlapped into the control group as compared to 9 hrs in the APP group and only 6% of the prone group reached the target goal of 16 hrs. Fralick et al. (2022) studied 248 patients requiring up to 0.5 $FiO_2$. Mortality, intubation, and worsening respiratory failure defined as the need for >0.6 $FiO_2$ were defined as primary outcomes. As the study by Rosén et al., research was stopped given futility and no significant differences in outcomes identified. In this study, the median time spent in prone position in the first 72 hrs was 6 hrs (ranging 1.5-12.8).

**Observational Studies**

Two studies showed improvement in dorsal lung function. A longer duration of APP was associated with a reduction in dorsal LUS score and therefore greater lung aeration and treatment success (Ibarra-Estrada, Gamero-Rodríguez et al., 2022). Dos Santos Rocha et al. (2022) confirmed increased ventilatory distribution in dorsal lung fields in those receiving APP and mechanical ventilation but not NIV with improvements in oxygenation in both groups.

Several studies showed immediate improvement in oxygenation after short periods of prone positioning. Two studies were conducted in the emergency department, one of which showed an increase in $SpO_2/FiO_2$ by a median of 5 (IQR, 0-15) after patients maintained APP for 30 minutes without significant change in respiratory rate with similar findings in additional studies (Dubosh et al., 2021; Wendt et al., 2021). This shows immediate benefit in oxygenation in patients with mild to moderate respiratory distress requiring supplementation with nasal cannula or nonrebreather when APP is started early. In those who maintained APP for at least 1 hr TID, improvements in oxygenation and clinical outcomes occurred regardless of the extent of lung parenchymal damage with $SpO_2/FiO_2$ >165 being predictive of being responsive to therapy and having a decreased risk of therapy failure and risk for intubation (Silva Junior et al., 2021).

Some observational studies have shown improvement in oxygen parameters of non-intubated patients after 1 hr (Bastoni et al., 2020; Thompson et al., 2020). Solverson et al. (2021) noted improvement in oxygen saturation of 17 patients with a median APP duration of 75 (30-480) minutes. Other studies have shown improvement in oxygenation with an average duration of 3 hrs of APP (Cherian et al.; 2021, Coppo et al, 2020; Elharrar et al., 2020). Coppo et al. (2020) identified that 50% of patients maintained oxygen improvement 1 hr after resupination though not significantly compared to original supine position with similar findings by Elharrar et al. (2020). Those who maintained oxygenation had elevated levels of C-reactive protein and shorter time between admission and prone positioning (2.7 days [SD 2.1] in responders vs 4.6 days [3.7] in non-responders). Improvement in inflammatory markers and the ROX index in patients with mild to moderate ARDS predicted success of treatment and decreased risk of intubation (Cherian et al., 2021).

In 41 patients, Oliveira et al. (2021) identified responders and non-responders according to a 20% increase in the $PaO_2/FiO_2$ before and after 2 hrs of APP with responders showing increase $SpO_2$, $PaO_2/FiO_2$, decreased respiratory rates, lower rates of intubation at the 48 hr mark accompanied by

fewer days of ventilation, shorter lengths of stay in the ICU, and lower mortality rates. APP for ≥6 hrs/day reduced the risk of endotracheal intubation, and exposure ≥ 8 hrs/day reduced the risk of hospital mortality according to Esperatti et al. (2022). In a separate study, a group with an average of 6 hrs APP had less risk of intubation compared to a group with 3 hrs with greater effect in those receiving NIV compared to HFNC (Tonelli et al., 2022). When APP was initiated within 1-2 days from admission for a median duration of 6 hrs per day, improvements in oxygen requirements and $PaO_2/FiO_2$ occurred after 3-5 days of APP in moderate to severe ARDS (Khanum et al., 2021).

In a study of 50 patients with mild to moderate ARDS with various modes of oxygen delivery who sustained a mean duration of APP for 8.5 hrs, the $PaO_2/FiO_2$ ratio increased and sustained 1 hr after re-supination without any adverse events (Aisa et al., 2022). A similar study by Sryma et al. (2021) of 45 patients with median duration of 7.5 hrs with a minimum 2 hr per session showed decreased need for mechanical ventilation and statistical improvement in the ROX index with NIV. In patients undergoing APP, a threshold ROX index ≤11.8 signified risk for intubation within 48 hrs of admission (Downing et al., 2021). This was supplemented by a study showing improvement in inspiratory effort and oxygenation in patients with NIV undergoing APP for a median of 4 hrs (Bianchi et al., 2023).

Singh et al. (2020) noted significant continuous improvement in $PaO_2/FiO_2$ over the course of 10 days with a target time of 10-12 hrs APP daily with no significance after 10 days to discharge. In a small study of 7 patients with a median duration of 10 hrs of APP, Taboada et al. (2021) confirmed a significant increase in $SaO_2$ and $PaO_2/FiO_2$ during APP and a maintained, but not significantly different, increase in $PaO_2/FiO_2$ after re-supination.

Simioli et al. (2021) evaluated the effects of early prone positioning in patients with severe ARDS in which APP was initiated within 12 hrs of hospital admission, with 18 of 29 patients tolerating a total duration of 10 hrs or more while alternating position every 2 hrs. In these patients, the $PaO_2/FiO_2$ during APP increased significantly compared with noncompliant controls (288 vs. 202; p=0.0002), the duration

of respiratory failure was significantly shorter (14 vs. 21 days; P=0.002), and the number of days to recover from respiratory failure inversely correlated with improved $PaO_2/FiO_2$ ratios after APP rather than being corresponsive to beginning $PaO_2/FiO_2$ prior to APP (Simioli et al., 2021). A study regarding early APP in patients with nonrebreather who maintained APP >12hrs/day showed improvements in oxygenation after 24 hrs, lower short-term mortality and intubation requirements in the APP group with no significant changes in length of ICU stay or ventilator-free days (Altinay et al., 2022).

The largest retrospective, multi-center study of 827 patients with a median of time to initiation of APP 15.5 (8–48) hrs and median time spent in APP 12 (8–24) hrs during the hospital stay identified APP as a protective factor for preventing mechanical ventilation after multivariable adjustment and use of low flow, high flow, and non-rebreather oxygen delivery (Perez-Nieto et al., 2022). Limitations of this study include unclear comparison to daily time spent in APP in contrast to total APP during the hospital stay in this study. In a prospective, multicenter study, Ferrando et al. (2020) found no significant contribution of APP in HFNC to intubation or mortality rates. Two studies confirmed no effect on intubation rates (Jouffroy et al., 2021; Padrão et al., 2020).

**Summary of Evidence**

Overall, evidence points to improved oxygenation, intubation and mortality rates, and possible decreases in length of hospital and ICU stay. Durations of 30 minutes to two hours of APP may improve immediate oxygenation needs, while durations of eight hours may decrease the need for mechanical ventilation and improve mortality rates. If patients are unable to tolerate the position, alternative positions could be trialed and shorter periods of 30 minutes to two hours could at least improve immediate oxygenation needs. Recommendations for timing of initiation is sparce but is advised early, approximately within 24-48 hrs of admission or the initiation of HFNC or NIV. Indices such as an $SpO_2/FiO_2$ <150 or ROX index ≤11.8 may assist in identifying those at greater risk of treatment failure and risk of intubation. The most significant contraindications to APP include spinal instability,

hemodynamic instability, or respiratory distress with impending need for intubation. The most frequent side effect of APP is back pain.

Much of research shows benefits in patients using HFNC or NIV and ICU environments in comparison to conventional oxygen therapy and general medical wards and in those who APP is initiated early with longer periods of duration. Given limited power sizes and lack of large-scale RCTs, more research is needed to this regard. Gaps in clinical practice reflect the gaps in research given the relatively new application of prone positioning to non-ICU environments and lack of standardized protocols.

## Methods

This is a non-experimental project involving the critical appraisal of a clinical practice guideline. The purpose is to improve the standardization of the APP protocol in non-ICU settings with objectives of performing a comprehensive literature review to identify the most current evidence regarding initiation, duration, and termination of prone positioning as well as indications and contraindications.

No patients were involved in the project. Healthcare providers such as physicians, advanced practice providers, nurses, and respiratory therapists, were invited to participate in a voluntary video meeting focus group for feedback on the updated protocol. The invitation was sent several days in advance with an additional reminder sent the day of the meeting. Two meeting sessions lasted one hour in length, one in the morning and one in the evening. The project was approved by the hospital and reviewed by the Seattle University Institutional Review Board (IRB) and determined to be exempt by the IRB as it is non-human subject research.

### Setting

The APP protocol is currently implemented in non-intubated adults with AHRF. For the purposes of understanding the applicability of prone positioning from the ICU to the non-ICU setting, healthcare personnel from various departments were invited for the focus group. Participation in the meeting was voluntary. An e-mail with a Zoom invitation link, a fact sheet to stimulate conversation, and a consent form explaining the purposes and voluntary participation was sent to all providers, nurses, and respiratory therapists in the hospital (excluding emergency nurses, pediatrics and labor and delivery).

### Participants

One participant attended the focus group. A small sample size could have resulted in sampling or selection bias and lack of generalizability to the perspectives of all healthcare providers. The department lists included hospitalist and intensivist groups and nurses in medical-surgical, oncology, orthopedic and neurosurgery, cardiac rehabilitation, progressive care, and intensive care units.

**Data Collection & Evaluation**

Following the synthesis and evaluation of evidence, adjustments were made to the APP protocol. The updated protocol, a consent form, fact sheet to promote discussion, and a request to e-mail a response if unable to attend the meetings was e-mailed to healthcare personnel along with Zoom links to the meetings. Information from the meetings was recorded, transcribed into a written document, and deleted post-completion of the project. The conversation was initiated with general feedback and thoughts about the protocol, experiences with APP, its applicability, and barriers. Content of the transcribed document was analyzed by thematic analysis with a second analyzer to ensure agreement on themes. After additional adjustments and feedback from stakeholders, the updated protocol and potential barriers to implementation were presented to the Nursing Shared Practice Council for further review and the head of the hospitalist team for further revision and decision to accept the changes.

## Results

One participant, a manager of the oncology department, attended the video meeting for an in-depth discussion of the protocol. Risks to the patient were identified as a theme with ambiguity regarding absolute and relative contraindications. A case was examined with a provider requesting APP in a patient with running tube feeds. Ultimately, a decision was made not to prone the patient due to aspiration risk. Ideas regarding bolus tube feeds over continuous tube feeds or alternative positions such as reverse Trendelenburg or the dolphin position to maintain elevation of the head of the bed and decrease the risk of aspiration were discussed. Additional concerns brought up included risk of skin breakdown, fall risk, patients sliding out of bed, and positioning and adequate padding when using specialty air mattresses to prevent occlusion of the face.

A separate theme of resources was identified: need for closer monitoring including equipment and staff resources. All patients would require monitoring with pulse oximetry. A centralized pulse oximeter supervised by telemetry monitor technicians opposed to a regular continuous pulse oximeter not observed by telemetry technicians would be selected based off nursing judgement on stability of oxygenation status and level of monitoring required. Resource barriers in terms of staff was brought up if the protocol was applied to a patient who was unable to self-prone and required assistance, which commonly includes a majority of patients in the hospital setting who lack strength and mobility. In this scenario, the manager of the floor confirmed it would be reasonable to adjust patient-nurse ratios to meet the acuity of the patients. A final theme identified included lack of awareness including nurses being unaware of the protocol or that the protocol could be nurse-initiated without a provider order.

## Discussion

The current protocol was critically appraised and evaluated according to current evidence from a comprehensive literature review of APP. Specific topics addressed in the updated protocol include time to initiation, duration, and termination of APP as well as alternative positions if patients are unable to tolerate the recommended flat position, inclusion and exclusion criteria, and suggestions for managing side effects of the intervention.

The existing APP protocol had no recommendations specifying when to initiate or terminate APP therapy. Recommendations were added to start APP early within a 24-48 hr period and to terminate therapy and contact the provider if the patient showed no improvement in oxygenation or worsening signs of respiratory distress. A duration of 30 minutes to two hours was proposed in the original protocol but revised as a duration to improve immediate oxygenation needs with an ideal duration of at least 8 and up to 16 hrs to reduce the risk of intubation. A waiting period of at least 30 minutes was added for bolus tube feeds in addition to the pre-existing waiting period after meals to decrease the risk of aspiration or nausea and vomiting. A recommendation to pre-medicate a patient as needed for nausea or pain was added to increase comfort and tolerance. Contraindications were classified as absolute and relative with guidance to contact the provider for further discussion regarding the risks and benefits to a patient with a relative contraindication and an order for APP. An image of alternative positions and updated resources were added to the references section.

Recommendations to sustain this project include increasing awareness of APP being a nurse-initiated intervention, stimulating discussion between nurses and providers, and increasing education of both staff and patients regarding its effects. With future growth in APP research, the Stetler Model of evidence-based practice can continue to inform the cycle of evaluating and applying new recommendations of APP to clinical practice with respect to initiation and duration of APP, and management of barriers.

A limited number of participants in the focus group resulted in an incomplete and potentially biased understanding of the experiences and barriers of staff. It was reported that the e-mail sent was diverted to a less important section of the mailbox and could have been missed. It is also acknowledged that work schedules and lack of incentive to attend the meetings could have contributed to poor attendance. Reflecting on this project, attendance could have been increased by prone positioning information and reminders about the meeting being dispersed at huddle reports for nurses during shift change. Building trust and engagement by being part of the hospitalist or intensivist team would likely have stimulated discussion more readily amongst providers. Meeting with department managers to set up an educational presentation regarding APP with offered continuing education credits could have encouraged participation, improved staff awareness regarding the protocol, and improved the quantity and quality of feedback for analysis.

In conclusion, given the healthcare system's needs for increasing efficiency while working with limited resources of staff and bed capacity, APP may be used as a non-invasive, feasible, nurse-driven intervention to prevent respiratory decompensation in patients in the non-ICU setting as well as non-intubated patients in the ICU. Although the research cannot be generalizable, it is important to consider the use of APP in future respiratory illnesses outside of COVID-19 whether it is influenza, respiratory syncytial virus, or viral or bacterial pneumonias in which the physiological effects of APP may have similar outcomes.

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## Appendix A

**Figure A1**

*Alternative positions if patients are unable to tolerate prone positioning (Chen et al., 2022)*

| Rodin's thinker | The dolphin position | Reverse Trendelenburg position |
|---|---|---|
| Patients sit on a chair and rest their chest on a flat, elevated surface (i.e., their bed or a desk, at an intermammillary line), thus placing the chest in a "semi-prone" position. The head is laid on the arms, elevated and crossed. | Patients reverse their position on the bed, placing their head in the "bed foot area." In this way, the joint of the bed, normally dedicated to the inclination of the lower limbs, is used to achieve a comfortable chest position. | In a supine position, the patients' hip and knees are not flexed, but the head and chest are elevated at 30° to the abdomen and legs. |
|  |  |  |

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**Figure A2**

*Original prone positioning protocol in non-intubated adult patients*

## Procedure : Self-Proning (non-intubated adult patients)

NOTE: The electronic version of this document or form is the latest and only acceptable version. You are responsible to ensure any printing of this document is identical to the e-version.

# Scope:

This procedure applies to non-intubated adult inpatients at EvergreenHealth Kirkland. For intubated patients or the ICU setting, see Proning procedure.

# Policy Statement:

Patients with Covid-19 experiencing oxygenation compromise are often admitted to medical units. Early self-proning is a viable, nurse-driven option to improve oxygenation, prevent transfer to intensive care, and decrease need for invasive mechanical ventilation.

# Procedures:

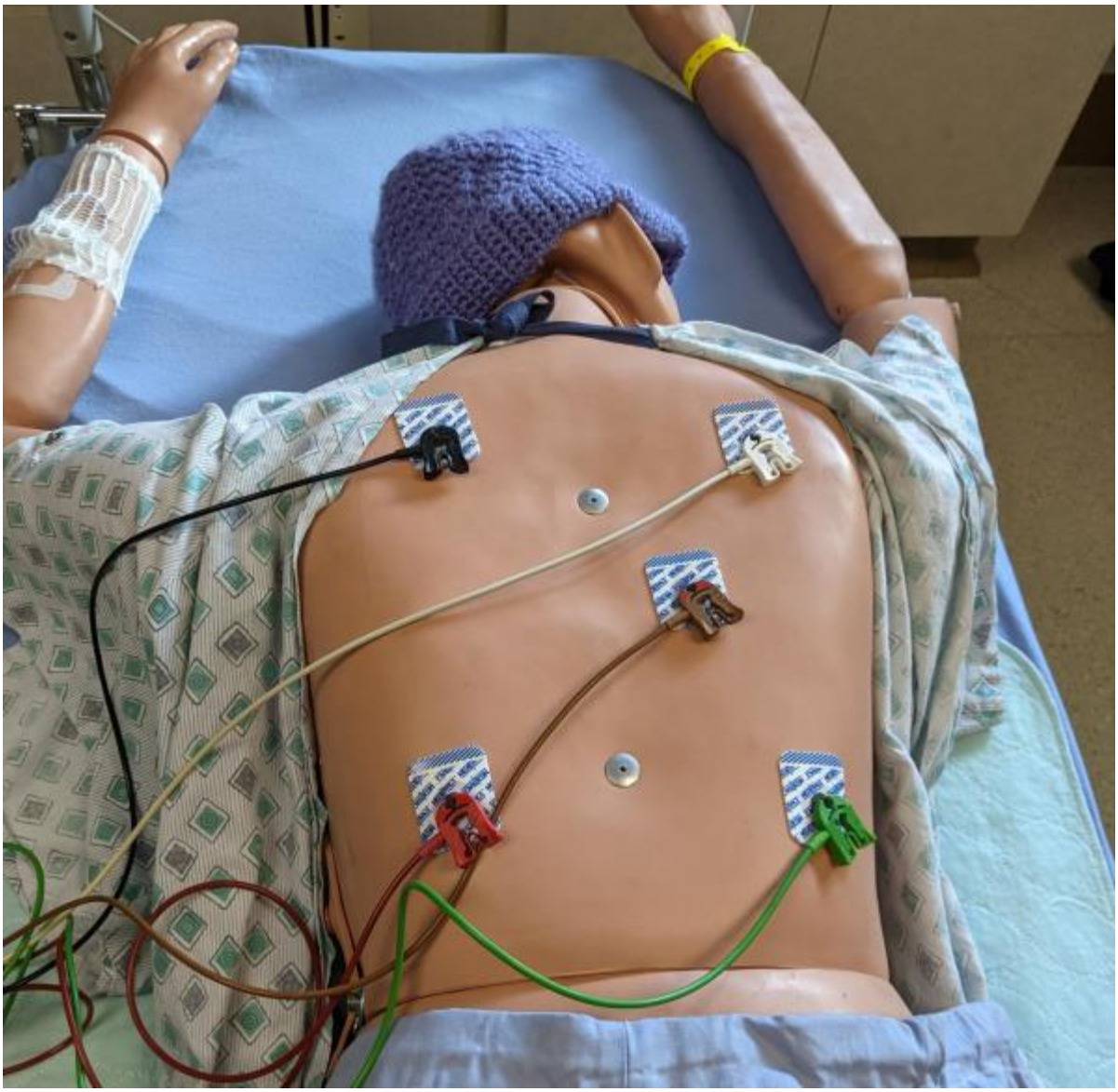
Begin by identifying whether the patient meets the inclusion criteria for self- proning. See inclusion and exclusion criteria below.

| Inclusion | Exclusion |
|---|---|
| Alert, awake and cooperative | Patient intubated |
| Able to reposition independently from supine to prone and prone to supine | Spinal Issues (Instability , vertebral compression fractures, etc.) |
| >30 minutes from last meal | Severe Reflux or Patient nauseated/vomiting |
| Respiration Rate <40 | Pregnancy |
| Hemodynamically Stable as evidenced by: | Documented aspiration risk |
| HR: 50-120 | Tube Feeds running |
| BP: 90-180 | Surgical and/or trauma precautions |

| Inclusion | Exclusion |
|---|---|
| | |
| MAP:≥65 | Morbid Obesity (BMI >45) |
| No new arrhythmia on EKG | Recent Pacemaker Implantation (within the last 4 weeks) |
| | New arrhythmia on EKG |
| | Chest Tube present |

**Patient Preparation:** Ensure patient meets criteria (above) to self-prone.

1. Verify patient has not eaten within the last 30 minutes.
2. Explain the procedure and purpose of proning to the patient. Goal is minimum of 30 minutes to maximum of 2 hours twice daily.
3. Assess patient for actual or potential skin breakdown; pad bony prominences (such as shoulder, knees, iliac crest) with foam dressings if indicated.
4. Evaluate patient's ability to turn head side to side: in prone position, patient will be asked to turn head to best ROM side.
5. Remove fitted sheet: place flat sheet under patient's shoulders and bed pad at their hips.
6. Take vital signs.
7. If on telemetry, remove EKG electrodes from chest and place on back, matching the right and left leads to the ***patient's*** *right and left sides*. Avoid placing the leads over bony areas such as the scapula and the spinal cord.



1. Remove stat lock from urinary catheter (if applicable).
2. Correctly position all tubes, taking into account the direction of the turn. Adjust IV pump position close to head of bed and verify the tubing has enough length to comfortably turn.
3. Place patient on continuous pulse oximetry if not already in place.

**Procedure for Manual Pronation**

1. Verify correct position of tubes to assure they will accommodate the turn.
2. Instruct the patient to raise arm with IV (if applicable) over their head.
3. Have patient roll over to prone position: adjust gown and tubing for comfort and safety.
4. Assist patient to assume swimmer's pose or position with both arms above head (one side slightly off the bed, adjust with pillows and position to avoid traction on the brachial plexus (the region from neck to shoulder) and lift the diaphragm off bed. Assist patient to best position of comfort. Assure able to breathe comfortably and change own position if needed.

1. Assure the patient has ready access to the call light to call for assistance if needed during proned time.
2. Assess patient's response, noting if they have any respiratory distress. ***If patient does not tolerate:*** assist them to supine position, raise Head of Bed (HOB). Notify provider and document.

## References:

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**Figure A3**

*Updated prone positioning protocol in adult non-intubated patients*

# Procedure : Awake Prone Positioning (Non-Intubated Adult Patients Requiring Supplemental Oxygen)

NOTE: The electronic version of this document or form is the latest and only acceptable version. You are responsible to ensure any printing of this document is identical to the e-version.

## Scope:

This procedure applies to non-intubated adult inpatients at EvergreenHealth Kirkland. For intubated patients or the ICU setting, see Proning procedure.

## Policy Statement:

Patients with COVID-19 experiencing oxygenation compromise are often admitted to medical units. Early self-proning is a feasible, nurse-driven option to improve oxygenation, prevent transfer to intensive care, and decrease need for invasive mechanical ventilation. Positioning may be considered in other viral or bacterial pneumonias.

## Procedures:

Begin by identifying whether the patient meets the inclusion criteria for self- proning. See inclusion and exclusion criteria below.

| Inclusion | Exclusion |
|---|---|
| Alert, awake and cooperative | **Absolute** |
| Able to reposition independently from supine to prone and prone to supine | Confused/combative |
| Respiration Rate <35 | Hemodynamically unstable |
| Hemodynamically Stable as evidenced by: | Severe respiratory distress eg RR>35, accessory muscle use |
| HR: 50-120 | Spinal Instability (eg vertebral compression fractures) |
| BP: 90-180 | **Relative** (Contact provider if risks outweigh benefits) |
| MAP:≥65 | Severe reflux or nausea/vomiting |

| Inclusion | Exclusion |
|---|---|
| >30 minutes from last meal or last bolus tube feed | Documented aspiration risk |
| | Tube feeds running |
| | Recent pacemaker implantation (within last 4 weeks) |
| | Chest tube present |
| | Pregnancy (2nd trimester or more) |
| | Morbid obesity (BMI>45) |

**Patient Preparation:** Ensure patient meets criteria (above) to self-prone.

8. Explain the procedure and purpose of prone positioning to the patient. Goal is to increase oxygenation to 92-96% (or 88-92% for CO2-retaining patients). Improvements in oxygenation may occur with 30 minutes to 2 hours of duration. However, best benefit to reduce risk of intubation is achieved with 8-16 hours per day, as long as tolerated, and with early initiation (within 1-2 days of admission or initiation of advanced respiratory therapy such as high flow nasal cannula or non-invasive ventilation).
9. Assess patient for actual or potential skin breakdown; pad bony prominences (such as shoulder, knees, iliac crest) with foam dressings if indicated.
10. Evaluate patient's ability to turn head side to side: in prone position, patient will be asked to turn head to best ROM side.
11. Premedicate for nausea or pain as needed.
12. Remove fitted sheet: place flat sheet under patient's shoulders and bed pad at their hips.
13. If on telemetry, remove EKG electrodes from chest and place on back, matching the right and left leads to the ***patient's*** *right and left sides*. Avoid placing the leads over bony areas such as the scapula and the spinal cord. Refer to Figure 1.
14. Remove stat lock from urinary catheter (if applicable).
15. Correctly position all tubes, taking into account the direction of the turn. Adjust IV pump position close to head of bed and verify the tubing has enough length to comfortably turn.
16. Place patient on continuous pulse oximetry if not already in place.

**Procedure for Manual Pronation**

5. Verify correct position of tubes to assure they will accommodate the turn.
6. Instruct the patient to raise arm with IV (if applicable) over their head.
7. Have patient roll over to prone position: adjust gown and tubing for comfort and safety.
8. Assist patient to assume swimmer's pose or position with both arms above head (one side slightly off the bed, adjust with pillows and position to avoid traction on the brachial plexus (the region from neck to shoulder) and lift the diaphragm off bed. Assist patient to best position of comfort. Assure able to breathe comfortably and change own position if needed. Consider alternative positions (Figure 2).
9. Assure the patient has ready access to the call light to call for assistance.
10. Monitor oxygen saturation and respiratory status. If oxygen desaturation, use of accessary muscles, or other signs of respiratory distress, ensure oxygen is connected, stop prone positioning, return to supine with HOB elevated, and notify provider. If the patient responds to the maneuver as evidenced by improved oxygenation, may continue prone positioning for several days or until oxygen therapy needs are decreased to satisfactory level by provider.

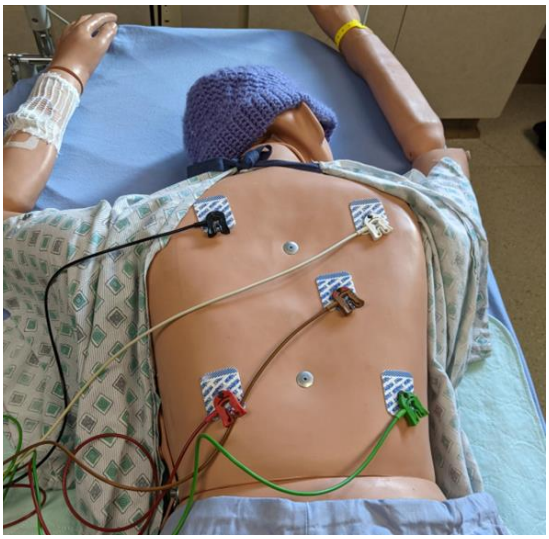

Figure 1: Prone positioning and placement of EKG leads.

| Rodin's thinker | The dolphin position | Reverse Trendelenburg position |
|---|---|---|
| Patients sit on a chair and rest their chest on a flat, elevated surface (i.e., their bed or a desk, at an intermammillary line), thus placing the chest in a "semi-prone" position. The head is laid on the arms, elevated and crossed. | Patients reverse their position on the bed, placing their head in the "bed foot area." In this way, the joint of the bed, normally dedicated to the inclination of the lower limbs, is used to achieve a comfortable chest position. | In a supine position, the patients' hip and knees are not flexed, but the head and chest are elevated at 30° to the abdomen and legs. |

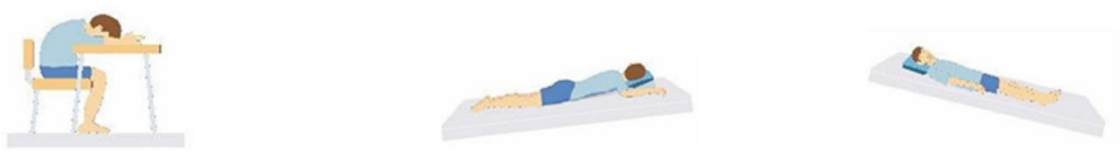

Figure 2: Alternative positions to assist with comfort and tolerance if patient unable to tolerate traditional prone position. Chen et al. 2022

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**Table A1**

*Meta-analyses*

| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
|---|---|---|---|
| Ashra et al. 2022 | 15 studies | Varied<br>30 min to 18 hrs | PaO2/FiO2 standardized mean difference 1.10 (95%CI 0.60-1.59)<br><br>SpO2 standardized mean difference 3.39 (95% CI 1.30-5.48)<br><br>PaO2 standardized mean difference 0.77 (95% CI 0.19-1.35).<br><br>Patients with higher body mass index and longer duration/day associated with larger standardized mean difference effect sizes |
| Beran et al. 2022 | 14 studies | Varied | Decreased mortality (RR 0.68 [95% CI 0.51-0.90]; P = .008, I2 = 52%)<br><br>Reduced intubation in sub-group analysis of RCTs (RR 0.83 [95% CI 0.72-0.97]; P = .02, I2 = 0%) |
| Chua et al. 2021 | 35 studies | Varied<br>30min to >16hrs | Improved $PaO_2/FiO_2$ (Mean difference, MD 52.15, 95% CI 37.08 to 67.22; $p < 0.00001$)<br><br>Improved $SpO_2$ (MD 4.17, 95% CI 2.53 to 5.81)<br><br>Reduced mortality (OR 0.44, 95% CI 0.24 to 0.80; $p = 0.007$). |

| | | | |
|---|---|---|---|
| | | | No significant difference intubation rate (OR 1.20, 95% CI 0.77 to 1.86) |
| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
| Fazzini et al. 2022 | 14 studies | Varied<br>Median 3 hrs (2-16)<br>Recommend<br>>4hrs | Improved PaO2/FiO2 (mean difference -23.10; 95% CI: -34.80 to 11.39; P=0.0001; $I^2$=26%)<br><br>Reduced mortality [OR] 0.51; 95% CI: 0.32-0.80<br><br>Unchanged intubation rate |
| Kang et al. 2022 | 22 studies | Varied<br>Recommend >8 hrs | Decreased intubation (OR 0.64; 95% CI 0.48-0.83; P = .001), particularly with daily median duration APP > 8 h and receiving high flow nasal cannula (HFNC) or non-invasive ventilation (NIV) |
| Kollias et al. 2022 | 23 studies | Varied | Mean PaO2/FiO2 difference 50.4±64.3 mmHg, p<0.01<br><br>Similar in awake (58.7±72.1 mmHg) versus intubated patients (44.1±57.5 mmHg, p=NS) |
| Li et al. 2022 | 29 studies | Varied | Reduced intubation (RR 0·84 [95% CI 0·72-0·97])<br><br>Further reduction in advanced respiratory support and ICU<br><br>Reduced mortality in observational studies (RR 0·56 [95% CI 0·48–0·65] |

| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
|---|---|---|---|
| Pb et al. 2021 | 16 studies | Varied<br>Most 2-3 hrs | Improved PaO2/ FiO2 (51.29 95% CI 13.91-88.67)<br><br>PaO2 (27.92 95% CI 15.2-40.69)<br>SpO2 (5.39 95% CI 1.53-9.25)<br><br>Respiratory rate -0.83 95% CI -3.02 to 1.37)<br><br>Time to initiation in responders 2.7 days vs non-responders 4.6 days |
| Schmid et al. 2022 | 5 RCTs | Varied | Reduced intubation (RR 0.83, 0.71-0.96)<br><br>Little or no effect on mortality (RR: 1.08, 0.51-2.31). |
| Siddiquie et al. 2023 | 11 RCTs | Varied | Reduced intubation (RR 0.84, 95% CI: 0.74-0.95) greater with advanced respiratory support and ICU |
| Tan et al. 2021 | 16 studies | Varied<br>Recommend >5h improved intubation and mortality | Increased PaO2/FiO2 [mean difference (MD) = 47.89, 95% CI: 28.12-67.66<br><br>SpO2 (MD = 4.58, 95% CI: 1.35-7.80)<br><br>Reduced respiratory rate (MD = -5.01, 95% CI: -8.49 to -1.52, p = 0.005, I2 = 85%) |

**Table A2**

*Randomized Control Trials*

| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
|---|---|---|---|
| Ehrmann et al. 2021 | N=1126 | Median daily APP 5hrs (IQR 1·6–8·8)<br><br>Recommend >8hrs | Reduced intubation HR 0·75 (0·62-0·91)<br><br>Reduced mortality HR 0·87 (0·68-1·11) |
| Ibarra-Estrada, Li et al. 2022 | N=430 | Recommend >8hrs | Reduced intubation rate (30% vs 43%, relative risk [RR] 0.70; CI95 0.54-0.90, P = 0.006)<br><br>Shorter hospital length of stay (11 interquartile range [IQR, 9-14] vs 13 [IQR, 10-17] days, P = 0.001) |
| Ibarra-Estrada, Vargas-Obieta et al., 2022 | N=430 | Mean duration 9.4 hrs (5.6-12.9)<br><br>Median of 6 days (3.7-9.0)<br><br>Treatment failure <7.7h | Best predictors of treatment failure: daily duration of APP < 7.7h (AUROC 0.96, p=< 0.001), respiratory rate at enrollment ≥25 bpm (AUROC 0.93, p=< 0.001), D-dimer >1.4 mg/dL (AUROC 0.82, p=< 0.001), and a decrease in respiratory rate < 3 bpm after the first session of APP (AUROC 0.79, p=< 0.001) |
| Taylor et al., 2021 | N=40 | Varied<br>12–16 hours recommended by physicians<br><br>Patients only able to tolerate 10 to 120 minutes per day | SaO2/FiO2 ratio after a 48-hour period was 253 (95% CI [197–267]) in the APP group versus 216 (95% CI [95–303]) in the control |

**Table A3**

*Observational Studies*

| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
|---|---|---|---|
| Aisa et al. 2022 | N=50 | Mean duration 8.5 hrs | Mild-mod ARDS<br>PaO2/FiO2 85 (SD 13.76) to 124 (SD 34.08) in prone position with substantial increase in mean PFR 1-h post proning to 138 (SD 28.01) |
| Altinay et al. 2022 | N=48 | >12 hrs | Mask therapy<br>APP group<br>SpO2: 95%, median<br>PaO2: 82 mmHg<br><br>Non-APP group<br>SpO2: 90%<br>PaO2: 66 mmHg |
| Cherian et al. 2021 | N=59 | At least 3 hrs | Improved ROX and inflammatory markers, Reduced risk of intubation in mild-mod ARDS |
| Coppo et al. 2020 | N=56 | At least 3 hrs | PaO2/FiO2 180·5 mm Hg [SD 76·6] in supine position vs 285·5 mm Hg [112·9] in prone position; p<0·0001<br><br>Maintained in 50% after re-supination<br><br>Shorter time between admission to hospital and prone positioning (2·7 days [SD 2·1] in responders vs 4·6 days [3·7] in non-responders) |
| Dubosh et al. 2021 | N=22 | 30 min | Emergency setting |

| | | | |
|---|---|---|---|
| | | | SpO2/FiO2 ratio increased by a median of 5 (IQR: 0-15) |
| Citation | Sample Size | Duration of APP or Recommendation | Outcomes |
| Esperatti et al. 2022 | N=335 | Recommend >6 hrs | APP for ≥ 6 h/day reduced endotracheal intubation<br>APP ≥ 8 h/d reduced mortality |
| Oliveira et al. 2021 | N=41 | 2 hrs | Responders (20% increase in PaO2/FiO2 after intervention) showed increased SpO2 (P < .001), PaO2 (P < .001), and PaO2 /FIO2 ratios (P < .001) with the maneuver and reduced breathing frequency. Responders had shorter lengths of stay in the ICU (P < .001) and hospital (P < .003), lower intubation rates at 48 h (P < .012), fewer days of ventilation (P < .02), and lower mortality (P < .001) |
| Silva Junior et al. 2021 | N=48 | At least 1 hr three times daily | Emergency setting SpO2/FiO2 >165 predictive of decreased risk of intubation |
| Simioli et al. 2021 | N=29 | At least 10 hrs alternating every 2 hrs | Severe ARDS PaO2/FiO2 (288 vs. 202; p=0.0002) with APP<br><br>Shorter duration of respiratory failure (14 vs. 21 days; p=0.002) |
| Thompson et al. (2020) | N=29 | 1 hr | Spo2 increased 1% to 34% (median [SE], 7% [1.2%]; 95% CI, 4.6%-9.4%) |

| | | | |
|---|---|---|---|
| | | | SpO2>95% after 1 hour PP associated with decreased intubation rate |

## Appendix B

**Figure B1**

*Seattle University IRB Exemption*

SEATTLEU
INSTITUTIONAL REVIEW BOARD

Admin 201 | 206-296-2585
irb@seattleu.edu

February 23, 2023

Alesia Filitovich
College of Nursing

Dear Alesia,

Your application for the project **Evaluating Awake Prone Positioning Protocol in a Community Hospital** indicates that activities will involve:

- Quality improvement via a focus group with healthcare providers at Evergreen Medical Center (Kirkland) to assess the organization's awake prone positioning policy in addition to a literature review regarding timing, duration, and termination of this therapy in order to provide recommendations.

Given the nature of these activities, this project does not meet the federal regulatory definition of human participant research, and your project does not need further IRB review. (This determination does **not** indicate IRB "approval." *Do not include statements for publication or otherwise that the SU IRB has "reviewed and approved" this study*; rather, say the SU IRB has identified the study as "Not Human Participant Research (NHPR).")

If your project alters in nature or scope, please contact the IRB right away. If you have any questions, I'm happy to assist.

Best wishes,

Andrea McDowell, PhD
IRB Administrator

cc: Dr. Benjamin Miller, Faculty Mentor

901 12th Avenue | P.O. Box 222000 | Seattle, WA 98122-1090

**Figure B2**

*Hospital Approval*


February 2, 2023

Re: EvergreenHealth Research Steering Committee Approval/Acknowledgement for **Evaluating an Awake Prone Positioning Protocol at a Community Hospital**

To whom it may concern,

The above-mentioned study has been processed through EvergreenHealth's Research Steering Committee and authorized by our Research Department for submission to the IRB for review if needed. For any questions or concerns regarding the study submission, please contact Anhaita Jamula at 425-899-5385 or ACJamula@evergreenhealthcare.org.

Kind regards,

Anhaita Jamula, Research Director & RSC Chair
EvergreenHealth