Fall 12-14-2021

Patients with COVID-19 and Prone Positioning: An Integrative Review

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Abstract

Aim: Describe nursing research that has studied prone positioning in patients with COVID-19 and the outcomes.

Background: Prone positioning has been a well-studied intervention in patients experiencing acute respiratory distress syndrome. The intervention has proven to provide beneficial physiological effects.

Methods: A comprehensive literature search was conducted using electronic databases. Key search terms were: *Covid-19, Coronavirus, outcomes, and prone position*. Inclusion and exclusion criteria were outlined and the articles examined for each. Whittemore and Knafl's (2005) integrative approach was used to conduct this review.

Discussion: This review evaluated the different criteria physicians utilized in their decision to implement prone positioning in patients with COVID-19; the onset, duration, and frequency of the intervention; and the patient outcomes. This information provides members of the healthcare team with the knowledge to create and implement policy that supports best practice.

Conclusion: This review examined evidence of prone positioning in patients with COVID-19. The beneficial effects of prone positioning in patients with COVID-19 were identified as well as the potential limitations. The review also acknowledged where additional research is needed to further the understanding and improve the implementation of prone positioning in patients with COVID-19.

Keywords: Covid-19, Coronavirus, outcomes, and prone position

Patients with COVID-19 and Prone Positioning: An Integrative Review

The Centers for Disease Control and Prevention (CDC) stated that in February of 2020 the first case of the respiratory disease known as COVID-19 was reported in the United States (2020). Shortly afterwards by March of 2020, they reported that all 50 states in the United States (U.S.) had cases of COVID-19. By April 7th, 2020 a total of 395,926 COVID-19 cases were reported in the U.S. and the estimated nationwide case doubling time was approximately six and half days.

The community transmission of COVID-19 posed a huge threat to public health (CDC, 2020). The unprecedented pandemic put some health systems under immense pressure and stretched others beyond their capacity (World Health Organization [WHO]; 2020). While the U.S. contains only 4% of the world's population, by July 16th of 2020, the U.S. had approximately 26% of the world's COVID-19 cases and 24% of its COVID-19 deaths (Blumenthal et al., 2020). Consequently, U.S. healthcare workers had to adapt their practices quickly in an effort to challenge and overcome the impacts of COVID-19 (CDC, 2020).

The SARS-CoV-2 is the virus that causes COVID-19 and is primarily transmitted by respiratory droplets (CDC, 2020). Some COVID-19 patients required hospitalization due to respiratory decline emanating from pneumonia as a complication of the virus (Murthy et al., 2020). Galiatsatos (2020) noted in those patients who have multiple comorbidities, advanced age, or immunosuppression, pneumonia has the high potential to develop into acute respiratory distress syndrome (ARDS). As a result of increasing cases of pneumonia, many medical facilities in the U.S. began implementing prone positioning as a method of improving gas exchange in patients with ARDS (Murthy et al., 2020).

Understanding the pathophysiology behind ARDS begins with knowing that gas exchange occurs within the tiny air sacs in the lungs called alveoli (Mayo Clinic, 2020). The Mayo Clinic (2020) provided a useful understanding of the pathophysiology behind ARDS. The process described begins with an understanding of the alveoli becoming fluid filled due to damage from infection, such as COVID-19 pneumonia, creating a compromise to the gas exchange in the alveoli. Following a compromise in normal gas exchange, an inadequate amount of oxygen is delivered throughout the body to vital organs and tissue. Acute respiratory distress syndrome is characterized by the alveolar damage and the resulting mismatch between ventilation and perfusion causing hypoxia (Penn Medicine Physicians, 2020). Improper oxygenation and ventilation creates severe distress and eventually death when left untreated.

Global Data Healthcare (2020) reported an estimated 80% mortality rate for COVID-19 related to ARDS. Statistics revealed that one in six patients with COVID-19 experienced difficulty breathing; and of those patients, 40% developed ARDS. Acute respiratory distress syndrome is considered a life-threatening condition that carries a high mortality rate, with few effective therapeutic practices known to treat the condition (Diamond et al., 2021).

Prone positioning has been a well-studied and recommended treatment method for ARDS since it was first proposed in the 1970s (Scholten et al., 2016). Prone positioning requires a patient to be placed on their stomach contrary to the typical supine position where a patient is left lying on their back. Scholten et al. (2016) described the pathophysiology of a patent in the supine position where gravity compresses the lungs causing alveolar collapse in the posterior part of the lung and increasing the difficulty of gas exchange in the alveoli. Furthermore, due to gravity, the blood is naturally pulled toward the poorly oxygenated alveoli in the posterior portion of the lung, creating a ventilation/perfusion mismatch (Penn Medicine Physicians, 2020). They noted that due to gravity the prone position allows for an increase in the volume and distribution of air, decreasing the probability of alveolar collapse and improving oxygenation and ventilation.

This literature review explored current studies that analyzed the utilization and outcomes of prone positioning in patients diagnosed with COVID-19. Existing literature was explored to evaluate prone positioning in ventilated and non-ventilated patients, duration of proning sessions, and outcomes related to placing patients with COVID-19 in the prone position. The specific aim of this integrative review was to identify the ideal duration for proning patients who have tested positive for COVID-19 in order to achieve the most favorable outcome for the patient.

When the pandemic peaked, healthcare systems throughout the nation became overwhelmed with a surge of patients infected with COVID-19 (Paul et al. 2020). While proning was a known intervention for ARDS, it often was implemented in patients requiring mechanical ventilation. The outcomes of patients requiring mechanical ventilation due to COVID-19 were highly variable and mostly dismal (Yang et al. 2020). Koulouras et al. (2016) found that early use of prone positioning decreased mortality in ARDS patients. This decrease in mortality prompted the examination of awake prone positioning and the evaluation of prone positioning at different stages of a patient's clinical course.

Methods

An integrative review was conducted on published literature related to COVID-19 and prone positioning. The Whittemore and Knafl (2005) approach was utilized for this integrative review process. The approach consisted of five stages: problem identification, literature search, data evaluation, data analysis, and presentation. This methodology allowed for a wide search of current articles, analysis of the diverse collection of articles, and then synthesis of the current evidence.

Problem Identification Stage

The problem identification stage identifies the specific problem by clarifying the purpose and objective of the research (Whittemore & Knafl, 2005). The focus of this integrative review was to provide evidence on the utilization of prone positioning in COVID-19 patients and the outcome. The following research questions guided this review and aided in identifying the problem:

- What are the identified markers or criteria considered before implementing prone positioning of patients with COVID-19?
- At what point or time in the patient's hospital course or diagnosis of COVID-19 was prone positioning implemented?
- What was the protocol for the duration and frequency of proning sessions?
- What were the patient outcomes after undergoing prone positioning?
- What factors interfered or limited prone positioning?

The intent of this integrative review is to identify successful implementation procedures for prone positioning in COVID-19 patients. The knowledge gained from this review will help the medical team caring for COVID-19 patients enhance the care they deliver. By synthesizing the current literature in this integrative review, gaps in the research will be identified and a focus for future studies acknowledged.

Literature Search

After identifying the problem, a literature search was conducted to obtain relevant literature on the topic, and a detailed record of this process needs to be described (Whittemore & Knafl 2005). Data collection was conducted from January to May of 2021. The comprehensive literature search was conducted using the following electronic databases: CINAHL, Ebsco Host, Complimentary Index, Medline, PubMed, and Academic Search Complete. The key search terms included: *Covid-19, Coronavirus, outcomes, and prone position*. The inclusion criteria for the studies were articles published from 2020-2021, articles written in English, availability of full text articles, and studies focused on evaluating how prone positioning affected patients with confirmed COVID-19 infections. Articles were excluded if they were written in other languages, full text articles were not available, and if the articles were not focused on how prone positioning in COVID-19 patients affected their outcome. Proquest RefWorks management software was utilized to save and categorize each article.

The initial search produced 175 articles using the search terms listed above. There was a total of 53 duplicates removed resulting in 129 individual articles. A title review was then conducted utilizing the inclusion criteria and an additional 103 articles were excluded resulting in 23 articles for further evaluation. After reviewing the abstracts of the final 23 articles, an additional 9 articles were removed based on the exclusion criteria. Fourteen abstracts (Padrao et al., 2020; Cohen et al., 2020; Portiuncula Hospital, 2020; Caputo et al., 2020; Xu et al., 2020; Bastoni et al., 2020; Francisco et al., 2020; Paul et al., 2020; Rodriguez-Huerta et al., 2020; Karpov et al., 2020; Shelhamer et al., 2020; Wendt et al., 2020; Garcia et al., 2020; Araujo et al., 2021) met the inclusion criteria and were further read and evaluated in their entire context. A Prisma flow diagram (Figure 1) details the data collection process by mapping out the number of records identified, included and excluded, and the reasons for exclusions.

Data Evaluation Stage

The data evaluation stage entails assessing the data within the articles considered for the integrated review. The 14 articles meeting the inclusion criteria were evaluated using the Johns Hopkins Nursing Evidence-Based Practice (JHNEBP) research appraisal tool (Table 1). The

JHNEBP appraisal tool was utilized to evaluate the level of evidence and quality of evidence in each article (Health Sciences Library, 2021). During this process four of the 14 articles were found to be of low quality due to an insufficient sample size and limited evidence. Excluding these four articles resulted in 10 articles to further extract specific study findings. Additionally, during this process three of the remaining 10 articles (Francisco et al., 2020; Rodriguez-Huerta et al., 2020; Garcia et al., 2020) were removed due to exclusion criteria. While each of the three studies addressed the effect of prone positioning in patients with COVID-19, the patient outcomes were not the main focus of the study, or additional factors, such as the inclusion of extracorporeal membrane oxygenation (ECMO) was not a consistent variable under consideration in our research. Garcia et al. (2020) studied prone positioning uniquely in ECMO patients with COVID-19. ECMO is a life supporting treatment that was not a consideration in this integrative review.

Of the seven remaining studies, four were appraised to be of good quality and three articles were appraised to be of high quality. Each of the seven studies were ranked on the level of evidence using a 7-level scale. The articles presented diverse levels of research evidence: two articles (Padrao et al., 2020; Shelhamer et al., 2020) were appraised as a level I (experimental); one article (Karpov et al., 2020) appraised as a level II (quasi-experimental); and four articles (Caputo et al., 2020; Xu et al., 2020; Wendt et al., 2020; Araujo et al., 2021) appraised as a level III (non-experimental) (Appendix, Table A1). The levels of evidence represent the strength of evidence in terms of the rigor of the research supporting the informational materials and its recommendations (Health Sciences Library, 2021).

Data Analysis Stage

During this stage, findings from the primary sources were organized and summarized based on the proposed research question (Whittemore & Knalf, 2005). Table 2 demonstrates the focus of each research question that guided this review including: criteria, initiation, duration, outcomes, and factors interfering. The data was extracted from the primary sources and organized in the table to aid in the synthesis and analysis of the data.

Review Presentation Stage

The final stage is the data presentation. During this stage the findings gathered from each primary source are exhibited to support the conclusion of the review (Whittemore &Knalf, 2005). The findings from the primary sources were synthesized, summarized, and recorded under the following subheadings: criteria outlined for prone positioning, initiation of prone positioning, duration of prone positioning sessions, outcomes of prone positioning, and factors interfering or limiting prone positioning. A summary of the results is displayed in Table 3. Identifying the data and evidence in each current study provides a summarization about what has been researched and what is known about prone positioning in patients with COVID-19.

Results

The results of the primary sources of this review encompassed the criteria for prone positioning, the initiation and duration of prone positioning, the outcomes of prone positioning, and the factors interfering or limiting prone positioning in patients with COVID-19.

Research Population

Participants in the research studies were described in terms of age, sex, race or ethnicity, and the existence of co-morbidities. All of the participants were at least 17 years old and the median age in years in each study was 58 (Padrao et al., 2020), 59 (Caputo et al., 2020), 51 (Xu et al., 2020), 71 (Karpov et al., 2020), 60 (Shelhamer et al., 2020), and 62 (Wendt et al., 2020). Participants were of the male sex in a majority of the studies comprising 67% (Padrao et al., 2020), 60% (Caputo et al., 2020), 75% (Karpov et al., 2020), 68% (Shelhamer et al., 2020) and 87% (Wendt et al., 2020) of the study's populations. Xu et al. (2020) reported the male sex comprised 50% of their population. Not all of the studies described participants' race or ethnicity (Padrao et al., 2020; Caputo et al., 2020; Xu et al., 2020; Karpov et al., 2020). Of the studies that did detail the participants' race or ethnicity the following was reported 61% Hispanic, 19% Black, 20% other (Shelhamer et al., 2020), 55% Hispanic, 23% White, 10% Asian, 6% African American, and 6% unspecified (Wendt et al., 2020).

Participants were also described by the existence of co-morbidities. A co-morbidity is the presence of more than one disease or illness that can impact the primary condition of concern, the COVID-19 infection, progression. Of the comorbidities reported in Padrao et al. (2020) study, the following were present in more than 15% of the population: hypertension in 54%, diabetes in 35%, and 33% reported to be a current or previous smoker. Xu et al. (2020) also reported diabetes in 20% of their population and hypertension in 40%. Karpov et al. (2020) reported hypertension in 75%, diabetes in 50%, dyslipidemia in 50%, and coronary artery disease and obesity in 25%. Shelhamer et al. (2020) reported 43.5% of their population with diabetes and 16.1% with obstructive lung disease, COPD or asthma. The studies that did not report the participants' co-morbidities include Caputo et al. (2020) and Wendt et al. (2020).

Criteria for Prone Positioning

Prone positioning in the acute care setting is a prescribed intervention. Identifying the criteria for subject selection for prone positioning is critical in understanding the precipitating condition that warrants the need for prone positioning. All seven studies were of the adult population, subjects at least 17 years or older. All of the participants in the seven studies had confirmed or suspected COVID-19 infections. Four of the articles (Padrao et al., 2020; Caputo et al., 2020; Xu et al., 2020; Wendt et al., 2020) studied awake prone positioning, two of the articles (Shelhamer et al., 2020; Araujo et al., 2021) studied prone positioning in mechanically ventilated patients, and one article (Karpov et al., 2020) studied awake prone positioning post-extubation.

All four articles that studied awake prone positioning required the utilization of supplemental oxygen (Caputo et al., 2020; Wendt et al., 2020) in various volumes: oxygen with a flow rate of 3 L/min or greater (Padrao et al., 2020), and oxygen delivered via a high flow nasal cannula (Xu et al., 2020). Two of the studies (Caputo et al., 2020; Wendt et al., 2020) also identified the following criteria: patient presents with hypoxia on room air as defined by a pulse oximetry less than 90%; a pre-prone pulse oximetry of less than 94% despite the use of supplemental oxygen; and the ability of the patient to self-prone (Caputo et al., 2020) and tolerate prone positioning for at least 30 minutes (Wendt et al., 2020). Additionally, Padrao et al. (2020) required a respiratory rate of 24 bpm or greater, and Xu et al. (2020) required a PaO2/FiO2 ratio of less than 300 mmHG.

Two of the articles studied prone positioning in mechanically ventilated patients. Araujo et al. (2021) identified the following as the criteria most studies adopted to support their decision-making concerning the implementation of prone positioning: PaO2/FiO2 ratio, oxygen saturation, and respiratory rate. Shelhamer et al. (2020) provided more specific values when they identified their criteria for prone positioning as a PaO2/FiO2 ratio less than or equal 150 mmHG, a PEEP of greater than or equal to 10 cm of water, and an FiO2 greater than or equal to 60%.

Only one article studied awake prone positioning in patient's post extubation (Karpov et al., 2020). The additional criteria required in this population was that each patient underwent mechanical ventilation for a median of 25 days and were currently off the ventilator. The purpose of their research was to identify if prone positioning post-extubation decreased re-intubation rates in patients with COVID-19.

Initiation and Duration of Prone Positioning

The initiation and duration of an intervention can have a direct effect on the outcome. Three of the articles (Padrao et al., 2020; Caputo et al., 2020; Wendt et al., 2020) reported that prone positioning began in the emergency department. Furthermore**,** Wendt et al. (2020) identified the median time for the start of their population's prone positioning to be 85 minutes from the time of patient arrival. Karpov et al. (2020) studied prone positioning in patients post-extubation but did not identify whether prone positioning was utilized while the patient was still being mechanically ventilated. The two articles (Shelhamer et al., 2020; Araujo et al., 2021) that addressed prone positioning of mechanically ventilated patients did not report when the intervention was begun. The unknowns in all three of these studies do serve as limitations in the research.

For the duration of the prone positioning, all seven studies provided a reference or recommendation. For awake prone positioning patient tolerance was a large factor in the length of the session. Caputo et al. (2020) recommended 30-120 minutes per session, followed by 30-120 minutes in an alternate position. Wendt et al. (2020) reported a median duration of 200 minutes per session and did not define the frequency of sessions. Padrao et al. (2020) reported a minimum of four hours per session with two sessions per day. Xu et al. (2020) identified a target time of more than 16 hours per day with a minimum of three days guided by the patient's ability to maintain an SpO2 greater than 90%. Karpov et al. (2020) studied prone positioning in patients post-extubation and reported a median of three prone sessions, lasting 90 minutes, over two and half days. Shelhamer et al. (2020) and Araujo et al. (2021) studied prone positioning in mechanically ventilated patients and recommended 12-16 hours daily, for a minimum of three days and up to four to seven days (Shelhamer et al., 2020).

Outcomes of Prone Positioning

The outcomes of prone positioning are reported from each individual study and grouped in terms of awake prone positioning, prone positioning in mechanically ventilated patients, and awake prone positioning post-extubation.

Awake Prone Positioning

In their study of awake prone positioning patients qualified if they required supplemental oxygen with a flow rate of greater than or equal to 3L/min and had a respiratory rate greater than or equal to 24 bpm (Padrao et al., 2020). The primary outcome Padrao et al. (2020) was that 58% of patients exposed to prone positioning were intubated through 15 days compared to 49% of control patients. Improvement in gas exchange, as evidenced by improved before and after SpO2/FiO2 ratios and reduction in respiratory rate, were noted in the group placed in prone positioning (Padrao et al., 2020). Other factors contributing to the primary outcome, included duration of the prone positioning sessions. Padrao et al. (2020) reported patients were asked to stay in the prone position for at least four hours, for two sessions a day.

Caputo et al. (2020) and Wendt et al. (2020) studied awake prone positioning with the condition of a pre-prone pulse oximetry of less than 94% despite supplemental oxygen use. Neither study identified the amount of supplemental oxygen utilized. The results showed an increase in the median SpO2 following placement in the prone position. Additionally, Wendt et al. (2020) noted a decrease in the median heart rate and respiratory rate for the patient population. Both studies initiated prone positioning in the emergency department and identified the duration of their prone positioning sessions to be 30-120 minutes (Caputo et al., 2020) and a median of 200 minutes (Wendt et al., 2020). In their outcomes, Caputo et al. (2020) had 36% of the patient population intubated and Wendt et al. (2020) had 45% intubated.

Xu et al. (2020) studied awake prone positioning in patients utilizing high flow nasal cannula as the supplemental oxygen source. The initiation of prone positioning was not identified but the target time for duration was more than 16 hours per day, for a minimum of three days. The results presented a significant increase in the PaO2/FiO2 ratio after prone positioning and none of the patients in this population progressed to critical condition or necessitated intubation.

Mechanically Ventilated Prone Positioning

Shelhamer et al. (2020) and Araujo et al. (2021) studied prone position in mechanically ventilated patients. Shelhamer et al. (2020) found a significant improvement in the PaO2/FiO2 ratio and a 40% reduction in mortality with prone positioning. Additionally, the study reported a benefit to additional days of prone positioning beyond three days (Shelhamer et al. 2020). Araujo et al. (2021) reported decrease in hypoxemia, decreased mortality, and improved pulmonary artery perfusion. Neither study identified a time for initiation of the intervention but reported a duration of each prone session to be between 12-16 hours.

Awake Prone Positioning Post-extubation

The final study addressed prone positioning in post-extubation patients to decrease the rate of reintubation. Karpov et al. (2020) found that the prone positioning improved their SpO2/FiO2 ratios and decreased their heart rate and respiratory rate. Of the patient population 25% required reintubation.

Factors Interfering or Limiting Prone Positioning

The research studying awake prone positioning provided data on factors that interfered or limited patients' ability to implement prone positioning (Xu et al., 2020; Karpov et al., 2020). Of the articles reporting influences such as patient intolerance or discomfort related to the prone position, patient anxiety and the inability to change position independently (Xu et al., 2020) as well as weakness (Karpov et al., 2020) contributed. The articles that studied prone positioning in mechanically ventilated patients reported concerns with securing the airway, maintaining lines and drains (Shelhamer et al., 2020), and incidents of accidental extubation, pressure ulcers, and facial edema (Araujo et al., 2021). Thus, there were several factors noted to limit the tolerance of being in the prone position.

Discussion

Critical illness from COVID-19 often results from severe pneumonia and hypoxemia with many patients developing ARDS (Murthy et al., 2020). Prone positioning is a recognized supplemental strategy available in managing patients with ARDS (Koulouras et al., 2020). When the pandemic hit its initial peak in the United States in March and April of 2020, healthcare workers in the acute care setting quickly adopted the practice of prone positioning in an effort to improve the respiratory status of patients. The aim of this integrative review was to evaluate the utilization and outcomes of prone positioning in patients with COVID-19.

Many institutions implemented policies for initiating prone positioning for patients with COVID-19. Criteria was established to evaluate a patient's need for prone positioning. Conditions warranting prone positioning included hypoxia, reduced PaO2/FiO2 ratio, and increased respiratory rate. Additionally, every study in this review required a patients need for supplemental oxygen. Assessment of each of these measures provides an indication as to the level of respiratory distress the patient is experiencing. One of the objectives of this integrative review was to identify the criteria being considered and assessed for in each study, and to distinguish if patients being placed in the prone position with earlier indications were benefiting.

The study in which medical providers initiated prone positioning with the least amount of identified supplemental oxygen and inclusion criteria concerning respiratory status was Padrao et al. (2020). Padrao et al. (2020) did not support early application of prone positioning in benefiting patients' respiratory status as evidenced by a higher percentage of the study group (58%) requiring intubation versus the control group (49%). The other three articles (Caputo et al., 2020; Xu et al., 2020; Wendt et al., 2020) studying prone positioning in emergency department patients who were awake yielded results showing a correlation and benefit to the early implementation of prone positioning. Koulouras et al. (2016) supports early use of prone positioning in combination with lung protective strategies to decrease mortality significantly. While the results are not unanimous it can be inferred that early identification for the need of prone positioning and implementation will provide benefit to the patient's outcome.

This integrative review aimed to evaluate how the duration and frequency for prone positioning sessions impacted patients' outcomes. Few of the studies (Padrao et al., 2020; Xu et al., 2020; Karpov et al., 2020; Shelhamer et al., 2020) documented the frequency of the prone sessions and therefore little evidence exist on frequency and duration of the intervention. In awake prone positioning the duration and frequency varied depending on the patients' tolerance and other medical interventions (Caputo et al., 2020). Studies have not been found that rule on the best duration and frequency of prone positioning sessions, and tolerance of the prone positioning session is a concern (Touchon et al., 2021).

This integrative review found that the length of the prone sessions varied greatly between awake prone positioning and proning mechanically ventilated patients. The documented time for awake prone positioning ranged from a recommended 30 minutes to four hours in four of the studies (Padrao et al., 2020; Caputo et al., 2020; Karpov et al., 2020; Wendt et al., 2020). Xu et al. (2020) reported a target time of more than 16 hours per day in the prone position for awake patients. In Xu et al. study, not a single participant progressed to critical condition or required intubation contrary to the other articles studying awake prone positioning (Padrao et al., 2020; Caputo et al., 2020; Wendt et al., 2020). Although more studies need to be done, increasing the duration of the prone position session seems to provide a more favorable outcome to the patient.

In comparison, the articles studying prone positioning in the mechanically ventilated patients reported an average 12-16 hours per prone session (Shelhamer et al., 2020; Araujo et al., 2021). While improvement was noticed in their assessment measures, research exists that provides evidence of a beneficial physiological effect after the initial 16 hours in the prone position and up to 24 hours (Jochmans et al., 2020). Extending the duration of prone positioning beyond 16 hours and up to 24 hours has not been studied in mechanically ventilated patients with COVID-19 and would provide more knowledge for future best practice.

Potential factors that interfered with or limited the ability to place a patient in prone position were identified in awake prone positioning as patient intolerance or discomfort, anxiety, and weakness (Xu et al., 2020; Karpov et al., 2020). Zaretsky et al. (2021) also reported anxiety manifesting from patients in awake prone positioning often stemmed from a concern of not being able to reach anyone if necessary and becoming uncomfortable. Ensuring call buttons and cellphones were within reach reduced anxiety, and promoted safety, as well as pharmacological interventions such as the use of anxiolytics (Zaretsky et al., 2021).

Factors interfering in mechanically ventilated patients were identified as accidental extubation, maintaining lines and drains, pressures ulcers, and facial edema (Shelhamer et al., 2020; Araujo et al., 2021). Zaretsky et al. (2021) studied the utilization of a prone positioning team. The team was well educated and prepared on the implementation of the intervention in an effort to eliminate the risk of potential complications in mechanically ventilated patients.

Furthermore, despite potential complications, all efforts should be made to manage and initiate prone positioning as each of the articles demonstrated a benefit in implementing prone positioning in patients with COVID-19. Each study provided evidence that implementing prone positioning at any point in the patients' clinical course provided a physiological benefit as evidenced by decreased hypoxemia, heart rate, and respiratory rate, as well as an increase in their PaO_2/FiO_2 ratio (Padrao et al., 2020; Caputo et al., 2020; Xu et al., 2020; Karpov et al., 2020; Shelhamer et al., 2020; Wendt et al., 2020; Araujo et al., 2021).

The following limitations can be concluded from this integrative review. Not all of the study populations were described in terms of race or ethnicity, and the existence of comorbidities (Padrao et al., 2020; Caputo et al., 2020; Xu et al., 2020; Karpov et al., 2020; Wendt et al., 2020; Araujo et al., 2021). Therefore, we are unable to conclude if the study populations were uniform across all research. The different characteristics of each population and presence of co-morbidities can impact the success and outcome of the intervention (Galiatsatos, 2020). Additionally, many of the studies did not contain all components of our research questions including: initiation, duration and frequency of the prone positioning sessions (Xu et al., 2020; Shelhamer et al., 2020; Wendt et al., 2020; Araujo et al., 2021). Inferences were made on what data was available amongst the research keeping in consideration this restraint. Finally, not all studies reported statistical findings but rather generalized their results by stating improvements in various assessment measures without detailing specific benchmarks (Xu et al., 2020; Araujo et al., 2021).

The COVID-19 pandemic presented a large challenge to healthcare systems as many patients exposed to the infection that required hospitalization were deteriorating rapidly and requiring increased respiratory support. Prone positioning became a large part of the treatment protocol for those infected with COVID-19, but its implementation was a fairly unknown method to so many in the healthcare field. Guerin et al. (2020) explains that for many years prone positioning was only utilized as a rescue therapy for severe hypoxemia. Prior to the COVID-19 pandemic Guerin et al. (2020) conducted a study that found a reduction in mortality from 41% to 23.6% after employing prone positioning in patients with severe ARDS. Furthermore, Guerin et al. (2020) states that preliminary studies of prone positioning have consistently demonstrated improvement in oxygenation across all severities of acute respiratory failure.

The evidence has confirmed implementing prone positioning in patients with COVID-19 provides a benefit to their clinical progression. Additionally, health care institutions should strive to implement awake prone positioning in their COVID-19 patients at the earliest indication of respiratory compromise to help prevent and delay the need for mechanical ventilation. The optimal frequency and duration of prone positioning sessions is still uncertain but the evidence supports an increase in the duration and number of sessions to positively impact the patient's outcome. Based on the findings in this integrative review a prone positioning session should aim to be a minimum of 12-16 hours and employed for a minimum of three days with the intention to extend either parameter when possible.

Additional research is needed on this topic to further understand prone positioning in patients with COVID-19. Research is needed to focus on the different components of prone positioning, the initiation, duration, and frequency, to evaluate its effectiveness and variance in patient outcomes. Further research on preventing or managing the factors outlined in this study that limit prone positioning would also serve to be beneficial in promoting the implementation of the intervention. With future supporting evidence, policies can be created and implemented throughout healthcare institutions to ensure a standard is established for delivering optimal, safe, evidenced-based care. Education on prone positioning in patients with COVID-19 throughout health care institutions supports the delivery of safe-evidenced base care. Additionally, proper education ensures each health care member is adequately prepared to give every patient the same standard of quality care.

Conclusion

The implementation of prone positioning in patients with COVID-19 has proven to be beneficial. Assessment measures including SpO2, PaO2/FiO2 ratio, and respiratory rate should be monitored to identify when a patient with COVID-19 will benefit from prone positioning. The evidence supports the utilization of awake prone positioning as a therapy to improve a patient's respiratory function and decrease the probability of the need for mechanical ventilation. Additionally, in patient's mechanically ventilated, prone positioning decreases mortality.

There is currently not enough evidence available to confirm the timing for the duration and frequency of each prone session needed to achieve optimal outcomes in patients with COVID-19. As this is still a fairly new subject in the field of medicine, further research will be needed to identify the various components of prone positioning in patients with COVID-19 to enhance the delivery of the intervention. We can conclude from this integrative review that the earliest initiation of prone positioning and prolonging the duration of each prone positioning session will serve to be a benefit to the patient with COVID-19.

References

Araújo, M. S. D., Santos, Marina Marisa Palhano Dos, Silva, Carlos Jordão De Assis, Menezes, Rejane Maria Paiva De, Feijão, A. R., & Medeiros, S. M. D. (2021). Prone positioning as an emerging tool in the care provided to patients infected with COVID-19: A scoping review. *Revista Latino-Americana De Enfermagem, 29*, e3397. doi:10.1590/1518-8345.4732.3397

Blumenthal, D., Fowler, E., Abrams, M., & Collins, S. (2020, October 8). COVID-19 implications for the health care system. *The New England Journal of Medicine*. https://www.nejm.org/doi/full/10.1056/nejmsb2021088

Caputo, N. D., Strayer, R. J., Levitan, R., & Kline, J. (2020). Early self-proning in awake, non-intubated patients in the emergency department: A single ED's experience during the COVID-19 pandemic. *Academic Emergency Medicine*, *27*(5), 375-378. doi:10.1111/acem.13994

Centers for Disease Control and Prevention. (2020, April 16). *Geographic differences in COVID-19 cases, deaths, and incidence.* https://www.cdc.gov/mmwr/volumes/69/wr/mm6915e4.htm#:%7E:text=Community%20transmission%20of%20COVID%2D,of%20COVID%2D19

Diamond, M., Peniston, H., Sanghavi, D., & Mahapatra, S. (2021, July 25). *Acute respiratory distress syndrome*. NCBI. https://www.ncbi.nlm.nih.gov/books/NBK436002/

Galiatsatos, P. (2020, April 13). What coronavirus does to the lungs. Retrieved from https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/what-coronavirus-does-to-the-lungs

Global Data Healthcare. (2020, May 6). *ARDS treatments are important for severe Covid-19*. https://www.pharmaceutical-technology.com/comment/ards-treatment-covid-19/

Guerin, C., Albert, R., Beitler, J., Gattinoni, L., Jaber, S., Marini, J., Munshi, L., Papazian, L., Pesenti, A., Vieillard-Baron, A., & Mancebo, J. (2020, November 10). *Prone position in ARDS patients: why, when, how and for whom*. US National Library of Medicine National Institutes of Health. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7652705/

Health Sciences Library. (2021). *Subject guides: Johns Hopkins nursing evidence-based practice: Johns Hopkins nursing EBP toolkit*. Upstate Medical University. https://guides.upstate.edu/c.php?g=1023176&p=7411265

Jochmans, S., Mazerand, S., Chelly, J., Pourcine, F., Sy, O., Thieulot-Rolin, N., Ellrodt, O., Mercier Des Rochettes, E., Michaud, G., Serbouce-Goguel, J., Vinsonneau, C., van Phach Vong, L., & Monchi, M. (2020, May 24). *Duration of prone position sessions: a prospective cohort study*. US National Library of Medicine National Institutes of Health. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7245995/

Karpov, A., Mitra, A. R., Crowe, S., & Haljan, G. (2020). Prone position after liberation from prolonged mechanical ventilation in COVID-19 respiratory failure. *Critical Care Research and Practice*, *2020*, 6688120. doi:10.1155/2020/6688120

Koulouras, V., Papathanakos, G., Papathanasiou, A., & Nakos, G. (2016, May 4). *Efficacy of prone position in acute respiratory distress syndrome patients: A pathophysiology-based review*. US National Library of Medicine National Institutes of Health. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4848155/

Mayo Clinic. (2020, June 13). *ARDS - Symptoms and causes*. https://www.mayoclinic.org/diseases-conditions/ards/symptoms-causes/syc-

20355576#:%7E:text=Acute%20respiratory%20distress%20syndrome%20(ARDS,oxygen%20they%20need%20to%20function.

Murthy S, Gomersall CD, Fowler R.A. Care for critically ill patients with COVID-19. *JAMA-J Am Med Assoc.* 2020; 323(15):1 499-500.

Padrão, E. M. H., Valente, F. S., Besen, Bruno A. M. P, Rahhal, H., Mesquita, P. S., Alencar, J. C. G., . . . Hiestand, B. (2020). Awake prone positioning in COVID-19 hypoxemic respiratory failure: Exploratory findings in a single-center retrospective cohort study. *Academic Emergency Medicine, 27*(12), 1249-1259. doi:10.1111/acem.14160

Paul, V., Patel, S., Royse, M., Odish, M., Malhotra, A., & Koenig, S. (2020). Proning in non-intubated (PINI) in times of COVID-19: Case series and a review. *Journal of Intensive Care Medicine, 35*(8), 818-824. doi:10.1177/0885066620934801

Penn Medicine Physicians. (2020, October 24). Proning during COVID-19 - Penn Medicine. https://www.pennmedicine.org/updates/blogs/penn-physician-blog/2020/may/proning-during-covid19

Scholten, E., Beitler, J., Prisk, G., & Malhotra, A. (2016, July 8). Treatment of ARDS with prone positioning. *US National Library of Medicine National Institutes of Health.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6026253/

Shelhamer, M. C., Wesson, P. D., Solari, I. L., Jensen, D. L., Steele, W. A., Dimitrov, V. G., . . . Baxi, S. M. (2021). Prone positioning in moderate to severe acute respiratory distress syndrome due to COVID-19: A cohort study and analysis of physiology. *Journal of Intensive Care Medicine, 36*(2), 241-252. doi:10.1177/0885066620980399

Touchon, F., Trigui, Y., Prud'homme, E., Lefebvre, L., Giraud, A., Dols, A., Martinez, S., Bernardi, M., Begne, C., Granier, P., Chanez, P., Forel, J., Papazian, L., & Elharrar, X.

(2021, June 30). *Awake prone positioning for hypoxaemic respiratory failure: past, COVID-19 and perspectives*. European Respiratory Society. https://err.ersjournals.com/content/30/160/210022

Wendt, C., Mobus, K., Weiner, D., Eskin, B., & Allegra, J. R. (2021). Prone positioning of patients with coronavirus disease 2019 who are nonintubated in hypoxic respiratory distress: Single-site retrospective health records review. *Journal of Emergency Nursing, 47*(2), 279-287.e1. doi:10.1016/j.jen.2020.12.006

Whittemore, R, & Knalf, K. (2005). The integrative review: updated methodology. *Journal of Advanced Nursing* 52, 546-553

World Health Organization. (2020, July 30). *Attacks on health care in the context of COVID-19*. https://www.who.int/news-room/feature-stories/detail/attacks-on-health-care-in-the-context-of-covid-19

Xu, Q., Wang, T., Qin, X., Jie, Y., Zha, L., & Lu, W. (2020). Early awake prone position combined with high-flow nasal oxygen therapy in severe COVID-19: A case series. *Critical Care (London, England), 24*(1), 250. doi:10.1186/s13054-020-02991-7

Yang X, Yu Y, Xu J, et al. (2020). Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med*. 8(5):475-481

Zaretsky, J., Corcoran, J., Savage, E., Berke, J., Herbsman, J., Fischer, M., Kmita, D., Laverty, P., Sweeney, G., & Horwitz, L. (2021, September 16). Increasing rates of prone positioning in acute care patients with COVID-19. *ScienceDirect*. https://www.sciencedirect.com/science/article/pii/S1553725021002373

Table 1

Johns Hopkins Nursing Evidence-based Practice Tool

Article Number	Author and Date	Research Design	Sample, Sample Size, Setting	Findings That Help Answer the EBP Question	Observable Measures	Limitations	Evidence Level, Quality
1	Padrao et al., 2020	Retrospective cohort study	Covid-19 patients admitted off mechanical ventilation, requiring more than 3L/min of o2, and RR >24 from March 1 – April 2020. Size: 166 patients. Emergency Department at a Sao Paulo hospital.	A beneficial physiologic improvement in gas exchange with a greater than 50% rate of responders to awake prone positioning; however, there was no significant result of a beneficial effect in intubation rates through 15 dates.	Effect of prone positioning on oxygenation, vital signs (respiratory rate, peripheral oxygen saturation, heart rate, systolic arterial pressure), and oxygen flow rate before and after proning. Primary outcome was orotracheal intubation up to 15 days after inclusion. Secondary outcomes included days alive and free of mechanical ventilation at 15 days, need for dialysis, need for vasoactive drugs, and ICU admission.	Being a retrospective study, no granular data on arterial blood gases analysis before and after proning sessions. Unable to blind the data collection. Did not assess effects of awake prone positioning with more advanced noninvasive methods of respiratory support. No pre-study written of awake prone positioning protocol.	Level I Good Quality
2	Cohen et al., 2020	Non-experimental	Two case reports of moderate coronavirus disease patients, suffering from hypoxemia	Early application of awake prone positioning in mild to moderate COVID-19 patients improves oxygenation and may avoid intubation and deterioration to severe disease.	Oxygenation saturation and respiratory support	No control group, small sample size	Level III Low Quality
3	Portiuncula Hospital, 2020	Non-experimental	One case study	Immediate observation that proning optimized the ventilation to perfusion ratio (V/Q) which improved	Oxygenation saturation. V/Q and PFR	No control group, small sample size	Level III Low Quality

				oxygenation and PFR. Patient experienced a positive outcome which can be attributed to the early intervention of a proning protocol.			
4	Caputo et al., 2020	Non-experimental	Adult patients >/= 18 years of age with a confirmed SARS-CoV-2 infection, who presented to the ED with hypoxia and without resolution despite supplemental oxygen and who were capable of self proning from March 1st to April 1st 2020. Excluded DNR/DNI code status, cardiac arrest, non-invasive ventilation, or intubated patients. Size: 50 patients. Urban, academic ED in New York City, USA	After 5 minutes of proning, the median SPO2 increased from 80% to 94%. 13 of the 50 patients still required intubation in the first 24 hours. Later. 5/ 37 remaining patients who were not intubated initially were intubated between 24 and 72 hours.	Oxygen saturation. SpO2 through standard finger oximeters	The patients described come from a convenience sample presenting to a single hospital and therefore may not represent other populations or the population at large.	Level III Good Quality
5	Xu et al., 2020	Retrospective observation study	10 patients between 3 hospitals in Wuhu and Manshan cities in Anhui Province graded to have severe diagnosis of COVID-19 from January 1 to April 2, 2020. Male and female, age 31 to	Target time of prone positioning is more than 16 hr per day. Target SpO2 > 90%. None of the patients progressed to critical condition or needed endotracheal intubation. All patients survived.	Length of hospital stay. Baseline PF. Time from onset of illness to hospitalization.	Small sample size. Limited details of control factors.	Level III Good quality.

			65.				
6	Bastoni et al., 2020	Quasi-experimental	10 patients (8 male and 2 female, mean age 73). SpO2 < 90 % on RA and RR > 20. 6 patients completed the cycle of prone ventilation, 4 did not.	Pronation for 16-19 hrs/ day. Worsening hypoxemia and unchanged lung US. All patients were admitted to ICU and underwent cycles of proning while intubated. Patient 1 recovering in a rehab with nasal prongs, patient 2, 3, 4, 5 moved to other ICUs. Patient 6 died. Of those that refused NIV prone positioning 7, 9 and 10 died. Patient 8 recovered after time in the ICU.	Lung US and PF ratio. Survival rate.	Small sample size. Limited details of control factors.	Level II Low quality.
7	Francisco et al., 2020	Quasi-experimental	From April 27 to June 6, 2020, 198 Covid-19 patients admitted to 4 nursing units. Approx. 41 (20.7%) patients self-proned. Site was a single urban tertiary care academic medical center.	7 (3.5%) patients were transferred to ICU, 1 self -proned while on the unit while the other 3 were not eligible. 4 patients (2%) in the sample died; all 4 were not eligible for self-proning. No adverse events related to self-proning were reported.	Survey amongst nursing staff. Tracked patient progress to higher level of care or expiration.	Study did not account for staffing patterns and acuity variations in the 4 different units and how the nursing workflow might affect the nurse's ability to assist patients with self-proning. Possible lack of documentation of patients whom self-proned.	Level II Good quality
8	Paul et al., 2020	Nonexperimental	Two case studies: Two patients	In both case studies patients were non-intubated when proned and resulted in an increase in SpO2, a decrease in oxygen requirements, and discharge at baseline.	SpO2, FiO2, hours proned, length of days.	Small sample size	Level V Low quality

9	Rodriguez-Huerta et al. 2020	Nonexperimental	Conducted in an adult ICU at the "La Princesa" university Hospital in the region of Madrid (Spain). Cases from March 6 to May 31, 2020. New Covid-19 admissions eligible for prone positioning. 44 patients included.	The average number of PP maneuvers was 3+/- 2.4. 6.1% experienced episodes of vomiting. 81.3% had facial edema, 12.5% eye injuries; accidental device removal 6.1%, and ETT obstruction 3.3%. No sentinel events occurred. 60.6% developed pressure ulcers.	Total number of PP maneuvers; duration of each PP session; total cumulative hours spent in the PP per patient; AE: pressure ulcers, frequency of device removal; frequency ETT obstruction; vomiting; Sentinel events	Recording of postural changes was neither systematic or comprehensive.	Level III High quality
10	Karpov et al., 2020	Quasi-experimental	4 patients from the ICU at Surrey Memorial Hospital admitted with Covid-19 between March 1 and May 1, 2020. That underwent prone positioning after liberation from mechanical ventilation	All 4 patients responded positively with improvement in their FiO2 use, SpO2, HR, and RR. None of the 4 patients who underwent PEPP were reintubated with 7 days. One patient was reintubated on the 9th day due to loss of consciousness.	PEPP sessions durations and number. Pre and post oxygen saturation, FiO2, HR, and RR	Small sample size and short follow-up period.	Level II Good quality
11	Shelhamer et al., 2020	Experimental	New York city hospital. 335 participants; 62 in the experimental group, 199 in the control group, 74 excluded. Criteria met: adult patient > 17 years of age, intubated, confirmed Covid infection, had not undergone prone positioning by others, met criteria for prone positioning	40% reduction in mortality with prone positioning; recommended durations 12-16 hours daily; Effect seen with 4-7 days of prone positioning	Physiological parameters: PaO2, FiO2 and SpO2 compared during periods of prone and supine positioning	Study conducted in a resource constrained environment under crisis operations. Patients in critical care needs cared for by non-critical care personnel. Decision to initiate or discontinue the intervention under study was left to the treating primary team without defining endpoints.	Level I High quality

12	Wendt et al., 2020	Non-experimental	From March 30, 2020 to April 30, 2020, an emergency department EMR retrospective chart review was conducted. 440 patients with confirmed Covid-19. 50 of those patients proned. 31 met inclusion criteria. And 19 did not. Inclusion criteria was a room air pulse oximetry < 90%4 and a prepone pulse oximetry of <94% who tolerated prone positioning for at least 30 minutes.	The median time from patient arrival to PP was 85 minutes and the duration of PP was 200 minutes. The median levels of SpO2 was 83% on room air, 90 % with supplemental oxygen and 96% with PP. For 7 patients' supplemental oxygen was increased when placed in PP. Fow al 31 patients, both HR and RR showed small decreases after being placed in PP. Of the 31 patients, 14 (45%) were intubated after a median time of 35 hours. At the time of this manuscript 18 (58%) patients had been discharged home, 3 (10%) were still in the hospital, 2 (6%) were transferred to another facility, and 8 (26%) had died after a median of 8 days.	SpO2 on room air, with supplemental oxygen before and after prone positioning. Time spent in PP. HR and RR. Intubation rates, survival rates, mortality rate.	Demographics that may have limited generalizability (87% male, 55% Hispanic), variations in the time the patient remained in the prone position, inability to ascertain if the patient maintained positive effects of PP once returned to supine position	Level III High quality
13	Garcia et al., 2020	Quasi-experimental	208 Covid patients. 125 patients with ARD, 25 required VV-ECMO, and 14 patients were placed at least once in PP. PP was considered in case of severe hypoxemia as defined by a PaO2/FiO2 ratio below 80mmHg despite FiO2 at 100% and in case of extensive lung consolidation on chest imaging.	PP median duration of 16 hours. Delay to PP was 1.5 days from ECMO implantation therapy. Median PaO2/FiO2 ratio improvement after PP was 28%. No major safety concerns were observed, 6 pressure sores, 3 minor hemorrhages at the injection canula, and 3 moderate drops in VV-ECMO requiring fluid resuscitation. Patient in the prone group were less likely to be weaned from ECMO and 28-day mortality rate was	PaO2/FiO2. Ventilation settings, Gas analysis. Safety concerns.	Prone ECMO patients may be more severe that supine ECMO patients. Prone ECMO had more consolidations.	Level II Good Quality

				significantly higher.			
14	Araujo et al., 2021	Meta-synthesis	12 studies were included. 83% of the studies used PP in patients affected with severe acute respiratory failure caused by Covid-19.	The duration of PP was suggested from 12-16 hours. Outcomes included: decreased hypoxemia (83%), decreased mortality (58.3%), and improved pulmonary artery perfusion (33.3%). Of the studies composing the sample, 67% report complications in the use of PP, the most frequent were: accidental extubation, pressure ulcers, and facial edema.	Decreased hypoxemia, decreased mortality, improved pulmonary perfusion, decreased pulmonary vascular resistance, reduction of alveolar collapse, increased tidal volume, secretion mobilization.	Lack of studies in the sample with high levels of evidence, such as randomized clinical trials. This gap is explained by the fact this is a recent disease.	Level III High quality

Table 2

Summary of Findings from Research Studies

Author/Year	Criteria for prone positioning	Initiation of prone positioning	Duration and frequency of prone positioning sessions	Outcomes of prone positioning	Factors interfering or limiting prone positioning
Padrao et al., 2020	(1) Age 18 years or older (2) Confirmed or suspected COVID-19 (3) spontaneous breathing (4) respiratory rate >/= 24 bpm (5) using supplemental oxygen with a flow rate >/= 3 L/min	Emergency department	Patients asked to stay in prone position for at least 4 hours in their first session, and to be complete sessions twice daily	Primary outcome analysis, 33 of 57 patients (58%) exposed to prone positioning were intubated through 15 days compared to 53 of 109 (49%) control patients. Among patients undergoing prone positioning, observed improvement in gas exchange as measured by improved before and after SpO2/FiO2 ratios and reduction in respiratory rate	Not reported
Caputo et al., 2020	(1) age 18 years or older (2) presented to ED with hypoxia (SpO2 <90%) without resolution (SpO2 > 93%) with supplemental oxygen (3) capable of self-	Emergency department	Guided by patient wishes; recommended 30-120 minutes in prone position, followed by 30-120 minutes in the left lateral decubitus, right lateral decubitus, and upright sitting position	Median SpO2 after supplemental oxygen 84%, increased to 94% after 5 minutes of patient in prone position. Of the 50 patients 13 (24%) were intubated within the first 24 hours. Of the 37 patients not intubated	Not reported

	proning (4) confirmed COVID-19 infection			within the first 24 hours, 5 (10%) were subsequently intubated after the initial 24 hours.	
Xu et al., 2020	(1) Confirmed COVID-19 infection (2) PF < 300mmHg (3) HFNC supplemental oxygen source	Not reported	Target time was more than 16 hours per day, guided by patient tolerance. Minimum of 3 days guided by patient maintaining SpO2 > 90%	Median PF ratio elevated significantly after PP. None of the patients progressed to critical condition or required endotracheal intubation.	Main reason for patient intolerance of prone position is discomfort, anxiety, or the inability to change position independently
Karpov et al., 2020	(1) Confirmed COVID-19 infection (2) underwent mechanical ventilation median duration 25 days (3) extubated	Prone positioning post extubation	Median of 3 prone sessions, lasting 90 minutes, over 2.5 days	None of the 4 patients were reintubated within 7 days. One patient (25%) required reintubation on the 9th day. Prone position improved SpO2/FiO2 ratios, HR and reduced RR.	Patient unable to position themselves due to weakness
Shelhamer et al., 2020	(1) age 17 years or older (2) intubated (3) confirmed COVID-19 infection (4) PaO2/FiO2 </= 150 mmHg, PEEP >/= 10 cm of water, and FiO2 >/= 60%	Not reported	12-16 hours daily, minimum of 3 days, up to 4-7 days	Prone vs supine positioning significantly associated with improvement in the PF ratio. 40% reduction in mortality with prone positioning. Benefit to additional days of prone positioning beyond 3 days.	Securing airway. Maintain lines and drains; avoiding dislodging tubes and catheters.

Wendt et al., 2020	(1) confirmed COVID-19 infection (2) room air pulse oximetry < 90% (3) a prepone pulse oximetry of <94% despite supplemental oxygen (4) tolerate prone positioning for at least 30 minutes.	Emergency department. Median time from patient arrival to PP was 85 minutes.	Median duration of PP was 200 minutes	Median levels of SpO2 were 83% on room air, 90 % with supplemental oxygen, and 96% with PP. For all 31 patients, both HR and RR showed small decreases while in prone position. Mean HR and RR before PP were 93 HR and 31RR; with PP median was 88 HR and 26 RR. Of the 31 patients, 14 (45%) were intubated after a median time of 35 hours. At the time of writing the manuscript 18 (58%) of the 31 patients had been discharged home, 3 (10%) were still in the hospital, 2 (6%) had been transferred to another facility, and 8 (26%) had died.	Not reported.
Araujo et al., 2021	The PaO2/FiO2 ratio, oxygen saturation, and respiratory rate were the criteria most studies adopted to support decision-making concerning implementation of PP	Not reported	Large disagreement, most studies (57%) suggested 12 to 16 hours continuously	Decreased hypoxemia, decreased mortality and improved pulmonary artery perfusion	Accidental extubation, pressure ulcers, facial edema

Table 3

Identified Themes

Criteria for Prone Positioning

- Age of participants in studies: 17 years or older
- Confirmed or suspected COVID-19 infection
- Use of supplemental oxygen
    - Varied based on study (>/= 3 L/min, HFNC, mechanical ventilation)
- Awake proning
    - Dependent on patient tolerance, and patient ability to self-prone
- Identified markers
    - Hypoxia (SpO2 <90%) without resolution
    - Increased respiratory rate
    - PaO2/FiO2 ratio
        - Varied based on study (PF < 300, PF < 150 mmHG)
    - Ventilator requirements
        - PEEP >/= 10 cm of water, FiO2 >/= 60%
- Post extubation proning
    - Underwent mechanical ventilation for a median of 25 days

Initiation of Prone Positioning

- Emergency department
    - Documented median time for one study was 85 minutes
- Following extubation
- Exact time not documented in numerous studies

Duration of Prone Positioning Sessions

- Awake prone positioning
    - Guided by patient wishes and tolerance
    - Recommended 30-120 minutes
    - Asked to remain in prone position for at least 4 hours, twice daily
    - More than 16 hours per day, 3 days minimum
    - Median duration 200 minutes
- Mechanical ventilation
    - 12-16 hours, minimum 3 days, increased benefit with longer duration

Outcomes of Prone Positioning

• Decreased hypoxemia
  ○ SpO2 90% on supplemental oxygen, 96% with PP
  ○ SpO2 84% on supplemental oxygen, 94% with PP
• Decreased HR and RR
• Improved SpO2/FiO2 ratio
• Decreased mortality
  ○ 40% reduction
• Improved pulmonary artery perfusion

Factors Interfering or limiting Prone Positioning

• Awake proning
  ○ Patient intolerance/discomfort
  ○ Anxiety
  ○ Inability to change positions independently/ weakness
• Mechanical ventilation
  ○ Securing airway
    ▪ Accidental extubation
  ○ Maintaining lines and drains
  ○ Pressure ulcers
  ○ Facial edema

Figure 1

Data Collection/ Prisma Flow Diagram