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The Application of Prone Position to Improving Pulmonary Ventilation in COVID-19 Cases Treated in The ICU: Literature Review †

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Abstract: An outbreak of a novel form of pneumonia due to a coronavirus occurred in Wuhan City, Hubei Province, China, in December 2019, and the disease was officially named coronavirus 2019 (COVID-19). COVID-19 is an infectious disease caused by the SARS-CoV-2 virus which attacks the human respiratory system. In critical cases of COVID-19, special treatment is administered in the ICU using a mechanical ventilator. However, since the results are less than optimal, additional interventions such as orienting the patient in the prone position can be employed, as this can reduce the pressure on the dorsal lung area so that alveolar recruitment can be improved. This study examines the effect of the prone position on increasing pulmonary ventilation. This study is a literature review study employing a narrative method and was conducted by tracing and analyzing articles relevant to the topic. This literature review searched three databases, namely, PubMed, Google Scholar, and ProQuest using the keywords "COVID-19 OR intubated COVID-19" AND "prone position OR mechanical ventilator" AND "Lung ventilation". From these databases, 1062 journals were found and filtered based on inclusion and exclusion criteria, resulting in the inclusion of 10 journals. Then, they were filtered again using a critical appraisal instrument called "JBI Critical Appraisal", which was conducted by two people, N.P. and A.S.; consequently, the results of 5 journals were obtained for further analysis; cumulatively, these papers represented a total population of 1789 patients. It was concluded that the prone position can improve pulmonary ventilation by up to 50% and reduce the total length of stay by up to 5 days in the hospital, as long as the patients do not possess any comorbid diseases.

Keywords: COVID-19; prone position; mechanical ventilator; pulmonary ventilation

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1. Introduction

An outbreak of a novel form of pneumonia due to a coronavirus occurred in Wuhan City, Hubei Province, China, in December 2019, and the disease was officially named coronavirus 2019 (COVID-19) by the World Health Organization (WHO) on 12 February 2020 [1]. COVID-19 is an infectious disease that is caused by the SARS-CoV-2 virus. The virus can be spread from the mouth or nose of an infected person in tiny fluid particles when they cough, sneeze, talk, sing, or breathe [2].

COVID-19 cases are divided into several classifications depending on the severity. Critical COVID-19 cases that are treated in the Intensive Care Unit (ICU) are those with symptoms such as sputum retention, a PaO_2/FiO_2 concentration <300, a SpO_2 concentration of 90%, persistent hypoxemia, and respiratory organ failure [3]. A decreased PaO_2/FiO_2 concentration is the result of damage to the alveoli that causes a decrease in gas exchange or pulmonary ventilation, which can ultimately decrease oxygen saturation in the blood.

To deal with this problem, patients are treated in the ICU using a mechanical ventilator. Mechanical ventilation in the ICU room can increase Positive End Expiratory Pressure (PEEP), reduce sputum with the help of suction, and increase pulmonary ventilation [4]. However, increased pulmonary ventilation will not lead to optimal results if only using a mechanical ventilator—the application of the prone position is required, whose combination with the use of a mechanical ventilator can influence the PaO_2/FiO_2 value and pulmonary compliance, which is expected to reduce hospitalization time and mortality [5]. There is a provision determining the position of the patient in a prone lying state; specifically, the recommended position is the swimmer's position.

Based on this, there is research interest in discussing the effect of the prone position on increasing pulmonary ventilation in COVID-19 cases treated in the ICU using a mechanical ventilator.

2. Research Methods

The authors will discuss or review the existing literature by classifying or identifying elements from several studies that discuss similar topics.

The data used in this study are secondary data that are not obtained from direct observation but from the results of research that has been carried out by previous researchers. The sourcing of the secondary data obtained consisting of the literature relevant to the topic was carried out using the PubMed, Google Scholar, and ProQuest databases. The search was carried out using the keywords "COVID-19 OR intubated COVID-19" AND "prone position OR mechanical ventilator" AND "Mechanical Ventilator without Prone Position" AND "Lung ventilator OR hospital length of stay".

3. Results

The researchers found 1062 articles that matched the specified keywords. Then, the journals were filtered by title and abstract, resulting in 10 remaining journals. The journals were then filtered using critical appraisal conducted by two people and employing the instrument JBI Critical Appraisal Tools; consequently, the results of five journals were retained for further analysis.

Maintaining the prone position for 18 h and 36 h can affect lung ventilation. This can be measured using Blood Gas Analysis (BGA), which shows an increase in PaO_2 (p value < 0.001) and PaO_2/FiO_2 (p value < 0.01) concentrations (Table 1) [6,7].

Table 1. Results regarding PaO_2 and PaO_2/FiO_2 concentration after lying in prone position [6,7].

Parameter (mmHg)	Supine Position	Prone Position
PaO_2	85 (±21)	142 (±90)
PaO_2/FiO_2	110–190	120–240

This result is quite different from other studies that examine samples with comorbid diseases, wherein if there are comorbidities, there is no decrease in the lung severity score (p value < 0.02) (Table 2). This resulted in the death of 17 out of the 23 samples used [8].

Table 2. Lung Severity Score Result [8].

Timeline	Deceased Patients' Score	Living Patients' Score
	Middle Lobe	
Pre-Prone	2.0	2.5
Post-Prone	0.4	−0.2
Follow-up 48 h	0.2	−0.2
	Lower Lobe	
Pre-Prone	2.3	3.5
Post-Prone	0.4	−0.7
48 h Follow-up	0.1	−1.0

The absence of a decrease in lung severity has an impact on the ineffectiveness of the prone position; specifically, this variable pulmonary ventilation did not increase significantly after a 48 h follow-up (Table 3) [8].

Table 3. Pulmonary Ventilation Results in Comorbid Patients [8].

Parameter	Pre-Prone	Post-Prone	Follow-Up (48 h)
PaO_2 (mmHg)	79.5	173	78.8
FiO_2 (%)	95.7	83.0	78.6
PaO_2/FiO_2 (mmHg)	84.8	202	109

Therefore, the prone position can improve pulmonary ventilation as long as the patient does not suffer from comorbid diseases. Accordingly, when compared to the use of only a mechanical ventilator, the length of stay in the ICU and the total hospital stay is reduced.

4. Discussion

The Royal National Orthopedic has recommended specific positions for the implementation of the prone position—one of which is using the 'Swimmer's Position'. This position involves the positioning of the neck in an ipsilateral rotation with the arm abducted at 45o-70o and employing elbow flexion and forearm pronation (Figure 1) [9].

Figure 1. 'Swimmer's Position' (British Orthopedic Association Guidance, 2020).

The prone position, when performed correctly in non-comorbid patients, can reduce pressure on the dorsal lung area due to gravity. Consequently, alveolar recruitment takes place, which means there is an increase in pulmonary ventilation and lung compliance [6].

This effect will be different if performed with patients who suffer from comorbidities. For example, one patient had a high pulmonary severity score. This means that there are many infiltrates present and the consolidation of the lung occurs. This denotes an inhibition in increasing pulmonary ventilation. If pulmonary ventilation does not increase, the percentage corresponding to the risk of death will increase [8,10].

Therefore, if the combination of the prone position while on a mechanical ventilator is compared with solely applying a mechanical ventilator, the result is a difference in the total hospital length of stay, which is reduced by up to five days. This can occur because a significant increase in the combination of these interventions can reduce the patient's dependence on mechanical ventilators more quickly. If only a mechanical ventilator is given, there is not a significant increase in pulmonary ventilation, and additional intravenous drugs, namely, vasopressors, are needed [11].

5. Conclusions

From the five journals that have been reviewed, it can be concluded that implementing a prone position intervention to patients treated in the ICU on a mechanical ventilator can increase the percentage of variable pulmonary ventilation or oxygenation as measured using AGD and PaO_2/FiO_2 by up to 50%. However, if the patient has comorbid diseases such as congestive heart failure, diabetes mellitus, hypertension, etc., greater attention must be paid. When compared with solely the supplementation of a mechanical ventilator, the addition of this prone position intervention can reduce the total time of hospitalization by up to 5 days.

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