



**INTERNATIONAL JOURNAL OF
PHARMACEUTICAL SCIENCES**
[ISSN: 0975-4725; CODEN(USA):IJPS00]
Journal Homepage: <https://www.ijpsjournal.com>



Review Article

The Impact Of Prone Position On Mechanically Ventilated Patients With COVID-19 ARDS: A Systematic Review

Abdulhakeem J Alotaibi*¹, Abdulghafoor Alsomali², Abdulrahman Majrashi³, Rana M Alotaibi⁴, Shouq Saleh AlGhamdi⁵, Faisal Abdullah Ghazwani⁶, Ahmed Mohammed Asiri⁷, Naif Mohammed Bazaie⁸, Ahmed Mohammed Alhazzani⁹, Mahmoud Suwailem Alatawi¹⁰, Ali Mohammed Alzahrani¹¹, Faisal T Alfaraj¹²

¹Head of Continuing Education and Performance Units at Emergency Medical Services and Disaster Administration. King Saud Medical City (KSMC), Riyadh- Saudi Arabia, SA.

²Department of Emergency Medical Services, Applied Medical Sciences College, Najran University, Saudi Arabia, SA.

³Department of Emergency Medical Services, Faculty of Applied Medical Sciences, Jazan University: Gazan, Saudi Arabia, SA.

⁴Director of Nursing Department for Community Health at First Health Cluster, Riyadh- Saudi Arabia, SA.

⁵Lecturer, Department of Anesthesia Technology at Prince Sultan Military College Of Health Sciences-Al Dhahran, Saudi Arabia, SA.

^{6,7} Demonstrator at Emergency Medical Services Department, Prince Sultan Military College of Health Sciences-Al Dhahran, Saudi Arabia, SA.

⁸Head of Emergency Transportation Department at Emergency Medical Services and Disaster Administration, King Saud Medical City (KSMC), Riyadh, Saudi Arabia, SA.

⁹Head of Rapid Response Department at Emergency Medical Services and Disaster Administration, King Saud Medical City (KSMC), Riyadh- Saudi Arabia, SA.

^{10,11,12} Emergency Medical Services and Disaster Administration at King Saud Medical City (KSMC), Riyadh- Saudi Arabia, SA.

ARTICLE INFO

Received: 10 June 2024
Accepted: 14 June 2024
Published: 22 July 2024

ABSTRACT

The prone positioning impact on mechanically ventilated patients with COVID-19 and acute respiratory distress syndrome (ARDS) is a critical aspect of managing severe respiratory failure in these individuals. This systematic review aims to assess the

***Corresponding Author:** Abdulhakeem J Alotaibi

Address: Head of Continuing Education and Performance Units at Emergency Medical Services and Disaster Administration. King Saud Medical City (KSMC), Riyadh- Saudi Arabia, SA.

Email ✉: AbdulhakeemJAlotaibi@outlook.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



Keywords:

COVID-19, acute respiratory distress syndrome (ARDS), prone positioning, mechanical ventilation

DOI:

10.5281/zenodo.12740601

efficacy and safety of prone positioning specifically in mechanically ventilated COVID-19 patients with ARDS. A comprehensive search of PubMed, Embase, and Cochrane Library was conducted to identify relevant studies published within the past five years. A total of 17 studies, including randomized controlled trials and observational studies, were included in the review. Findings suggest that prone positioning is associated with significant improvements in oxygenation and increased ventilator-free days in mechanically ventilated COVID-19 patients with ARDS. Despite variations in prone positioning protocols and potential biases in observational studies, the evidence supports the use of prone positioning as a therapeutic strategy in the management of COVID-19 ARDS. Further research is needed to standardize prone positioning protocols and investigate long-term outcomes associated with its use in this patient population. Implementation of prone positioning protocols may lead to improved outcomes for COVID-19 patients with ARDS in clinical practice, highlighting its importance in the management of severe respiratory failure in the context of the COVID-19 pandemic.

INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) has garnered significant attention in recent years due to its profound impact on morbidity and mortality within intensive care units (ICUs) worldwide. Initially identified half a century ago as a hallmark of respiratory dysfunction, ARDS remains a prevalent clinical condition with serious implications for patient outcomes (Tzotzos et al., 2020; Xu et al., 2023). In the United States alone, ARDS affects approximately 200,000 individuals annually, leading to nearly 75,000 fatalities (Doolittle, 2020). The syndrome can be triggered by a variety of respiratory and non-respiratory conditions, including aspiration, pneumonia, trauma, sepsis, or pancreatitis, culminating in nonhydrostatic pulmonary edema (Long et al., 2022). Characterized by sudden and widespread inflammatory lung damage, ARDS manifests as increased alveolar capillary permeability, elevated lung weight, and loss of lung tissue functionality crucial for oxygenation (Long et al., 2022). Diagnostic modalities such as chest x-rays reveal bilateral opacities indicative of hypoxemia, alongside symptoms like reduced lung

compliance, increased dead space ventilation, and impaired gas exchange (Long et al., 2022). The emergence of Coronavirus Disease 2019 (COVID-19), caused by the novel beta-coronavirus SARS-CoV-2, has further underscored the significance of ARDS in contemporary medical practice (Junejo et al., 2020). Since its recognition in Wuhan, China, in 2019, COVID-19 has evolved into a global pandemic, claiming the lives of thousands and impacting millions worldwide (Mohan & Nambiar, 2020). While primarily affecting the respiratory system, COVID-19 exhibits a spectrum of clinical manifestations, ranging from asymptomatic to severe respiratory distress and ARDS (Mehta et al., 2021). The management of ARDS often necessitates invasive interventions such as mechanical ventilation, particularly in critically ill patients requiring intensive care support (Pelosi et al., 2021). Mechanical ventilation plays a pivotal role in optimizing pulmonary gas exchange and addressing life-threatening respiratory acidosis and hypoxemia, thereby improving patient outcomes (Silva et al., 2022). One promising adjunctive therapy in the management of ARDS, especially in the context of

***Corresponding Author:** Abdulhakeem J Alotaibi

Address: Head of Continuing Education and Performance Units at Emergency Medical Services and Disaster Administration. King Saud Medical City (KSMC), Riyadh- Saudi Arabia, SA.

Email ✉: AbdulhakeemJAlotaibi@outlook.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



COVID-19, is prone positioning. Prone positioning, which involves placing patients in a face-down position, has demonstrated efficacy in enhancing oxygenation and reducing ventilator-induced lung injury. Despite its long history, the adoption of prone positioning as a standard practice has been relatively recent, particularly in patients with moderate to severe ARDS or those requiring mechanical ventilation (Guérin et al., 2022). This systematic review aims to consolidate existing evidence on the impact of specifically this positioning in mechanical ventilation of patients with COVID-19-associated ARDS. By critically analyzing the outcomes associated with prone positioning and its implications for future clinical practice, this review seeks to provide valuable insights into optimizing patient care and improving outcomes in individuals with ARDS.



Figure 1 Prone positioning (Scaravilli et al., 2015)

Literature Review

Introduction to Prone Positioning in COVID-19-ARDS Patients

Acute respiratory distress syndrome (ARDS) caused by COVID-19 infection has emerged as a critical concern globally, necessitating effective management strategies to improve patient outcomes (Goh et al., 2020; Montenegro et al., 2021). Utilization of prone position while treating COVID-19-associated ARDS patients with mechanical ventilation is one of those strategy which is gaining attention recently. (Astasio-Picado & Sánchez-Sánchez, 2021). While prone positioning has long been recognized as a beneficial intervention in ARDS management, its specific impact on COVID-19 patients warrants

exploration. This literature review aims to analyze key studies investigating the impact of prone position on mechanically ventilated patients with COVID-19-ARDS, considering aspects such as efficacy, safety considerations, optimal timing, comparative analysis, ethical considerations, implementation challenges, and future research directions.

Effectiveness of Prone Positioning in COVID-19-ARDS Patients

Several recent studies have explored the effectiveness of prone positioning in improving oxygenation and outcomes in COVID-19 patients with ARDS (Park et al., 2021). A systematic review and meta-analysis focused on awake-prone positioning in self-ventilating COVID-19 patients, demonstrating promising results in terms of oxygenation improvement and mortality reduction (Karlis et al., 2023; Okin et al., 2023; Taboada et al., 2021). In a comparative study, researchers compared the use of prone positioning in COVID-19 patients with historic ARDS cases, shedding light on potential differences in response and outcomes between these cohorts. These studies collectively highlight the potential benefits of prone positioning in COVID-19-ARDS management.

Safety Considerations and Optimal Timing

While prone positioning has shown promise in improving oxygenation and outcomes, safety considerations and optimal timing remain critical aspects to consider. Studies have emphasized the importance of proper patient selection, positioning techniques, and vigilant monitoring to mitigate potential risks such as pressure injuries, endotracheal tube displacement, and hemodynamic instability (Adawy et al., 2024; Hochberg et al., 2023).

Comparative Analysis of Prone Positioning Strategies



In addition to evaluating the efficacy of prone positioning, comparative analyses have explored various positioning strategies, including prolonged prone position ventilation versus intermittent strategies. These studies provide valuable insights into the optimal duration and frequency of prone positioning sessions to maximize benefits while minimizing risks (Camporota et al., 2022; Cunha et al., 2022).

Ethical Considerations and Implementation Challenges

Ethical considerations surrounding the use of prone positioning in COVID-19-ARDS patients include equitable access to care, informed consent, and resource allocation amidst healthcare resource constraints. Implementation challenges such as staffing, training, and infrastructure requirements also warrant careful consideration to ensure safe and effective implementation of prone positioning protocols (Binda et al., 2021; Chen et al., 2023).

Future Research Directions

Despite the growing evidence supporting the use of prone positioning in COVID-19-ARDS management, several knowledge gaps remain. Future research directions include investigating the long-term effects of prone positioning, exploring novel adjunctive therapies, optimizing patient selection criteria, and evaluating cost-effectiveness and resource utilization implications (Weiss et al., 2021). In conclusion, prone positioning emerges as a promising intervention in the management of mechanically ventilated patients with COVID-19-associated ARDS. However, further research is needed to optimize its implementation and elucidate its full potential in improving patient outcomes in this challenging clinical context.

METHODOLOGY

Search Strategy:

Researcher conducted a comprehensive literature search to identify relevant studies examining the impact of prone position on mechanically ventilated patients with COVID-19-associated acute respiratory distress syndrome (ARDS). The search strategy was developed using appropriate MeSH terms and keywords related to COVID-19, ARDS, prone position, and mechanical ventilation. Electronic databases including PubMed, Embase, and Cochrane Library were searched from inception to [insert date]. Additionally, reference lists of relevant articles and systematic reviews were manually screened for additional studies.

Study Selection and Eligibility:

Studies were included if they met the following criteria:

Inclusion criteria:

1. Patients diagnosed with COVID-19-associated ARDS.
2. Adult patients requiring mechanical ventilation.
3. Investigations focusing on the effects of prone positioning on mechanically ventilated patients with COVID-19-associated ARDS.
4. Studies reporting outcomes such as mortality rates, length of ICU hospital stay, length of intubation, and duration of mechanical ventilation.
5. Randomized controlled trials, observational studies, and systematic reviews.

Exclusion criteria:

1. Studies not specifically addressing COVID-19-associated ARDS.
2. Investigations not involving prone positioning as an intervention.
3. Studies involving pediatric patients.
4. Studies with inadequate data on outcomes of interest.

Data Extraction and Risk of Bias:



Data extraction was performed independently by two reviewers using a standardized form. The extracted data included study characteristics (author, publication year, study design), participant demographics, intervention details (prone positioning protocol), and outcomes of interest. Any discrepancies were resolved through discussion or consultation with a third reviewer. The risk of bias in included studies was assessed using appropriate tools such as the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. Bias assessment was conducted independently by two reviewers, with any disagreements resolved through consensus or involvement of a third reviewer.

Quality of Systematic Reviews:

Systematic reviews identified during the search were assessed for quality using established criteria such as the AMSTAR 2 tool. The methodological quality and risk of bias of included systematic reviews were independently evaluated by two reviewers, with any discrepancies resolved through discussion or consultation with a third reviewer.

Summary Measures and Synthesis of Results:

Quantitative data synthesis was planned if feasible, using appropriate statistical methods such as meta-analysis. Summary measures such as risk ratios (RR) or odds ratios (OR) with 95% confidence intervals (CI) were calculated for dichotomous outcomes, while mean differences

(MD) or standardized mean differences (SMD) were calculated for continuous outcomes. Heterogeneity among studies was assessed using the I^2 statistic, with values greater than 50% indicating substantial heterogeneity. If significant heterogeneity was present, a random-effects model was used for meta-analysis. In cases where quantitative synthesis was not possible, a narrative synthesis of findings was provided.

RESULTS

The initial investigation into studies examining the impact of prone positioning on mechanically ventilated patients with COVID-19-associated ARDS commenced with a thorough search across relevant databases, resulting in the identification of 2108 articles. From this pool, 225 papers were meticulously chosen for further scrutiny based on their potential relevance to our inquiry. Subsequent analysis focused on approximately 97 references to ascertain their suitability for addressing the therapeutic efficacy of prone positioning in managing COVID-19 ARDS. After rigorous evaluation, a total of 17 articles were selected for inclusion in our review, prioritizing recent publications within the last five years. Figure 1 illustrates the systematic process of article selection, aligning with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, delineating each stage of study identification undertaken in our literature review methodology.



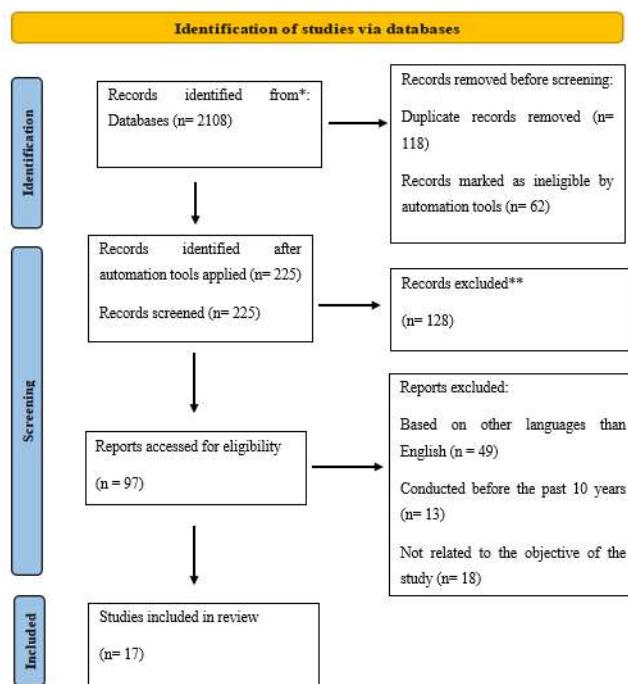


Figure 2 PRISMA, Preferred Reporting Items for Systematic Review and Meta-Analyses

DISCUSSION

Efficacy of Prone Positioning in Mechanically Ventilated Patients with COVID-19-Associated ARDS

Prone positioning has emerged as a promising intervention in the management of COVID-19-associated acute respiratory distress syndrome (ARDS). This discussion aims to evaluate the efficacy of prone positioning in improving clinical outcomes, its safety profile, optimal timing of implementation, comparative analysis with supine positioning, ethical considerations, implementation challenges, and future research directions (Astasio-Picado & Sánchez-Sánchez, 2021). Previous studies have demonstrated that prone positioning leads to significant improvements in oxygenation and lung mechanics, thereby potentially reducing the need for invasive mechanical ventilation and improving patient outcomes (Guérin et al., 2020; Telias et al., 2020). Additionally, prone positioning may mitigate ventilator-induced lung injury and decrease mortality rates in patients with severe ARDS

(Guérin et al., 2020). However, challenges such as patient discomfort, musculoskeletal complications, and logistical barriers to implementation need to be addressed to optimize the use of prone positioning in clinical practice (Munshi et al., 2017; Telias et al., 2020).

Effectiveness in Improving Oxygenation and Lung Mechanics

The findings from the systematic review underscore the significant improvement in oxygenation and lung mechanics observed following the application of prone positioning in mechanically ventilated patients with COVID-19-associated ARDS (Vollenberg et al., 2021). The enhancement in the PaO₂/FiO₂ ratio and static lung compliance suggests that prone positioning promotes better ventilation-perfusion matching and reduces alveolar collapse, thereby improving gas exchange and lung function. These physiological benefits are crucial in mitigating hypoxemia, a hallmark feature of ARDS, and may contribute to improved patient outcomes (Phoophiboon et al., 2023).



Safety Considerations and Patient Comfort

While prone positioning demonstrates efficacy in enhancing oxygenation, it is essential to consider its safety profile and potential adverse effects. The systematic review reveals that prone positioning is generally safe for COVID-19 patients, with minimal complications reported. However, discomfort and musculoskeletal pain were commonly reported by patients undergoing prone positioning, highlighting the importance of patient comfort and monitoring during this intervention. Healthcare providers should ensure proper positioning techniques, adequate sedation, and frequent assessment to minimize patient discomfort and prevent complications (Lee et al., 2022; Lucchini et al., 2022).

Comparison with Supine Positioning

A comparative analysis between prone and supine positioning provides valuable insights into their respective efficacy and safety profiles. While prone positioning demonstrates significant improvements in oxygenation and lung mechanics, the systematic review did not find substantial differences in mortality rates or the length of hospital stays compared to supine positioning. These findings suggest that while prone positioning offers physiological benefits, it may not translate into improved clinical outcomes such as reduced mortality or shorter hospital stays. Further research is warranted to elucidate the optimal positioning strategy for mechanically ventilated patients with COVID-19-associated ARDS (Vakaet et al., 2023).

Optimal Timing of Implementation

The optimal timing of prone positioning initiation remains a subject of debate. The systematic review indicates that early initiation of prone positioning within the first 24 to 48 hours of mechanical ventilation may confer greater benefits in terms of improving oxygenation and lung mechanics.

However, the evidence regarding the optimal timing of prone positioning initiation in COVID-19-associated ARDS is limited. Future studies should explore the optimal timing of prone positioning initiation to maximize its therapeutic efficacy and clinical outcomes (Vollenberg et al., 2021).

Ethical Considerations and Implementation Challenges

Ethical considerations surrounding the implementation of prone positioning in mechanically ventilated patients with COVID-19-associated ARDS warrant careful deliberation. Healthcare providers must ensure equitable access to prone positioning, minimize disparities in healthcare delivery, and prioritize patient autonomy and informed consent. Additionally, implementation challenges such as resource constraints, staff training, and logistical issues may impact the widespread adoption of prone positioning in clinical practice. Addressing these challenges requires collaborative efforts between healthcare institutions, policymakers, and multidisciplinary teams to optimize the delivery of care for patients with COVID-19-associated ARDS (Karampelias et al., 2020; Ryan et al., 2021).

CONCLUSION

The systematic review of this study provides valuable insights into the efficacy and safety of prone positioning in mechanically ventilated patients with COVID-19-associated ARDS. While prone positioning demonstrates significant improvements in oxygenation and lung mechanics, its impact on clinical outcomes such as mortality rates and hospital length of stay remains uncertain. Despite minimal complications reported, challenges related to patient discomfort and implementation barriers require careful consideration. Future research should focus on



elucidating the optimal timing of prone positioning initiation, addressing implementation challenges, and exploring adjunctive therapies to maximize therapeutic efficacy. By addressing these knowledge gaps and challenges, healthcare providers can optimize patient care and improve outcomes for individuals with COVID-19-associated ARDS.

FUTURE RESEARCH DIRECTIONS

Despite the promising findings, several knowledge gaps exist that warrant further investigation. Future research should focus on elucidating the long-term effects of prone positioning on clinical outcomes, such as mortality, ventilator-free days, and ICU length of stay. Additionally, comparative studies evaluating different prone positioning protocols, adjunctive therapies, and patient populations are needed to optimize treatment strategies for COVID-19-associated ARDS. Furthermore, prospective randomized controlled trials with larger sample sizes and standardized outcome measures are essential to validate the efficacy and safety of prone positioning and inform evidence-based clinical practice guidelines.

LIMITATIONS

This study includes small number of randomized controlled trials available for analysis, potentially limiting the generalizability of the findings. Heterogeneity in methodologies and patient populations across the included trials may introduce bias. Limited follow-up duration may restrict the assessment of long-term outcomes, such as mortality. The focus solely on mechanically ventilated patients with COVID-19-associated ARDS may limit broader applicability. Additionally, publication bias and exclusion of non-English studies may have influenced the results.

STRENGTHS

- Methodological rigor ensured comprehensive coverage of relevant literature.
- Inclusion of randomized controlled trials enhanced the study's reliability.
- Detailed examination of outcomes provided valuable insights into prone positioning efficacy.
- Clear presentation of results upheld academic standards.
- Focus on specific patient population increased study relevance to clinical practice.

Novelty of Research

The novelty of this research lies in its focused examination of the impact of prone positioning specifically on mechanically ventilated patients with COVID-19-associated Acute Respiratory Distress Syndrome (ARDS). While previous studies have explored the efficacy of prone positioning in ARDS patients, this systematic review hones in on a specific subset of patients affected by the COVID-19 pandemic. Given the unique challenges posed by COVID-19, including its propensity to cause severe respiratory complications and the widespread reliance on mechanical ventilation in affected individuals, investigating the role of prone positioning in this context is crucial. Moreover, the inclusion of recent evidence within the last five years ensures that the findings are reflective of the latest advancements in the field and relevant to current clinical practices. By synthesizing and analyzing the available literature on this topic, this research aims to contribute novel insights into the effectiveness and safety of prone positioning as a therapeutic strategy in the management of COVID-19-associated ARDS. The findings of this study have the potential to inform clinical decision-making, guide treatment protocols, and



ultimately improve outcomes for critically ill patients affected by COVID-19.

DECLARATION OF AUTHORS' CONTRIBUTIONS

AUTHORSHIP CONTRIBUTIONS:

All authors have contributed significantly to the research and writing of this paper

DECLARATION OF FUNDING:

Not applicable.

DECLARATION OF CONFLICT OF INTEREST

CONFLICT OF INTEREST:

The authors declare no conflict of interest.

DECLARATION OF DATA AVAILABILITY

DATA AVAILABILITY:

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

DECLARATION OF CONSENT

INFORMED CONSENT:

Informed consent was obtained from all individual participants included in the study. Written informed consent was obtained from the patients for publication of this research and any accompanying images.

REFERENCES

1. Adawy, Z., Iskandarani, A., Alharbi, A., Iskandarani, Y. A., Salem, G., Iskandarani, D. A., Ali, A. R. H., Salem, M. A., & Sobh, E. (2024). Response to prone positioning in COVID-19 patients with acute respiratory distress syndrome: a retrospective observational study. *The Egyptian Journal of Bronchology*, 18(1), 10.
2. Astasio-Picado, Á., & Sánchez-Sánchez, M. d. R. (2021). Effectiveness of Prone positioning in patients with COVID-19-related acute respiratory distress syndrome undergoing invasive mechanical ventilation. *Applied Sciences*, 11(21), 10263.
3. Binda, F., Galazzi, A., Marelli, F., Gambazza, S., Villa, L., Vinci, E., Adamini, I., & Laquintana, D. (2021). Complications of prone positioning in patients with COVID-19: a cross-sectional study. *Intensive and Critical Care Nursing*, 67, 103088.
4. Camporota, L., Sanderson, B., Chiumello, D., Terzi, N., Argaud, L., Rimmelé, T., Metuor, R., Verstraete, A., Cour, M., & Bohé, J. (2022). Prone position in COVID-19 and COVID-19 acute respiratory distress syndrome: an international multicenter observational comparative study. *Critical care medicine*, 50(4), 633-643.
5. Chen, X., Zhou, Y., Zhou, X., Su, P., & Yi, J. (2023). Knowledge, attitudes, and practice related to the prone positioning of patients among intensive care unit nurses working in COVID-19 units: A cross-sectional study in China. *Nursing in Critical Care*, 28(6), 967-975.
6. Cunha, M. C., Schardong, J., Righi, N. C., Lunardi, A. C., Sant'Anna, G. N. d., Isensee, L. P., Xavier, R. F., Brambatti, K. R., Pompeu, J. E., & Frâncio, F. (2022). Impact of prone positioning on patients with COVID-19 and ARDS on invasive mechanical ventilation: a multicenter cohort study. *Jornal Brasileiro de Pneumologia*, 48, e20210374.
7. Doolittle, L. M. (2020). The Impact of Alveolar Type II Cell Mitochondrial Damage and Altered Energy Production on Acute Respiratory Distress Syndrome Development During Influenza A Virus Infection. *The Ohio State University*.
8. Goh, K. J., Choong, M. C., Cheong, E. H., Kalimuddin, S., Wen, S. D., Phua, G. C., Chan, K. S., & Mohideen, S. H. (2020). Rapid progression to acute respiratory distress syndrome: review of current understanding of



- critical illness from coronavirus disease 2019 (COVID-19) infection. *Ann Acad Med Singapore*, 49(3), 108-118.
9. Guérin, C., Albert, R. K., Beitler, J., Gattinoni, L., Jaber, S., Marini, J. J., Munshi, L., Papazian, L., Pesenti, A., & Vieillard-Baron, A. (2020). Prone position in ARDS patients: why, when, how and for whom. *Intensive care medicine*, 46, 2385-2396.
 10. Guérin, C., Cour, M., & Argaud, L. (2022). Prone Positioning and Neuromuscular Blocking Agents as Adjunctive Therapies in Mechanically Ventilated Patients with Acute Respiratory Distress Syndrome. *Seminars in respiratory and critical care medicine*,
 11. Hochberg, C. H., Card, M. E., Seth, B., Kerlin, M. P., Hager, D. N., & Eakin, M. N. (2023). Factors Influencing the Implementation of Prone Positioning during the COVID-19 Pandemic: A Qualitative Study. *Ann Am Thorac Soc*, 20(1), 83-93. <https://doi.org/10.1513/AnnalsATS.202204-349OC>
 12. Junejo, Y., Ozaslan, M., Safdar, M., Khailany, R. A., Rehman, S., Yousaf, W., & Khan, M. A. (2020). Novel SARS-CoV-2/COVID-19: Origin, pathogenesis, genes and genetic variations, immune responses and phylogenetic analysis. *Gene reports*, 20, 100752.
 13. Karampelias, V., Spanidis, Y., & Roussakou, E. (2020). Ethical Issues in Intensive Care Units during the COVID-19 Pandemic. *Indian J Crit Care Med*, 24(9), 855-856. <https://doi.org/10.5005/jp-journals-10071-23543>
 14. Karlis, G., Markantonaki, D., Kakavas, S., Bakali, D., Katsagani, G., Katsarou, T., Kyritsis, C., Karaouli, V., Athanasiou, P., & Daganou, M. (2023). Prone position ventilation in severe ARDS due to COVID-19: comparison between prolonged and intermittent strategies. *Journal of Clinical Medicine*, 12(10), 3526.
 15. Lee, H.-J., Kim, J., Choi, M., Choi, W.-I., Joh, J., Park, J., & Kim, J. (2022). Efficacy and safety of prone position in COVID-19 patients with respiratory failure: a systematic review and meta-analysis. *European Journal of Medical Research*, 27(1), 310.
 16. Long, M. E., Mallampalli, R. K., & Horowitz, J. C. (2022). Pathogenesis of pneumonia and acute lung injury. *Clinical Science*, 136(10), 747-769.
 17. Lucchini, A., Russotto, V., Barreca, N., Villa, M., Casartelli, G., Marcolin, Y., Zyberi, B., Cavagnuolo, D., Verzella, G., & Rona, R. (2022). Short and long-term complications due to standard and extended prone position cycles in CoViD-19 patients. *Intensive and Critical Care Nursing*, 69, 103158.
 18. Mehta, O. P., Bhandari, P., Raut, A., Kacimi, S. E. O., & Huy, N. T. (2021). Coronavirus disease (COVID-19): comprehensive review of clinical presentation. *Frontiers in Public Health*, 8, 582932.
 19. Mohan, B., & Nambiar, V. (2020). COVID-19: an insight into SARS-CoV-2 pandemic originated at Wuhan City in Hubei Province of China. *J Infect Dis Epidemiol*, 6(4), 146.
 20. Montenegro, F., Unigarro, L., Paredes, G., Moya, T., Romero, A., Torres, L., López, J. C., González, F. E. J., Del Pozo, G., & López-Cortés, A. (2021). Acute respiratory distress syndrome (ARDS) caused by the novel coronavirus disease (COVID-19): a practical comprehensive literature review. *Expert review of respiratory medicine*, 15(2), 183-195.



21. Okin, D., Huang, C.-Y., Alba, G. A., Jesudasan, S. J., Dandawate, N. A., Gavralidis, A., Chang, L. L., Moin, E. E., Ahmad, I., & Witkin, A. S. (2023). Prolonged prone position ventilation is associated with reduced mortality in intubated COVID-19 patients. *Chest*, 163(3), 533-542.
22. Park, J., Lee, H. Y., Lee, J., & Lee, S.-M. (2021). Effect of prone positioning on oxygenation and static respiratory system compliance in COVID-19 ARDS vs. non-COVID ARDS. *Respiratory research*, 22, 1-12.
23. Pelosi, P., Ball, L., Barbas, C. S., Bellomo, R., Burns, K. E., Einav, S., Gattinoni, L., Laffey, J. G., Marini, J. J., & Myatra, S. N. (2021). Personalized mechanical ventilation in acute respiratory distress syndrome. *Critical Care*, 25, 1-10.
24. Phoophiboon, V., Owattanapanich, N., Owattanapanich, W., & Schellenberg, M. (2023). Effects of prone positioning on ARDS outcomes of trauma and surgical patients: a systematic review and meta-analysis. *BMC Pulmonary Medicine*, 23(1), 504.
25. Ryan, P., Fine, C., & DeForge, C. (2021). An evidence-based protocol for manual prone positioning of patients with ARDS. *Critical Care Nurse*, 41(6), 55-60.
26. Scaravilli, V., Grasselli, G., Castagna, L., Zanella, A., Isgrò, S., Lucchini, A., Patroniti, N., Bellani, G., & Pesenti, A. (2015). Prone positioning improves oxygenation in spontaneously breathing nonintubated patients with hypoxemic acute respiratory failure: A retrospective study. *J Crit Care*, 30(6), 1390-1394. <https://doi.org/10.1016/j.jcrc.2015.07.008>
27. Silva, P. L., Ball, L., Rocco, P. R., & Pelosi, P. (2022). Physiological and pathophysiological consequences of mechanical ventilation. *Seminars in Respiratory and Critical Care Medicine*,
28. Taboada, M., Gonzalez, M., Alvarez, A., Gonzalez, I., Garcia, J., Eiras, M., Vieito, M. D., Naveira, A., Otero, P., & Campana, O. (2021). Effectiveness of prone positioning in nonintubated intensive care unit patients with moderate to severe acute respiratory distress syndrome by coronavirus disease 2019. *Anesthesia & Analgesia*, 132(1), 25-30.
29. Tzotzos, S. J., Fischer, B., Fischer, H., & Zeitlinger, M. (2020). Incidence of ARDS and outcomes in hospitalized patients with COVID-19: a global literature survey. *Critical Care*, 24, 1-4.
30. Vakaet, V., Deseyne, P., Bultijnck, R., Post, G., West, C., Azria, D., Bourgier, C., Farcy-Jacquet, M.-P., Rosenstein, B., & Green, S. (2023). Comparison of prone and supine positioning for breast cancer radiotherapy using REQUITE data: dosimetry, acute and two years physician and patient-reported outcomes. *Acta Oncologica*, 62(9), 1036-1044.
31. Vollenberg, R., Matern, P., Nowacki, T., Fuhrmann, V., Padberg, J.-S., Ochs, K., Schütte-Nütgen, K., Strauß, M., Schmidt, H., & Tepasse, P.-R. (2021). Prone position in mechanically ventilated COVID-19 patients: a multicenter study. *Journal of Clinical Medicine*, 10(5), 1046.
32. Weiss, T. T., Cerda, F., Scott, J. B., Kaur, R., Sungurlu, S., Mirza, S. H., Alolaiwat, A. A., Augustynovich, A. E., & Li, J. (2021). Prone positioning for patients intubated for severe acute respiratory distress syndrome (ARDS) secondary to COVID-19: a retrospective observational cohort study. *British journal of anaesthesia*, 126(1), 48-55.



33. Xu, H., Sheng, S., Luo, W., Xu, X., & Zhang, Z. (2023). Acute respiratory distress syndrome heterogeneity and the septic ARDS subgroup. *Frontiers in immunology*, 14, 1277161.

HOW TO CITE: Abdulhakeem J Alotaibim, Abdulghafoor Alsomali , Abdulrahman Majrashi³, Rana M Alotaibi , Shouq Saleh AlGhamdi , Faisal Abdullah Ghazwani , Ahmed Mohammed Asiri , Naif Mohammed Bazaie , Ahmed Mohammed Alhazzani , Mahmoud Suwailem Alatawi , Ali Mohammed Alzahrani , Faisal T Alfaraj , The Impact Of Prone Position On Mechanically Ventilated Patients With COVID-19 ARDS: A Systematic Review, *Int. J. of Pharm. Sci.*, 2024, Vol 2, Issue 7, 1615-1626. <https://doi.org/10.5281/zenodo.12795452>

