Module

Evidence Based Critical Care

Does prone position affect mortality in ARDS patients, a systematic review?

ABSTRACT

BACKGROUND:

Acute Respiratory distress syndrome (ARDS) is a life-threatening lung injury resulting from a build-up of fluid in the lungs, resulting in difficulty breathing and a lack of oxygen to the entire body. Acute Respiratory distress syndrome (ARDS), the severity of this illness, causes patients to be hospitalized. Pruning was first used as the intervention for treating Hypoxia in patients with Acute Respiratory Distress Syndrome, and the patient was treated lying on his stomach. In Europe, it has affected approximately 3 million patients per year. A severe mortality rate was reported at 46.1% in an observational study across 50 countries.

OBJECTIVES:

This systematic review investigates the effect of prone positioning on mortality risk and other clinical outcomes associated with the therapy in patients with Acute Respiratory distress syndrome (ARDS).

SEARCH STRATEGY:

A search strategy was created to search for relevant studies taking into account the guidelines of the CASP tool, Use of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), to select relevant quantitative studies and computerized data search through the EBSCOhost. The analysis and the Systemic Review accumulate evidence-based research available online as cost-free articles, such as by the National Library of Medicine, Yale Medicine, CHEST, etc.

FINDINGS:

Three studies were eligible, and the use of population, outcomes, comparison, and intervention were collated on a template. Using Boolean operations like AND OR suggested that considering the severity level of ARDS, proning is most effective in the early management of ARDS.

CONCLUSION:

Three randomized controlled trials of studies were performed. Gas exchange is controlled by mechanisms and physiology of exchange of gases changes during prone ventilation, which is multifactorial. The horizontal position increases the tension of the stress gradient between the dorsal and ventral parts of the lungs, which reduces pressure on the lungs and lung perfusion. Hence, the findings indicate that the use of proning for ARDS patients is effective and is highly recommended.

KEYWORDS: Pruning, Prone, ARDS, Mortality,

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a life-threatening condition where the lungs cannot provide the body's vital organs with enough oxygen (National Health Service [NHS], 2020). Gonzales et al. (2015) defined ARDS as a lung condition resulting in low blood oxygen caused by a build-up of fluid in the alveoli (air sacs) and the surfactant to break it down. A lack of surfactant and fluids prevents the lungs from expanding and contracting to draw in oxygen and exhale carbon dioxide. Fanelli et al. (2013) also described ARDS as a syndrome with multiple risk factors that trigger the acute onset of respiratory insufficiency. Stating the acute onset of respiratory failure, bilateral infiltrates on chest radiograph, Hypoxemia as defined by a PaO2/FiO2 ratio to be <200mmHg with no evidence of left atrial hypertension or a pulmonary capillary pressure <18 mmHg to rule out cardiogenic edema... Bos et al. (2022) added that damage to the alveolar-capillary membrane, composed of endothelial, interstitial, and epithelial components, allows for protein-rich pulmonary edema to accumulate in the airspaces of the lung. Ranieri et al. (2012) also defined ARDS as the acute onset of bilateral chest infiltrates characterized by impaired oxygenation that is not explained by cardiac failure or fluid overload.

The common symptoms of ARDS include shortness of breath, low blood oxygen, rapid breathing, and clicking, bubbling, or rattling sounds in the lungs when breathing.

The respiratory distress caused by ARDS laid siege to the idea of prone positioning, which was first medicated to the patient with ARDS in 1970. The observed improvement, like a dramatic increase in oxygen level after proning, opened up the criteria for multiple types of research on this for the next several decades.

Hence this systemic review will follow the research strategy of undertaking the analysis and reporting with the help of the guidelines of the CASP tool, Use of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), to select relevant quantitative studies and computerized data search through the EBSCOhost to define the effective management of prone positioning that proves to be lifesaving approach in the patients of ARDS, by making a tentative analysis on the comparison of prone over supine positioning where required.

BACKGROUND

Pruning was first recommended for patients with ARDS, primarily to deal with Hypoxemia aimed at improving oxygen distribution in the lungs (Guérin et al., 2020).

ARDS arises from different chronic illnesses; in recent times, most cases of ARDS in Europe derived from COVID-19. Poland had the highest mortality rate from ARDS at 73%, and Germany the lowest with 13% (Gujskin et al., 2022). Other possible causes and comorbidity include "Multiple trauma, H1N1, influenza A, burn injury, Hematologic malignancy, Sepsis, Miliary TB (Tuberculosis), CAP (Community Acquired Pneumonia), Neutropenia, Pregnancy, TBI, Alcohol abuse, Cor pulmonale, Paraquat, Lung cancer, Hemorrhagic fever with renal syndrome" (Máca et al., 2017).

Prone positioning refers to placing a patient in the back facing position upward; the patient lies on their chest and stomach. This position is known to have significant medical benefits for patients with respiratory problems over the prone position.

Prone positioning significantly affects respiratory health; for instance, it improves oxygenation by increasing lung capacity. A study conducted on twenty-three patients, in which three were excluded due to Hypoxemia and technical problems, revealed a decrease in the functional residual capacity and an increase in the end-expiratory lung volume in proning compared to supine position. Leading to "a minor decrease in non-aerated lung tissue (3%), a major decrease in poorly aerated tissue (17%), and a major increase (20%) in well-aerated tissue" (Aguirre-Bermeo *et al.*, 2018)

Pruning prevents ventilator-induced lung injury, as it leads to a uniform distribution of Tran's pulmonary pressure and an increase in the PaO_2/FIO_2 with the ventral shift of the ventilation distribution than the dorsal in the supine position.

Compliance refers to the changes in lung volume or pressure. Guérin et al. (2020) report that the prone position significantly affects lung and chest wall compliance, ventilation and perfusion, recruit ability, oxygenation, and carbon dioxide removal. This position is known to have significant medical benefits for patients with respiratory problems.

The posterior boundaries of the lungs are less flexible and compliant. Therefore, the posterior boundaries and the bed surface hinder expansion in the prone position and reduce chest compliance (Guérin et al., 2020). In the prone position, the lack of expansion indicates a reduced volume, which causes an improvement in lung pressure. This improvement in lung compliance offsets the decrease in chest wall compliance and helps air reach more pulmonary units. "Prone position induced recruitment in the dorsal part of the lungs (12.5% ± 8.0%; $p < 0.001$ from baseline) and de-recruitment in the central regions (-6.9% ± 5.2%; $p < 0.001$). These changes led to a global increase in recruitment (6.0% ± 6.7%; $p < 0.001$)" hence improving the ventilation-perfusion ratio referencing to" Fossali T, Pavlovsky B, Ottolina D, Colombo R, Basile MC, Castelli A, Rech R, Borghi B, Ianniello A, Flor N, Spinelli E, Catena E, Mauri T. Effects of Prone Position on Lung Recruitment and Ventilation-Perfusion Matching in Patients With COVID-19 Acute Respiratory Distress Syndrome: A Combined CT Scan/Electrical Impedance Tomography Study. Crit Care Med. 2022 May 1;50(5):723-732. DOI: 10.1097/CCM.0000000000005450. Epub 2022 Apr 11. PMID: 35200194; PMCID: PMC9005091".

Recruiting occurs because oxygen is distributed evenly in the prone position, especially in the most important places in the lungs. (Guérin et al., 2020). Jochmans et al. (2020) criticize the use of proning by stating that there are issues with the duration of proning and that it is difficult to identify which patient will benefit from prone positioning before the technique is applied (Jochmans et al. 2020). This makes us question practice because while prone positioning helps improve the lungs, there are still uncertainties. After all, it cannot be used for emergencies and is only suitable for routine therapy.

According to Jochmans et al. (2020), complications and invasive ventilation increase the mortality rate for ARDS.

SEARCH STRATEGY

This study used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to select relevant quantitative studies that report the impact of prone positioning on ARDS patients' mortality rates. The study utilizes a computerized data search through the EBSCOhost. The database provides a compilation of online journals and articles available on the internet. The investigation involved using keywords and key phrases to identify relevant studies. The keywords include "Does Prone Positioning Affect Mortality in ARDS Patients," "The effect of prone positioning on ARDS mortality rate," AND "Prone positioning and ARDS mortality rate."

For cohort studies, the guidelines of the CASP tool concentrated on a focused issue, participant recruitment, biases, confounding factors, follow-up, and results. For the random control trial, the CASP suggests three essential appraisal tools to determine the suitability of the trial; a clear focus on the research question, randomization, and reporting.

Relevant keywords were established by using PICO elements. Boolean operators OR and AND were used to combine the search terms based on the following.
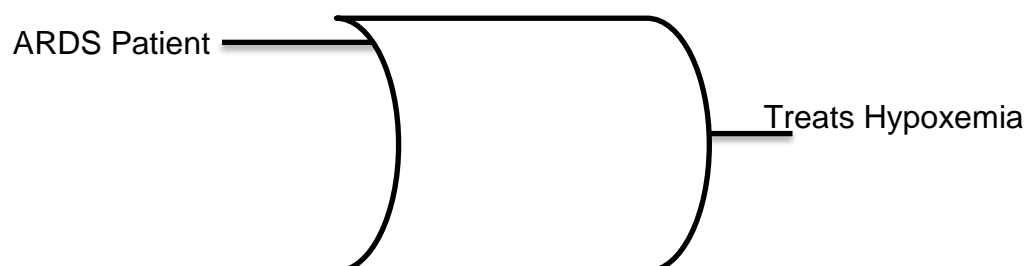
- Use lung-protective ventilation, considering the increased ventilation-perfusion ratio and improved oxygenation than in supine position.

- A comparison between ARDS patient intervened Prone Position to that intervened Supine Position upon factors influencing prone positioning in treating ARDS.

| Pico elements	Keywords	Search terms and strategy
Population	ARDS patient in critical care098	(ARDS) **+** (Critically Ill patients) **OR** (Pronation treats Hypoxia) **OR**

Intervention	ARDS patient who are prone against ARDS patients who are not prone.	(Decrease rate of mortality) **+ (**increase rate of Survival) **NOT** (Pronation) **AND**
Comparison	No proning in ARDS patient	(Proning) **NOT (**Treats Hypoxia) **(**Supination) **NOT** (Doesn't treats Hypoxia) **NOT**
Outcome	mortality	Mortality rate **OR** Mortality **OR** Survival rate

Table 1: Database search and strategy.

MOREOVER, Operation applied at pronation (GATE)

ARDS Patient ─────

Treats Hypoxemia

Critically ill (ICU) Patient ——————

Decrease in Mortality rate ——————

Increase in Survival rate ——————
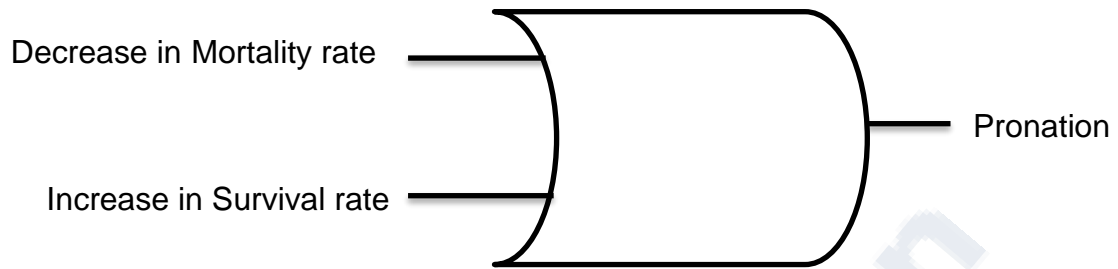
Pronation

NOT Operation applied for comparison in supination and pronation

Pronation ——————

Treats Hypoxia

Supination ——————

Doesn't treats Hypoxia
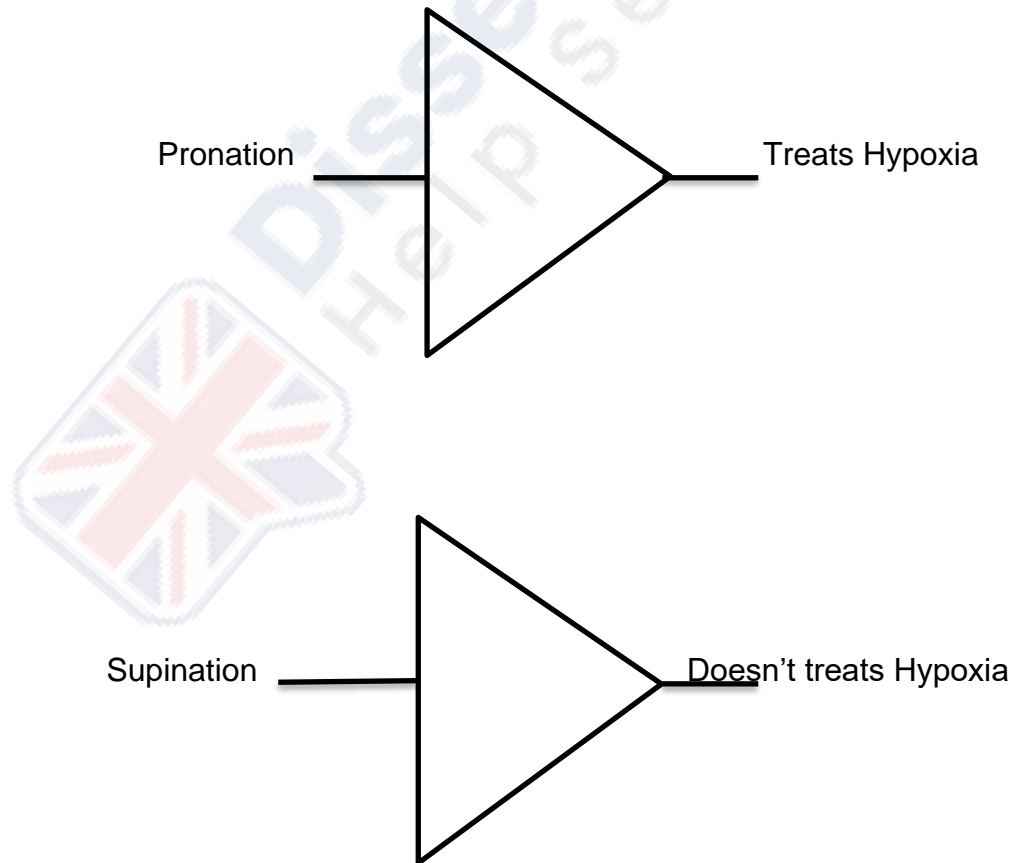
Hence, the studies based on Boolean operation states,

- OR operation declares that both, the patient of ARDS and the critically ill patient is ICU can be given treatment by the intervention of Pronation.

- Second OR operation Diagram tells that both the decrease in the rate of mortality and the increase in the survival rate are obtained by intervening Pronation in ARDS patient.

- NOT operation proves that a patient with Acute Respiratory Stress Syndrome AND Critically ill ICU Patient in intervening Supine (Doesn't treats Hypoxia) or Prone Positions(Treats Hypoxia) show different prognosis.

A systematic review was used to minimize bias and random errors, and it aims to synthesize the result of primary research (Cook et al., 1997).

An electronic search was done on academic databases such as Science Direct, Academic Search, CINAHL, MEDLINE, BASE, and Scopus.

The Librarian was consulted on Apr 6, 2022, to help medical search databases.

Under the research applied and improvements observed, it is analysed that, considering the severity level of ARDS, proning is most effective in the early management of ARDS. It is observed that patients who intervened proning within two days of appearance in ICU show more improvement than after two days.

Selection criteria: The articles included in this study were dated from 2018 to 2022. The study focused on adults in critical care settings confirmed with the ARDS diagnosis. The study outcome had a mortality rate. The search included relevant

studies with key phrases such as ARDS patients, prone position, acute respiratory distress syndrome, mortality rate, and prone positioning.

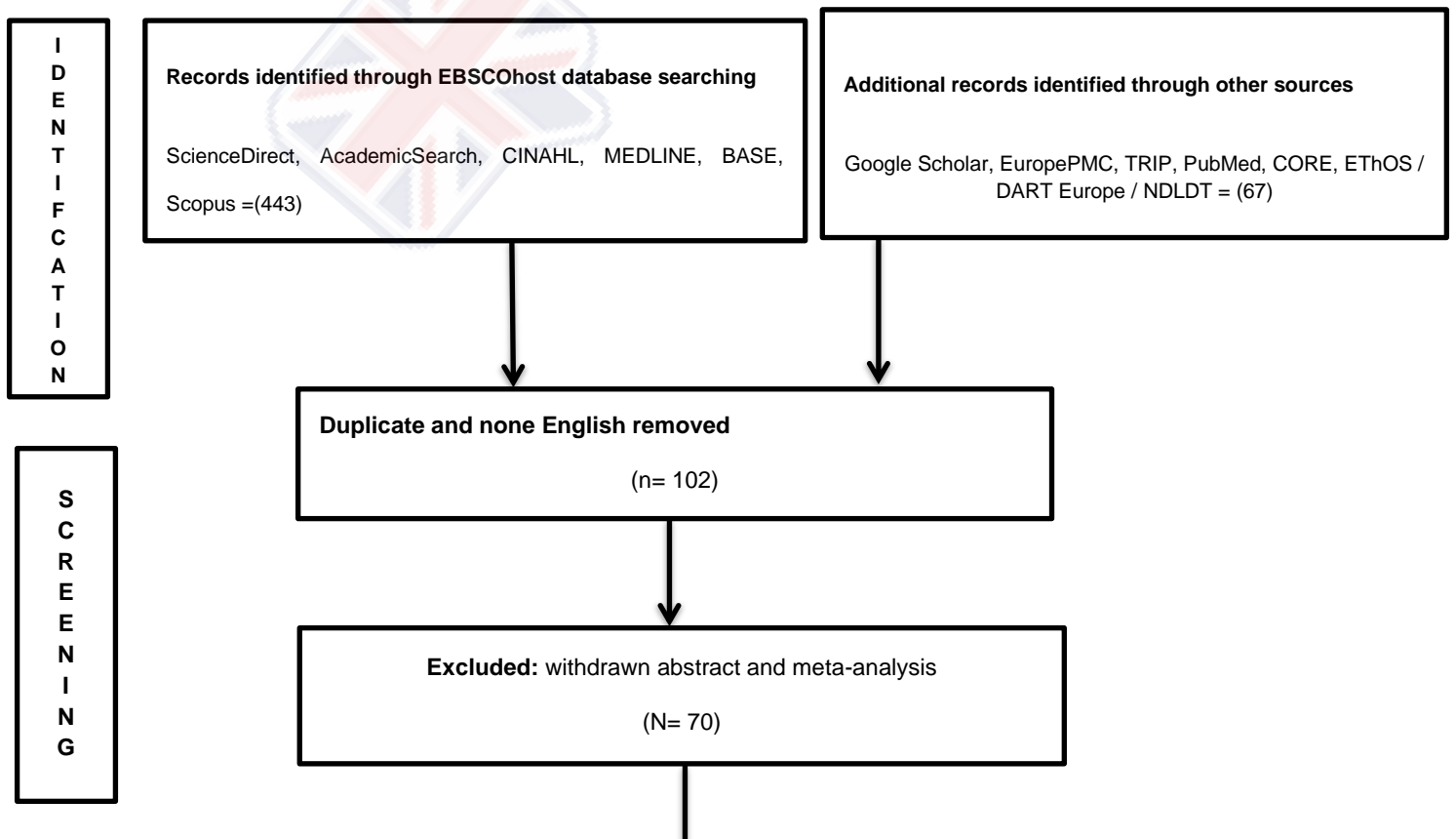Please see Table 2 for a detailed explanation.

FINDINGS

Table 2: Selection criteria and rationale.

Inclusion	Rationale	Limitations
Adults over 18 years with diagnosed case of ARDS irrespective of gender were taken into consideration.	It is the population of choice as this age group falls under the category that is being studied.	Studies may be relevant in under 18 population with diagnosed cases of ARDS.
Patients admitted in critical care setting with reported ARDS were also taken into consideration in order to explore the impacts of prone position in such patients.	To formulate a bias free quantitative approach towards the systemic review and increase inclusiveness for better comprehensive results.	Other healthcare environment may present with relative cases.
Confirmed diagnosis of	Most relevant to the	Uncertain patients with

ARDS as per medical reports.	study. To put forward more reliable review.	initial symptoms of ARDS could have been taken into account for a more comprehensive research.
Published from 2018 to 2022	Relevant to current practice with enough information\data to thoroughly explore the area with upcoming shortfalls.	Older studies might be useful.
Outcome of mortality rate	Patients outcome	Outcome measures

Table 3: Prisma flow chart of article selection

IDENTIFCATION

Records identified through EBSCOhost database searching

ScienceDirect, AcademicSearch, CINAHL, MEDLINE, BASE, Scopus =(443)

Additional records identified through other sources

Google Scholar, EuropePMC, TRIP, PubMed, CORE, EThOS / DART Europe / NDLDT = (67)

SCREENING

Duplicate and none English removed

(n= 102)

Excluded: withdrawn abstract and meta-analysis

(N= 70)

CRITICAL ANALYSIS

This systemic review incorporated evidence-based research about the effect of proning on the mortality rate in ARDS patients, which is written as one out of every four patients that are about 25% to 40% of people with ARDS(Critical Appraisal Skills Programme, 2018) (Siegel MD, Parsons MD, Finlay MD, Nov 8, 2021)

The studies most importantly follow the comparison, where we conclude the practical and immediate management of the patient of ARDS intervening Prone than Supine Position.

Gas exchange and hemodynamic were inspected before the test, during it, and after it lasted for two hours in 13 moderate-severe ARDS patients. In two of these patients, lung computerized tomography examinations were taken from both the supine and prone positions. One patient was a responder, while the other was not. In both cases studied, computerized tomographic tomograms were arranged into the

prone position to analyse poster dorsal densities and note their disappearance and reappearance in anterior regions.

Hence critical analyses present that the systemic studies and the evidence-based research support the Hypothesis that "Mortality rate has been decreased by the intervention of Prone Position in the patients of ARDS" due to improvement in Oxygenation, Ventilation- Perfusion ratio, Uniform Trans-pulmonary Pressure distribution and eventually increased Lung Capacity.

(Please see Appendix 1 for the diagram.)

The current studies between 2020 and 2022 focus on ARDS arising from the coronavirus disease.

Discussion

ARDS is one of the most dangerous and life-threatening respiratory system diseases as quoted, "Even with treatment, about 25% to 40% of people with ARDS do not survive" (Research by Yale University). Being prostrate while lying on your back is sometimes considered a prone position. This position may be used to help patients suffering from respiratory difficulties. The mechanisms for prone positioning indicate that the prone position improves lung compliance and recruitment and these features help improve respiratory health.

Similarly, the patient of ARDS fights Hypoxia when they get better oxygenation through increased lung capacity, uniform Tran's pulmonary distribution of pressure

and an improved ventilation-perfusion ratio, by the change in the physiology of respiratory mechanisms. These changes are attained through achieving the prone position, which elevates the vertebrae above lungs, increasing the chest cavity, than increasing the capacity of Lungs and ultimately enhancing the ventilation mechanism.

Scientists have discovered that patients with acute respiratory distress syndrome who undergo prolonged positive-pressure ventilation show better outcomes than those who are only ventilated for a short period. Additionally, it has been shown that high PEEP (Positive end-expiratory pressure) levels in the ventilator settings affect Proning efficacy.

EVALUATION OF LOCAL PRACTICE

The author uses the Intensive care Unit guidelines & manual 2017 in their trust; it is recommended that low tidal volume be used in ARDS patients. This strategy is known to employ low ventilator-delivered tidal volumes, with an additional goal of limiting airway pressures. The protocol instructs users to use specific combinations of inspired oxygen (FiO2) and Positive end-expiratory pressure (PEEP). These settings have been proved helpful in the outcome of ARDS patients and have been advised in use for the treatment of patients with these conditions. "The application of PEEP and recruitment manoeuvres seems to be more effective in the prone than in the supine position in improving respiratory function" (Gattinoni, Brazzi, Pelosi 2020).

Ventilation modes help in adjusting the tidal volume. However, newer ventilators with different settings can now be used per the clinician and patient's needs.

Proning requests initiated within 48 hours were completed within 227 of 389 patients (58.4 %) with COVID-19 and 11 of 123 patients (8.9 %) with historic acute respiratory distress syndrome (ARDS) 49.4 absolute increase [95% CI for quantile increase, 41.7-57.1]). Comparing COVID-19 to predictive risk, proning proceeded quickly in medical ICUs but was slightly less rapid in nonmedical ICUs (Critical care explorations, May 2022, volume 4)

Limitation

The research is specific for ages over 18 years, which may not be implemented for adolescence and infancy.

The research enlightens the effect of Pronation on Mortality but does not specify the proportion of impact on different patients.

Financial limitations bounded the research to cost-free resources.

The research is not valid for non-ARDS patients, where Pronation may be hazardous to health in some diseases, especially for a critically ill patient.

The absence of a proper communication barrier due to Studies not in English emphasizes the limitation of this research.

CONCLUSION

Considering the severity of ARDS, proning is often the most significant given intervention to expect better outcomes in treating Hypoxia. Affiliating to the number of evidence-based research and observation undertaken in several Hospital settings, it is concluded that proning can be considered as immediate front-line treatment of acute respiratory distress syndrome. The Boolean law under AND and OR function implicated that Prone Lying over rules Supine Lying as a treatment therapy in the patient of ARDS with no side effects.

Gas exchange is improved due to the changing mechanics and physiology of gas exchange during prone ventilation, which is multifactorial. Prone positioning improves the pressure gradient between the ventral and dorsal parts of the lungs, reducing dorsal lung compression and improving lung perfusion.

Hence, lying a patient in a prone (down) position improves the oxygenation of individuals with acute respiratory failure 60 to 70 percent of the time.

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APPENDIX 1

Review studies.

Study	Type	No.of Participants	Location	Duration Of Proning	Level of bias	No. of Mortality
Ehrmann et al. (2021)	RCT	567	Ireland Canada Mexico France Spain	28 days	Low	25
Gleissman et al. (2021)	RCT	44	Sweden university hospital	30 days	Low	12
Mathews et al. (2021)	RCT	2338	68 US hospitals	30 days	Low	1636

Exclusion

Patients under 18 years/ pediatrics	Differences between adults and children	Studies may be relevant in adult population
None ARDS patients	Not relevant to topic	May be able to compare
Payed articles	Financial limitations	May be relevant
Studies not in English	Communication barrier	May be relevant