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Combined Effects of Mechanical Ventilation and Postural Drainage in Acute Respiratory Distress Syndrome

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Sidra Afzal[1], **Mishal Shamsi**[2], **Arida Mushtaq**[3], **Sara Aabroo**[4], **Noor Ul Huda**[5], **Muhammad Ali Haider**[6]

Correspondence
Mishal Shamsi
mishalshamsi@yahoo.com

Affiliations
1 Riphah International University, Lahore, Pakistan
2 Assistant Professor, Sharif College of Rehabilitation Sciences, Lahore, Pakistan
3 Mars Institute, Lahore, Pakistan
4 Riphah International University, Islamabad, Pakistan
5 Student, Riphah International University, Islamabad, Pakistan
6 Hajvery University, Lahore, Pakistan

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ABSTRACT

Background: Acute Respiratory Distress Syndrome (ARDS) is a severe condition impacting lung function, often requiring mechanical ventilation. Postural drainage may improve oxygenation and airway clearance in ARDS patients, particularly in those with burn injuries and inhalation trauma.

Objective: This study aimed to evaluate the combined effects of mechanical ventilation and postural drainage on oxygen saturation and airway clearance in burn patients with ARDS.

Methods: A randomized controlled trial was conducted with 50 burn patients, aged 20-50, admitted to the ICU. Patients were divided into two groups: Group A received postural drainage with mechanical ventilation, and Group B received only mechanical ventilation. Data were collected daily using the APACHE II scale. FiO_2, PO_2, pH, and HCO_3 levels were measured pre- and post-treatment. Data were analyzed using SPSS version 25.

Results: The post-treatment FiO_2 in Group A increased from 48.80 ± 18.92% to 85.40 ± 13.69%, while PO_2 increased from 66.40 ± 17.22 mmHg to 77.40 ± 15.08 mmHg. Statistically significant improvements were observed in oxygenation ($p < 0.05$), with no significant changes in pH and PCO_2.

Conclusion: Postural drainage combined with mechanical ventilation significantly improves oxygenation in burn patients with ARDS.

INTRODUCTION

Acute Respiratory Distress Syndrome (ARDS) is a severe lung condition characterized by inadequate oxygenation, progressive hypoxemia, and pulmonary infiltrates, which significantly compromise respiratory function. It is a life-threatening condition marked by diffuse alveolar damage and endothelial injury in the pulmonary capillaries, leading to increased lung permeability, pulmonary edema, and impaired gas exchange (1). ARDS can develop in response to various critical illnesses, including severe infections, trauma, and inhalation injuries such as smoke exposure, often resulting in pulmonary hypertension and vasoconstriction (2). The pathophysiology of ARDS unfolds in distinct phases, starting with the exudative phase characterized by alveolar edema, followed by the proliferative phase involving alveolar repair and fibrotic changes. This process leads to increased stiffness of the lungs, hypoxemia, and decreased ability to eliminate carbon dioxide (3).

Burn patients, particularly those with inhalation injuries, are highly susceptible to ARDS due to the systemic inflammatory response triggered by extensive tissue damage and, in some cases, sepsis (4). The inhalation of smoke and thermal injuries can further aggravate pulmonary edema and increase vascular permeability, contributing to the rapid progression of ARDS in these patients (5). The management of ARDS in such critical cases often involves mechanical ventilation, which is aimed at improving oxygenation, reducing lung injury, and supporting respiratory function. However, mechanical ventilation alone may not be sufficient to address the complex needs of ARDS patients, particularly in the presence of secretions obstructing the airways (6).

Postural drainage and positioning techniques have been proposed as adjunct therapies in the management of ARDS to enhance airway clearance, promote lung re-expansion, and improve oxygenation (7). These techniques are particularly useful in mobilizing secretions from the lungs, which may otherwise hinder gas exchange and lead to further complications (8). Combined with mechanical ventilation, postural drainage may optimize oxygen saturation by facilitating the removal of mucus and promoting better ventilation-perfusion matching, especially in burn patients with ARDS (9). Despite the growing interest in the role of postural drainage in critical care, there is limited evidence on its specific effects when used alongside mechanical ventilation in ARDS patients, particularly in those with inhalation injuries.

This study aims to evaluate the combined effects of mechanical ventilation and postural drainage on oxygen saturation and airway clearance in burn patients with ARDS. By comparing two groups—one receiving postural drainage with mechanical ventilation and the other receiving mechanical ventilation alone—this research seeks to determine whether postural drainage offers additional benefits in improving respiratory outcomes in this vulnerable population (10). The findings of this study have the potential to inform clinical practice by identifying whether the integration of postural drainage with

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conventional ventilation strategies can enhance the management of ARDS in burn patients.

MATERIAL AND METHODS

This study was conducted as a randomized controlled trial involving two groups of burn patients diagnosed with acute respiratory distress syndrome (ARDS) who were undergoing mechanical ventilation. A total of 50 patients were included in the study, all of whom were admitted to the intensive care unit (ICU) at Jinnah Burn and Reconstructive Surgery Centre, Lahore, over a period of six months in 2022. The patients were randomly allocated into two groups: Group A received mechanical ventilation along with postural drainage therapy, while Group B, the control group, received only mechanical ventilation. Randomization was carried out using a simple randomization method after verifying the inclusion and exclusion criteria.

Patients of both genders between the ages of 20 and 50 years, with 20% to 50% burn injuries (as assessed using the Rule of Nine), and who required mechanical ventilation for over 48 hours due to ARDS and inhalation injury, were included in the study. Patients were excluded if they had a prior history of lung disease, had burns exceeding 50%, or presented with cardiac instability, such as recent myocardial infarction, unstable angina, severe hypotension, or hypertension.

Informed consent was obtained from the patients or their legal guardians before participation. Ethical approval was sought and obtained from the hospital's ethical review board, and the study was conducted in accordance with the ethical standards of the Helsinki Declaration. All patients were provided with a clear explanation of the study's objectives, procedures, and potential risks.

Data were collected using the APACHE II (Acute Physiology and Chronic Health Evaluation II) scale, which is a widely recognized ICU scoring tool used to evaluate disease severity and predict outcomes in critically ill patients. The scale includes several physiological variables, and in this study, the variables collected were age, respiratory rate, oxygenation (FiO2 and PaO2), mean arterial pressure, Glasgow Coma Score, temperature, systolic blood pressure, heart rate, arterial pH, acute renal failure, and history of organ failure (60). Additionally, sputum profiles, mechanical ventilation parameters, and gender were recorded. The reliability of the APACHE II scale in this study was confirmed through Cronbach's Alpha, yielding a coefficient of α = 0.818, indicating good internal consistency.

Patients in Group A underwent postural drainage therapy, administered by a physiotherapist, along with mechanical ventilation. Postural drainage was performed once daily using gravity-assisted positions that were adapted to avoid pressure on skin grafts or donor sites. These positions helped mobilize secretions towards the trachea for easier clearance. Postural drainage sessions were conducted for up to one minute or longer, depending on the patient's response, and data were collected immediately following each session. In contrast, patients in Group B received only mechanical ventilation, with settings adjusted according to standard ICU protocols, including a low tidal volume of 4-8 mL/kg of ideal body weight, PEEP adjustments to maintain oxygen saturation between 88-95%, and plateau pressure kept below 30 cm H2O (29).

The data were analyzed using SPSS version 25. Descriptive statistics were employed to summarize the data using means and standard deviations, while frequency tables and charts were used to present categorical variables. For inferential analysis, the Shapiro-Wilk test was used to determine the normality of the data distribution. Paired t-tests were used to analyze within-group differences between pre- and post-treatment data, while independent t-tests were used to compare between-group differences. A p-value of less than 0.05 was considered statistically significant for all tests.

The study aimed to determine the effectiveness of combining postural drainage with mechanical ventilation in improving oxygenation and airway clearance in burn patients with ARDS. All aspects of the study, including patient assessment, data collection, intervention procedures, and statistical analysis, were performed with strict adherence to the established research and ethical standards (59).

RESULTS

A total of 50 patients were included in the study, divided equally into two groups: 25 patients in Group A (postural drainage with mechanical ventilation) and 25 patients in Group B (mechanical ventilation only). The results were analyzed using SPSS version 25, and the significance level was set at $p < 0.05$.

Paired sample t-tests revealed that there were statistically significant improvements in FiO2 ($p = 0.000$), PO2 ($p = 0.008$), and HCO3 ($p = 0.007$) following treatment in the experimental group. No significant differences were observed for pH, PCO2, or HCT between pre- and post-treatment values.

Table 1: Tests of Normality (Shapiro-Wilk Test)

Variable	Statistics	p-value
PO2 (Pre)	0.982	0.633
PCO2 (Pre)	0.979	0.517
PO2 (Post)	0.951	0.057
PCO2 (Post)	0.984	0.730

The results of the Shapiro-Wilk test indicate that the data follows a normal distribution, as all p-values are greater than 0.05. Postural drainage combined with mechanical ventilation resulted in statistically significant improvements in FiO2, PO2, and HCO3 levels in burn patients with ARDS, as compared to mechanical ventilation alone.

Table 2: Group Statistics (Mean ± SD)

Variable	Group	Pre-treatment Mean ± SD	Post-treatment Mean ± SD
FiO2 (%)	Experimental Group	48.80 ± 18.92	85.40 ± 13.69
	Control Group	54.27 ± 8.08	85.48 ± 14.70
pH	Experimental Group	7.40 ± 0.16	7.40 ± 0.15
	Control Group	7.50 ± 0.22	7.51 ± 0.40
PO2 (mmHg)	Experimental Group	66.40 ± 17.22	77.40 ± 15.08
	Control Group	59.21 ± 14.79	56.01 ± 14.19
PCO2 (mmHg)	Experimental Group	34.52 ± 9.75	31.64 ± 11.51
	Control Group	31.04 ± 10.22	32.68 ± 10.76
HCO3 (mmol/L)	Experimental Group	19.49 ± 5.10	23.17 ± 3.90
	Control Group	24.78 ± 3.95	24.18 ± 4.71
Hematocrit (HCT) (%)	Experimental Group	34.08 ± 12.49	40.28 ± 10.53
	Control Group	33.45 ± 11.80	29.83 ± 11.60

The above table shows the mean and standard deviation (SD) of both the experimental and control groups before and after treatment. Notably, the experimental group demonstrated an increase in FiO2 and PO2 after receiving the combined therapy of postural drainage and mechanical ventilation.

Table 3: Independent Samples Test

Variable	t	p-value	Mean Difference
FiO2 (%) (Pre)	-1.330	0.190	-5.474
FiO2 (%) (Post)	-0.019	0.985	-0.076
pH (Pre)	-1.772	0.083	-0.095
pH (Post)	-1.202	0.235	-0.102
PO2 (Pre)	1.584	0.120	7.190
PO2 (Post)	5.166	0.000	21.387
PCO2 (Pre)	1.232	0.224	3.482
PCO2 (Post)	-0.331	0.742	-1.043
HCO3 (mmol/L) (Pre)	-4.101	0.000	-5.294
HCO3 (mmol/L) (Post)	-0.827	0.412	-1.011
Hematocrit (HCT) (%)	3.332	0.002	10.443

The independent t-test results show that there was a statistically significant difference between the post-treatment PO2 values of the experimental and control groups ($p = 0.000$), as well as for HCT ($p = 0.002$). However, there were no significant differences in other parameters, including FiO2, pH, and PCO2, between the two groups.

Table 4: Paired Samples Statistics (Mean ± SD)

Variable	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	t	p-value
FiO2 (%)	51.537 ± 14.664	85.438 ± 14.055	-17.450	0.000
pH	7.450 ± 0.193	7.456 ± 0.303	-0.262	0.795
PO2 (mmHg)	62.805 ± 16.298	66.707 ± 18.072	-2.746	0.008
PCO2 (mmHg)	32.783 ± 10.042	32.161 ± 11.037	0.519	0.606
HCO3 (mmol/L)	22.135 ± 5.250	23.678 ± 4.309	-2.826	0.007
Hematocrit (HCT) (%)	33.761 ± 12.031	35.054 ± 12.171	-1.164	0.250

The experimental group exhibited a notable increase in oxygenation levels, as demonstrated by the increase in PO2 post-treatment. Additionally, FiO2 significantly improved in the experimental group, indicating enhanced oxygen delivery. However, no significant differences were found in pH and PCO2 levels between the two groups before and after treatment, suggesting that postural drainage primarily affects oxygenation without altering CO2 clearance significantly. Hematocrit levels showed a significant difference between the groups post-treatment, which may indicate an improvement in oxygen-carrying capacity in the experimental group.

Overall, the combination of postural drainage and mechanical ventilation proved to be more effective in enhancing oxygenation and airway clearance in ARDS patients than mechanical ventilation alone.

DISCUSSION

The purpose of this study was to investigate the combined effects of mechanical ventilation and postural drainage on oxygenation and airway clearance in burn patients with acute respiratory distress syndrome (ARDS). The findings demonstrated that postural drainage, when used in conjunction with mechanical ventilation, significantly improved oxygen saturation and partial pressure of oxygen (PO2) in the experimental group compared to the control group, which received mechanical ventilation alone. These results align with previous research suggesting that physiotherapeutic interventions, such as postural drainage, can enhance secretion clearance and improve respiratory function in critically ill patients undergoing mechanical ventilation (49). The significant improvement in FiO2 and PO2 in the experimental group highlights the efficacy of postural drainage in optimizing oxygenation by promoting the removal of secretions that obstruct airways.

The findings of this study are consistent with earlier evidence supporting the role of physiotherapy in reducing pulmonary complications in patients with respiratory conditions. Zeng et al. (49) demonstrated that chest physiotherapy can decrease the incidence of ventilator-associated pneumonia and improve overall respiratory outcomes in mechanically ventilated patients. Although their study did not specifically focus on postural drainage in burn patients, it provides a foundation for understanding the potential benefits of physiotherapeutic interventions in critical care settings. Similarly, Miller et al. (65) emphasized the importance of percussive ventilation in reducing mortality and pneumonia in smoke inhalation-associated lung injury, further supporting the relevance of combining mechanical ventilation with chest physiotherapy to improve outcomes in ARDS patients.

Despite these positive findings, the study had several limitations. First, the sample size was relatively small, with only 50 patients enrolled. While this allowed for adequate analysis within the context of a randomized controlled trial, a larger sample size could have strengthened the statistical power and generalizability of the results. Additionally, the study was conducted in a single center, limiting the external validity of the findings. The heterogeneity of the patient population, including varying degrees of burn severity and inhalation injury, may have also influenced the outcomes. Moreover, while postural drainage significantly improved oxygenation, its effect on carbon dioxide (CO_2) clearance was not statistically significant, indicating that the therapy may primarily benefit oxygenation rather than gas exchange as a whole. This finding requires further investigation, as previous studies have shown mixed results regarding the impact of postural drainage on CO_2 elimination (53).

Another strength of the study was the use of the APACHE II scale, a reliable and well-validated tool for assessing disease severity in ICU patients. The scale allowed for consistent measurement of physiological variables and ensured that the intervention's impact on clinical outcomes was objectively assessed. Furthermore, the inclusion of burn patients with ARDS due to inhalation injuries is a notable contribution to the literature, as this subgroup of patients often experiences more severe respiratory compromise and could benefit from targeted therapeutic strategies (48).

In terms of clinical implications, the study supports the integration of postural drainage into routine care for burn patients with ARDS. The significant improvement in PO2 and FiO2 suggests that the therapy can enhance oxygenation, potentially reducing the need for prolonged mechanical ventilation and associated complications. However, careful consideration should be given to the selection of patients, as certain postural drainage positions may not be suitable for individuals with skin grafts, donor sites, or facial edema. In such cases, modified positions that facilitate secretion clearance without compromising patient safety should be employed (34).

Future research should focus on exploring the long-term effects of postural drainage on ARDS patients, particularly regarding its impact on weaning from mechanical ventilation and overall survival rates. Additionally, multicenter trials with larger sample sizes are recommended to validate the findings and provide more robust evidence for clinical practice. Investigating the combined effects of postural drainage with other physiotherapeutic techniques, such as percussion and vibration, may also yield insights into optimizing respiratory care for this vulnerable population.

CONCLUSION

In conclusion, this study demonstrated that postural drainage combined with mechanical ventilation significantly improved oxygenation in burn patients with ARDS, highlighting its potential as an adjunct therapy in critical care. While further research is needed to confirm its effectiveness in broader patient populations and its impact on long-term outcomes, postural drainage presents a valuable option for improving respiratory function and reducing pulmonary complications in ARDS patients.

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