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Aerosol Therapy and Its Effects on Arterial Blood Gas Parameters in Critically Ill Patients

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ABSTRACT

Background: Aerosol therapy is widely used in respiratory care to deliver medications directly to the lungs and improve airway function while minimizing systemic side effects. It may also influence gas exchange by improving ventilation and oxygenation. However, limited local evidence is available regarding its effect on arterial blood gas (ABG) parameters and breathing patterns. **Objective:** To assess the effect of aerosol therapy on arterial blood gas parameters and breathing. **Methodology:** A descriptive cross-sectional study was conducted from June to December 2024 in the ICUs and pulmonology wards of three tertiary care hospitals in Peshawar: LRH, KTH, and HMC. 100 patients receiving aerosol therapy were included using convenience sampling. Patients aged >16 years who were able to respond to the questionnaire were included, while DNR and brain-death patients were excluded. Data were collected using a questionnaire and analyzed in SPSS version 22 using descriptive statistics. Ethical approval and informed consent were

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obtained before data collection. **Results:** 100 patients receiving aerosol therapy were included. Most patients were aged 30–50 years (43%), and 54% were male. COPD (34%) was the most common diagnosis, followed by asthma (24%). Aerosol therapy was administered mainly via nebulizers (72%). Overall, 91% of patients showed clinical improvement after therapy. The most common improvements were improved breathing (39%) and improved oxygen level (30%). Following aerosol therapy, the proportion of patients with normal pH increased from 39% to 63%, normal $PaCO_2$ from 33% to 63%, normal HCO_3^- from 32% to 66%, and oxygen saturation of 80–100% from 52% to 90%. Patients with low PaO_2 (40–60 mmHg) decreased from 57% to 15% after therapy. **Conclusion:** Aerosol therapy was associated with improved breathing, oxygenation, and arterial blood gas parameters in hospitalized respiratory patients. These findings support the clinical value of aerosol therapy and the importance of ABG monitoring in respiratory care.

Keywords: Aerosol therapy**,** Arterial Blood Gas, Effects, Parameter, and Critically Ill Patient

Introduction

Aerosol therapy is a fundamental intervention in respiratory medicine and is widely used to deliver medications directly to the lungs to improve local therapeutic effect while minimizing systemic adverse effects. It is commonly employed in the management of respiratory disorders such as asthma, chronic obstructive pulmonary disease (COPD), cystic fibrosis, and other airway diseases. By delivering medication in the form of fine particles, aerosol therapy enhances drug deposition in the respiratory tract and may influence pulmonary function and gas exchange (1). Aerosolized medications are administered using devices such as nebulizers, metered-dose inhalers (MDIs), and dry powder inhalers (DPIs). The effectiveness of aerosol delivery depends on several factors, including particle size, inhalation technique, device performance, and the patient's underlying respiratory condition (2,3). Appropriate aerosol delivery can improve bronchodilation, reduce airway inflammation, and enhance alveolar ventilation, thereby potentially improving oxygenation and ventilation. Arterial blood gas (ABG) analysis is an important clinical tool used to evaluate respiratory and metabolic status. Key ABG parameters,

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including arterial oxygen tension (PaO_2), arterial carbon dioxide tension ($PaCO_2$), pH, and bicarbonate (HCO_3^-), provide essential information regarding oxygenation, ventilation, and acid-base balance (4). In patients with respiratory disease, these parameters are often altered due to airway obstruction, ventilation-perfusion mismatch, and impaired gas exchange. Several studies have suggested that aerosol therapy may improve ABG values by reducing airway resistance and enhancing ventilation. In obstructive airway diseases such as asthma and COPD, aerosolized bronchodilators have been shown to improve oxygenation and reduce carbon dioxide retention by improving airflow and ventilation-perfusion matching (5,6). Similarly, aerosolized corticosteroids may improve gas exchange by reducing airway inflammation and edema (7). These physiological effects may contribute to measurable changes in ABG parameters following treatment. With recent advancements in inhalation devices and aerosol delivery systems, including improved particle engineering and smart inhaler technologies, aerosol therapy has become increasingly effective and individualized (2,8). However, despite its widespread use, the direct effect of aerosol therapy on ABG parameters and breathing patterns remains insufficiently explored in many clinical settings. Therefore, this study was conducted to assess the effect of aerosol therapy on arterial blood gases and breathing, with the aim of providing evidence to support clinical decision-making and optimize respiratory care practices.

Methodology

A descriptive cross-sectional study was conducted from June 2024 to December 2024 in the intensive care units (ICUs) and pulmonology wards of three tertiary care hospitals in Peshawar: Lady Reading Hospital (LRH), Khyber Teaching Hospital (KTH), and Hayatabad Medical Complex (HMC). A total of 100 hospitalized patients receiving aerosol therapy were enrolled using a convenience sampling technique. The sample size was calculated using the sample size formula, $n = (Z^2 p(1-p))/d^2$, with a 95% confidence level ($Z = 1.96$), assumed prevalence of 50%, and margin of error of 9.8%, yielding a required sample size of 100 participants. The study included patients older than 16 years admitted to the ICU or pulmonology ward who were receiving aerosol therapy. Patients with do-not-resuscitate (DNR)

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status and brain death were excluded from the study. Data were collected using a questionnaire consisting of 13 items to assess the effect of aerosol therapy on arterial blood gases (ABGs) and breathing. Data were analyzed using IBM SPSS version 22. Descriptive statistics, including frequencies and percentages, were used to summarize the findings. Ethical approval was obtained from the institutional review board, and informed consent was obtained before data collection. Confidentiality was ensured throughout the study.

Results

A total of 100 patients receiving aerosol therapy were included in the study. Most patients were aged 30–50 years (43%), followed by >50 years (37%) and 16–30 years (20%). There was a slight male predominance, with 54% males and 46% females. Regarding primary respiratory diagnosis, COPD was the most common condition (34%), followed by asthma (24%), bronchitis (17%), ARDS (15%), and pneumonia (10%). With respect to associated chronic illnesses, diabetes (24%) and no chronic comorbidity (24%) were the most common, followed by kidney disease (22%), hypertension (17%), and heart disease (13%).

Table 1: ***Clinical changes observed after aerosol therapy***

Clinical outcome	Frequency	Percentage
Improved breathing	39	39.0
Reduced wheezing	19	19.0
Less coughing	3	3.0
Improved oxygen level	30	30.0
No change	9	9.0

Aerosol therapy was delivered predominantly through nebulizers (72%), while metered-dose inhalers (MDIs) were used in 28% of patients. Overall, 91% of patients demonstrated clinical improvement following aerosol therapy, whereas 9% showed no noticeable change. The most frequently reported improvements were improved breathing (39%), improved oxygen level (30%), and reduced wheezing (19%), while less coughing was observed in 3% of patients.

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Table 2: ***Type of aerosol therapy and overall clinical response***

Variable	Category	Frequency	Percentage
Aerosol delivery device	Nebulizer	72	72.0
	Metered-dose inhaler (MDI)	28	28.0
Overall clinical response	Improved	91	91.0
	No change	9	9.0

Among aerosolized medications, steroids (40%) and anti-cholinergics (38%) were the most commonly administered, followed by beta agonists (17%) and combined steroids + beta agonists (5%). Symptomatic improvement was observed in 91% of patients overall, with particularly favorable responses among those receiving steroids and combination therapy. Arterial blood gas parameters showed noticeable improvement after aerosol therapy. The proportion of patients with normal pH (7.35–7.45) increased from 39% before therapy to 63% after therapy. Similarly, patients with PaO_2 in the lowest range (40–60 mmHg) decreased from 57% to 15%, while those with higher oxygenation values (85–100 mmHg) increased from 3% to 25% after therapy. Likewise, normal $PaCO_2$ values (35–45 mmHg) increased from 33% before therapy to 63% after therapy, while abnormal low and high $PaCO_2$ categories decreased. The proportion of patients with normal HCO_3^- values (22–28 mEq/L) improved from 32% to 66% after therapy. Oxygen saturation also improved substantially, with patients in the 80–100% saturation range increasing from 52% before therapy to 90% after therapy. Base excess values also showed improvement following treatment. Patients within the near-normal −2 to +2 mEq/L range increased from 42% before therapy to 57% after therapy, while more ranges that are abnormal became less frequent.

Table 3: ***Comparison of ABG parameters before and after aerosol therapy***

Parameter	Category	Before therapy n (%)	After therapy n (%)
pH	7.35–7.45	39 (39.0)	63 (63.0)
	6.0–7.0	44 (44.0)	21 (21.0)

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	7.45–7.9	16 (16.0)	16 (16.0)
	>7.9	1 (1.0)	0 (0.0)
PaO_2 (mmHg)	40–60	57 (57.0)	15 (15.0)
	65–75	38 (38.0)	40 (40.0)
	80–85	2 (2.0)	20 (20.0)
	85–100	3 (3.0)	25 (25.0)
$PaCO_2$ (mmHg)	35–45	33 (33.0)	63 (63.0)
	45–70	26 (26.0)	20 (20.0)
	20–30	41 (41.0)	17 (17.0)
HCO_3^- (mEq/L)	22–28	32 (32.0)	66 (66.0)
	28–35	9 (9.0)	2 (2.0)
	10–20	59 (59.0)	32 (32.0)
SaO_2 (%)	80–100	52 (52.0)	90 (90.0)
	60–80	39 (39.0)	8 (8.0)
	40–60	9 (9.0)	2 (2.0)
Base excess (mEq/L)	−2 to +2	42 (42.0)	57 (57.0)
	−5 to +5	38 (38.0)	24 (24.0)
	−8 to +8	9 (9.0)	15 (15.0)
	−10 to +10	11 (11.0)	4 (4.0)

Discussion

The present study found that aerosol therapy was associated with clinical and physiological improvement in most patients. Overall, 91% of patients showed improvement after therapy, with favorable changes in breathing, oxygenation, and ABG parameters. In this study, COPD (34%) and asthma (24%) were the most common conditions requiring aerosol therapy. This is consistent with previous literature showing that aerosol therapy remains a cornerstone in the management of obstructive airway diseases such as asthma and COPD (8,9). These diseases commonly present with airway narrowing, ventilation-perfusion mismatch, and impaired gas exchange, making them particularly responsive to inhaled bronchodilators and anti-inflammatory agents. The majority of patients in our study received therapy via nebulizers (72%), while MDIs were used less frequently. This

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pattern is supported by previous evidence showing that nebulizers remain widely used in acute and hospitalized respiratory care due to their ease of use and ability to deliver medication effectively in patients with severe respiratory distress (3,8). Earlier work by Anderson also emphasized the role of improved aerosol devices in enhancing targeted lung drug delivery and optimizing clinical outcomes (3). Clinically, the most common beneficial effects observed after aerosol therapy were improved breathing (39%), improved oxygen level (30%), and reduced wheezing (19%). These findings are in agreement with previous studies demonstrating that aerosolized bronchodilators reduce airway resistance, improve airflow, and enhance alveolar ventilation, particularly in asthma and COPD patients (10–12). The high overall improvement rate in our study further supports the effectiveness of aerosol therapy in acute respiratory management. An important finding of the present study was the improvement in ABG parameters after aerosol therapy. The proportion of patients with normal pH increased from 39% to 63%, indicating improvement in acid-base balance after treatment. Similarly, the percentage of patients with normal $PaCO_2$ increased from 33% to 63%, suggesting improved ventilation and reduced carbon dioxide retention. These findings are consistent with previous studies reporting reductions in $PaCO_2$ following nebulized bronchodilator therapy, especially in acute asthma and COPD exacerbations (6,12). Oxygenation also improved substantially in our patients. The proportion of patients with PaO_2 in the lowest range (40–60 mmHg) decreased markedly after therapy, while higher oxygenation categories became more common. In addition, oxygen saturation (SaO_2 80–100%) increased from 52% before therapy to 90% after therapy. These findings are in line with studies showing that aerosolized bronchodilators and corticosteroids improve oxygenation by enhancing ventilation-perfusion matching and reducing airway inflammation (5,7,9). Similar benefits have also been described in patients with acute severe asthma and ARDS (11,13,14). In the present study, steroids and anti-cholinergics were the most frequently administered aerosolized medications, and steroids demonstrated a particularly favorable clinical response. This finding is consistent with earlier studies that emphasized the role of inhaled corticosteroids in reducing airway inflammation, improving ventilation, and contributing to better

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ABG outcomes (7,14). Combination therapy also appeared beneficial, which supports previous reports showing that bronchodilator and corticosteroid combinations may provide superior physiological improvement in obstructive airway disease (9). Overall, the findings of this study suggest that aerosol therapy contributes to improved breathing patterns, oxygenation, and arterial blood gas values in hospitalized respiratory patients. These results support the continued use of aerosol therapy as an important intervention in respiratory care and highlight the value of ABG monitoring in evaluating treatment response.

Conclusion

Aerosol therapy demonstrated a positive effect on arterial blood gas parameters and breathing among hospitalized patients with respiratory disorders. Most patients showed clinical improvement after therapy, particularly in terms of breathing, oxygenation, and symptom relief. Significant improvement was also observed in pH, PaO_2, $PaCO_2$, HCO_3^- , and oxygen saturation after treatment. These findings suggest that aerosol therapy is an effective supportive intervention for improving respiratory function and gas exchange in patients with pulmonary disease. Routine monitoring of ABG parameters may help clinicians better assess treatment response and optimize aerosol-based respiratory care.

Limitations

This study has several limitations. First, it used a descriptive cross-sectional design, which limits the ability to establish causal relationships between aerosol therapy and ABG improvement. Second, the study used a convenience sampling technique, which may reduce the generalizability of the findings. Third, the sample was taken from only three tertiary care hospitals in Peshawar, so the results may not represent all healthcare settings. Fourth, the study did not stratify outcomes according to disease severity, exact medication doses, or duration of therapy, which may influence ABG response. Finally, inferential statistical tests were not applied to compare pre- and post-therapy ABG changes, which limits the strength of conclusions regarding statistical significance.

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