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Original Article

Clinical Outcomes of High-Flow Nasal Oxygen Therapy in Acute Respiratory Failure in the Emergency Department: A Retrospective Observational Study.

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ABSTRACT

Background: High-flow nasal oxygen (HFNO) is an effective respiratory support modality for patients with acute respiratory failure in the emergency department. It improves oxygenation, reduces the work of breathing, and may decrease the need for invasive mechanical ventilation.

Objective: To determine both the effectiveness and various clinical outcomes achieved through high-flow nasal oxygen therapy when treating patients with acute respiratory failure in emergency departments.

Methods: Adults aged ≥18 years who received high-flow nasal oxygen (HFNO) for acute respiratory failure were eligible. Investigators abstracted demographics, baseline clinical measures (vital signs, arterial blood gas, SpO_2/FiO_2), HFNO settings, and clinical response, and recorded outcomes of endotracheal intubation, ICU admission, and in-hospital mortality.

Results: Among 100 patients, the mean (SD) age was 64.7 (13.2) years, and 58% were male (n=58). Pneumonia was the leading etiology of acute respiratory failure (34%), followed by COPD exacerbation (22%) and pulmonary edema (19%), and within 2 hours of HFNO initiation, oxygenation and respiratory rate improved (SpO_2 from 85.2% ± 5.4% to 94.7% ± 3.8%; $p<0.001$). During hospitalization, 18% required endotracheal intubation and 37% were admitted to the ICU; overall in-hospital mortality was 13%.

Conclusion: High-flow nasal oxygen therapy is a safe and effective modality for managing acute respiratory failure in the emergency department. It significantly improves oxygenation, reduces respiratory distress, and may decrease the need for invasive mechanical ventilation and escalation to intensive care in appropriately selected patients.

INTRODUCTION

The emergency department (ED) frequently manages acute respiratory failure (ARF). This life-threatening condition requires rapid recognition and timely initiation of oxygen therapy to stabilize patients and prevent progression to respiratory arrest or the need for invasive mechanical ventilation [1]. ARF is associated with high morbidity and mortality, particularly when there is a delay in appropriate respiratory support. Conventional oxygen delivery systems, including nasal cannulas and non-rebreather masks, are commonly used as first-line therapies; however, they often prove inadequate in patients with moderate-to-severe hypoxemia due to limited oxygen flow rates, inconsistent FiO_2 delivery, and insufficient humidification [2]. High-flow nasal oxygen (HFNO) therapy has emerged as an effective alternative for managing ARF. It delivers heated and humidified oxygen at high flow rates up to 60 L/min, enabling better oxygen delivery and improved patient tolerance [3]. The physiological benefits of HFNO include improved oxygenation, reduced anatomical dead space, and the generation of low-level positive airway pressure, which together contribute to decreased work of breathing [4]. Additionally, HFNO enhances mucociliary clearance and maintains airway hydration, which further supports respiratory function. Multiple clinical studies have demonstrated that HFNO improves gas exchange and reduces the need for endotracheal intubation in patients with both hypoxemic and hypercapnic respiratory failure [5]. It has also been associated with improved patient comfort compared to conventional oxygen therapy and non-invasive ventilation, leading to better compliance and tolerance [6]. Furthermore, HFNO facilitates carbon dioxide washout from the upper airway, thereby improving ventilatory efficiency. Despite these advantages, most of the existing literature evaluating HFNO has been conducted in intensive care units (ICUs) or inpatient settings. There remains a paucity of real-world data on its early initiation and effectiveness in the ED setting, where clinical decisions must often be made rapidly, and resources may be limited [7]. The ED presents unique challenges, including high patient turnover, time constraints, and variability in disease severity, making it essential to evaluate interventions that are both effective and easy to implement. Given these considerations, HFNO represents a promising frontline therapy for ARF in emergency settings. Early application of HFNO may improve oxygenation, reduce the need for invasive ventilation, and potentially decrease ICU admissions [8]. Identifying patient characteristics and early clinical indicators associated with HFNO success or failure is crucial for guiding timely escalation of care and optimizing patient outcomes [9]. This study aims to evaluate the clinical outcomes of HFNO therapy in the ED among patients presenting with ARF. Specifically, we assess its impact on oxygenation parameters, respiratory rate, intubation rates, ICU admission, and in-hospital mortality, thereby contributing to the growing evidence base for HFNO use in emergency medicine [10].

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational study was conducted in the Department of Diabetes, Endocrinology & Metabolic Diseases, Hayatabad Medical Complex, Peshawar, Pakistan, from January 2023 to January 2024.

Sampling Technique

Consecutive non-probability sampling was used to recruit all eligible patients. adult patients with acute respiratory failure who received high-flow nasal oxygen therapy during the study period. Adult patients receiving HFNO therapy to manage acute respiratory failure comprised the study sample in the emergency department. Patients received treatment through an HFNO system that delivered heated humidified air and adjusted both airflow up to 60 L/min and FiO_2 levels to maintain SpO_2 above 92%. The investigators obtained demographic and clinical data by reviewing the electronic medical record system. Ethical approval was obtained from the Institutional Review Board before data extraction was initiated.

Inclusion Criteria

Adult patients aged ≥18 years who received high-flow nasal oxygen (HFNO) therapy for acute respiratory failure (ARF) as the primary diagnosis in the emergency department were included in the study.

Exclusion Criteria

Patients with do-not-intubate (DNI) orders, those requiring immediate invasive mechanical ventilation at presentation, and patients with incomplete clinical records were excluded.

Sample Size Calculation

Sample size was calculated using OpenEpi version 3.01 at a 95% confidence level based on the anticipated proportion of patients requiring high-flow nasal oxygen therapy reported in previous studies. Since all eligible patients meeting the inclusion criteria during the study period were available, a total of 100 patients were included in the final analysis.

Operational Definitions

- Acute respiratory failure: Inability to maintain adequate oxygenation (SpO_2 <90% on room air or PaO_2 <60 mmHg) requiring advanced oxygen therapy.
- HFNO success: Improvement in oxygenation without requiring endotracheal intubation.
- HFNO failure: Requirement for invasive mechanical ventilation after initiation of HFNO.
- ICU admission: Transfer to the intensive care unit for advanced respiratory or hemodynamic support.
- Endotracheal intubation: Placement of an endotracheal tube for invasive mechanical ventilation.

Data Collection Procedure

Data were collected from the hospital's electronic health record system. Variables included demographic characteristics, primary diagnosis, comorbidities, baseline vital signs, arterial blood gas (ABG) parameters, and HFNO settings. Clinical outcomes such as duration of stay in the emergency department, need for endotracheal intubation, intensive care unit (ICU) admission, and in-hospital mortality were also recorded.

Statistical Analysis

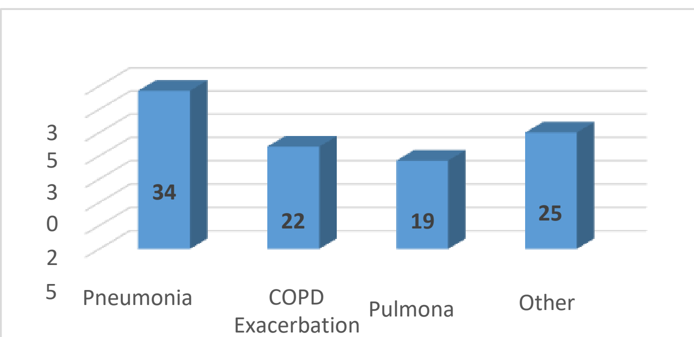
Statistical analysis was performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize baseline characteristics. Continuous variables were analyzed using the independent samples t-test, while categorical variables were compared using the chi-square test. A p-value < 0.05 was considered statistically significant. Multivariable logistic regression analysis was performed to identify independent predictors of HFNO failure. Variables with p <

0.20 in the univariate analysis were entered into the multivariable model. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated, and $p < 0.05$ was considered statistically significant.

RESULTS

A total of 100 patients were included in the study, with a mean age of 64.7 ± 13.2 years; 58% were male. The most common causes of acute respiratory failure were pneumonia (34%), chronic obstructive pulmonary disease (22%), and cardiogenic pulmonary edema (19%). Following initiation of HFNO therapy, significant clinical improvement was observed. The mean respiratory rate decreased from 28.6 ± 6.1 to 22.3 ± 4.9 breaths per minute ($p < 0.001$), while oxygen saturation improved from 85.2% ± 5.4% to 94.7% ± 3.8% within the first two hours ($p < 0.001$). Endotracheal intubation was required in 18% of patients, and ICU admission in 37%. The mean duration of stay in the emergency department was 6.2 ± 3.4 hours. The overall in-hospital mortality rate was 13%. Patients who demonstrated early improvement in oxygen saturation had significantly lower rates of intubation and ICU admission. No significant differences in outcomes were observed by gender or across age groups.

Figure 1: Etiology of Acute Respiratory Failure Among Study Participants



Distribution of the underlying causes of acute respiratory failure among study participants. Pneumonia was the most common etiology, followed by chronic obstructive pulmonary disease (COPD), cardiogenic pulmonary edema, and other causes.

Table 1. Baseline Characteristics of Patients (n = 100)

Variable	Value
Number of patients	100
Age (years), mean ± SD	64.7 ± 13.2
Male, n (%)	58 (58%)
Female, n (%)	42 (42%)

Values are presented as mean ± standard deviation (SD) for continuous variables and frequency (n) with percentage (%) for categorical variables. The study population was male-predominant, with a mean age of 64.7 ± 13.2 years.

Table 2. Etiology of Acute Respiratory Failure

Etiology	n	%
Pneumonia	34	34
COPD exacerbation	22	22
Pulmonary edema	19	19
Others	25	25
Total	**100**	**100**

Distribution of the Underlying causes of acute respiratory failure among study participants. Pneumonia was the most common etiology, followed by chronic obstructive pulmonary disease (COPD) exacerbation and pulmonary edema. Values are presented as frequency (n) and percentage (%).

Table 3. Clinical Outcomes of HFNO Therapy

Outcome	n	%
Endotracheal intubation	18	18
ICU admission	37	37
In-hospital mortality	13	13

Clinical outcomes observed following initiation of high-flow nasal oxygen (HFNO) therapy. Overall, 18% of patients required endotracheal intubation, 37% were admitted to the intensive care unit (ICU), and 13% died during hospitalization.

Table 4. Predictors of HFNO Failure

Variable	Adjusted OR	95% CI	P-value
Severe hypoxemia	2.89	1.34–6.25	0.004
Respiratory rate >30/min	2.18	1.10–4.30	0.021
Delayed HFNO initiation	2.61	1.29–5.28	0.011

Multivariable Logistic regression analysis identified independent predictors of HFNO failure. Severe hypoxemia, respiratory rate greater than 30 breaths/minute, and delayed initiation of HFNO therapy were significantly associated with an increased likelihood of treatment failure. OR = Odds Ratio; CI = Confidence Interval. A p-value <0.05 was considered statistically significant.

DISCUSSION

This study demonstrates that high-flow nasal oxygen (HFNO) therapy is an effective intervention for patients presenting with acute respiratory failure (ARF) in the emergency department (ED), leading to significant improvements in oxygenation and respiratory parameters while reducing the need for invasive ventilation [11,12]. The observed early improvements in oxygen saturation and respiratory rate within the first two hours are consistent with previous studies that highlight the physiological benefits of HFNO in enhancing gas exchange and reducing the work of breathing [13]. The intubation rate of 18% in our cohort is comparable to findings reported in previous studies. Jean-Pierre Frat et al. demonstrated lower intubation rates with HFNO compared to conventional oxygen therapy and non-invasive ventilation in patients with ARF [14]. Although most studies have been conducted in ICU settings, our findings confirm that similar benefits can be achieved in the ED, supporting HFNO as a frontline therapy across different clinical environments [11]. The in-hospital mortality rate of 13% observed in our study is relatively favorable and may reflect early intervention and close monitoring in the ED setting [15,16]. Previous studies, including those by Katsunori Nagata et al., have also demonstrated improved patient outcomes and better tolerance with HFNO compared to non-invasive ventilation [17,18,19].HFNO was well tolerated across a wide range of ARF etiologies, including both hypoxemic and hypercapnic respiratory failure. Studies by Jean-Damien-Ricard et al. have shown improved secretion clearance, enhanced comfort, and better tolerance with HFNO compared to conventional oxygen therapy [20]. The increased use of HFNO during the COVID-19 pandemic further supports its safety and effectiveness when appropriate infection-control measures are in place [21]. Additionally, studies by Gonzalo Hernández et al. demonstrated that HFNO reduces reintubation rates in critically ill patients, highlighting its role in preventing respiratory deterioration [22,23]. These findings align with our results and reinforce the potential of HFNO as a noninvasive strategy to reduce disease progression. However, this study has limitations. It was conducted as a retrospective analysis in a single center, which may limit generalizability. Larger, multicenter prospective studies are needed to validate these findings and to identify predictors of HFNO success in the ED setting.

LIMITATIONS

This study is limited by its retrospective design, single-center setting, and relatively small sample size. Potential confounding factors and missing data may have influenced outcomes. Additionally, the absence of a control group limits direct comparison with other oxygen delivery modalities.

CONCLUSION

HFNO therapy is an effective and safe modality for managing acute respiratory failure in the emergency department. It significantly improves oxygenation, reduces respiratory distress, and may decrease the need for invasive mechanical ventilation. HFNO should be considered a first-line non-invasive respiratory support strategy in acute care settings.

Conflict of Interest: The authors declare no conflict of interest.

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Authors' Contributions (ICMJE)

Ziaullah Khan: Conceptualization, study design, supervision, manuscript drafting, and final approval.

Aftab Khattak: Data collection, data acquisition, statistical analysis, and manuscript review.

Khalid Usman: Data interpretation, critical revision of the manuscript, supervision, and final approval.

All authors read and approved the final manuscript and agree to be accountable for all aspects of the work in accordance with the ICMJE authorship criteria.

Ethical Approval

Ethical approval was obtained from the Institutional Review Board/Ethics Committee of Hayatabad Medical Complex, Peshawar (Ref. No. **812/HEC/B&PSC/04/2022)** before commencement of the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Patient confidentiality was strictly maintained, and all data were anonymized before analysis.

Data Availability Statement

All data generated or analyzed during this study are available from the corresponding author upon reasonable request.

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