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Original Research Article

# A Retrospective Comparative Study of High-Flow Nasal Oxygen versus Non-Invasive Ventilation in the Management of Acute Respiratory Failure in a Tertiary Care Intensive Care Unit

**Soubhagya Kumar Das[1], Bikram Keshari Marthy[2], Sumanta Kumar Dansana[3]**

[1]Associate Professor, Department of Anaesthesiology, SJMCH Puri, Odisha, India
[2]Assistant Professor, Department of Anaesthesiology & Critical Care, SCB Medical College & Hospital, Odisha, India
[3]Assistant Professor, Department of Anaesthesiology, SCBMCH Cuttack, Odisha, India

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**Corresponding author: Dr. Soubhagya Kumar Das**
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**Abstract**

**Background:** In intensive care units (ICUs), acute respiratory failure (ARF) is a frequent and potentially fatal condition that frequently requires immediate breathing support. High-flow nasal oxygen (HFNO), which offers better comfort and physiological advantages, has arisen as an alternative to non-invasive ventilation (NIV), which has long been the primary non-invasive modality. There is still little data comparing various modalities in actual intensive care units, especially in situations with restricted resources.

**Objectives:** To evaluate the physiological response, treatment failure rates, and clinical results of HFNO and NIV in patients hospitalized to a tertiary care intensive care unit due to severe respiratory failure.

**Methods:** The Central ICU of the Department of Anaesthesiology and Critical Care at SCB Medical College and Hospital in Cuttack, Odisha, was the site of this retrospective observational study. We examined the medical records of adult ARF patients who were admitted between July 2024 and June 2025. Included were patients whose initial non-invasive respiratory support was either HFNO or NIV. The two groups' demographics, the cause of ARF, baseline clinical parameters, arterial blood gas readings, length of respiratory support, requirement for intubation, length of stay in the intensive care unit, and in-hospital mortality were examined and contrasted.

**Results:** The analysis covered about 150 patients in total. The baseline features of the HFNO and NIV groups were similar. HFNO was linked to a decreased incidence of interface-related discomfort and showed improved patient tolerance. While HFNO was successful in increasing oxygenation in hypoxemic ARF, NIV demonstrated a quicker improvement in hypercapnic parameters. The groups' rates of treatment failure, as measured by the requirement for invasive mechanical breathing, were similar, with variations depending on the underlying cause and severity of the illness.

**Conclusion:** Both HFNO and NIV were successful strategies for treating acute respiratory insufficiency in this retrospective ICU-based investigation. While NIV continued to be beneficial in certain hypercapnic conditions, HFNO became a well-tolerated substitute, especially in hypoxemic patients. Optimizing results may need tailored respiratory support selection based on ARF subtype and clinical characteristics.

**Keywords:** Acute respiratory failure; High-flow nasal oxygen; Non-invasive ventilation; Intensive care unit; Retrospective study.



## Introduction

One of the most common reasons for admission to intensive care units (ICUs) is acute respiratory failure (ARF), which is linked to high rates of morbidity, death, and medical expenses. It is generally defined by the respiratory system's incapacity to sustain sufficient oxygenation, carbon dioxide removal, or both [1]. It is a final common pathway of various disease conditions affecting the respiratory system. ARF can manifest as hypoxemic (type I), hypercapnic (type II), or mixed respiratory failure, depending on the underlying aetiology. Each of these conditions calls for a different approach to ventilatory support. In an effort to lessen consequences such ventilator-associated pneumonia, airway trauma, the requirement for sedation, and extended ICU stays, non-invasive respiratory support techniques have become more popular over the past 20 years as

alternatives to invasive mechanical ventilation [2]. Delivered via interfaces like face masks or helmets, non-invasive ventilation (NIV) has established itself as a treatment for acute respiratory failure (ARF), especially in cases of severe exacerbations of cardiogenic pulmonary edema and chronic obstructive pulmonary disease (COPD) [3]. NIV enhances alveolar ventilation, lessens breathing effort, and fixes irregularities in gas exchange by supplying positive airway pressure. However, poor patient tolerance, pain from the mask, air leakage, and the requirement for constant supervision and knowledge frequently restrict its efficacy [4].

In recent years, high-flow nasal oxygen (HFNO) has become a viable substitute for non-invasive respiratory assistance. HFNO produces low levels of positive end-expiratory pressure, reduces anatomical dead space, improves mucociliary clearance, and delivers heated and humidified oxygen at high flow rates, enabling accurate fraction of inspired oxygen ($FiO_2$) administration [5]. Nasal cannulae, which are typically better tolerated and make it easier for patients to eat, speak, and expectorate, are used in HFNO as opposed to NIV. Because of these benefits, HFNO is being used more frequently in post-extubation care, peri-procedural oxygenation, and hypoxemic respiratory failure [6].

The relative efficacy of HFNO versus NIV is still being studied, despite increased interest. Conflicting results have been found in randomized trials and meta-analyses; some studies highlight the ongoing superiority of NIV in hypercapnic respiratory failure, while others demonstrate comparable or better outcomes with HFNO in specific patient categories [7, 8]. Crucially, the majority of the evidence now available comes from controlled trial environments or illness subgroups, which may not accurately represent ICU practice in the real world, particularly in the diverse patient populations found in tertiary care facilities in low- and middle-income nations.

The selection and effectiveness of non-invasive respiratory modalities in Indian intensive care units are further influenced by staff-to-patient ratios, frequent patient turnover, and resource limitations. Retrospective analyses from these contexts offer insightful information about the practical use, tolerability, and results of HFNO and NIV in standard clinical practice [9]. Contextualizing the effectiveness of these modalities also requires a grasp of local disease patterns, such as pneumonia, sepsis-related ARF, acute exacerbations of COPD, and postoperative respiratory failure.

Comparative data evaluating HFNO's efficacy, safety, and results in actual ICU settings is required given the growing use of HFNO in conjunction with established NIV protocols. In order to compare HFNO and NIV in the treatment of acute respiratory failure in the Central ICU of a tertiary care teaching hospital in eastern India, this retrospective study was created. This study intends to provide evidence that may help clinicians choose the best non-invasive respiratory support strategy based on patient profile and clinical context by examining patient characteristics, physiological responses, the need for escalation to invasive ventilation, and short-term clinical outcomes.

**Aim and Objectives:** This retrospective study's main goal was to evaluate the efficacy of non-invasive ventilation (NIV) and high-flow nasal oxygen (HFNO) as initial non-invasive respiratory support modalities in patients hospitalized to a tertiary care intensive care unit due to acute respiratory failure. Over the course of a year, the study aimed to assess and compare the clinical outcomes related to these two modalities in standard ICU treatment.

The specific goals were to evaluate and compare the clinical and demographic profiles of patients receiving NIV and HFNO, to examine how physiological and arterial blood gas parameters changed after respiratory support was started, and to ascertain whether treatment was successful or unsuccessful based on the need for escalation to invasive mechanical ventilation. The study also sought to uncover clinical characteristics that might affect the decision to use HFNO or NIV in various subtypes of acute respiratory failure, as well as to compare ICU length of stay and in-hospital mortality between the two groups.

## Materials and Methods

**Study Design and Setting:** This retrospective observational study was conducted in the Central Intensive Care Unit (ICU) of the Department of Anaesthesiology and Critical Care, SCB Medical College and Hospital, Cuttack, Odisha, a tertiary care teaching hospital catering to a large population from eastern India. The study period spanned one year, from July 2024 to June 2025. The ICU is a multidisciplinary unit equipped to provide advanced respiratory and hemodynamic support, including non-invasive and invasive mechanical ventilation.

**Study Population:** During the study period, medical records of adult patients diagnosed with acute respiratory failure (ARF) and admitted to the intensive care unit (ICU) were screened. ARF was described as the sudden start of respiratory distress that requires non-invasive respiratory support and is accompanied by either hypoxemia ($PaO_2 < 60$ mmHg on room air), hypercapnia ($PaCO_2 > 45$ mmHg with $pH < 7.35$), or both. Patients were deemed eligible for participation if their first respiratory support was either non-invasive

ventilation (NIV) or high-flow nasal oxygen (HFNO).

**Inclusion and Exclusion Criteria:** The trial comprised patients 18 years of age or older who were started on HFNO or NIV for the treatment of ARF within the first 24 hours after ICU admission. Patients who received a do-not-intubate or do-not-resuscitate order, had face trauma or anatomical anomalies that precluded the administration of NIV, had insufficient medical records, or needed emergency endotracheal intubation upon presentation were all eliminated. To preserve clarity in result attribution, patients who were transferred between HFNO and NIV for logistical reasons within a very short period of time (less than two hours) were also eliminated.

**Data Collection:** A standardized data extraction methodology was used to retroactively obtain data from patient case files, electronic medical records, and ICU admission registers. Demographic information (age, sex), underlying comorbidities, the major cause of acute respiratory failure, baseline vital signs, severity indicators at admission, and first arterial blood gas (ABG) values were among the characteristics gathered. The kind of modality (HFNO or NIV), initial settings, length of therapy, and patient tolerance were among the details pertaining to respiratory support.

Changes in ABG parameters following the start of respiratory support, the need for escalation to invasive mechanical ventilation, the length of ICU stay, and the in-hospital outcome (survival or mortality) were among the follow-up data.

The requirement for invasive mechanical ventilation and endotracheal intubation because of increased respiratory distress, declining gas exchange, or hemodynamic instability in spite of non-invasive assistance was considered treatment failure.

**Intervention Protocols:** Heated humidified oxygen systems with variable flow rates and fraction of inspired oxygen ($FiO_2$) were used to supply HFNO. These systems were titrated in accordance with ICU procedure to maintain target oxygen saturation levels. Through the proper interfaces, NIV was administered using either continuous positive airway pressure or bilevel positive airway pressure modes, with settings modified according to gas exchange metrics, respiratory effort, and patient comfort. The treating intensivist selected the method based on patient tolerability, ARF subtype, and clinical judgment.

**Outcome Measures:** Treatment failure, as indicated by the need for intrusive mechanical ventilation, was the main outcome measure. Improvements in oxygenation and ventilation parameters, length of non-invasive respiratory support, length of ICU stay, and in-hospital mortality were among the secondary outcomes.

**Statistical Analysis:** Standard statistical software was used to examine the data after it was entered into a spreadsheet. Categorical variables were expressed as frequencies and percentages, whilst continuous variables were expressed as mean with standard deviation or median with interquartile range, depending on the data distribution.

Appropriate statistical tests were used to compare the HFNO and NIV groups; a p-value of less than 0.05 was deemed statistically significant.

**Ethical Considerations:** Informed consent was not required for this retrospective record-based study. The SCB Medical College and Hospital's Institutional Ethics Committee gave the study approval.

No identifying personal information was used in data analysis or reporting, and patient confidentiality was rigorously upheld.

## Results

During the course of the trial, 158 patients with acute respiratory failure were screened. 150 patients were included in the final analysis following the application of inclusion and exclusion criteria. Of these, non-invasive ventilation (NIV) was the major respiratory support modality for 72 patients (48%) and high-flow nasal oxygen (HFNO) for 78 patients (52%).

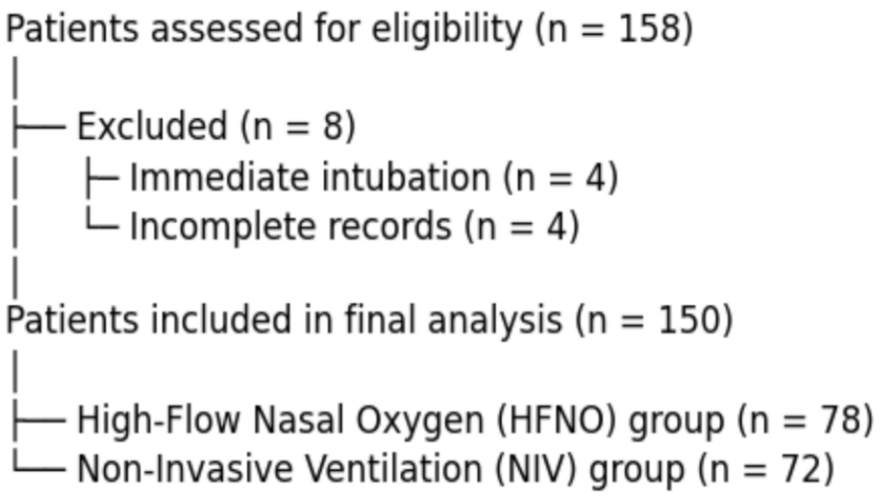


**Figure 1: Patient Flow Selection Diagram**

**Baseline Demographic and Clinical Characteristics**: Patients in the HFNO and NIV groups had similar baseline demographics. The study population's mean age was 56.4 ± 14.2 years, and both groups had a little male predominance. Diabetes mellitus, ischemic heart disease, hypertension, and chronic obstructive pulmonary disease (COPD) were common comorbidities. Pneumonia, abrupt aggravation of COPD, cardiogenic pulmonary edema, and sepsis-related respiratory failure were the most common causes of acute respiratory failure.

**Table 1: Baseline Demographic and Clinical Characteristics**

| Variable | HFNO (n = 78) | NIV (n = 72) | p-value |
|---|---|---|---|
| Mean age (years) | 55.8 ± 13.9 | 57.1 ± 14.6 | 0.58 |
| Male sex, n (%) | 46 (59.0) | 41 (56.9) | 0.79 |
| COPD, n (%) | 18 (23.1) | 26 (36.1) | 0.08 |
| Pneumonia, n (%) | 32 (41.0) | 22 (30.6) | 0.18 |
| Cardiogenic pulmonary edema, n (%) | 10 (12.8) | 15 (20.8) | 0.19 |
| Sepsis-related ARF, n (%) | 12 (15.4) | 9 (12.5) | 0.61 |

**Physiological and Arterial Blood Gas Parameters:** Both groups had similar degrees of aberrant gas exchange and respiratory distress at admission. The baseline $PaCO_2$ levels of patients in the NIV group were higher, indicating a higher percentage of hypercapnic respiratory failure. Following the start of treatment, oxygenation significantly improved with both modalities. \

While HFNO exhibited a consistent improvement in $PaO_2$ and oxygen saturation, NIV showed a more noticeable decrease in $PaCO_2$ levels.

**Table 2: Arterial Blood Gas Parameters Before and After Initiation of Therapy**

| Parameter | HFNO (Baseline) | HFNO (6 hours) | NIV (Baseline) | NIV (6 hours) |
|---|---|---|---|---|
| pH | 7.33 ± 0.07 | 7.36 ± 0.05 | 7.29 ± 0.08 | 7.35 ± 0.06 |
| $PaO_2$ (mmHg) | 58.6 ± 9.4 | 82.3 ± 12.1 | 56.9 ± 10.1 | 79.1 ± 11.6 |
| $PaCO_2$ (mmHg) | 42.8 ± 7.6 | 40.2 ± 6.9 | 58.4 ± 9.2 | 48.6 ± 8.3 |
| $SpO_2$ (%) | 88.1 ± 4.5 | 95.2 ± 2.8 | 87.6 ± 4.8 | 94.1 ± 3.1 |

**Treatment Outcomes and Failure Rates:** There was no statistically significant difference between the two modalities ($p = 0.71$), with 17 patients (21.8%) in the HFNO group and 14 patients (19.4%) in the NIV group experiencing treatment failure, which is defined as the necessity for escalation to invasive mechanical ventilation. In the HFNO group, patients with severe pneumonia and sepsis-related ARF accounted for most treatment failures, whereas patients with poor mask tolerance or substantial air leakage were more likely to have NIV failure.

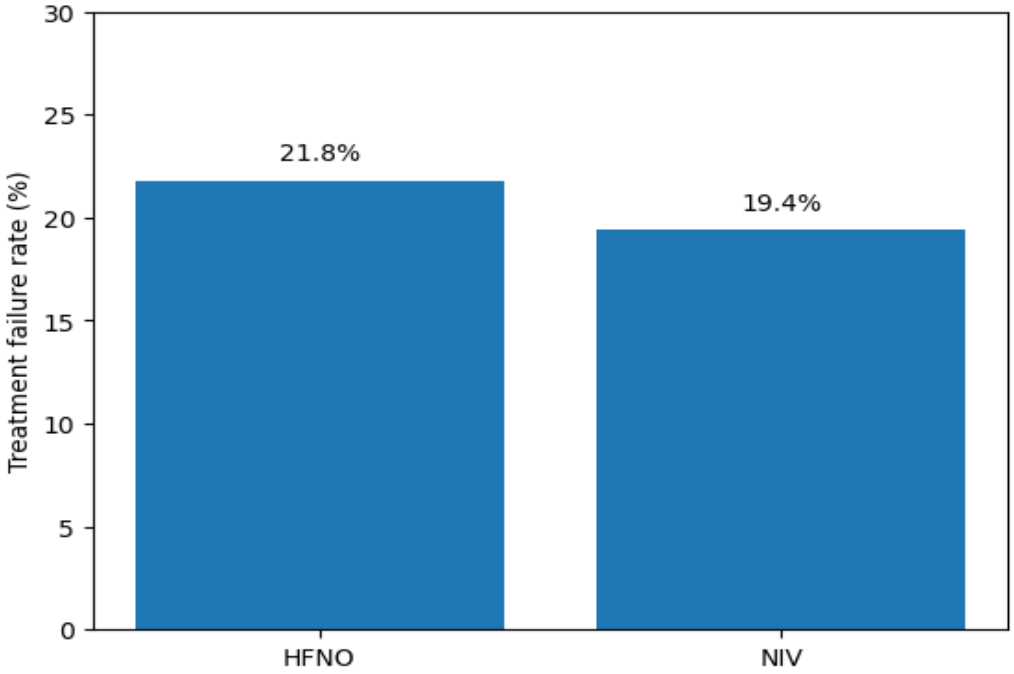


**Figure 2: Comparison of treatment failure rates between HFNO and NIV.**

**ICU Length of Stay and Mortality:** Although the difference was not statistically significant, the HFNO group's median ICU stay was somewhat shorter than that of the NIV group. The two groups' rates of in-hospital death were similar.

**Table 3: Clinical Outcomes**

| Outcome | HFNO (n = 78) | NIV (n = 72) | p-value |
|---|---|---|---|
| Treatment failure, n (%) | 17 (21.8) | 14 (19.4) | 0.71 |
| Median ICU stay (days) | 6 (IQR 4–9) | 7 (IQR 5–10) | 0.27 |
| In-hospital mortality, n (%) | 11 (14.1) | 10 (13.9) | 0.97 |
| Duration of NIV/HFNO (days) | 3.2 ± 1.6 | 3.6 ± 1.8 | 0.18 |

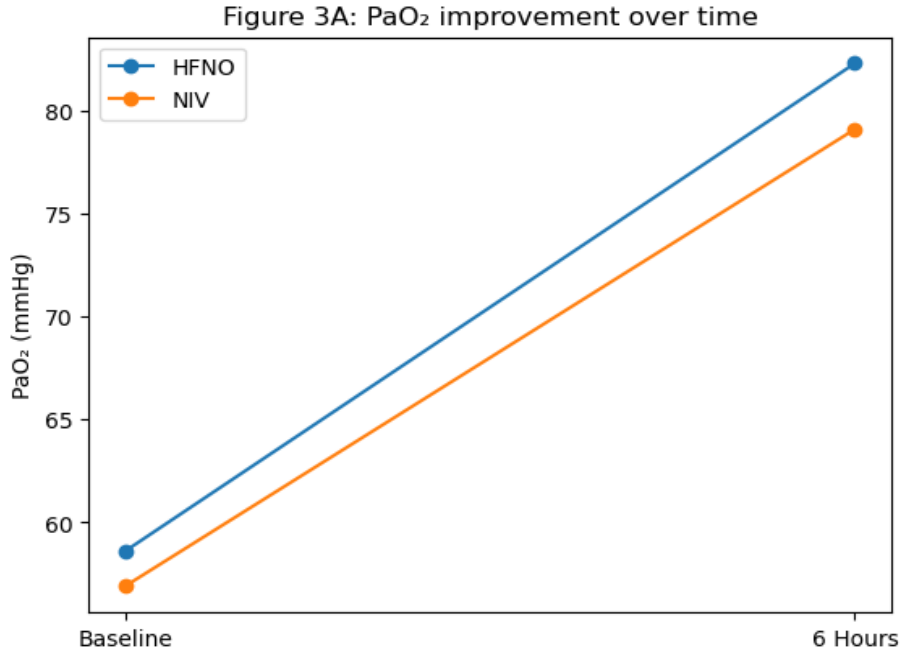


**Figure 3A: Change in arterial oxygen tension ($PaO_2$) following initiation of respiratory support.**

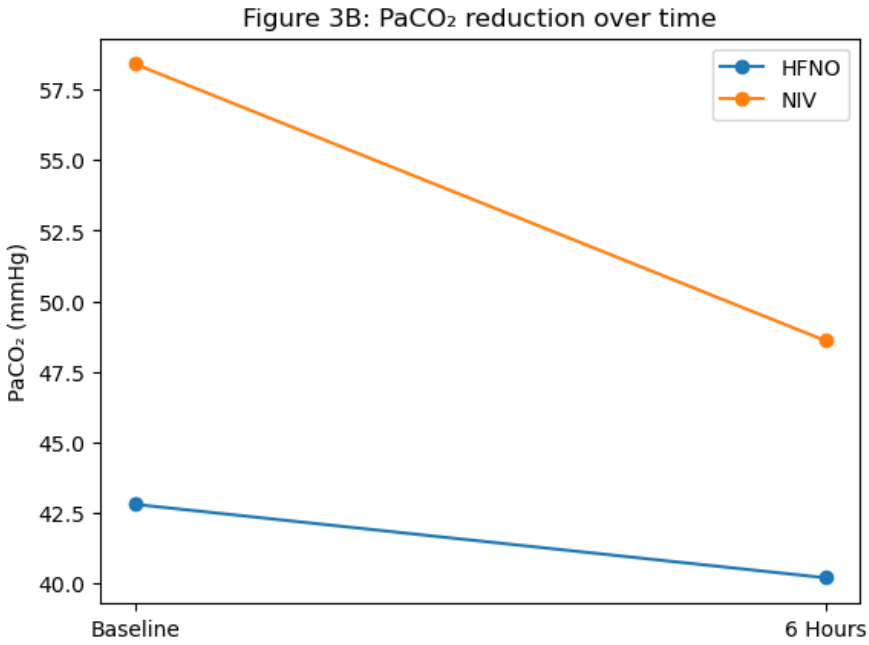


**Figure 3B: Trend in arterial carbon dioxide tension ($PaCO_2$) after initiation of respiratory support.**

## Discussion

High-flow nasal oxygen (HFNO) and non-invasive ventilation (NIV) were compared in this retrospective analysis as the first non-invasive respiratory support techniques for patients with acute respiratory failure admitted to a tertiary care intensive care unit. With similar rates of treatment failure, ICU length of stay, and in-hospital mortality, the results imply that both HFNO and NIV were successful in enhancing gas exchange and clinical outcomes. Nonetheless, variations in physiological response, tolerance, and clinical application were apparent and should be thoroughly examined.

A relevant comparison was possible in this study since the two groups' baseline demographics and the etiological distribution of ARF were comparable. The most common causes of ARF were pneumonia and exacerbations of COPD, which is consistent with the usual illness burden found in Indian tertiary care ICUs. This case mix is in line with earlier observational studies conducted in comparable environments, where respiratory failure is still mostly caused by infectious and chronic airway disorders [10].

Both the HFNO and NIV groups showed improvements in oxygenation, and within the first few hours of treatment, $PaO_2$ and $SpO_2$ values significantly increased. Due to washout of nasopharyngeal dead space, low-level positive airway pressure, and high-flow delivery that matched inspiratory demand, HFNO consistently improved oxygenation [11]. As seen in patients with pneumonia and sepsis-related ARF in our cohort, these physiological benefits make HFNO especially beneficial in hypoxemic respiratory failure. Similar results have been shown in previous clinical trials, where HFNO demonstrated non-inferior or superior oxygenation outcomes in hypoxemic patients when compared to NIV and conventional oxygen therapy [12].

On the other hand, particularly in patients with hypercapnic respiratory failure, NIV was linked to a more noticeable decrease in $PaCO_2$ levels and an improvement in pH. This result is consistent with the body of research that supports NIV as the preferred treatment for acute exacerbations of COPD and cardiogenic pulmonary edema, when ventilatory support and respiratory muscle unloading are crucial [13]. The improved effectiveness of NIV in correcting hypercapnia, a benefit that HFNO may not consistently attain in advanced ventilatory failure, can be explained by its capacity to offer higher amounts of pressure support.

In the current trial, there was no statistically significant difference in treatment failure rates between HFNO and NIV. This finding adds credence to the increasing amount of research indicating that, in certain ARF patients, HFNO can be used as a first modality without raising the risk of delayed intubation as long as proper monitoring is maintained [14].

Crucially, patients with severe pneumonia or sepsis conditions marked by quick illness progression and high oxygen requirements accounted for the majority of HFNO failures in this trial. This emphasizes the necessity of selecting patients carefully and identifying non-responders as soon as possible when using HFNO. One significant

practical benefit of HFNO was shown to be patient tolerance. Clinical documentation often reported higher acceptance of HFNO compared to NIV, however this was not measured using formal comfort levels in this retrospective review. In line with earlier findings highlighting NIV's interface-related problems, mask intolerance, air leakage, and patient discomfort were occasionally blamed for NIV failure [15].

Improved tolerance and ease of use with HFNO may result in more efficient clinical workflows and a decrease in the requirement for sedation in ICUs with limited resources and high nurse-to-patient ratios.

There was no significant difference between the two groups in terms of ICU duration of stay or in-hospital mortality. These results imply that, when properly guided by clinical context, the decision between HFNO and NIV may not have an independent impact on short-term mortality. Rather, concomitant diseases, the severity of the underlying disease, and the promptness of progression to invasive ventilation when necessary are probably what determine outcomes. Meta-analyses comparing HFNO and NIV have reached similar conclusions, showing that despite differences in physiological endpoints, mortality differences were negligible [16].

This study has various limitations because of its retrospective approach. The choice of respiratory modality may have been impacted by selection bias because treatment choices were made using clinician judgment rather than established procedures. Furthermore, risk-adjusted comparisons were limited by the inconsistent availability of severity rating systems like APACHE II or SOFA. However, the study offers useful real-world data from a busy tertiary care ICU that illustrates the practical application of NIV and HFNO in a diverse patient group.

All things considered, the results are in favor of a customized strategy for non-invasive breathing assistance in cases of acute respiratory failure. While NIV is still essential in hypercapnic conditions, HFNO seems to be a safe and useful treatment for hypoxemic ARF. To maximize results and prevent delayed escalation of care, patient phenotype, physiological response, and close clinical monitoring must be integrated.

## Conclusion

Both high-flow nasal oxygen and non-invasive ventilation are useful non-invasive respiratory support techniques in the treatment of acute respiratory failure, according to this retrospective study carried out at a tertiary care intensive care unit. When used correctly in ordinary clinical practice, the two strategies demonstrated similar results in terms of treatment failure, ICU length of stay, and in-hospital mortality.

In patients with hypoxemic respiratory failure, such as pneumonia and sepsis-related ARF, high-flow nasal oxygen has proven to be a well-tolerated treatment that consistently improves oxygenation. It is a useful substitute in some situations due to its simplicity of use and increased patient acceptance. However, because non-invasive ventilation is better at lowering $PaCO_2$ and correcting acidosis, it continues to have a distinct benefit in patients with hypercapnic respiratory failure, particularly those experiencing acute exacerbations of chronic obstructive pulmonary disease.

The results emphasize the significance of careful monitoring and tailored patient selection when deciding between HFNO and NIV. These modalities should be seen as supplementary instruments within the range of non-invasive respiratory assistance rather than as a competing substitute. To further improve selection criteria and maximize results in a variety of ICU groups, prospective studies utilizing standardized severity assessment and protocol-driven therapies are necessary.

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