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Original Research Article

Effect of Non-Invasive Ventilation on Intubation Risk in Prehospital Patients with Acute Cardiogenic Pulmonary Edema: A Retrospective Study

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Conflict of interest: Nil

Abstract:

Background: Acute cardiogenic pulmonary edema (ACPE) is a frequent and life-threatening emergency encountered in the prehospital setting. Early respiratory support plays a critical role in reducing respiratory failure and the need for endotracheal intubation.

Objective: To evaluate the effect of prehospital non-invasive ventilation (NIV) on the risk of endotracheal intubation in patients presenting with acute cardiogenic pulmonary edema.

Methods: This retrospective observational study was conducted at DMCH, Darbhanga. Medical records of patients with ACPE managed in the prehospital setting were reviewed. Patients were categorized into NIV and conventional oxygen therapy groups. The primary outcome was the need for endotracheal intubation. Secondary outcomes included changes in oxygen saturation, respiratory rate, arterial blood gas (ABG) parameters including PaO_2, and in-hospital mortality.

Results: A total of 120 patients were included. The NIV group required intubation significantly less often than the conventional oxygen group (18.3% vs. 36.7%, $p = 0.01$). NIV was associated with significant improvement in oxygen saturation, reduction in respiratory rate, and higher PaO_2 levels on hospital arrival compared with conventional oxygen therapy.

Conclusion: The administration of NIV before going to the hospital greatly lowers the probability of endotracheal intubation in patients with acute cardiogenic pulmonary oedema and improves early respiratory outcomes.

Keywords: Non-Invasive Ventilation, Cardiogenic Pulmonary Edema, Prehospital Care, Intubation Risk, Emergency Medicine.

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Introduction

Acute cardiogenic pulmonary edema is a common cause of acute respiratory distress in emergency and prehospital settings and is associated with significant morbidity and mortality [1]. It results from elevated pulmonary capillary pressure leading to rapid accumulation of fluid in the alveolar spaces, thereby impairing gas exchange and lung compliance [2].

Early recognition and prompt respiratory support are essential to prevent clinical deterioration and progression to respiratory failure requiring endotracheal intubation [3]. Traditionally, supplemental oxygen therapy has been used as the initial management strategy; however, oxygen alone does not address the underlying pathophysiological mechanisms such as increased preload, afterload, and work of breathing [4].

Non-invasive ventilation, including continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BiPAP), has gained increasing acceptance in the management of ACPE. NIV improves oxygenation by recruiting alveoli, reducing preload and afterload, and decreasing the work of breathing [5,6]. Several hospital-based studies have demonstrated that NIV reduces the need for intubation and improves clinical outcomes [7–9].

In the prehospital environment, early initiation of NIV may offer additional benefits by stabilizing patients before hospital arrival. However, evidence

regarding its effectiveness in reducing intubation risk in prehospital ACPE patients remains limited, particularly in resource-constrained settings [10–12].

This study was undertaken to evaluate the effect of prehospital non-invasive ventilation on the requirement for endotracheal intubation in patients presenting with acute cardiogenic pulmonary edema.

Materials and Methods

Study Design: A retrospective observational study.

Study Place: Darbhanga Medical College and Hospital (DMCH), Bihar.

Study Duration: January 2024 to December 2024.

Sample Size: A total of 120 patients with acute cardiogenic pulmonary edema.

Inclusion Criteria

- Age ≥18 years
- Clinical diagnosis of acute cardiogenic pulmonary edema
- Managed in the prehospital setting
- Complete medical records available

Exclusion Criteria

- Non-cardiogenic pulmonary edema
- Patients with altered sensorium requiring immediate intubation
- Trauma-related respiratory distress

Study Groups

- **Group A:** Patients receiving prehospital non-invasive ventilation
- **Group B:** Patients receiving conventional oxygen therapy

Outcome Measures

- **Primary outcome:** Requirement of endotracheal intubation
- **Secondary outcomes:** Oxygen saturation (SpO_2), respiratory rate, blood pressure, arterial blood gas (ABG) parameters including PaO_2 on hospital arrival, and in-hospital mortality.

Statistical Analysis

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± SD and compared using Student's t-test. Categorical variables were analyzed using the Chi-square test. A p-value <0.05 was considered statistically significant.

Results

A total of 120 patients diagnosed with acute cardiogenic pulmonary edema and managed in the prehospital setting were included in the study. Of these, 60 patients received non-invasive ventilation (NIV group) and 60 patients received conventional oxygen therapy (oxygen group).

Baseline Characteristics

The baseline demographic and clinical characteristics of the study population are summarized in Table 1. The mean age of patients in the NIV group was 61.4 ± 9.2 years, while that of the oxygen group was 62.1 ± 10.1 years, with no statistically significant difference between the two groups (p = 0.68). Male patients constituted 58.3% of the NIV group and 56.7% of the oxygen group, which was also not statistically significant (p = 0.84). Baseline oxygen saturation levels were comparable between the two groups (78.6 ± 6.4% vs 79.1 ± 7.1%, p = 0.71), indicating that both groups were similar at presentation.

Additional physiological parameters including respiratory rate, blood pressure, and arterial blood gas (ABG) findings were also assessed at baseline. The mean respiratory rate at presentation was 30.4 ± 5.1 breaths/min in the NIV group and 31.2 ± 5.6 breaths/min in the oxygen group (p = 0.42). The mean systolic and diastolic blood pressure in the NIV group was 158 ± 18 / 96 ± 12 mmHg compared to 160 ± 20 / 98 ± 13 mmHg in the oxygen group (p = 0.55). Baseline PaO_2 values obtained from ABG analysis were also comparable between the two groups (58.3 ± 7.5 mmHg vs 57.6 ± 8.1 mmHg, p = 0.63) (Table 1)

Table 1: Baseline Characteristics of the Study Population

Parameter	NIV Group (n = 60)	Oxygen Group (n = 60)	p-value
Mean age (years)	61.4 ± 9.2	62.1 ± 10.1	0.68
Male (%)	58.3	56.7	0.84
Baseline SpO_2 (%)	78.6 ± 6.4	79.1 ± 7.1	0.71
Respiratory rate (breaths/min)	30.4 ± 5.1	31.2 ± 5.6	0.42
Blood pressure (mmHg)	158 ± 18 / 96 ± 12	160 ± 20 / 98 ± 13	0.55
PaO_2 (ABG) (mmHg)	58.3 ± 7.5	57.6 ± 8.1	0.63

Requirement for Endotracheal Intubation: The primary outcome of the study was the need for endotracheal intubation. Patients in the NIV group had a significantly lower intubation rate compared to those receiving conventional oxygen therapy (18.3% vs 36.7%). This difference was statistically

significant ($\chi^2 = 6.3$, $p = 0.01$) and is illustrated in Figure 1. These findings suggest that prehospital use of non-invasive ventilation effectively reduces the risk of invasive airway management.

Physiological Parameters on Hospital Arrival: Secondary outcome measures included oxygen saturation, respiratory rate, and arterial blood gas findings upon arrival at the hospital. Patients treated with NIV demonstrated a significantly higher mean oxygen saturation on arrival compared to the oxygen group (92.4 ± 4.1% vs 87.6 ± 5.3%, $p < 0.001$). Additionally, the mean respiratory rate was significantly lower in the NIV group (22.1 ± 3.4 breaths/min) compared to the oxygen group (27.6 ± 4.2 breaths/min, $p < 0.001$).

Arterial blood gas analysis further showed that PaO_2 levels on hospital arrival were significantly higher among patients treated with NIV (78.5 ± 9.3 mmHg) compared to those receiving conventional oxygen therapy (68.2 ± 10.1 mmHg), indicating improved oxygenation ($p < 0.001$). These findings indicate better early physiological stabilization in patients receiving NIV (Table 2).

In-Hospital Mortality: In-hospital mortality was lower in the NIV group (10.0%) compared to the oxygen group (18.3%); however, this difference did not reach statistical significance ($p = 0.19$), as shown in Table 2.

Table 2: Comparison of Clinical Outcomes Between Groups

Outcome	NIV Group	Oxygen Group	p-value
Intubation (%)	18.3	36.7	0.01
SpO_2 on arrival (%)	92.4 ± 4.1	87.6 ± 5.3	<0.001
Respiratory rate (/min)	22.1 ± 3.4	27.6 ± 4.2	<0.001
PaO_2 on arrival (mmHg)	78.5 ± 9.3	68.2 ± 10.1	<0.001
Mortality (%)	10.0	18.3	0.19

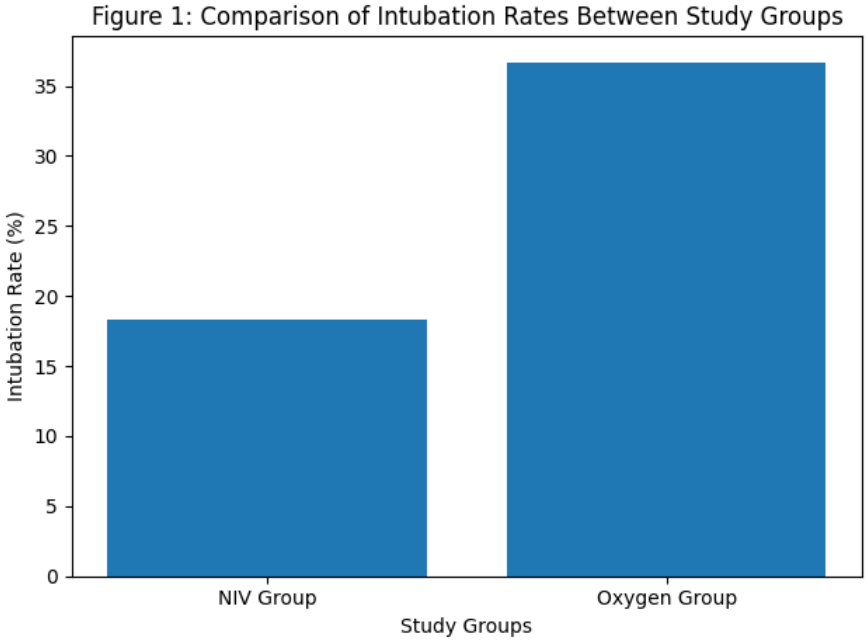

Figure 1: Comparison of Intubation Rates Between Study Groups

Discussion

The present study demonstrates that the use of non-invasive ventilation in the prehospital management of acute cardiogenic pulmonary edema is associated with a significant reduction in the need for endotracheal intubation. Avoiding invasive ventilation is clinically important, as intubation has been linked to increased complications, longer hospital stay, and higher morbidity in acutely ill patients [13]. Early respiratory stabilization before hospital arrival may therefore play a crucial role in improving patient outcomes.

Patients who underwent non-invasive ventilation exhibited improved oxygenation and diminished respiratory distress upon arrival at the emergency department. The physiological effects of positive airway pressure, such as alveolar recruitment, lessening of pulmonary congestion, and lessening of the work of breathing, can help explain these results [14]. Improvement in these parameters at an initial

stage may avert additional clinical deterioration and the ensuing necessity for invasive airway management [15].

The lower intubation rates seen in the NIV group in this study are consistent with previous studies that highlight the benefits of early non-invasive ventilation in acute cardiogenic pulmonary oedema. Several studies have shown that timely application of NIV slows the progression to respiratory failure and improves short-term clinical outcomes [16–18]. Early initiation in the prehospital setting may offer an added advantage by shortening the time to effective respiratory support.

In addition to reducing intubation risk, prehospital NIV may also contribute to better utilization of emergency department and intensive care resources. Stabilization prior to hospital arrival has been shown to decrease the immediate need for aggressive interventions and may improve workflow in high-volume emergency settings [19]. Although mortality was lower in the NIV group in the present study, the difference was not statistically significant, which may be related to sample size and the retrospective nature of the analysis [20].

Current international guidelines recommend the early use of non-invasive ventilation in patients with acute cardiogenic pulmonary edema who do not have contraindications [21,22]. The findings of this study support these recommendations and suggest that extending NIV use into the prehospital phase is both feasible and beneficial. However, appropriate patient selection and trained prehospital personnel are essential to ensure safe application [23].

While emerging technologies and advanced monitoring tools are being explored to optimize respiratory support, non-invasive ventilation remains a simple, effective, and widely applicable intervention in acute heart failure-related respiratory distress [24]. Future prospective studies with larger sample sizes are needed to further evaluate long-term outcomes and refine prehospital NIV protocols [25].

Conclusion

Prehospital use of non-invasive ventilation significantly reduces the risk of endotracheal intubation and improves early respiratory parameters in patients with acute cardiogenic pulmonary edema. Early initiation of NIV should be encouraged as part of standard prehospital management protocols for ACPE.

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