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Original Research Article

Outcome of Non-Invasive Ventilation (NIV) Therapy in Acute Exacerbation of Chronic Obstructive Pulmonary Disease (COPD)

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Abstract

Introduction: Acute exacerbations of chronic obstructive pulmonary disease often lead to respiratory failure, necessitating ventilatory support. Non-invasive ventilation (NIV) has proven effective in reducing the need for intubation, improving gas exchange, and decreasing hospital mortality. This study aims to evaluate the outcomes of NIV in AECOPD patients and correlate clinical, radiological, and laboratory parameters with NIV success or failure.

Materials and Methods: This prospective observational study included 106 patients with AECOPD who required NIV support. Clinical profiles, laboratory parameters including ABG, chest radiographs were recorded. The patients were monitored for NIV success or failure. Data were analyzed to identify predictors of NIV outcome.

Results: NIV success was achieved in 73.58%, while 26.42% experienced NIV failure. The mean pH and $PaCO_2$ levels improved significantly in the success group compared to the failure group. Patients with hypercapnic respiratory failure responded better to NIV. Common radiographic findings included Hyperinflation and consolidation. Comorbidities, low baseline pH, high $PaCO_2$, and altered sensorium were significant predictors of poor outcome.

Conclusion: NIV is an effective initial ventilatory strategy in AECOPD patients, particularly in those with hypercapnic respiratory failure. Early identification of predictors of NIV failure can help guide timely escalation of care, ultimately improving patient outcomes.

Keywords: Copd, Niv, Aecopd, Pap, Endotracheal Intubation.

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Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a prevalent respiratory condition characterized by progressive, irreversible airflow limitation, commonly presenting with chronic cough, dyspnea, and sputum production, ultimately leading to substantial impairment in pulmonary function and deterioration in quality of life [1].

COPD has emerged as a major global health burden, currently ranking among the top three leading causes of mortality worldwide [2]. Alarmingly, nearly 90% of COPD-related deaths occur in low- and middle-income countries (LMICs), where access to healthcare resources remains limited [3,4] . Despite being a preventable and treatable condition, COPD continues to pose a significant public health challenge, leading to prolonged suffering and premature deaths due to disease progression or associated complications. With an aging global population and continued exposure to key risk factors such as tobacco smoke, environmental pollutants, and occupational hazards, the burden of COPD is projected to rise substantially in the coming decades [5].

COPD primarily develops due to prolonged exposure to harmful environmental factors, with tobacco smoke being the most significant risk factor. Additionally, inhaling toxic gases and particulate matter from both indoor and outdoor air

pollution contributes to disease progression. However, other influences, such as impaired lung development and accelerated lung aging, may also play a role in increasing susceptibility. [6] Poverty has been consistently linked to airflow obstruction, with lower socioeconomic status being a significant risk factor for the development of COPD [7]. Inadequate lung emptying during expiration leads to air trapping and progressive lung hyperinflation. This increased lung volume limits inspiratory capacity, forcing the respiratory muscles to work harder. As a result, the heightened effort required for breathing contributes to breathlessness and reduced exercise tolerance [8]

Non-invasive ventilation (NIV) is a method of delivering ventilatory support that avoids the need for endotracheal intubation. It plays a vital role in the management of patients with acute exacerbation of COPD by effectively decreasing respiratory rate, alleviating breathing effort, and easing dyspnea. NIV has been shown to significantly decrease both intubation rates and overall mortality, making it a cornerstone in the management of respiratory failure in COPD patients [9].

The mechanism of NIV involves using two distinct pressure settings: one for inspiration and another for expiration. During the inspiratory phase, inspiratory positive airway pressure (IPAP) assists the patient by delivering a pressure boost that enhances tidal volume and reduces the work of breathing. This inspiratory support functions similarly to the peak airway pressure seen in conventional mechanical ventilation systems, helping to improve gas exchange and relieve respiratory distress. The dual-pressure setup allows for better patient comfort and synchronization with spontaneous breathing efforts. Generally, the selected pressure value corresponds closely to the inspiratory positive airway pressure (IPAP) level.

The expiratory positive airway pressure (EPAP) functions similarly to positive end-expiratory pressure (PEEP) in invasive ventilation or continuous positive airway pressure (CPAP) during spontaneous respiration. Both IPAP and EPAP can be adjusted based on the individual patient's requirements for oxygenation and carbon dioxide clearance. As the primary goals of NIV include enhancing arterial oxygen (pO_2) and reducing carbon dioxide levels (pCO_2), these gas exchange parameters serve as key targets for titration. [10,11] An elevated IPAP leads to increased tidal volume and overall minute ventilation. Meanwhile, EPAP enhances oxygenation by elevating functional residual capacity. Beyond this, EPAP also plays a vital role in alleviating upper airway obstruction through its airway-splinting effect, maintaining patency during exhalation.

It is considered the standard of care for reducing both morbidity and mortality in patients admitted with acute exacerbations of COPD complicated by respiratory failure. [12] NIV also helps in lowering the respiratory rate, reducing the work of breathing, and easing the intensity of breathlessness. When arterial blood gas values are available, improvements in oxygenation (PaO_2) and ventilation ($PaCO_2$) can be effectively monitored and used as clinical endpoints. NIV helps reduce complications like ventilator-associated pneumonia and shortens the overall length of hospital stay. More importantly, its use has been associated with a significant decline in both intubation rates and mortality, making it a vital intervention in the management of acute respiratory failure. [13,14,15]

This study provides updated, region-specific insights into NIV outcomes in acute exacerbation COPD, focusing on clinical and laboratory factors influencing its effectiveness. The findings aim to improve patient management, optimize NIV use, and reduce complications. This is a one-of-a-kind study conducted in this part of the country.

Aims & Objective

- To study the outcome of Non-invasive Ventilation (NIV) therapy in Acute Exacerbation of Chronic Obstructive Pulmonary Disease (COPD), based on Clinical Parameters
- To study the outcome of Non-invasive Ventilation (NIV) therapy in Acute Exacerbation of Chronic Obstructive Pulmonary Disease (COPD), based on Laboratory Parameters.

Material & Method

Study Design: This study was conducted as a 'hospital-based observational study'.The study was conducted over a 12-month period, from March 2024 to February 2025.The study was performed in the Department of Pulmonary Medicine and Allied specialties at Gauhati Medical College in Guwahati, Assam.All adult patients with COPD with exacerbations admitted in the RICU of Department of Pulmonary Medicine and Allied Specialties over a period of 12 months

Selection of Patients

1. Age >14 years
2. Informed Written Consent
3. Respiratory acidosis is characterized by a $PaCO_2$ level of 6.0 kPa (or 45 mmHg) and an arterial pH of 7.35.
4. Severe dyspnea accompanied by clinical signs of respiratory muscle exhaustion, increased work of breathing, or both, such as the use of accessory muscles for respiration, paradoxical

abdominal movement, or retraction of the intercostal spaces.
5. Persistent hypoxemia that does not improve with supplemental oxygen administration.

Exclusion Criteria:

1. Age<14 years
2. Negative Consent
3. Copious respiratory secretions that could not be cleared easily by the patients.
4. Hemodynamically Unstable
5. Diagnosis of asthma, sleep apnea syndrome or respiratory failure not due to COPD.
6. Recent facial trauma.
7. Upper abdominal surgery

Results & Analysis

A total of 106 patients of Acute Exacerbation of COPD requiring NIV were enrolled. Clinical history, physical examination, and laboratory investigations, including ABG, were performed before NIV initiation. Responses were recorded after one hour. Appropriate statistical methods were applied, calculated and presented. The majority patients had a successful outcome with NIV (73.58%), while remaining 26.42% experienced failure.

The majority of patients with NIV success had age group between 61-70 years (32.05%), followed by 51-60 years (29.49%) and ≤50 years (25.64%), while the majority of patients with NIV failure had age group between 71-80 years (53.57%), and followed by 61-70 years (21.43%) and 51-60 years (17.56%). The age is ranged from 45 to 88 with mean 59.69 ± 9.53 years in NIV success and 71.07 ± 9.39 years in NIV failure. The p value from independent sample t-test and Chi-square test indicates that the statistically significant difference in outcomes (p=0.0002, 0.0000125 respectively).

In the patients with NIV success, the majority of patients were Male (71.79%), followed by Female (28.21%). While, in patients with NIV failure, the majority of patients were also Male (78.57%), followed by Female (21.43%). The p-value of 0.6543 from Chi-square test indicates that there is no significant difference between outcomes.

In the patients with NIV success, the majority of patients were in Class III and IV (44.87% each), followed Class II (6.41%) and Class I (3.85%). While, in patients with NIV failure, the majority of patients were in Class IV (57.14%), followed by Class III (35.71%), Class II and Class I (3.75% each). The p-value of 0.7175 from the Chi-square test indicates no significant In the normal BMI category, 37.18% had experienced the NIV success and 64.29% had experienced the NIV failure. In overweight category 17.95% had in NIV success and 14.29% had NIV failure of non-invasive ventilation. In the Obesity category, 44.87% of NIV success and 21.43% of the NIV failure were observed. The p-value of 0.0386from the Chi-square test indicates that there is no significant difference in the outcomes difference in the outcomes with socioeconomic status.

. In the patients with NIV success, the majority of patients had Dyspnoea (94.87%), followed Cough (79.49%), Sputum production (67.95%), Fever (29.49%), Chest pain (16.67%) and Loss of Appetite (14.10%). While, in patients with NIV failure, the majority of patients had Dyspnoea (92.86%), followed Cough (89.29%), Sputum production (75.00%), Fever (35.71%), Chest pain (28.57%) and Loss of Appetite (3.57%). The p value of 0.0039 from Chi-square test shows there is statistically significant differences between outcomes in loss of appetite, for remaining presenting illness the Chi-square test shows no statistically significant difference between outcomes.

Out of 78 NIV Success patients, 30.77% were of Grade-3, followed by 25.64% of Grade-2 and 24.36% of Grade-4, while among 28 NIV Failure patients, 47.06% were of Grade-4, followed by 38.82% of Grade-3 and 11.76% of Grade-2. The p-value of 0.0039 from Chi-square test indicates that there is statistically significant difference in mMRC dyspnoea scale and outcomes.

In the patients with NIV success, the majority of patients had Biomass exposure (44.87%), followed by Previous ICU admissions for AECOPD (38.46%), History of NIV use in past exacerbations (19.23%) and Family history (5.13%). In the patients with NIV Failure, the majority of patients had Biomass exposure (57.14%), followed by Previous ICU admissions for AECOPD (42.86%), History of NIV use in past exacerbations (32.14%) and Family history (17.86%). The p value from Chi square test indicates that there is no statistically significant difference in outcomes.

In the patients with NIV success, the majority of patients had hypertension (41.03%), followed by diabetes mellitus (29.49%) chronic kidney disease (12.82%) and ischemic heart disease (12.82%). In the patients with NIV failure, the majority of patients had hypertension (46.42%), followed by diabetes mellitus (42.86%), ischemic heart disease (21.42%) and chronic kidney disease (14.28%) Fewer patients in both outcomes had tuberculosis (5.12% in NIV success and 7.14% in NIV failure) and chronic liver disease (3.84% in NIV success and 10.71% in NIV failure). The p value of 0. 0639 from Ch-square test indicates that there is no statistically significant difference in outcomes.

In the Patients with NIV Success, the majority of patients had 0-10 packs per years (43.59%),

followed by 11-20 packs per year (35.90%) and 21-30 packs per year (20.51%). In the Patients with NIV Failure, the majority of patients had 0-10 packs per years (42.86%), followed by 11-20 packs per year and 21-30 packs per year (28.57% in each). The p value of 0. 6316 from Chi-square test revealed that there is no statistically significant difference in outcomes.

The mean was slightly higher in patients with NIV failure than those with NIV success in respiratory rate (39.03 ± 4.19 vs 26.06 ± 5.30), heart rate (115.90 ± 13.31 vs 95.90 ± 15.42) and temperature (37.93 ± 0.95 vs 37.70 ± 1.00). However, on analysis by independent sample t-test indicates the respiratory rate and heart rate differ significantly (p=0.000, 0.0000 respectively), while temperature did not differ significantly (p=0.3817). The mean was higher in patients with NIV success than those of NIV failure in systolic blood pressure (129.90 ± 23.68 vs 126.04 ± 19.71), diastolic blood pressure (81.09 ± 14.25 vs 77.64 ± 18.72) and oxygen saturation (78.37 ± 7.92 vs 48.11 ± 12.01). However, on analysis by independent sample t-test indicates that the systolic blood pressure and diastolic blood pressure did not differ significantly (p=0.5982, 0.9797 respectively) but oxygen saturation differ significantly (p=0.0000).

The mean was slightly higher in patients with NIV failure than those with NIV success in ABG – $PaCO_2$ (86.28 ± 12.28 vs 61.61 ± 12.89), ABG – HCO_3^- (28.10 ± 3.52 vs 28.02 ± 3.73), respiratory rate (38.17 ± 6.53 vs 29.64 ± 6.37), heart rate (119.53 ± 25.95 vs 92.97 ± 15.12) and diastolic blood pressure (75 ± 9.10 vs 74.37 ± 8.99). However, on analysis by independent sample t-test indicates the ABG – $PaCO_2$, respiratory rate and heart rate differ significantly (p=0.0000, 0.0000, 0.0000 respectively), while ABG – HCO_3^- and diastolic blood pressure did not differ significantly (p=0.9221, 0.5609 respectively).

The mean was higher in patients with NIV success than those of NIV failure in ABG – pH (7.38 ± 0.05 vs 7.23 ± 0.07), ABG – PaO_2 (71.73 ± 11.90 vs 65.64 ± 11.32), lactate (2.34 ± 1.03 vs 2.10 ± 0.86), systolic blood pressure (112.37 ± 14.44 vs 110.21 ± 13.30) and Glasgow coma scale (14.30 ± 0.76 vs 10.82 ± 1.65). However, on analysis by independent sample t-test indicates that the ABG – pH and Glasgow coma scale differ significantly (p=0.0000, 0.0000 respectively), while ABG – PaO_2, lactate and systolic blood pressure did not differ significantly (p=0.9947, 0.3037, 0.7974 respectively).

The patients with NIV success had majority of length of hospital stay 1-10 (64.10%) and 11-20 days (35.90%), while the patients with NIV failure had majority of length of hospital stay 11-20 days (50.00%) and >20 days (28.57. The length of hospital stay in are ranged from 3 to 29 days with mean 8.87 ± 3.37 for patients with NIV success and 15.89 ± 6.94 for patients with NIV failure. Analysis by independent sample t-test and Chi-square test revealed significant difference in length of hospital stay between the outcomes (p = 0.0001 and p = 0.0000 respectively).

In the patients with NIV success all patients had Low risk (100%), while in the patients with NIV failure, majority of patients had High risk (92.86%) and remaining 7.14% had Low risk as per HACOR score. The p value of 0.00003 from Chi-square test indicates that there is statistically significant difference in outcomes.

Summary

Outcome: In the present study, the majority of patients had a successful outcome with NIV 73.58%, while the remaining 26.42% experienced failure.

Association of Outcomes with Age: In the present study, NIV success was most common among patients aged 61–70 years (32.05%), followed by those aged 51–60 years (29.49%) and ≤50 years (25.64%).

Association Of Outcomes With Gender: In the present study, the majority of patients in both the NIV success and NIV failure groups were male, comprising 71.79% and 78.57%, respectively, with no significant difference between the groups (p = 0.6543).

Association Of Outcomes With Socioeconomic Status: In the present study, the majority of patients in the NIV success and NIV failure groups were in class IV (44.87% and 57.14%, respectively) and class III (44.87% and 35.71%, respectively).

Association of Outcomes with BMI: In the present study, majority of the patients with NIV success were Obese (44.87%), while majority of the patients with NIV failure had normal BMI (64.29%). This suggested that being Obese was associated with significantly higher chances of NIV success (p = 0.0386).

Association of Outcomes with Presenting Illness in the present study, the most common symptom among patients in both the NIV success and failure groups was dyspnea, observed in 94.87% and 92.86% of cases, respectively.

Association of Outcomes with MMRC Dyspnoea Scale: In the present study, most patients with NIV success were classified as grade 3 (30.77%) and grade 2 (25.64%), whereas NIV failure was predominantly observed in grade 4 (47.06%) and grade 3 (38.82%). NIV failure was less common in grade 2 (11.76%) and rare in grade 1 (2.35%),

where 19.23% of patients had successful NIV outcomes. The association between disease severity grade and NIV outcome was statistically significant ($p = 0.0039$).

Association Of Outcomes With Clinical History And Risk Factors: In the present study, biomass exposure was the most common factor in both the NIV success (44.87%) and NIV failure (57.14%) groups, followed by previous ICU admissions for AECOPD (38.46% and 42.86%, respectively).

Association of Outcomes with Comorbidities: In the present study, hypertension was the most common comorbidity, observed in 41.03% of all patients, followed by diabetes mellitus (29.49%), ischemic heart disease (12.82%), and chronic kidney disease (12.82%) in the NIV success group.

Association of Outcomes with Occupation: In the present study, among patients with NIV success, the most common occupations were farmers (25.64%), laborers (24.36%), and factory workers (20.51%). Among those with NIV failure, laborers (50.00%) were the majority, followed by factory workers (17.86%) and farmers (10.71%). Office workers and housewives constituted a smaller proportion in both groups. The analysis showed no significant association between occupation and NIV outcomes.

Association of Outcomes with Smoking History: In the present study,the majority of patients in both the NIV success and failure groups had a smoking history of 0–10 packs per year (43.59% and 42.86%), followed by 11–20 packs per year (35.90% and 28.57%). Fewer patients had a history of 21–30 packs per year (20.51% and 28.57%) ($p= 0.6316$), which were statistically insignificant.

Association Of Outcomes with Duration of COPD (Years): In the present study, among NIV success patients, the majority had COPD for 1–5 years (35.90%) and 6–10 years (28.21%), while smaller proportions had COPD for >20 years (15.38%), 11–15 years (11.54%), and 16–20 years (8.97%). In the NIV failure group, the majority had COPD for 11–15 years (25.00%) and 16–20 years (21.43%), with the remaining patients distributed equally (17.86%) across 1–5 years, 6–10 years, and >20 years. The analysis showed no significant association between COPD duration and NIV outcomes ($p = 0.0852$).

Association of Outcomes with Baseline Vital Parameters: In the present study, baseline vital parameters were compared between NIV success and failure groups. The mean respiratory rate (39.03 ± 4.19 vs. 26.06 ± 5.30), heart rate (115.90 ± 13.31 vs. 95.90 ± 15.42), and temperature (37.93 ± 0.95 vs. 37.70 ± 1.00) were slightly higher in the NIV failure group.

Association of Outcomes with Use of Accessory Muscles and Presence of Altered Sensorium: In the present study, the association between NIV outcomes and baseline clinical parameters showed that among patients with NIV success, 93.59% exhibited accessory muscle use, and 78.21% had an altered sensorium.

Association of Outcomes with Baseline Clinical Examination Parameters: In the present study, the mean values of $PaCO_2$ (mmHg) (78.42 ± 13.69 vs. 67.96 ± 12.50) and total leukocyte count (13157 ± 6359.13 vs. 9624.92 ± 3236.22) were higher in NIV failure patients compared to NIV success patients, with a significant association ($p=0.0070$, $p=0.0092$, respectively). Additionally, PaO_2 (mmHg) was higher in NIV success patients (54.80 ± 11.04 vs. 49.17 ± 13.08) and showed a significant association with outcomes ($p=0.0496$). Other parameters, including HCO_3^-, lactate, hemoglobin, and arterial blood gas-pH, did not show significant associations.

Association of Outcomes with Radiographic Assessment: In the present study, radiographic findings such as hyperinflation (58.97% in NIV success vs. 50.00% in NIV failure), consolidation (39.74% vs. 25.00%), and pleural effusion (6.41% vs. 14.28%) varied between groups. Normal chest X-rays were observed in 10.25% of NIV success patients and 25.00% of NIV failure patients. However, the analysis revealed no significant association between radiographic patterns and NIV outcomes ($p=0.1537$).

Association of Outcomes with NIV Settings and Therapy Details: In the present study, NIV failure patients had significantly more NIV hours per day (18.78 ± 3.94) compared to the success group (9.66 ± 4.07; $p=0.0004$). They also had higher initial FiO_2 (49.92 ± 21.11 vs. 43.08 ± 20.79; $p=0.3319$) and total NIV duration (46.53 ± 11.46 vs. 44.58 ± 16.15; $p=0.3371$), though not statistically significant. Initial IPAP (15 ± 2.97 vs. 13.78 ± 1.59; $p=0.0784$) and EPAP (5.23 ± 1.08 vs. 4.48 ± 0.62; $p=0.1032$) were higher in the success group, but also not statistically significant.

Association of Outcomes with NIV Response Parameters after 1 Hour of Therapy: In the present study, the association of NIV response parameters with patient outcomes after 1 hour of therapy was analyzed. The mean values were higher in the NIV failure group compared to the NIV success group for ABG – $PaCO_2$ (86.28 ± 12.28 vs. 61.61 ± 12.89), ABG – HCO_3^- (28.10 ± 3.52 vs. 28.02 ± 3.73), respiratory rate (38.17 ± 6.53 vs. 29.64 ± 6.37), heart rate (119.53 ± 25.95 vs. 92.97 ± 15.12), and diastolic blood pressure (75 ± 9.10 vs. 74.37 ± 8.99). ($p < 0.001$ for all). However, ABG – HCO_3^- and diastolic blood pressure did not show a significant association ($p =$

0.9221 and 0.5609, respectively). Conversely, the mean values were higher in the NIV success group compared to the NIV failure group for ABG – pH (7.38 ± 0.05 vs. 7.23 ± 0.07), ABG – PaO_2 (71.73 ± 11.90 vs. 65.64 ± 11.32), lactate (2.34 ± 1.03 vs. 2.10 ± 0.86), systolic blood pressure (112.37 ± 14.44 vs. 110.21 ± 13.30), and Glasgow Coma Scale (14.30 ± 0.76 vs. 10.82 ± 1.65). Statistical analysis revealed a significant association of outcomes with ABG – pH and Glasgow Coma Scale ($p < 0.001$ for both). However, ABG – PaO_2, lactate, and systolic blood pressure did not show significant associations ($p = 0.9947$, 0.3037, and 0.7974, respectively).

Association Of Outcomes With Endotracheal Intubation: In the present study, none of the patients in the NIV success group required intubation (100%), whereas all patients in the NIV failure group required intubation (100%), demonstrating a highly significant association ($p < 0.0001$).

Association of Outcomes with Length of Hospital Stay: In the present study, patients in the NIV success group had significantly shorter hospital stays, with 64.10% staying between 1–10 days, compared to only 21.43% in the NIV failure group ($p < 0.0001$). 50.00% of patients in the NIV failure group required hospitalization for 11–20 days, compared to 35.90% in the success group, indicating a trend toward prolonged hospital stays in the failure group.

Association of Outcomes with In-Hospital Mortality: In the present study, in-hospital mortality was significantly higher in the NIV failure group, with 92.86% mortality, compared to 0.00% in the NIV success group ($p < 0.0001$). Conversely, all patients in the success group survived, whereas only 7.14% of the failure group survived.

Conclusion

This study highlights the significant impact of various clinical, demographic, and physiological parameters on the success of non-invasive ventilation (NIV) in patients with acute exacerbation of COPD (AECOPD).

NIV was successful in a majority of patients (73.58%), with failure observed in 26.42%. Key predictors of NIV success included younger age, higher BMI, better baseline oxygen saturation, and absence of altered sensorium. Significant improvements in arterial blood gas parameters and vital signs were observed post-NIV initiation, particularly in successful cases. Conversely, failure was strongly associated with higher respiratory and heart rates, elevated $PaCO_2$ and leukocyte counts, prolonged hospital stays, increased need for intubation, and higher in-hospital mortality. While factors like comorbidities, smoking history, and radiographic findings did not show a significant association, early physiological response and severity markers were crucial in predicting NIV outcomes. These findings underscore the importance of early risk stratification and continuous monitoring to optimize NIV efficacy and reduce complications in AECOPD patients.

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