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Research Article

Outcome of Non-Invasive Ventilation and Its Predictors in COPD Patients with Acute or Acute On Chronic Type 2 Respiratory Failure

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ABSTRACT

Background: Noninvasive ventilation (NIV) constitutes a primary therapeutic modality in the management of chronic obstructive pulmonary disease (COPD) patients presenting with acute or acute-on-chronic type 2 respiratory failure [1,4–6]. Despite its clinical utility, considerable variability in patient outcomes persists, and the early identification of reliable predictors of NIV success or failure remains a significant clinical challenge [7,13,14].

Objective: To evaluate the outcomes of noninvasive ventilation and identify clinical and biochemical predictors of its success or failure in patients with chronic obstructive pulmonary disease (COPD) presenting with acute or acute-on-chronic type 2 respiratory failure.

Methods: A prospective observational study was conducted on 85 patients with chronic obstructive pulmonary disease (COPD) presenting with acute or acute-on-chronic type 2 respiratory failure, admitted between May 2023 and May 2024. All patients were initiated on noninvasive ventilation (NIV) as per institutional protocol [4,6,9]. Baseline clinical parameters, arterial blood gas values, and comorbidities were recorded. Patients were monitored throughout the course of NIV therapy, and outcomes were classified as success (clinical improvement without need for intubation) or failure (requirement of invasive mechanical ventilation or death). Statistical analysis was performed to identify clinical and biochemical predictors associated with NIV outcomes [7,13,14].

Results: Among the 85 COPD patients included in the study, NIV was successful in 65 patients (76.5%) and failed in 20 patients (23.5%). Patients in the failure group had significantly lower baseline pH and PaO_2 levels, and higher $PaCO_2$ and respiratory rates compared to those in the success group ($p < 0.05$). $PaCO_2$ at 12, 24, 48, 72 hrs in NIV success are 52.04±2.93, 49.63±2.89, 44.78±4.31, 43.22±5.20 and in NIV failure are 54.78±2.33, 54.89±1.83, 54.44±1.27, 55.44±1.33, respectively with a significant P value.

Conclusion: Noninvasive ventilation was effective in the majority of COPD patients with acute or acute-on-chronic type 2 respiratory failure [4–6,9,12]. Higher baseline $PaCO_2$ and respiratory rate, along with lower pH, were significantly associated with NIV failure [13,14]. Early identification of these predictors may aid in timely clinical decision-making and improve patient outcomes.

Keywords: NIV, COPD, AECOPD, IMV, FEV_1, pH, Ventilator, $PaCO_2$.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is the third leading cause for mortality in the world [2]. It caused 3 million deaths and substantial morbidity in 2016, resulting in 63.5 million disability-adjusted life years (DALY) lost globally [2]. Acute exacerbation of COPD (AECOPD) is a common consequence of COPD that can lead to hospitalization, which has significant costs to the healthcare system and

society [3]. It is also the cause of higher rates of morbidity and mortality [3].

Rapid-acting bronchodilators, systemic steroids, antibiotics, and regulated oxygen therapy are all part of the standard treatment for severe COPD exacerbations [3]. The addition of non-invasive ventilation (NIV) regimen given in patients of acute hypercapnic respiratory failure has lower rates of endotracheal intubation (ETI) and overall mortality [4–6,9]. Since respiratory intermediate care units were established, NIV use for COPD exacerbations outside of the critical care unit has developed [5,6]. However, poor patient selection at admission or a failure to recognize NIV failure results in a delay in ETI, which is linked to a higher mortality rate [7,13,14]. According to reports, failure rates vary between 9 and 50% [7,13,14].

Comorbidities, an over-reliance on NIV effectiveness, a shortage of skilled personnel, and a lack of specific recommendations for the ideal NIV duration and settings were all possible causes for NIV failure [7,13]. Based on recommendations from experts and individual or group experience, the responsible physician determines the NIV settings and duration [8,9]. The factors that determine NIV settings and duration, as well as how these parameters affect outcomes like NIV failure or mortality, are not well documented in the literature.

The Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2020 states that COPD is a common, treatable and preventable disease characterized by persistent respiratory symptoms and airflow limitation due to airway or alveolar abnormality, typically caused by significant exposure to noxious particles or gases and influenced by host factors including abnormal lung development [1]. Many people with severe, progressive COPD eventually develop respiratory failure [1,8]. Oxygenation, bronchodilators, antibiotics, and corticosteroids are used to treat patients experiencing exacerbations of COPD [1,3,8]. Mechanical ventilation, which can be either invasive or non-invasive, is used to treat patients who do not respond to conventional treatment [4,8,9].

Because of its substantial benefit in the ventilatory therapy of acute type 2 respiratory failure due to COPD, NIV is regarded as safer and better than invasive ventilation [4–6,9,10,11]. The necessity for endotracheal intubation and related complications are significantly reduced when NIV is used [5,6,9]. NIV treatment has a higher success rate, though failure has also been observed [7,13]. In order to prevent a disaster, patients on NIV should be constantly monitored for indications of therapy failure and intubated as soon as possible [7,13,14]. Therefore, it is essential to identify the early predictors in order to manage those patients for a better outcome [13,14].

METHODOLOGY

Design: An observational prospective study.

Participants: Eighty five patients who were having COPD - type 2 respiratory failure and were admitted into the ICU.

All the patients with COPD will be sampled for ABG. Patients will be ventilated in NIV mode using schillers ventilator full-face masks. The following ventilator settings which were initially used were : PSV of 7- 10 cm of H2O, PEEP of 3- 5 cm of H2O, I:E ratio of 1:2.0 respiratory rate of 14/min, with target tidal volume of 5-7 ml/kg. Depending on the demands of the patient, these settings were changed based on ABG analysis, oximetry, patient tolerance and patient-ventilator synchrony. Serial ABGs are collected every 12th hourly and noted. The final results of patient outcome and length of ICU stay will be compared with the initial samples.

Outcomes: The primary outcome assessed was NIV failure, i.e need for endotracheal intubation or in-hospital mortality.

Statistical Analysis: Independent t-test and chi-square test, $p<0.05$ considered significant.

RESULTS

A total of 85 patients with COPD and type 2 respiratory failure were enrolled. The **mean age** was **58.81 ± 8.06 years**, with the majority in the **56–65 year** age group (44.7%). A **male predominance** was observed (84.7%).

Baseline Vital Parameters

- Mean heart rate: **81.84 bpm**
- Mean respiratory rate: **20.6 breaths/min**
- Mean systolic BP: **123.06 mmHg**
- Mean diastolic BP: **75.04 mmHg**
- Mean SpO_2: **98.08%**

Table 1. Demographic and Baseline Characteristics

Characteristic	Mean(SD)	Range

Age (years)	58.81±8.06	45-74
Heart Rate	81.84±10.05	65-100
RR	20.60±4.19	14-28
SBP	123.06±14.20	100-170
DBP	75.04±16.03	53-120
pH-t0	7.06±0.08	6.9-7.26
SpO_2	98.08±1.27	95-100
$PaCO_2$ – t0	62.94±4.55	53-77

Clinical Outcomes

- **NIV Success**: 76.5% (65/85)
- **NIV FAILURE**: 23.5% (20/85)
- **In-Hospital Mortality**: 10.6% (9/85)

Predictors of Mortality

There was **no statistically significant difference in age, HR, RR, BP**, or **temperature** between survivors and non-survivors. However, **SpO_2 was significantly lower in non-survivors** (97% vs 98.24%, **p = 0.002**).

Predictors of NIV Failure

A **higher respiratory rate** at admission was significantly associated with NIV failure (**24.78 vs 17.93, p < 0.001**). Other parameters, including age and heart rate, did not differ significantly.

Table 2. Distribution of Study Participants According To Gender

Gender distribution	Frequency (n)	Percentage (%)
Female	13	15.3
Male	72	84.7
Total	85	100

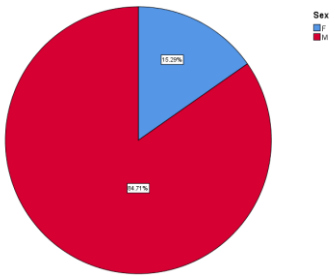


Figure 1. Gender Distribution

Out of 85 patients, 13 (15.3%) were females and 72 (84.7%) were males

Table 3. Mortality-Wise Distribution

Mortality	Frequency	Percentage
Survived	76	89.4
Died	9	10.6
Total	85	100

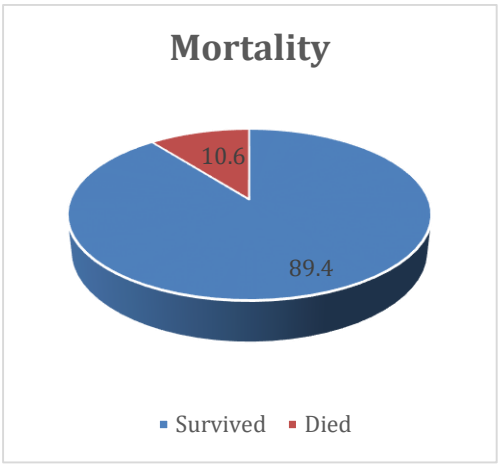


Figure 2. Mortality Wise Distribution

Among 85 patients, 9 (10.6%) were died and 76 (89.4%) were survived

Table 4. NIV Success / Failure Wise Distribution

NIV failure	Frequency	Percentage
Success	65	76.5
Failure	20	23.5
Total	85	100

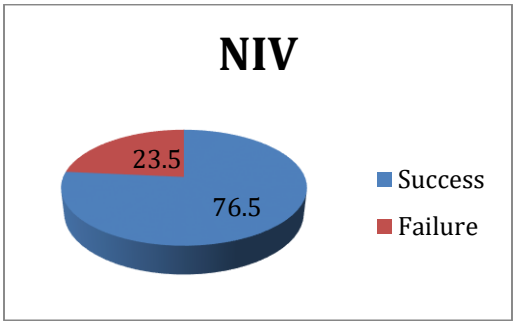


Figure 3. NIV Success/Failure Wise Distribution

Among 85 patients, 20 (23.5%) had NIV failure and 65 (76.5%) had successful NIV.

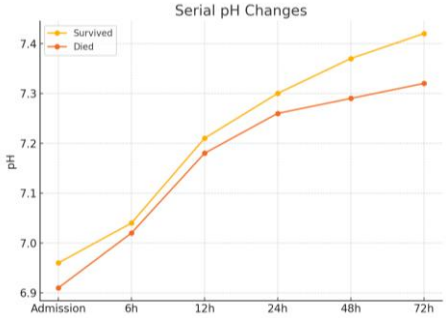
Serial ABG Trends

pH

Survivors: Increased from **6.96** at admission to **7.42** at 72 hours (**p < 0.001**)

Non-survivors: Modest increase from **6.91** to **7.32**

Figure 4. Serial pH Changes in Survivors vs Non-survivors



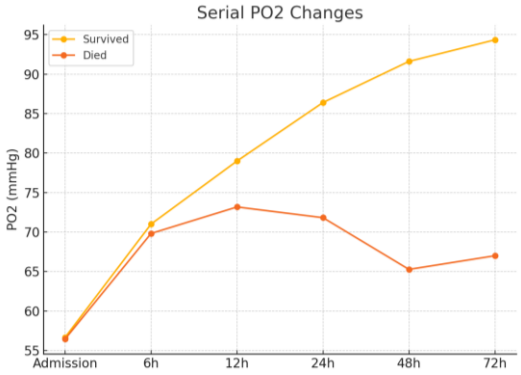
PaO_2

Survivors: Rose from **56.66 mmHg** to **94.35 mmHg** over 72 hours

Non-survivors: Initially rose to **71.82 mmHg** but dropped again by 72 hours to **67 mmHg**

(**Significant differences at 12, 24, 48, and 72 hrs; p < 0.001**)

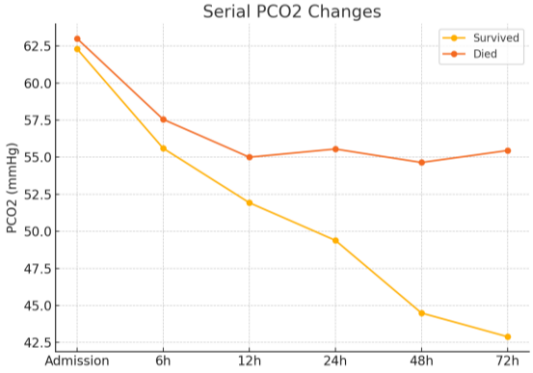
Figure 5. Serial PaO_2 Trends in Survivors vs Non-survivors



$PaCO_2$
Survivors: Declined significantly from **62.30 mmHg** to **42.89 mmHg**

Non-survivors: Plateaued around **55 mmHg** after initial decline
(**Significant difference from 12 hrs onward, p < 0.001**)

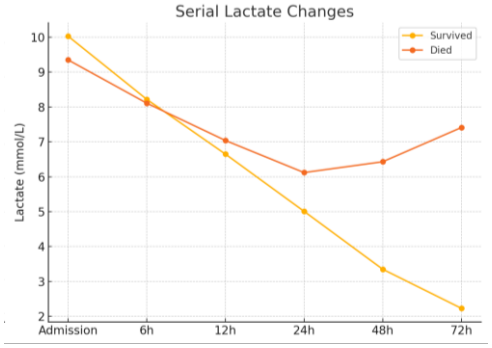
Figure 6. Serial $PaCO_2$ Trends in Survivors vs Non-survivors



Lactate
Survivors: Decreased from **10.03 mmol/L** to **2.23 mmol/L**

Non-survivors: Fluctuated and **increased to 7.41 mmol/L** at 72 hours
(**Significant differences from 24 hrs onward, p < 0.001**)

Figure 7. Serial Lactate Trends in Survivors Vs Non-Survivors



Key Observations
Improvement in ABG parameters over 72 hours is strongly associated with survival and NIV success.

Patients who showed **plateaued or worsening trends** in PaO_2, $PaCO_2$, lactate, and pH were more likely to experience NIV failure or death.

The **greatest divergence** in outcomes appeared after the **first 24 hours** of NIV.

DISCUSSION

This study evaluated the outcomes and predictors of noninvasive ventilation (NIV) in patients with acute exacerbation of COPD with type 2 respiratory failure. The **NIV success rate was 76.5%**, which is consistent with prior studies reporting success rates between 70–80%. This affirms NIV as an effective intervention in appropriately selected COPD patients.

Mortality was 10.6%, similar to rates reported in studies by Plant et al. and others. Importantly, **no significant differences** in age, gender, or baseline vitals were noted between survivors and non-survivors, except for **SpO_2**, which was significantly lower in the latter group.

Among predictors of **NIV failure**, a **higher respiratory rate** at admission was the most consistent finding, aligning with earlier evidence suggesting that tachypnea is an early marker of respiratory distress and impending decompensation.

Serial arterial blood gas (ABG) trends were strongly associated with clinical outcomes. Patients who **survived or had NIV success** demonstrated:

- Progressive **rise in pH and PaO_2**
- Steady **decline in $PaCO_2$ and lactate**
- Appropriate **compensation in bicarbonate levels**

In contrast, **non-survivors and NIV failures** showed **worsening or plateaued ABG parameters**, with elevated lactate levels persisting or rising over time. These findings support the use of **serial ABG monitoring** as a dynamic tool for early prognostication and timely escalation of care.

Overall, the study emphasizes the value of **early identification of NIV failure predictors**, including initial RR and dynamic ABG trends, to improve patient outcomes in COPD with type 2 respiratory failure.

Limitations of Our Study Include

Single-Center Design: The study was conducted in one tertiary care hospital, limiting generalizability.

Small Sample Size: With 85 patients, the sample may not capture the full heterogeneity of the COPD population.

Short Follow-Up Duration: Only in-hospital outcomes were assessed; long-term NIV efficacy and readmission rates were not evaluated.

No Control Group: The absence of a comparison group (e.g., invasive ventilation or medical management only) limits direct assessment of NIV impact.

Exclusion of Comorbidities: Detailed analysis of co-existing conditions such as cardiac disease or sepsis was not performed.

CONCLUSION

Noninvasive ventilation (NIV) is an effective and life-saving intervention in COPD patients presenting with acute exacerbation and type 2 respiratory failure, with a success rate of 76.5% and a relatively low mortality of 10.6%. A higher respiratory rate at admission and failure of early improvement in arterial blood gas parameters—especially pH, PaO_2, $PaCO_2$, and lactate—are strong predictors of NIV failure and mortality. Serial monitoring of ABG trends can provide critical insight for early clinical decision-making and escalation of care.

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Conflicts of Interest Statement

The authors declare no conflicts of interest.

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