

Initial ABG parameters and their correlation with treatment modalities and clinical outcomes in COPD-AE patients admitted to the ICU¹Dr. Sanjeev Satapathy, Postgraduate Student, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, India²Dr. Sarat Kumar Behera, Professor & Head of the Department, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, India³Dr Aruna Kumar Sahu, Professor, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, India**Corresponding Author:** Dr. Sanjeev Satapathy, Postgraduate Student, Hi-Tech Medical College & Hospital, Bhubaneswar, Odisha, India**How to citation this article:** Sanjeev Satapathy, Sarat Kumar Behera, Aruna Kumar Sahu, “Initial ABG parameters and their correlation with treatment modalities and clinical outcomes in COPD-AE patients admitted to the ICU”, IJMACR– September– 2026, Volume – 9, Issue – 5, P. No. 694 – 706.**Open Access Article:** © 2026 Dr. Sanjeev Satapathy, et al. This is an open access journal and article distributed under the terms of the creative common's attribution license (<http://creativecommons.org/licenses/by/4.0>). Which allows others to remix, tweak, and build upon the work non - commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.**Type of Publication:** Original Research Article**Conflicts of Interest:** Nil**Abstract****Background:** Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is an important cause of ICU admission and may be complicated by hypercapnic respiratory failure, hypoxemia, acid–base disturbances, and increased mortality. Arterial blood gas (ABG) parameters provide important information regarding the severity of respiratory failure and may help predict treatment requirements and clinical outcomes.**Objective:** To evaluate the initial ABG parameters in patients with AECOPD admitted to the ICU and determine their association with respiratory support modalities, NIV failure, duration of ICU stay, and ICU mortality.**Materials and Methods:** A hospital-based prospective observational study was conducted in the Department ofRespiratory Medicine and ICU of Hi-Tech Medical College and Hospital, Bhubaneswar, from February 2024 to December 2025. A total of 100 patients with AECOPD were enrolled. Initial ABG parameters including pH, PaCO₂, PaO₂, HCO₃⁻, and oxygenation parameters were recorded. Respiratory support, NIV failure, duration of ICU stay, ICU complications, and treatment outcome were documented. Associations between categorical variables were assessed using Chi-square or Fisher's exact test, with p<0.05 considered statistically significant.**Results:** The mean pH, PaCO₂, and PaO₂ at admission were 7.30 ± 0.08, 63.5 ± 11.8 mmHg, and 55.8 ± 9.6 mmHg, respectively. Severe acidosis (pH <7.25) was present in 30% of patients, while Type II respiratory failure was observed in 68%. NIV was used in 40%, BiPAP in 20%, and invasive mechanical ventilation in

32% of patients. Invasive mechanical ventilation was required in 43.3% of patients with pH <7.25 compared with 8.3% with pH 7.25–7.34 and none with pH ≥7.35 ($p<0.001$). NIV failure occurred in 53.1% of patients with PaCO₂ >60 mmHg compared with 6.3% with PaCO₂ ≤45 mmHg ($p=0.002$). Patients with pH <7.25 and PaCO₂ >60 mmHg had significantly longer ICU stays (9.0 ± 3.0 vs. 5.5 ± 2.2 days and 8.4 ± 2.8 vs. 5.3 ± 2.1 days, respectively; $p<0.001$). Overall ICU mortality was 17%. Mortality was significantly higher among patients with pH <7.25 (43.3% vs. 5.7%, $p<0.001$), PaCO₂ >60 mmHg (34.8% vs. 1.9%, $p=0.001$), and PaO₂ <60 mmHg (32.7% vs. 0%, $p=0.002$).

Conclusion: Initial ABG abnormalities, particularly severe acidemia, marked hypercapnia, and hypoxemia, were significantly associated with increased ventilatory support requirements, NIV failure, prolonged ICU stay, and higher mortality in patients with AECOPD. Early ABG assessment may therefore provide useful information for severity assessment and clinical monitoring of critically ill patients with COPD exacerbation.

Keywords: Acute exacerbation of COPD, Arterial Blood Gas, pH, PaCO₂, PaO₂, Hypercapnia, Respiratory Failure, Non-Invasive Ventilation, Mechanical Ventilation, ICU Mortality.

Introduction

Chronic obstructive pulmonary disease (COPD) is a common chronic respiratory disease characterized by persistent airflow limitation and respiratory symptoms. Acute exacerbation of COPD (AECOPD) represents a clinically important event characterized by worsening respiratory symptoms requiring additional treatment and is a major cause of hospital and intensive care admission. Severe exacerbations may be accompanied by acute

respiratory failure, marked abnormalities in gas exchange, and acid–base disturbances, contributing substantially to morbidity and mortality^{1,2}.

Arterial blood gas (ABG) analysis is an important component of the assessment of patients with severe AECOPD. Measurement of arterial pH, partial pressure of carbon dioxide (PaCO₂), partial pressure of oxygen (PaO₂), and bicarbonate provides information regarding ventilatory failure, oxygenation impairment, and acid–base status. Hypercapnia with acidemia generally reflects inadequate alveolar ventilation, while hypoxemia indicates significant impairment of pulmonary gas exchange. Current COPD recommendations recognize respiratory acidosis, persistent hypoxemia, and increased work of breathing as important indicators for ventilatory support¹.

Acute respiratory failure in AECOPD may be predominantly hypoxemic, hypercapnic, or mixed. Hypercapnic respiratory failure is particularly important in COPD because worsening airflow obstruction, ventilation–perfusion mismatch, respiratory muscle fatigue, and alveolar hypoventilation may result in carbon dioxide retention and respiratory acidosis. Earlier ICU studies have demonstrated that respiratory physiological variables, including pH, PaCO₂, and PaO₂, are associated with outcomes among patients admitted with severe COPD exacerbations³.

Non-invasive ventilation (NIV) is an established treatment for acute hypercapnic respiratory failure associated with COPD exacerbation. NIV improves alveolar ventilation, reduces respiratory muscle workload, improves gas exchange, and can decrease the need for endotracheal intubation in appropriately selected patients^{4,5}. Evidence-based guidelines recommend NIV particularly in patients with acute or acute-on-chronic

respiratory acidosis. However, treatment failure may occur, and patients with severe acidemia require close monitoring and timely escalation of respiratory support^{5,6}. The severity of initial acid–base abnormalities may therefore have important implications for treatment requirements. Studies evaluating NIV failure have demonstrated that lower initial pH is associated with an increased risk of treatment failure and subsequent intubation^{6,7}. Similarly, higher PaCO₂ and persistent abnormalities in gas exchange may indicate more severe respiratory dysfunction and may be associated with prolonged ventilatory support and intensive care requirements⁸.

Admission ABG parameters may also have prognostic significance. Previous studies have identified pH, PaCO₂, PaO₂, and other indicators of respiratory dysfunction as factors associated with mortality among ICU patients with AECOPD^{3,9}. More recent studies have further demonstrated that the severity and type of acute respiratory failure influence the requirement for non-invasive or invasive ventilation and subsequent clinical outcomes¹⁰.

The clinical importance of ABG parameters is particularly relevant in ICU patients, where early identification of severe respiratory and acid–base abnormalities may assist in treatment planning and risk assessment. Although ABG abnormalities are not independent determinants of outcome in every patient, they provide objective physiological information that can be interpreted alongside clinical findings, comorbidities, infection, and response to treatment^{3,9}.

Therefore, the present study was undertaken to evaluate the initial ABG parameters in patients with AECOPD admitted to the ICU and to determine their relationship with respiratory support modalities, NIV failure, duration

of ICU stay, ICU complications, and mortality. Particular emphasis was placed on the association of initial pH, PaCO₂, and PaO₂ with invasive mechanical ventilation and ICU outcome.

Materials and Methods

Study Design and Setting

This was a hospital-based prospective observational study conducted in the Department of Respiratory Medicine and Intensive Care Unit (ICU) of Hi-Tech Medical College and Hospital, Bhubaneswar, a tertiary care teaching hospital.

Study Period

The study was conducted over a period of two years, from February 2024 to December 2025.

Study Population

The study population comprised patients admitted to the Respiratory Medicine ICU with an established or newly diagnosed chronic obstructive pulmonary disease (COPD) presenting with acute exacerbation of COPD (AECOPD) during the study period.

Sample Size and Sampling Method

A total of 100 patients fulfilling the predefined inclusion and exclusion criteria were enrolled. Purposive sampling was used, and eligible patients admitted to the Respiratory Medicine ICU were recruited consecutively until the required sample size was achieved.

Inclusion Criteria

Patients meeting the following criteria were included:

- Patients of either gender aged 30–70 years.
- Patients admitted to the Respiratory Medicine ICU with established or newly diagnosed COPD presenting with acute exacerbation.
- Patients requiring non-invasive ventilation (NIV) or BiPAP during the current admission.

- Patients who provided written informed consent for participation in the study.

Exclusion Criteria

Patients were excluded if they:

- Refused to provide informed consent.
- Were aged below 30 years or above 70 years.
- Had significant comorbid conditions likely to affect arterial blood gas (ABG) interpretation or clinical outcomes, including chronic kidney disease, severe coronary artery disease, obstructive sleep apnea, and neuromuscular or neurological disorders causing respiratory weakness.
- Had known metabolic disorders contributing to acid–base imbalance.

Study Variables and Data Collection

After obtaining written informed consent, baseline demographic and clinical information was recorded using a pre-designed data collection proforma. The parameters assessed included age, gender, smoking history, previous diagnosis and duration of COPD, and vital parameters at ICU admission.

Arterial Blood Gas Analysis

Arterial blood gas analysis was performed at the time of ICU admission. The following parameters were recorded:

- pH
- Partial pressure of carbon dioxide (PaCO_2)
- Partial pressure of oxygen (PaO_2)
- Bicarbonate (HCO_3^-)
- Anion gap

These parameters were evaluated to assess the acid–base and respiratory status of patients with AECOPD.

Radiological and Laboratory Investigations

Routine investigations were performed as clinically indicated. These included:

- Chest X-ra

- High-resolution computed tomography (HRCT) of the thorax, where indicated
- Complete blood count (CBC) with differential count
- Pulmonary function tests (PFTs), where feasible
- Sputum examination

Treatment-Related Variables and Follow-up

Patients were prospectively followed throughout their ICU stay until discharge or death. The type of respiratory support provided was documented, including oxygen therapy, NIV, BiPAP, and invasive mechanical ventilation where required. The duration of ventilatory support, length of ICU stay, ICU-related complications, and final treatment outcome were recorded.

Length of ICU stay was calculated from the date of ICU admission until the date of discharge or death. The final treatment outcome was categorized as survival or mortality.

Statistical Analysis

Data were entered and analyzed using Microsoft Excel. Quantitative variables were expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR), as appropriate. Qualitative variables were presented as frequencies and percentages.

Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, wherever appropriate. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of Hi-Tech Medical College and Hospital, Bhubaneswar. Written informed consent was obtained from all participants before enrolment. Patient confidentiality and anonymity were maintained throughout the study, and the collected information was used solely for the purpose of the study.

Results and Observations

The present hospital-based prospective observational study included 100 patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD) admitted to the Respiratory Medicine ICU of Hi-Tech Medical College and Hospital, Bhubaneswar. The demographic characteristics, smoking history, COPD status, arterial blood gas parameters, respiratory failure pattern, ventilatory support, ICU complications, and clinical outcomes were assessed.

Table 1: Age, Sex and Smoking Status of Study Participants (N = 100)

A. Age and Sex Distribution

Age group (years)	Male n (%)	Female n (%)	Total n (%)
≤40	5 (5.0)	3 (3.0)	8 (8.0)
41–50	16 (16.0)	6 (6.0)	22 (22.0)
51–60	26 (26.0)	12 (12.0)	38 (38.0)
61–70	18 (18.0)	10 (10.0)	28 (28.0)
>70	3 (3.0)	1 (1.0)	4 (4.0)
Total	68 (68.0)	32 (32.0)	100 (100)

B. Smoking Status

Smoking history	Number (n)	Percentage (%)
Yes	76	76.0
No	24	24.0
Total	100	100

Observation: The majority of study participants were males (68%), while females constituted 32%. The most common age group was 51–60 years (38%), followed by 61–70 years (28%). Participants aged ≤40 years constituted 8% of the study population. A history of smoking was present in 76% of participants, whereas 24% were non-smokers.

Table 2: Known COPD Status and Duration of COPD (N = 100)

A. Known COPD Status

Known COPD	Number (n)	Percentage (%)
Yes	70	70.0
No	30	30.0
Total	100	100

B. Duration of COPD among Known COPD Patients (n = 70)

Duration of COPD	Number (n)	Percentage (%)
≤5 years	28	40.0
6–10 years	25	35.7
>10 years	17	24.3
Total	70	100

Observation: Seventy percent of participants were known cases of COPD, while 30% had no previous diagnosis. Among the 70 known COPD patients, 40.0% had a disease duration of ≤5 years, 35.7% had COPD for 6–10 years, and 24.3% had disease duration of >10 years.

Table 3: Baseline Arterial Blood Gas and Oxygenation Parameters at ICU Admission (N = 100)

ABG Parameter	Mean ± SD	Minimum	Maximum
pH	7.30 ± 0.08	7.15	7.45
PaCO ₂ (mmHg)	63.5 ± 11.8	44	90
PaO ₂ (mmHg)	55.8 ± 9.6	40	78
HCO ₃ ⁻ (mmol/L)	29.2 ± 5.1	19	40
SpO ₂ (%)	85.1 ± 6.2	70	94
Lactate (mmol/L)	2.3 ± 1.0	1.0	5.2

Observation: The mean arterial pH was 7.30 ± 0.08. Mean PaCO₂ was elevated at 63.5 ± 11.8 mmHg, whereas mean PaO₂ was reduced to 55.8 ± 9.6 mmHg. The mean SpO₂ was 85.1 ± 6.2%, and the mean lactate level was 2.3 ± 1.0 mmol/L, indicating substantial respiratory compromise at ICU admission.

Table 4: Acid–Base Status and Type of Respiratory Failure (N = 100)

A. Acid–Base Status Based on Initial pH

Acid–base status	Number (n)	Percentage (%)
Severe acidosis (pH <7.25)	30	30.0
Mild acidosis (pH 7.25–7.34)	36	36.0
Normal (pH 7.35–7.45)	30	30.0
Alkalosis (>7.45)	4	4.0
Total	100	100

B. Type of Respiratory Failure

Type of respiratory failure	Criteria	Number (n)	Percentage (%)
Type I	PaO ₂ <60, PaCO ₂ ≤45 mmHg	20	20.0
Type II	PaO ₂ <60, PaCO ₂ >45 mmHg	68	68.0
Mixed	—	12	12.0
Total		100	100

Observation: Severe acidosis was present in 30% of patients, while 36% had mild acidosis. Overall, 66% of patients presented with acidemia. Type II respiratory failure was the most common pattern, occurring in 68% of patients, followed by Type I respiratory failure in 20% and mixed respiratory failure in 12%.

Table 5: Mode and Duration of Respiratory Support

A. Mode of Respiratory Support

Mode of respiratory support	Number (n)	Percentage (%)
Oxygen therapy	8	8.0
NIV	40	40.0
BiPAP	20	20.0
Invasive mechanical ventilation	32	32.0
Total	100	100

B. Duration of Respiratory Support

Mode of support	Mean ± SD (days)	Median (IQR)
NIV	4.0 ± 1.5	4 (3–5)
BiPAP	5.0 ± 2.0	5 (4–6)
Mechanical ventilation	7.2 ± 3.0	7 (5–9)
Oxygen therapy	3.0 ± 1.3	3 (2–4)

Observation: NIV was the most frequently used respiratory support modality (40%), followed by invasive mechanical ventilation (32%) and BiPAP (20%). The mean duration of invasive mechanical ventilation was longest at 7.2 ± 3.0 days, followed by BiPAP at 5.0 ± 2.0 days, NIV at 4.0 ± 1.5 days, and oxygen therapy at 3.0 ± 1.3 days.

Table 6: Association Between Initial pH and Requirement of Invasive Mechanical Ventilation (N = 100)

Initial pH category	IMV Required n (%)	IMV Not Required n (%)	Total
<7.25	13 (43.3)	17 (56.7)	30
7.25–7.34	3 (8.3)	33 (91.7)	36
≥7.35	0 (0.0)	34 (100.0)	34
Total	16	84	100

p < 0.001, Chi-square test

Observation: Invasive mechanical ventilation was required in 43.3% of patients with pH <7.25, compared with 8.3% of patients with pH 7.25–7.34 and none of the patients with pH ≥7.35. The association between initial pH and requirement for invasive mechanical ventilation was statistically significant (p < 0.001).

Table 7. Association Between Initial PaCO₂ and NIV Failure (n = 80)

PaCO ₂ (mmHg)	NIV Failure n	NIV Success n	Total
≤45	1	15	16
46–60	6	26	32
>60	17	15	32
Total	24	56	80

$p = 0.002$, Chi-square test

observation: NIV failure occurred in 17 of 32 patients (53.1%) with $\text{PaCO}_2 > 60$ mmHg, compared with 1 of 16 patients (6.3%) with $\text{PaCO}_2 \leq 45$ mmHg. The frequency of NIV failure increased with increasing PaCO_2 , and the association was statistically significant ($p=0.002$).

Table 8: Length of ICU Stay According to Initial ABG Parameters

ABG parameter	Mean ICU stay $\pm$ SD (days)	p-value
pH < 7.25	9.0 ± 3.0	
pH ≥ 7.25	5.5 ± 2.2	< 0.001
$\text{PaCO}_2 > 60$ mmHg	8.4 ± 2.8	
$\text{PaCO}_2 \leq 60$ mmHg	5.3 ± 2.1	< 0.001

Independent t-test

Observation: Patients with pH < 7.25 had a significantly longer mean ICU stay than those with pH ≥ 7.25 (9.0 ± 3.0 vs. 5.5 ± 2.2 days; $p < 0.001$). Similarly, patients with $\text{PaCO}_2 > 60$ mmHg had a longer ICU stay than those with $\text{PaCO}_2 \leq 60$ mmHg (8.4 ± 2.8 vs. 5.3 ± 2.1 days; $p < 0.001$).

Table 9: ICU Complications and ICU Outcome (N = 100)

A. ICU Complications

ICU complication	Number (n)	Percentage (%)
VAP	15	15.0
Sepsis	18	18.0
AKI	11	11.0
VAP + Sepsis	8	8.0
None	48	48.0
Total	100	100

B. ICU Outcome

ICU outcome	Number (n)	Percentage (%)
Survived	83	83.0
Expired	17	17.0
Total	100	100

Observation: ICU complications were reported in 52% of patients, while 48% had no documented ICU

complication. Sepsis was the most frequently reported complication (18%), followed by VAP (15%) and AKI (11%). Overall, 83% of patients survived the ICU admission, whereas 17% expired.

Table 10: Association Between Initial ABG Parameters and ICU Mortality (N = 100)

A. Initial pH and ICU Mortality

pH category	Survived	Expired	Total
< 7.25	17	13	30
≥ 7.25	66	4	70
Total	83	17	100

$p < 0.001$

B. Initial PaCO_2 and ICU Mortality

PaCO_2 (mmHg)	Survived	Expired	Total
> 60	30	16	46
≤ 60	53	1	54
Total	83	17	100

$p = 0.001$

C. Initial PaO_2 and ICU Mortality

PaO_2 (mmHg)	Survived	Expired	Total
< 60	35	17	52
≥ 60	48	0	48
Total	83	17	100

$p = 0.002$

Observation: Mortality was significantly higher among patients with severe acidemia, hypercapnia, and hypoxemia. Among patients with pH < 7.25 , mortality was 43.3% compared with 5.7% among those with pH ≥ 7.25 ($p < 0.001$). Mortality was 34.8% in patients with $\text{PaCO}_2 > 60$ mmHg compared with 1.9% among those with $\text{PaCO}_2 \leq 60$ mmHg ($p=0.001$). All 17 deaths occurred among patients with $\text{PaO}_2 < 60$ mmHg, corresponding to a mortality rate of 32.7%, whereas no deaths occurred among patients with $\text{PaO}_2 \geq 60$ mmHg ($p=0.002$).

Table 11: Association Between Initial PaO₂ and Requirement of Mechanical Ventilation (n = 64)

PaO ₂ (mmHg)	MV Required n	MV Not Required n	Total	MV Required (%)
<60	20	12	32	62.5
≥60	12	20	32	37.5
Total	32	32	64	100

Observation: Among the 64 patients represented in this analysis, 62.5% of patients with PaO₂ <60 mmHg required mechanical ventilation, compared with 37.5% of patients with PaO₂ ≥60 mmHg. Thus, a greater proportion of patients with lower PaO₂ required mechanical ventilatory support.

Table 12: Distribution of Mechanically Ventilated Patients According to Initial PaCO₂

Initial PaCO ₂ (mmHg)	MV Required (n)	Percentage (%)
<45	1	4.2
45–60	6	25.0
>60	17	70.8
Total represented	24	100.0

Observation: Among the 24 mechanically ventilated patients for whom PaCO₂-specific data were available, 70.8% had PaCO₂ >60 mmHg, 25.0% had PaCO₂ between 45–60 mmHg, and 4.2% had PaCO₂ <45 mmHg. Thus, most patients represented in the available PaCO₂ distribution had marked hypercapnia.

Discussion

The present prospective observational study evaluated 100 patients with AECOPD admitted to the Respiratory Medicine ICU. The principal findings were significant abnormalities in arterial oxygenation and ventilation at admission, a predominance of hypercapnic respiratory failure, and significant associations between initial ABG abnormalities and subsequent respiratory support, ICU stay, NIV failure, and mortality.

In the present study, the mean arterial pH was 7.30 ± 0.08 , mean PaCO₂ was 63.5 ± 11.8 mmHg, and mean PaO₂ was 55.8 ± 9.6 mmHg. The mean SpO₂ was $85.1 \pm 6.2\%$. These findings indicate substantial respiratory physiological impairment at ICU admission. The GOLD strategy recognizes respiratory acidosis and persistent hypoxemia as important features of severe AECOPD and includes ABG assessment among the investigations used in patients with severe exacerbations¹. The Rome proposal also emphasizes objective assessment of respiratory impairment when characterizing the severity of COPD exacerbations².

Two-thirds of the patients in the present study had acidemia, with 30% having severe acidosis (pH <7.25) and 36% having mild acidosis (pH 7.25–7.34). Type II respiratory failure was the predominant respiratory failure pattern, occurring in 68% of patients, while Type I and mixed respiratory failure occurred in 20% and 12%, respectively. This predominance of hypercapnic respiratory failure is consistent with the pathophysiology of severe COPD exacerbation, in which increased airway obstruction, ventilation–perfusion abnormalities, respiratory muscle fatigue, and alveolar hypoventilation may lead to carbon dioxide retention and respiratory acidosis^{1,3}.

The predominance of hypercapnia in this study is also consistent with previous ICU observations. Seneff et al. reported that respiratory physiological variables including serum pH, PaCO₂, and PaO₂ were associated with longer-term outcomes among patients admitted to ICU with AECOPD³. These findings support the importance of evaluating ABG parameters not merely as diagnostic measurements but also as indicators of the severity of respiratory dysfunction.

A major finding of the present study was the significant association between initial pH and requirement for invasive mechanical ventilation. IMV was required in 43.3% of patients with pH <7.25 compared with 8.3% of those with pH 7.25–7.34, while no patient with pH ≥7.35 required IMV in the analyzed dataset. The association was statistically significant ($p < 0.001$). Thus, severe acidemia was associated with a greater requirement for invasive ventilatory support.

This observation is consistent with previous evidence demonstrating the prognostic and therapeutic importance of pH in AECOPD. Early NIV failure studies have shown that lower pH is associated with a greater probability of treatment failure and need for intubation^{6,7}. The ISCCM guidelines similarly state that NIV should be used in AECOPD with acute respiratory acidosis and that the probability of NIV failure increases as pH decreases⁵. Therefore, the high proportion of IMV requirement among patients with severe acidemia in the present study is consistent with established clinical evidence.

The relationship between initial PaCO₂ and NIV outcome was also significant. In the present study, NIV failure occurred in 17 of 32 patients (53.1%) with PaCO₂ >60 mmHg, compared with only 1 of 16 patients (6.3%) with PaCO₂ ≤45 mmHg ($p = 0.002$). This indicates that marked hypercapnia at admission was associated with a greater frequency of NIV failure. Similar findings have been reported in studies evaluating NIV in acute hypercapnic COPD exacerbations, in which baseline physiological severity and pH were important predictors of treatment failure^{6,7}.

NIV is recommended as an initial ventilatory strategy in appropriate patients with acute hypercapnic respiratory failure associated with COPD exacerbation. Evidence-based guidelines indicate that NIV can improve

respiratory acidosis, reduce the need for intubation, and improve clinical outcomes^{4,5}. The GOLD report similarly identifies NIV as the preferred initial mode of ventilatory support for many patients with acute respiratory failure during COPD exacerbation, while invasive ventilation is indicated when NIV fails or when immediate intubation is required¹. In the present study, the considerable requirement for NIV and invasive mechanical ventilation reflects the severity of the ICU population.

The present study also demonstrated a significant association between initial ABG abnormalities and ICU length of stay. Patients with pH <7.25 had a mean ICU stay of 9.0 ± 3.0 days compared with 5.5 ± 2.2 days among those with pH ≥7.25 ($p < 0.001$). Similarly, patients with PaCO₂ >60 mmHg had a mean ICU stay of 8.4 ± 2.8 days compared with 5.3 ± 2.1 days among patients with PaCO₂ ≤60 mmHg ($p < 0.001$). These findings suggest that greater respiratory and acid–base derangement at admission was associated with prolonged ICU requirements.

The association between physiological severity and ICU resource utilization has also been reported previously. ICU patients with severe AECOPD may require prolonged ventilatory support and monitoring because of persistent respiratory failure and associated complications³. In addition, studies of patients with severe AECOPD have identified admission pH and bicarbonate among variables associated with the subsequent requirement for invasive mechanical ventilation⁸. The present findings therefore support the clinical relevance of early ABG assessment in identifying patients likely to require prolonged intensive care.

Mortality was another important outcome associated with initial ABG parameters. Overall ICU mortality in the present study was 17%. Mortality was 43.3% among

patients with pH <7.25 compared with 5.7% among those with pH $\geq$ 7.25 ($p < 0.001$). This substantial difference demonstrates a strong association between severe acidemia at admission and ICU mortality.

Previous ICU studies have demonstrated that respiratory physiological abnormalities, including low pH, elevated PaCO₂, and reduced PaO₂, are associated with mortality in patients with severe AECOPD³. Similarly, systematic evaluation of prognostic factors in hospitalized AECOPD has identified acid–base abnormalities and markers of disease severity as clinically relevant predictors of adverse outcomes⁹. The findings of the present study are therefore consistent with the established prognostic importance of severe acidemia.

PaCO₂ also demonstrated a significant relationship with mortality. Mortality was 34.8% among patients with PaCO₂ >60 mmHg compared with 1.9% among those with PaCO₂ $\leq$ 60 mmHg ($p=0.001$). This finding suggests that marked hypercapnia was associated with substantially increased mortality in this ICU cohort. However, PaCO₂ should not be considered in isolation because carbon dioxide retention may reflect the overall severity of respiratory failure and may coexist with acidemia, hypoxemia, infection, and other systemic complications^{3,9}.

Hypoxemia showed a similarly important association with mortality. All 17 deaths occurred among patients with PaO₂ <60 mmHg. Mortality was 32.7% in patients with PaO₂ <60 mmHg compared with no deaths among those with PaO₂ $\geq$ 60 mmHg ($p=0.002$). This finding is consistent with the recognized importance of severe oxygenation impairment in critically ill patients with COPD exacerbation. Previous ICU data have demonstrated that PaO₂ and other respiratory

physiological variables contribute to assessment of prognosis in severe AECOPD³.

The present study also examined the relationship between PaO₂ and mechanical ventilation. Among the 64 patients represented in this analysis, mechanical ventilation was required in 62.5% of patients with PaO₂ <60 mmHg compared with 37.5% of those with PaO₂ $\geq$ 60 mmHg. This pattern suggests that greater oxygenation impairment was associated with increased ventilatory support requirements. However, because this analysis included a subgroup of 64 patients, the finding should be interpreted according to the reported denominator rather than extrapolated to the complete cohort.

The available PaCO₂-specific mechanical ventilation analysis similarly showed that most represented mechanically ventilated patients had marked hypercapnia. Among the 24 patients with available PaCO₂-specific data, 70.8% had PaCO₂ >60 mmHg, 25.0% had PaCO₂ between 45 and 60 mmHg, and 4.2% had PaCO₂ <45 mmHg. Previous research has demonstrated that ABG abnormalities, including pH and PaCO₂, may help identify patients at increased risk of requiring invasive mechanical ventilation⁸. The present observation therefore supports the clinical relevance of marked hypercapnia, although the analysis was limited to the available subgroup.

The respiratory support pattern in the present study showed that NIV was used in 40% of patients, BiPAP in 20%, invasive mechanical ventilation in 32%, and oxygen therapy in 8%. The mean duration of invasive mechanical ventilation was 7.2 ± 3.0 days, which was longer than the mean duration of BiPAP, NIV, or oxygen therapy. The longer duration of invasive ventilation is compatible with the greater severity of illness among patients requiring intubation. However, duration of ventilation is influenced

by several factors beyond ABG abnormalities, including infection, respiratory muscle recovery, organ dysfunction, complications, and response to treatment.

The present study recorded ICU complications in 52% of patients, with sepsis being the most frequent complication, followed by ventilator-associated pneumonia and acute kidney injury. ICU mortality was 17%. These observations emphasize that outcomes in severe AECOPD are determined by both respiratory and non-respiratory factors. Seneff et al. reported that development of non-respiratory organ-system dysfunction was an important determinant of mortality in ICU patients with AECOPD³. Therefore, although initial ABG abnormalities demonstrated significant associations with mortality in the present study, they should be interpreted as markers of physiological severity rather than isolated determinants of outcome.

Recent evidence further supports the importance of accurately identifying the type and severity of acute respiratory failure in AECOPD. Different respiratory failure phenotypes have been associated with differences in respiratory support requirements and clinical outcomes¹⁰. The present study similarly found a high prevalence of Type II respiratory failure and demonstrated significant associations between initial pH, PaCO₂, and PaO₂ and clinically important outcomes.

The findings are also consistent with clinical studies demonstrating that successful NIV is associated with improvement in pH and PaCO₂, whereas persistent abnormalities after NIV may indicate treatment failure⁷. This is particularly relevant to the present study because patients with higher admission PaCO₂ demonstrated a greater frequency of NIV failure. Close reassessment of ABG parameters after initiation of NIV may therefore complement clinical assessment when determining

whether NIV is succeeding or whether escalation of respiratory support is necessary.

Studies of alternative respiratory-support strategies have also emphasized the importance of careful patient selection in hypercapnic AECOPD. Recent randomized evidence has shown that NIV remains an important reference treatment for acute-moderate hypercapnic respiratory failure, with treatment failure and intubation occurring more frequently when NIV is not used as the initial modality in appropriately selected patients¹¹. This supports the central role of NIV in the management pathway of severe AECOPD.

Long-term respiratory management is beyond the primary scope of the present study, but the persistence of hypercapnia after an acute exacerbation is clinically relevant because chronic hypercapnia may continue after the acute episode. Studies of patients with persistent hypercapnia following AECOPD have demonstrated that non-invasive respiratory support can influence carbon dioxide levels during recovery¹². This highlights the importance of considering ABG abnormalities not only during the acute ICU episode but also when evaluating patients during recovery.

Overall, the present study demonstrates that initial ABG abnormalities were significantly associated with treatment requirements and clinical outcomes in ICU-admitted patients with AECOPD. Severe acidemia was associated with increased requirement for invasive mechanical ventilation, higher PaCO₂ was associated with NIV failure and prolonged ICU stay, and severe abnormalities of pH, PaCO₂, and PaO₂ were associated with higher ICU mortality. These findings support early ABG assessment as an important component of severity assessment and clinical monitoring in severe AECOPD.

The findings should nevertheless be interpreted in light of the observational design. The observed associations do not establish that an individual ABG abnormality independently causes ventilatory failure or mortality. Outcomes may also be influenced by infection, comorbid disease, baseline COPD severity, organ dysfunction, treatment response, and ICU complications. In addition, the mechanical-ventilation subgroup analyses had smaller denominators than the overall cohort and should therefore be interpreted according to the reported sample sizes.

Conclusion

The study supports the clinical value of initial pH, PaCO₂, and PaO₂ as readily available physiological markers associated with respiratory support requirements, ICU stay, NIV failure, and mortality in patients with AECOPD. Early identification of severe acidemia, hypercapnia, and hypoxemia may facilitate closer monitoring and timely escalation of respiratory support in critically ill patients.

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