Original Article

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Arterial Blood Gas Analysis and Dyselectrolytemia in Acute Exacerbation of Chronic Obstructive Pulmonary Disease (COPD)

Nivedita Tayamgol Reddy,[1] Sachin Patil,[2] Kailash Reddy [3]

[1]Department of General Medicine, Gulbarga Institute of Medical Sciences, Kalaburagi, India
[2]Department of General Medicine, Bidar Institute of Medical Sciences, Bidar, India
[3]Department of Anaesthesia, ESIC Hospital, Kalaburagi, India

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Correspondence:
Nivedita Tayamgol Reddy,
Department of General Medicine,
Gulbarga Institute of Medical Sciences, Kalaburagi, India.
Email: docnivt@gmail.com

Abstract

Background: Acute exacerbations of chronic obstructive pulmonary disease (AECOPD) is one of the important causes of morbidity, mortality, and healthcare burden. Electrolyte disturbances and acid–base imbalances are frequent but under-recognized complications that may worsen outcomes in cases of AECOPD.

Objective: To understand the prevalence of serum electrolyte abnormalities and arterial blood gas (ABG) parameters in patients admitted with AECOPD.

Methods: This prospective observational study enrolled 200 patients with confirmed AECOPD admitted to a tertiary care hospital in Kalaburagi, India, over an 18 month period. The ABG analysis and serum electrolytes (sodium, potassium, magnesium, chloride) measurement were performed at admission. Demographic, clinical, and radiological data were also collected. Data were then analyzed using SSPS 23.0, with a P value of < 0.05 considered statistically significant.

Results: Abnormalities related to sodium (91.5%), potassium (90.5%), magnesium (80.5%), and chloride (56%) were common in cases admitted with AECOPD. In 45% cases, the PaO_2 <50 mmHg was seen whereas $PaCO_2$ >45 mmHg was found in 43%. Acid–base imbalance was seen in 35% cases, with 4.5% showing severe acidosis (pH ≤7.1). Cough (72.5%) and breathlessness (60.5%) were most common symptoms. The majority were elderly males (65%) whereas 57% were smokers. Diabetes was the most common comorbidity (30.5%).

Conclusion: Electrolyte abnormalities and ABG derangements are nearly universal in AECOPD and have important prognostic implications. Routine metabolic profiling should be integrated into the acute management of COPD to improve outcomes, particularly in resource-constrained settings.

Keywords: Chronic obstructive pulmonary disease, electrolyte imbalance, hypokalemia, hyponatremia, respiratory acidosis

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is one of the major global health problems. It is characterized by presence of persistent respiratory symptoms and airflow limitation that is not fully reversible. Acute exacerbations of COPD (AECOPD) can be defined as episodes of worsening respiratory symptoms which often need a change in treatment strategy. These exacerbations are known to contribute significantly to the overall morbidity and mortality in patients of COPD. These exacerbations are also cause of frequent hospital admissions, accelerated decline in lung function and impaired quality of life.

Globally, COPD affects an estimated 480 million people. These numbers corresponds to the prevalence of approximately 10.6% in

adults. As far as India is concerned population-based studies and meta-analyses report a COPD prevalence of roughly 7–8% among adults. The prevalence is a higher in older age groups and rural populations. Among patients with established COPD, approximately 30–50% experience at least one acute exacerbation every year, and exacerbation rates typically range from 0.5 to 3.5 events per patient-year, making AECOPD the main driver of COPD-related emergency visits and hospitalizations.[1]

The burden of COPD is not limited to mortality alone and it also encompasses substantial healthcare costs, loss of productivity and considerable psychosocial stress for both patients and caregivers. The acute exacerbations of COPD are the principal events that drive this burden. The cost implications are particularly marked in developing countries, where limited healthcare infrastructure amplifies the strain on patients and health systems.

Identifying the determinants of poor prognosis in AECOPD is therefore of paramount importance for better clinical management and reduction in healthcare costs. While the clinical presentation of AECOPD is dominated by respiratory manifestations it is increasingly recognized that systemic effects and comorbidities play an equally critical role in influencing outcomes. Among these, metabolic and electrolyte disturbances are frequently under-recognized contributors to adverse prognosis.[2]

Patients with AECOPD may develop hyponatremia, hypokalemia, hypomagnesemia and other biochemical abnormalities. These imbalances may arise from multiple mechanisms that includes the underlying disease pathophysiology or iatrogenic effects of commonly used therapies such as β2-agonists, corticosteroids and diuretics. These metabolic derangements are often overlooked in the acute care setting which may result in preventable complications and higher mortality. Disturbances such as hyponatremia as well as hypokalemia can precipitate a series of complications that may include cardiac arrhythmias, altered mental status seizures, impaired diaphragmatic contractility and even respiratory muscle paralysis leading to need for mechanical ventillation.[3]

In critically ill patients, these derangements can aggravate hypoxemia, worsen respiratory failure and may increase the risk of invasive ventilation. Therefor in patients of AECOPD electrolyte abnormalities may carry prognostic implications which may be as crucial as the severity of airflow obstruction or arterial hypoxemia. Arterial blood gas (ABG) analysis remains important in the evaluation of COPD exacerbations, providing critical information on oxygenation, carbon dioxide retention, and acid–base balance.

The severity of hypoxemia and hypercapnia has long been correlated with poor outcomes in COPD. Hypoxemia and hypercapnia both are indications for initiation of non-invasive ventilation and escalation to intensive care management. However, integration of ABG findings with serum electrolyte status offers a more comprehensive understanding of the metabolic status during acute exacerbations. For instance, it is known that hypokalemia in the setting of respiratory acidosis may predispose patients to malignant arrhythmias while hyponatremia can complicate the neurological status of hypercapnic individuals.[4]

This correlation between metabolic derangements and outcomes in patients of AECOPD underscores the need for comprehensive metabolic monitoring in these cases beyond conventional respiratory parameters. Several observational studies have highlighted the prognostic importance of biochemical parameters in COPD exacerbations However the evidence remains fragmented.[5] This is more so in low- and middle-income countries where COPD prevalence is high and healthcare access is limited. Given these considerations, the present study was undertaken to evaluate arterial blood gas parameters and serum electrolyte levels in patients admitted with acute exacerbations of COPD.

Methods

This descriptive observational study was conducted in the Department of General Medicine at Basaveshwar Teaching and General Hospital (Mahadevappa Rampure Medical College, Kalaburagi, India) over an 18-month period from 1 December 2022 to 31 December 2024. Patients presenting with AECOPD were enrolled based on predefined inclusion and exclusion criteria.

The sample size was calculated using the standard formula $n=(Z\alpha/2 + Z1-\beta)^2 \times p \times q/d^2$) was used taking into account the expected prevalence (p), allowable error (d), and its complement (q=1–p). A 95% confidence interval and 80% power were considered for the calculation. On the basis of this formula and sample size calculations a total of 200 patients were enrolled.

Ethical approval was obtained from the Institutional Ethics Committee (HKES/MRMCK/IEC/202220753), and written informed consent was obtained in the patient's vernacular language. Individuals aged >18 years with a confirmed diagnosis of COPD presenting with acute symptom exacerbation were included. Patients with chronic renal failure or diabetic ketoacidosis were excluded in order to avoid confounding metabolic derangements. At admission all patients underwent a detailed clinical history and examination. Clinical Examination findings were documented in a structured proforma.

Particular emphasis was placed on evaluating parameters that could influence prognosis. Arterial blood gas (ABG) analysis was performed and PaO_2, $PaCO_2$, bicarbonate (HCO_3^-), and oxygen saturation were recorded. These parameters were analyzed to assess the degree of hypoxemia, hypercapnia as well as acid–base imbalance. Similarly, serum electrolytes including sodium, potassium, magnesium and chloride were measured to detect abnormalities such as hyponatremia, hypokalemia and hypomagnesemia. Additional biochemical tests such as renal function tests (serum urea and creatinine) and liver function markers (bilirubin, transaminases) were done to hepatic and renal functions. An Xray was done in all cases to rule out presence of concurrent pneumonia.

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared using the Student's t-test. A p-value of less than 0.05 was considered statistically significant.

Results

Of the 200 cases studied, 130 (65%) were males and 70 (35%) were females, demonstrating a male preponderance with a male-to-female ratio of 1:0.53. The mean age of males was 65.81±9.96 years, while that of females was 65.41±10.76 years, with no statistically significant difference between the two groups (t = 0.264, p=0.792). The majority of patients (41.0%) belonged to the 61–70-year age group, followed by 25.5% in the 51–60-year group and 19.5% in the 71–80-year group. Only 7.5% of patients were ≤50 years, while 6.5% were aged >80 years. The majority of patients were engaged in household activity (n=110, 55.0%), followed by laborer (n=81, 40.5%). A smaller proportion (n=9, 4.5%) were classified under other occupations. This distribution highlights the predominance of household workers in the study population, with a substantial proportion also being laborer.

The most common presenting complaint was cough (72.5%) followed by Breathlessness (60.5%), and Expectoration (24.0%). Fever was present in 30 patients (15.0%). Overall respiratory symptoms predominated with

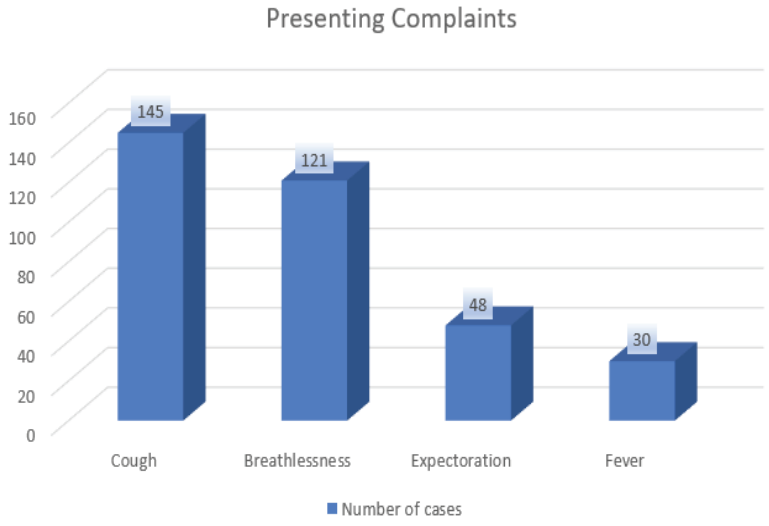

Fig. 1 Distribution of Presenting Complaints Among Study Patients

Table 1 Comorbidities, Lifestyle Habits, and Occupation of the Study Population

Variables	Category	Number of Cases (n)	Percentage (%)
Comorbidities	Diabetes mellitus	61	30.5
	Hypertension	24	12.0
Lifestyle habits	Smoking	114	57.0
	Alcohol	28	14.0
Occupation	Household activity	110	55
	Labor work	81	40.5
	Others	9	4.5

Table 2 Distribution of Electrolyte Abnormalities in Studied Cases

Electrolytes	Levels (Normal Range)	Number of patients	Percentage
Sodium	Normal (135–145 mmol/L)	17	8.5
	Abnormal	183	91.5
Potassium	Normal (3.6–5.2 mEq/L)	19	9.5
	Abnormal	181	90.5
Magnesium	Normal (1.7–2.2 mg/dL)	39	19.5
	Abnormal	161	80.5
Chloride	Normal (96–106 mEq/L)	88	44.0
	Abnormal	112	56.0

cough and breathlessness together accounting for the majority of clinical presentations (Fig. 1).

Diabetes mellitus was the most frequent comorbidity, observed in 61 cases (30.5%), followed by hypertension in 24 cases (12%). Regarding lifestyle habits in 114 patients (57%) were smokers, while alcohol consumption was present in 28 patients (14.0%). Overall, smoking constituted the most prevalent risk factor, whereas diabetes mellitus was the leading comorbidity. The majority of patients were engaged in household activity (n=110, 55.0%), followed by laborer (n=81, 40.5%). A smaller proportion (n=9, 4.5%) were classified under other occupations (Table 1).

Vital parameters were within expected clinical ranges: the mean pulse rate was 79.2±14.7/min, mean systolic and diastolic blood pressures were 128.9±12.4 mmHg and 79.1±12.7 mmHg, respectively, while the mean respiratory rate was 24.9±2.7/min.

Hematological parameters showed a mean hemoglobin of 12.1±2.2 g/dL, mean corpuscular volume of 81.6±10.3 fL, and a mean platelet count of $3.05\pm0.86 \times 10^5/\mu L$.

Table 3 Oxygenation Status of the Studied Cases

Variables	Levels	Number of Patients	Percentage (%)	Mean ± SD	Range
PaO_2	Normal (>50 mmHg)	110	55	62.11 ± 20.94	36–98
	Abnormal	90	45		
$PaCO_2$	Normal (<45 mmHg)	114	57	53.16 ± 10.18	26.8–86
	Abnormal	86	43		

Table 4 Arterial Blood Gas (ABG) pH Categories of the Studied Cases

ABG pH	Category	Number of Patients	Percentage (%)
≤ 7.1	Severe	9	4.5
7.11–7.3	Moderate	61	30.5
> 7.3	Mild	130	65.0
Total	–	200	100.0

Mean random blood sugar was 173.5±16.3 mg/dL, mean urea and creatinine levels were 35.8±8.0 mg/dL and 1.08±2.7 mg/dL respectively. Liver function tests revealed normal total bilirubin (mean= 1.05±0.22 mg/dL, mean AST= 35.4±3.2 U/L, mean ALT= 43.9±8.4 U/L, and mean ALP = 78.2±14.5 U/L.

All patients were negative for HBsAg and sputum AFB. Urine albumin positivity was observed in 61 patients (30.5%), whereas 139 patients (69.5%) had no albuminuria. Urine sugar was detected in 31 patients (15.5%) On chest X-ray evaluation of 200 patient Emphysematous changes were observed in 55 cases (27.5%), while chronic bronchitis was seen in 45 cases (22.5%). Electrolyte abnormalities were highly prevalent in the study population. Hyponatremia or hypernatremia was seen in in 183 patients (91.5%), with only 17 patients (8.5%) having normal sodium levels. Similarly, potassium abnormalities were observed in 181 patients (90.5%) while 19 patients (9.5%) had normal values. Magnesium derangements were present in 161 patients (80.5%), with normal levels in 39 patients (19.5%). Chloride levels were abnormal in 112 patients (56.0%) Overall, the data demonstrate that sodium and potassium disturbances were nearly universal, while chloride and magnesium abnormalities were also frequent but relatively less pronounced (Table 2).

Analysis of oxygenation status of studied cases showed that 110 patients (55.0%) had normal PaO_2 values (>50 mmHg) with a mean of 62.11 ± 20.94 mmHg (range 36–98). Ninety patients (45.0%) showed abnormal PaO_2. For $PaCO_2$ 114 patients (57.0%) had values within the normal range (<45 mmHg), while 86 patients (43.0%) exhibited abnormalities. The mean $PaCO_2$ was 53.16±10.18 mmHg (range 26.8–86) (Table 3).

Arterial blood gas analysis of pH revealed that the majority of patients had mild derangement (>7.3), accounting for 130 cases (65.0%). Moderate acidosis (pH 7.11–7.3) was seen in 61 patients (30.5%), while severe acidosis (pH ≤7.1) was present in only 9 patients (4.5%) (Table 4).

Discussion

The findings of this underscore's role of metabolic and electrolyte abnormalities in cases of AECOPD cases. These abnormalities are frequently under-recognized contributors to adverse clinical outcomes. Electrolyte disturbances were remarkably prevalent in this study, with 91.5% of patients exhibiting sodium imbalance and 90.5% having potassium derangements. These observations are Similar to those reported by Lindner G *et al* who reported a similarly high prevalence of hyponatremia and hypokalemia among hospitalized AECOPD patients.[6] Similarly García-Sanz MT *et al* found that hyponatremia in cases of AECOPD cases was associated with higher in-hospital mortality and longer length of stay.[7] These findings support these associations and further suggest that serum sodium and potassium monitoring should be considered an integral part of initial risk stratification in AECOPD management.

In this study a substantial proportion of patients had abnormal $PaCO_2$ levels (43.0%) and varying degree of acid–base imbalance. 61 (30.5%) of the patients showed moderate acidosis and 9 (4.5%) cases were found to have severe acidosis. These findings are similar to the observations of Csoma B who reported that hypercapnia and respiratory acidosis were independently associated with poor clinical outcomes and increased need for ventilatory support in cases of AECOPD.[8] Similarly Slenter RH reported that there is a direct correlation between elevated $PaCO_2$ and in-hospital mortality in COPD patients particularly when combined with acidemia.[9] These findings further reinforce the prognostic implications of ABG parameters. These parameters particularly when interpreted in addition to serum electrolytes can identify cases prone for serious complications. For instance, hypokalemia in the setting of respiratory acidosis may predispose to

malignant ventricular arrhythmias and this synergy warrants prompt correction.

Magnesium imbalance, observed in 80.5% of this study population, has been relatively underreported in AECOPD literature but is gaining attention due to its physiological role in bronchodilation and respiratory muscle function. In a prospective study by Sreekumar the study found that low serum magnesium levels were having a definite association with exacerbations of COPD.[10] Similarly, Kılıc *et al.* emphasized that hypomagnesemia contributes to bronchial hyperreactivity and worsens hypoxemia during exacerbations.[11] These findings are similar to this study where magnesium derangements were frequently coexistent with ABG abnormalities and respiratory symptoms such as breathlessness and cough. Given its significant functional role routine monitoring and early correction of magnesium may aid in improving ventilatory efficiency and potentially reduce progression to respiratory failure.

This results also highlight chloride abnormalities in over half of the patients (56.0%). While chloride derangements are often overlooked, they have important implications in the context of acid–base balance. Hyperchloremic metabolic acidosis can complicate the clinical course of AECOPD, especially in patients receiving large volumes of saline or those with renal dysfunction. Ouf *et al.* found that chloride levels were significantly correlated with bicarbonate concentrations and had a significant bearing on acid–base disturbances during COPD exacerbations.[12] In another study Shao M demonstrated that hyperchloremia was independently associated with worse outcomes and prolonged hospital stays in critically ill patients with respiratory disorders.[13] Although this study did not directly quantify acid–base interactions involving chloride the significant prevalence of chloride abnormalities in conjunction with ABG derangements supports these associations.

The demographic and clinical profile of this study population also sheds light on risk factors that may predispose individuals to possibility of severe metabolic complications during AECOPD. The predominance of older males with high rates of smoking and comorbid diabetes are similar to the findings of Salvi *et al* who reported a similar demographic profile in COPD cohorts and emphasized the cumulative risk posed by age and metabolic syndrome.[14] Additionally, Lopez-Campos *et al*. noted that COPD patients with comorbid diabetes and cardiovascular diseases had a significantly higher frequency of exacerbations and hospital readmissions.[15] The metabolic burden in these subgroups may reflect underlying pathophysiology as well as iatrogenic factors such as diuretic use and corticosteroid therapy. Key limitations of this study were is that its relatively small sample size and non-exclusion of patients with confounding factors such as those on medication (use of diuretics, corticosteroids, or β_2-agonists) which could have influenced the prevalence and severity of electrolyte disturbances and ABG abnormalities.

In conclusion, the findings of this study emphasize the importance of comprehensive assessment and timely correction of electrolyte and ABG abnormalities in patients admitted with AECOPD. The combined assessment of respiratory and metabolic parameters can help in offering a comprehensive risk assessment and guide individualized therapeutic strategies in cases of AECOPD.

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