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A study on electrolyte abnormalities in acute exacerbation of chronic obstructive pulmonary disease

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a significant respiratory disorder characterized by persistent respiratory symptoms and airflow limitations. Acute exacerbations of COPD (AECOPD) are associated with systemic complications, including electrolyte imbalances, which can worsen clinical outcomes. This study investigates the prevalence and impact of electrolyte disturbances in AECOPD patients.

Methods: This prospective observational study was conducted in a tertiary care hospital in Karnataka, India, from May 2023 to May 2024. A total of 100 COPD patients aged 40 years or older presenting with acute exacerbations were included. Data on demographics, comorbidities, severity of COPD (GOLD classification), and prior exacerbations were collected. Serum levels of sodium, potassium, and calcium were analyzed. Statistical analyses included Chi-square and ANOVA tests.

Results: The mean age of participants was 62.4 ± 8.3 years, with 72% being male. Hyponatremia (<135 mEq/L) was present in 76% of patients, with a mean sodium level of 132.43 ± 12.76 mEq/L. Hypokalemia (<3.5 mEq/L) was observed in 81%, with a mean potassium level of 3.23 ± 0.08 mEq/L, and hypocalcemia (<7 mg/dL) was identified in 85%, with a mean calcium level of 6.35 ± 0.98 mg/dL. Electrolyte imbalances were more severe in GOLD Stage IV, with sodium at 125.87 ± 14.29 mEq/L, potassium at 2.32 ± 0.32 mEq/L, and calcium at 4.76 ± 1.05 mg/dL.

Conclusion: Electrolyte abnormalities are common in AECOPD patients, particularly in severe cases. Regular monitoring and correction of these disturbances can improve respiratory function, muscle strength, and overall clinical outcomes. Further research is needed to explore underlying mechanisms and therapeutic interventions.

Keywords: Chronic Obstructive Pulmonary Disease; Acute Exacerbations of COPD; Electrolyte Imbalance; Hyponatremia; Hypokalaemia; Hypocalcemia

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) represents a significant respiratory disorder that can be effectively managed through appropriate therapeutic interventions. Persistent respiratory symptoms and diminished airflow characterize the clinical presentation attributable to impaired airway and alveolar structures. The observed damages are predominantly attributable to extended exposure to harmful particles or gases.[1] In 2020, the global prevalence of COPD is estimated at 10.6%, corresponding to approximately 480 million cases impacting individuals of both sexes.[2] The prevalence of Chronic Obstructive Pulmonary Disease (COPD) in India is estimated at 7.4%, derived from a pooled sample of 8,569 individuals, with a higher incidence observed in the male population.[3] Tobacco smoking is extensively acknowledged as the primary causal factor for COPD in high- and medium-income nations. Simultaneously, exposure to

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biomass smoke remains a significant source of deleterious compounds and a primary factor in the increased risk of chronic obstructive pulmonary disease (COPD) in low-income nations.

COPD patients encounter approximately two acute exacerbations of COPD (AECOPD) annually, with 10% of these exacerbations necessitating hospitalization. Acute exacerbations significantly impair quality of life and reduce respiratory function, frequently leading to respiratory failure. Patients with AECOPD often experience various systemic complications in addition to the respiratory symptoms. One such complication is electrolyte imbalance, which can arise due to several factors, including the disease's chronic nature, medications (such as diuretics or corticosteroids), comorbid conditions, and altered fluid balance.[4] Electrolyte abnormalities can have significant implications on the clinical course, affecting respiratory function, muscle strength, and the overall quality of life of patients.[5]

The most typical electrolyte disturbances observed in AECOPD patients include hypernatremia, hypokalaemia, and hypercalcemia. These abnormalities can worsen respiratory symptoms, lead to arrhythmias, and complicate the management of the disease.[6] Despite the clinical importance of electrolyte abnormalities, there is limited research addressing their prevalence and impact on COPD patients with acute exacerbations. This study aims to assess the types and frequency of electrolyte disturbances in patients diagnosed with COPD and to explore any associations with the severity of the disease, comorbidities, and the use of medications.

2. Materials and methods

This was a prospective observational study conducted at the Department of General Medicine, Al Ameen Medical College, Vijayapura, Karnataka, India from May 2023 – May 2024, involving patients diagnosed with COPD who present with acute exacerbations.

The study included 100 patients aged 40 years and above who have a confirmed diagnosis of COPD and present with acute exacerbations. The Institutional ethical committee approved the study.

2.1. Inclusion criteria

- Patients aged 40 years and above.
- A confirmed diagnosis of COPD based on spirometric criteria (forced expiratory volume in 1 second [FEV1]/forced vital capacity [FVC] < 70%) and clinical findings.
- Patients who present with an acute exacerbation of COPD, defined as worsening of at least one of the following symptoms:
    - Increased dyspnea
    - Increased sputum volume
    - Increased sputum purulence

2.2. Exclusion Criteria

- Patients with acute renal failure or chronic kidney disease (CKD) (defined as an eGFR < 60 mL/min/1.73m^2).
- Patients who have a history of malignancy or active cancer.
- Patients with conditions that could interfere with electrolyte balance such as hyperthyroidism, primary hyperaldosteronism, or other systemic diseases.
- Pregnant women.
- Patients who were unwilling or unable to provide informed consent.

2.3. Study Procedure

Age, gender, smoking history (current smoker, ex-smoker, never smoked), and comorbid conditions such as diabetes mellitus, hypertension, and cardiovascular diseases were recorded. The severity of COPD was assessed using the Global Initiative for Chronic Obstructive Lung Disease (GOLD) classification based on FEV1 percentage and clinical symptoms. The duration and frequency of previous exacerbations was recorded, as well as any prior hospitalizations for COPD exacerbations. Dyspnea, cough, sputum production, and other associated symptoms like fatigue, chest pain, and wheezing were also documented.

Serum electrolytes, sodium (Na), potassium (K), and ionized calcium (Ca), were quantified for all participants using the auto analyzer. The reference range for the electrolytes were as sodium (Na) 135–145 mEq/l, potassium (K) at 3.5–5.5

mEq/l, and for total calcium (Ca) 4.4–8.5–10.3 mg/dL respectively.[7] Pulmonary function assessments were conducted for patients utilizing spirometry and the oxygen saturation was assessed using pulse oximetry.

2.4. Data analysis

The data were shown as mean ±SD and frequency (%).Chi-square test was used for categorical variables, such as the presence of electrolyte imbalances for COPD severity. Multiple regression analysis was done to determine the relationship between electrolyte abnormalities and clinical outcomes.

3. Results

The demographics and clinical characteristics of the COPD patients with acute exacerbations were shown in table 1. The mean age of the COPD with acute exacerbations was 62.4 ± 8.3 years and majority of the patients in the age range of 60-69 years in 35% of the cases. Majority of the cases were current smoker (54%), the most common comorbidity was hypertension in 45% of the cases and majority of the patients had GOLD stage II severity in 52% respectively.

Table 1 Demographics and clinical characteristic of the COPD patients

Variables	Value (n=100)
Age (years) mean±SD	62.4 ± 8.3
Gender (n, %)	
Male	72 (72%)
Female	28 (28%)
Smoking status (n, %)	
Current Smoker	54 (54%)
Ex-Smoker	24 (24%)
Non-Smoker	22 (22%)
Comorbidities (n, %)	
Hypertension	45 (45%)
Diabetes Mellitus	38 (38%)
Ischemic Heart Disease	25 (25%)
Gold Stage (n, %)	
GOLD Stage I	8 (8%)
GOLD Stage II	52 (52%)
GOLD Stage III	28 (28%)
GOLD Stage IV	12 (12%)

The lung spirometry parameters of COPD patients with acute exacerbations are shown in Table 2. The mean FEV1 was 1.34± 0.6 L, FVC was 2.52± 0.7L and the FEV1/FVC ratio was 0.53 ± 0.09 L. The mean PEFR was 192.76±76.23 L/min.

Table 2 Spirometry parameters in COPD patients with acute exacerbations

Parameter	Value (Mean± SD)
FEV1 (L)	1.34± 0.6
FVC (L)	2.52± 0.7
FEV1/FVC	0.53 ± 0.09
PEFR (L/min)	192.76±76.23

The mean serum electrolytes level in of COPD patients with acute exacerbations was shown in table 3. The mean sodium level was 132.43±12.76 mEq/L, potassium level was 3.23±0.08 mEq/L and calcium level was 6.35±0.98 mg/dl respectively.

Table 3 Serum electrolytes level in COPD patients with acute exacerbations

Parameter	Value (Mean± SD)
Sodium (mEq/L)	132.43±12.76
Potassium (mmol/L)	3.23±0.08
Calcium (mg/dl)	6.35±0.98

The distribution of sodium, potassium and calcium levels among the COPD patients with acute exacerbation was shown in table 4. In this study, the incidence of hyponatermia (76%), hypokalemia (81%) and hypocalcemia (85%) was higher in COPD patients with acute exacerbations.

Table 4 Distribution of serum electrolytes level in COPD patients with acute exacerbation

Serum electrolytes	Range	AECOPD (n=100)	P value
Sodium			
Hyponatremia	<135 mEq/L	76 (76%)	0.000*
Normal	135–145 mEq/L	8 (8%)	
Hypernatremia	>145 mEq/L	16 (16%)	
Potassium			
Hypokalaemia	<3.5 mEq/L	81 (81%)	0.000*
Normal	3.5–5.5 mEq/ L	4 (4%)	
Hyperkalaemia	>5.5 mEq/ L	15 (15%)	
Calcium			
Hypocalcemia	<7mg/dl	85 (85%)	0.003*
Hypercalcemia	>7mg/dl	28 (78%)	

* indicates significant (p<0.05); Chi square test.

The distribution of sodium, potassium and calcium levels across GOLD staging was shown in table 5. The sodium (p=0.001), potassium (p=0.001) and calcium level (p=0.006) was significantly lower in GOLD stage IV when compared to stage III. II and I.

Table 5 Association between electrolyte levels and GOLD stage

Gold stages	Sodium mEq/L (mean±SD)	Potassium mEq/L (mean±SD)	Calcium (mg/dl)
GOLD Stage I (n=8)	138.76±27.65	4.12±1.12	8.12±2.12
GOLD Stage II (n=52)	134.34±15.34	3.53±0.98	6.54±1.65
GOLD Stage III (28%)	130.76±12.76	3.98±0.76	5.98±1.32
GOLD Stage IV (n=12)	125.87±14.29	2.32±0.32	4.76±1.05
P value	0.001*	0.001*	0.006*

The data is shown as mean±SD. Comparison of electrolyte level in GOLD stage is done using One Way ANOVA. * indicates significant (0<0.05).

4. Discussion

This study investigates the electrolyte abnormalities in patients with acute exacerbations of chronic obstructive pulmonary disease (AECOPD). The results highlight the prevalence of significant electrolyte disturbances and their association with COPD severity. The findings from this study underline the importance of monitoring electrolyte levels in COPD patients during acute exacerbations; as such abnormalities could have a substantial impact on clinical outcomes.[8]

The study cohort comprised 100 patients, with a mean age of 62.4 ± 8.3 years. The majority of patients were male (72%), and most of them were either current (54%) or ex-smokers (24%). Hypertension (45%) and diabetes mellitus (38%) were the most common comorbidities observed, which is consistent with the known associations between COPD and cardiovascular diseases. The higher prevalence of hypertension in this cohort might also contribute to the electrolyte disturbances observed, as medications such as diuretics used to manage hypertension can affect electrolyte balance. In a study done by Goli et al. [9] mean age of the COPD patients with acute exacerbation was 61.22±11.45 with male preponderance (77.41%).

Regarding the severity of COPD, 52% of patients were classified under GOLD Stage II (moderate COPD), with 28% in Stage III (severe COPD) and 12% in Stage IV (very severe COPD). These findings suggest that the majority of patients in this study had moderate to severe disease, which is likely to have contributed to the higher incidence of acute exacerbations. Likewise in a study done by Shah et al.[10] majority of the COPD patients were in GOLD stage II of moderate severity in 74.4% of the cases.

The spirometry results showed reduced lung function with a mean FEV1 of 1.34 ± 0.6 L, FVC of 2.52 ± 0.7 L, and FEV1/FVC ratio of 0.53 ± 0.09. These values indicate significant airflow limitation, particularly evident in patients with higher GOLD stages. The mean PEFR of 192.76 ± 76.23 L/min also indicates reduced peak expiratory flow, which is commonly seen during COPD exacerbations due to increased airway obstruction.

In the present study, Hyponatremia (sodium <135 mEq/L) was observed in 76% of patients, which is considerably higher than the typical 10–30% prevalence of hyponatremia in general COPD populations. The significant hypokalemia (potassium <3.5 mEq/L) in 81% of patients is also a concern, as low potassium levels can lead to muscle weakness, arrhythmias, and further respiratory complications. Hypocalcemia (calcium <7 mg/dl) was observed in 85% of the patients, which is often associated with impaired neuromuscular function, leading to muscle cramps and weakness.

These findings are consistent with the hypothesis that electrolyte abnormalities arise due to a combination of factors, including the use of diuretics, corticosteroids, and changes in fluid balance during acute exacerbations of COPD. The use of medications like diuretics and corticosteroids, both of which can affect electrolyte levels, might be a contributing factor to these disturbances. In a study done by Rathore et al.[7] 62% of the AECOPD patients had hyponatremia, 52% had hypokalaemia and 80% of the cases had hypocalcemia. In another study done by Deep et al.[5] 70.7% had hyponatremia, 56.1% had hypokalaemia and 12.2% of the cases had hypocalcemia. In a study conducted by Acharya and Paudel,[11] 50% had hyponatremia and 42% had hypokalaemia. Electrolyte imbalances in AECOPD occur due to multiple factors, including hypoxemia and respiratory acidosis, which cause potassium shifts between compartments, leading to hypokalaemia. Corticosteroids promote sodium retention and potassium loss, contributing to hypernatremia and hypokalaemia. Additionally, diuretics used to manage fluid retention further exacerbate hypokalaemia and hyponatremia by increasing renal potassium and sodium excretion.[12] Chalela et al.[13] demonstrated that, in comparison to AECOPD patients with normonatremia, those with hyponatremia exhibited significantly elevated levels of LHS, mechanical ventilation needs, in-hospital mortality, and all-cause mortality.

The association between electrolyte levels and COPD severity (as classified by the GOLD stages) was significant. Sodium, potassium, and calcium levels were significantly lower in GOLD Stage IV patients compared to those in Stage I, II, and III. The p-values for sodium ($p=0.001$), potassium ($p=0.001$), and calcium ($p=0.006$) suggest a clear trend of worsening electrolyte abnormalities with increasing COPD severity. In GOLD Stage IV, the mean sodium level was 125.87 ± 14.29 mEq/L, potassium was 2.32 ± 0.32 mEq/L, and calcium was 4.76 ± 1.05 mg/dl, indicating more severe electrolyte imbalances in the most advanced stage of the disease. Conversely, GOLD Stage I patients had relatively normal electrolyte levels, with mean sodium at 138.76 ± 27.65 mEq/L, potassium at 4.12 ± 1.12 mEq/L, and calcium at 8.12 ± 2.12 mg/dl. This suggests that as COPD progresses and exacerbations become more severe, the likelihood of significant electrolyte imbalances increases, which can contribute to poor clinical outcomes. Likewise in a study done by Haque et al.[14] the sodium (128.32 vs 131.05; $p=0.007$) and potassium (3.28 vs 3.11 mEq/L; $p<0.05$) level was lower in very severe GOLD stage as compared to severe GOLD stage.

The high incidence of electrolyte disturbances in COPD patients with acute exacerbations emphasizes the need for vigilant electrolyte monitoring in this patient population. Hyponatremia, hypokalemia, and hypocalcemia can worsen respiratory symptoms, increase the risk of arrhythmias, and impair muscle function, all of which can contribute to poor clinical outcomes.[15,16,17] The findings from this study suggest that electrolyte imbalances should be promptly addressed in patients with AECOPD, particularly in those with severe disease (GOLD Stage III and IV). Correction of these imbalances may help improve respiratory function, muscle strength, and potentially reduce complications such as arrhythmias and respiratory failure.

While the study provides valuable insights, there are several limitations. This is a single-center study with a relatively small sample size, and the results may not be generalizable to the broader COPD population. Furthermore, the study is observational, so causal relationships between electrolyte abnormalities and COPD exacerbations cannot be definitively established. Larger, multi-center studies are needed to further validate these findings and explore the underlying mechanisms of electrolyte disturbances in AECOPD.

5. Conclusion

In conclusion, electrolyte abnormalities, particularly hyponatremia, hypokalemia, and hypocalcemia, are common in patients with acute exacerbations of COPD. These imbalances are more prevalent in patients with severe COPD (GOLD Stage III and IV) and are associated with worse clinical outcomes. Therefore, regular monitoring of serum electrolytes in patients with AECOPD is critical for timely intervention and management to improve patient outcomes.

Compliance with ethical standards

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Disclosure of Conflict of interest:

No Conflict of interest to be disclosed.

Statement of Ethical approval

The study was approved by the Institutional Ethical Committee.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study

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