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Study of Serum Electrolytes in Patients Presenting with Acute Exacerbation of Chronic Obstructive Pulmonary Disease

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HIGHLIGHTS

- Electrolyte imbalance in AECOPD.
- Hyponatremia, hypokalemia frequent.
- Disturbances worsen severity.
- Imbalances delay recovery.
- Early correction beneficial.

Key Words:
Acute exacerbation of COPD
Hyponatremia
Hypokalemia
Serum electrolytes
mMRC
qSOFA
Hospital outcomes
Electrolyte imbalance

ABSTRACT

Introduction: Electrolyte imbalances, particularly hyponatremia and hypokalemia, are common in acute exacerbation of COPD (AECOPD) and may worsen outcomes. **Aim & Objective:** To assess the prevalence and impact of serum electrolyte imbalances, specifically hyponatremia and hypokalemia, in patients with AECOPD. **Materials & Methods:** A prospective observational study included 113 AECOPD patients admitted to G.R. Medical College, Gwalior (May 2023–Sept 2024). Serum sodium and potassium were measured at admission and discharge. Clinical severity was assessed using mMRC and qSOFA scores, and associations with smoking status, ECG findings, recovery, hospital stay, and mortality were analyzed. **Results:** Most patients were male (79.6%), smokers (61.9%), and aged >70 years (45.1%). Hyponatremia and hypokalemia were observed in 55.8% and 43.4%, respectively, and were significantly associated with smoking. Lower electrolyte levels correlated with higher mMRC and qSOFA scores ($p<0.05$). Patients with electrolyte imbalances had delayed recovery, prolonged hospitalization, and higher mortality, with the worst outcomes in those with both imbalances. ECG changes, including sinus tachycardia and pulmonale, were more frequent in patients with these disturbances. **Conclusion:** Hyponatremia and hypokalemia are prevalent in AECOPD and linked to increased disease severity, longer hospital stay, and higher mortality. Early detection and correction of these imbalances are crucial to improve outcomes.

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory disorder characterized by persistent airflow limitation and symptoms such as breathlessness, cough, and sputum production, primarily caused by tobacco smoke, air pollution, and occupational exposures [1]. The two main subtypes are chronic bronchitis, with excessive mucus and productive cough, and emphysema, involving alveolar wall destruction that impairs gas exchange. COPD often progresses to acute exacerbations, defined by sudden worsening of symptoms, frequently triggered by infections or environmental irritants, leading to heightened airway inflammation, mucus overproduction, dynamic hyperinflation, hypoxemia, and hypercapnia, which may escalate to respiratory failure [2]. Diagnosis is confirmed by spirometry showing a reduced FEV1/FVC ratio, while treatment aims to alleviate symptoms and slow progression [2]. Globally, COPD accounts for 3.5 million deaths annually, with rising prevalence in low- and middle-income countries (LMICs) due to smoking, biomass fuel use, and limited healthcare access [3]. The economic burden is considerable, exceeding $50 billion annually in the U.S. alone, with indirect costs from disability and premature death [3]. COPD remains underdiagnosed, particularly in LMICs, due to limited access to spirometry and lack of awareness [4]. Management strategies focus on smoking cessation, pollution reduction, pharmacologic therapy, pulmonary rehabilitation, and global initiatives such as WHO programs [5]. Acute exacerbations of COPD (AECOPD) are clinically important events, associated with increased hospitalizations, systemic inflammation, and worse outcomes [6,7]. Their management requires bronchodilators, corticosteroids, antibiotics or antivirals when infections are present, and supportive measures like oxygen or ventilation [8]. Serum electrolyte and venous blood gas (VBG) analyses play a critical role in evaluating AECOPD by identifying acid-base imbalances, monitoring hypoxemia or hypercapnia, and guiding therapy [9]. Electrolyte disturbances such as hyponatremia, hypokalemia, hypomagnesemia, hypochloremia, and metabolic alkalosis are common, influenced by hypoxia, acidosis, and medications, and may worsen respiratory function, arrhythmias, or prognosis if uncorrected [10–11]. These abnormalities often correlate with exacerbation severity, ICU needs, and hospitalization duration, while compensatory bicarbonate changes reflect chronic respiratory acidosis [12–13]. Recognizing these patterns is essential to optimize outcomes. The present study investigates electrolyte imbalances in AECOPD patients, comparing smokers and non-smokers, and evaluates correlations with severity (using modified qSOFA score), outcomes, and ECG findings.

MATERIALS & METHODS

This prospective observational study was conducted in the Department of General Medicine, G.R. Medical College, Gwalior, from May 2023 to September 2024, including 113 patients admitted with acute exacerbation of COPD (AECOPD). Patients with renal failure, congestive cardiac failure, liver failure, diabetic ketoacidosis, or pregnancy were excluded. Clinical evaluation, demographic details, and medical histories were recorded, with diagnosis confirmed through history, examination, pulmonary function testing, and mMRC dyspnoea grading. Serum sodium and potassium levels were measured at admission and discharge using the Electrolyte Analyzer (NuLYTE SMART), with normal ranges defined as sodium 135–145 mMol/L and potassium 3.5–5.5 mMol/L. Data were entered in Microsoft Excel and analyzed using Epi Info (TM) 7.2.2.2. Descriptive statistics were used to calculate means with standard deviations, while Z-tests and Chi-square tests assessed differences and associations, with $p<0.05$ considered statistically significant.

RESULT

Among 113 patients with AECOPD, 31% were aged 51–60 years, 23.9% were 61–70 years, and 45.1% were above 70 years. The proportion of patients >70 years was significantly higher compared to other groups ($Z=2.04$; $p=0.041$) (Figure 1). Of the 113 AECOPD patients, 90 (79.6%) were male and 23 (20.4%) female, giving a male-to-female ratio of 3.9:1. This male predominance was statistically significant ($Z=8.49$; $p<0.0001$) (Figure 2). Of 113 patients, 70 (61.9%) were smokers and 43 (38.1%) non-smokers, with smokers significantly outnumbering non-smokers ($Z=3.39$; $p<0.0001$) (Figure 3). Among 113 patients, serum sodium was normal in 48 (42.9%) and decreased in 63 (55.8%), while serum potassium was normal in 62 (54.9%) and decreased in 49 (43.4%); only 2 patients (1.7%) showed increased levels of either electrolyte. Patients with decreased sodium and potassium were significantly higher than those with increased levels ($p<0.0001$) (Table 1). Among patients with decreased sodium, 50 (79.5%) were smokers and 13 (20.5%) non-smokers, while all patients with increased sodium were non-smokers. Of those with normal sodium, 20 (31.7%) were smokers and 28 (58.3%) non-smokers. Chi-square analysis showed a significant association between serum sodium levels and smoking status ($\chi^2=16.08$; $p<0.0001$), with normal sodium levels significantly higher in non-smokers than smokers ($Z=3.70$; $p<0.001$) (Table 2). Among patients with decreased potassium, 37 (75.5%) were smokers and 12 (24.5%) non-smokers, while all patients with increased potassium were non-smokers. Of those with normal potassium, 33 (63.2%) were smokers and 29 (46.8%) non-smokers. Chi-square analysis revealed a significant association between serum potassium levels and smoking status ($\chi^2=9.08$; $p=0.0106$), with normal potassium levels significantly higher in smokers than non smokers ($Z=2.27$; $p=0.023$) (Figure 4). Among patients with mMRC grade 2, 29 (87.9%) had normal potassium and 4 (12.3%) decreased. In grade 3, 30 (43.5%) had normal potassium, 38 (55.1%) decreased, and 1 (1.4%) increased. For grade 4, 3 (27.3%) had normal potassium, 7 (63.6%) decreased, and 1 (9.1%) increased. Chi-square analysis showed a significant association between serum potassium levels and mMRC grade ($\chi^2=18.28$; $p=0.019$), with potassium levels decreasing significantly as mMRC grade increased ($p<0.05$) (Table 3). No patients had mMRC grades 0 or 1. Grade 2 was observed in 33 (29.2%), grade 3 in 60 (53.1%), and grade 4 in 20 (17.7%) patients. The proportion of patients with grade 3 dyspnoea was significantly higher than other grades ($Z=3.45$; $p<0.001$) (Figure 5). Among patients with mMRC grade 2, 26 (78.8%) had normal sodium and 7 (21.2%) had decreased levels. In grade 3, 19 (31.2%) had normal sodium, 41 (67.2%) decreased, and 1 (1.6%) increased. For grade 4, 3 (15%) had normal sodium, 15 (75%) decreased, and 2 (10%) increased. Chi-square analysis showed a significant association between serum sodium levels and mMRC grade ($\chi^2=24.78$; $p=0.0106$), with sodium levels decreasing significantly as mMRC grade increased ($p<0.05$) (Figure 6). Among 113 patients, 33 (29.3%) had a qSOFA score of 1, 60 (53%) had score 2, and 20 (17.7%) had score 3. The proportion of patients with score 2 was significantly higher than other scores ($Z=3.45$; $p<0.0001$) (Table 4). Among patients with normal sodium, 21 (43.8%) had qSOFA score 1, 20 (41.7%) score 2, and 7 (14.6%) score 3. In those with decreased sodium, 12 (19%) had score 1, 38 (60.3%) score 2, and 13 (20.6%) score 3. Both patients with increased sodium had score 2. Chi-square analysis showed a significant association between serum sodium levels and qSOFA scores ($\chi^2=9.83$; $p=0.043$), with normal sodium levels significantly higher in patients with lower qSOFA scores ($p<0.05$) (Table 5). Among patients with normal potassium, 27 (43.5%) had qSOFA score 1, 28 (45.2%) score 2, and 7 (11.3%) score 3. In those with decreased potassium, 12 (24.5%) had score 1, 24 (49%) score 2, and 13 (26.5%) score 3. Both patients with increased potassium had score 2. Chi-square analysis showed a significant association between serum potassium levels and qSOFA scores ($\chi^2=9.78$; $p=0.044$), with potassium levels decreasing significantly as qSOFA scores increased ($p<0.05$) (Figure 7). Among patients with hyponatremia, 44.4% had prolonged hospital stay and 4.8% mortality. In hypokalemia, delayed recovery (46.9%) and prolonged stay (36.7%) were most common. Patients with both hyponatremia and hypokalemia had prolonged stay in 53.3% and mortality in 16.7%. Those with normal electrolytes showed 67.7% normal recovery. Prolonged stay was significantly higher in hyponatremia ($Z=2.20$; $p=0.028$) and combined electrolyte disturbances ($Z=3.75$; $p<0.0001$), delayed recovery predominated in hypokalemia ($Z=4.11$; $p<0.0001$), and normal recovery was higher in patients with normal electrolytes ($Z=6.99$; $p<0.0001$) (Figure 8). Among 112 patients with sinus tachycardia, 63 (56.2%) had hyponatremia and 49 (43.8%) had hypokalemia ($Z=1.70$; $p=0.09$). In 68 patients with P pulmonale, 38 (55.9%) showed hyponatremia and 30 (44.1%) hypokalemia ($Z=1.70$; $p=0.09$). All 12 patients with flat F curve had hypokalemia, with none showing hyponatremia, demonstrating a significant predominance of hypokalemia ($Z=14.14$; $p<0.0001$) (Figure 9).

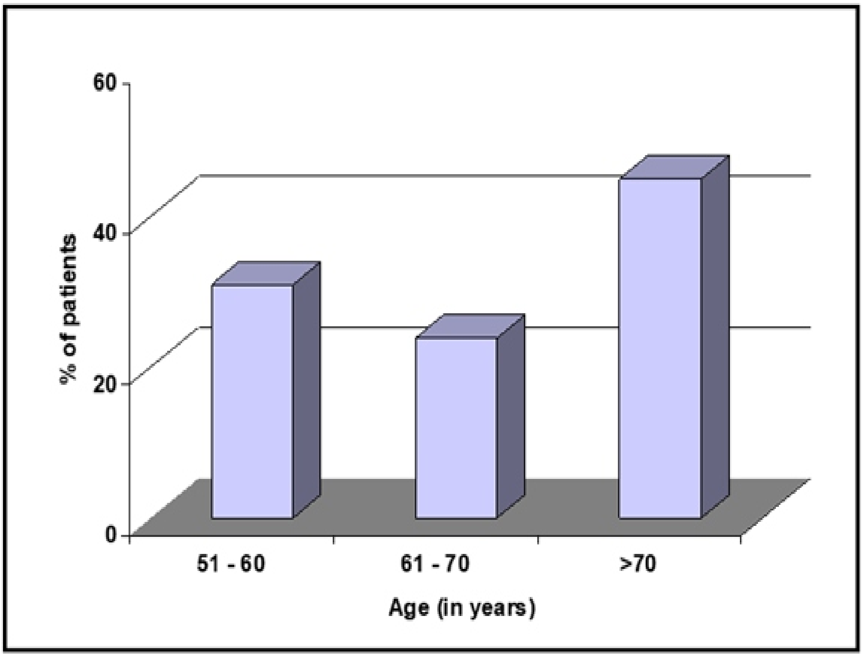

Figure 1: Age Distribution of Study Patients

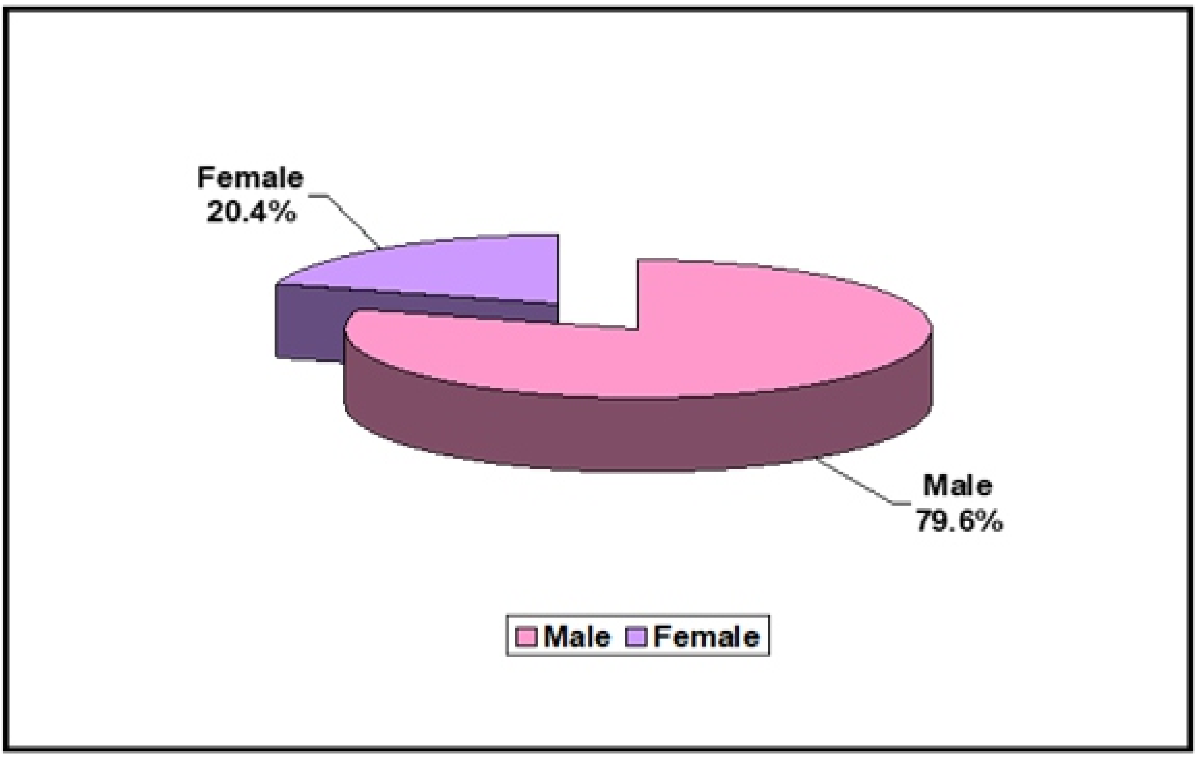

Figure 2: Gender Distribution in Study Patients

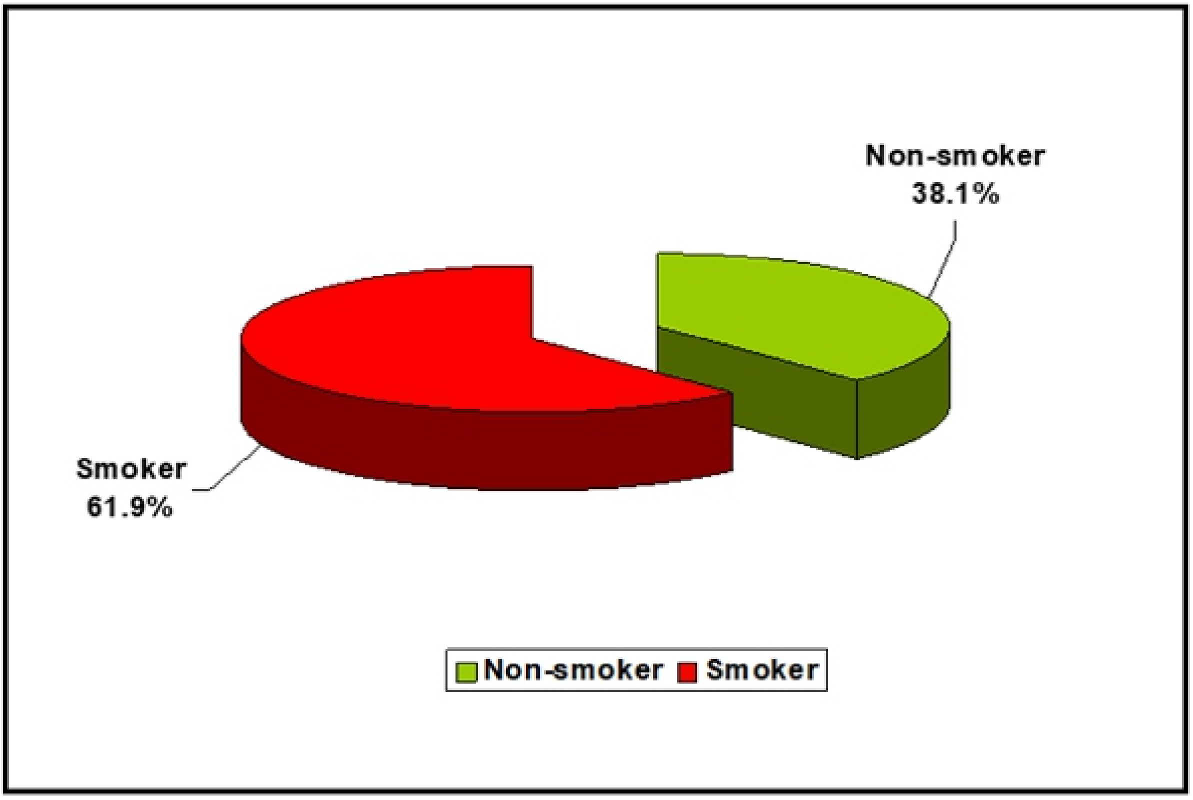

Figure 3: Smoking Status in Study Patients

Table 1: Serum electrolyte levels in Study Patients

Serum Level	Normal n (%)	Decreased n (%)	Increased n (%)
Serum sodium	48 (42.9%)	63 (55.8%)	2 (1.7%)
Serum potassium	62 (54.9%)	49 (43.4%)	2 (1.7%)
Total	180 (100%)		

Table 2: Association between Serum Sodium levels and Smoking Status in Study Patients abscess

Smoking status	Decreased n (%)	Increased n (%)	Normal n (%)
Non smoker	13 (20.5%)	2 (100.0%)	28 (58.3%)
Smoker	50 (79.5%)	0 (0%)	20 (31.7%)
Total	63 (100.0%)	2 (100.0%)	48 (100.0%)

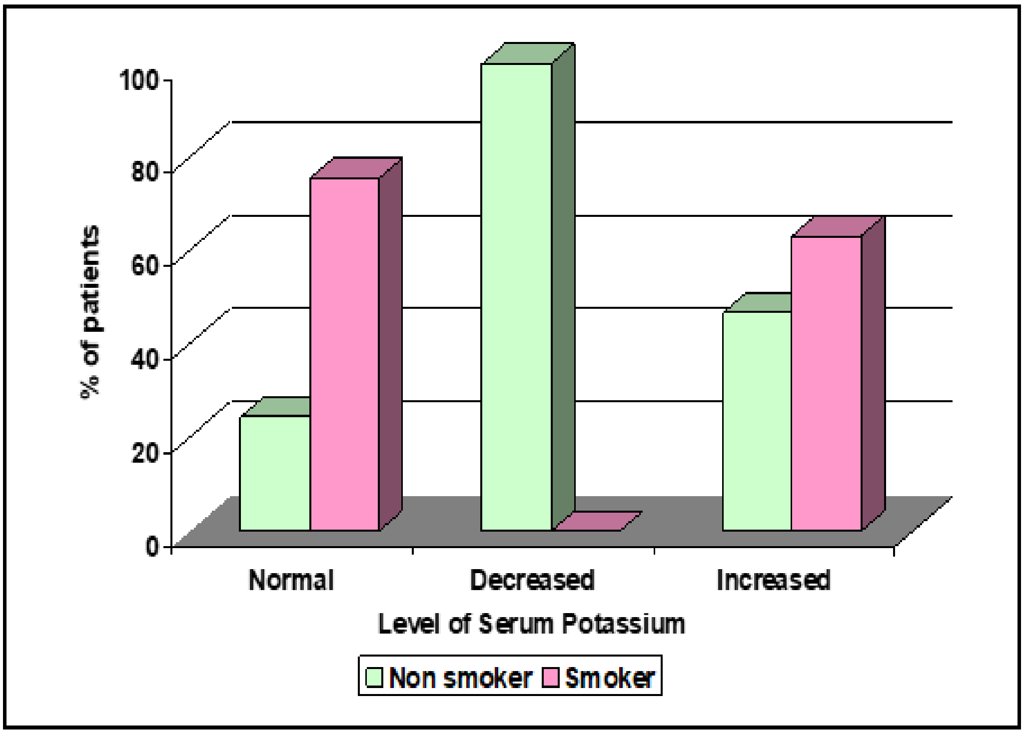

Figure 4: Association between Serum Potassium levels and Smoking Status in Study Patients

Table 3: Distribution of Serum Potassium levels by mMRC grading in Study Patients

Potassium	mMRC grading				
	0	**1**	**2**	**3**	**4**
Normal	0 (0.0%)	0 (0.0%)	29 (87.9%)	30 (43.5%)	3 (27.3%)
Decreased	0 (0.0%)	0 (0.0%)	4 (12.3%)	38 (55.1%)	7 (63.6%)
Increased	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.4%)	1 (9.1%)
Total	0 (0.0%)	0 (0.0%)	33 (100.0%)	69 (100.0%)	11 (100.0%)

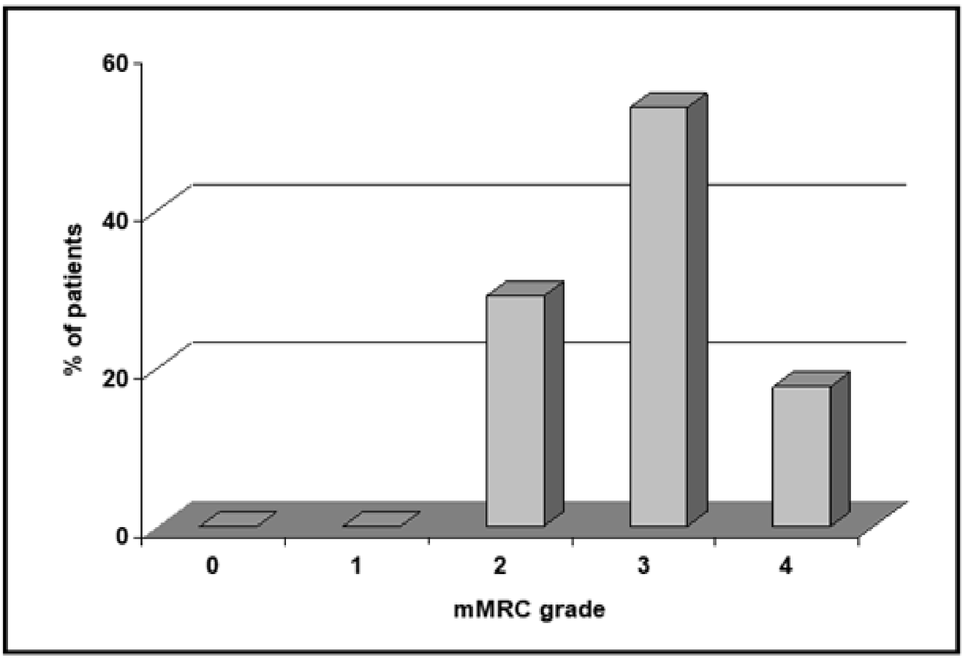

Figure 5: mMRC Grading in Study Patients

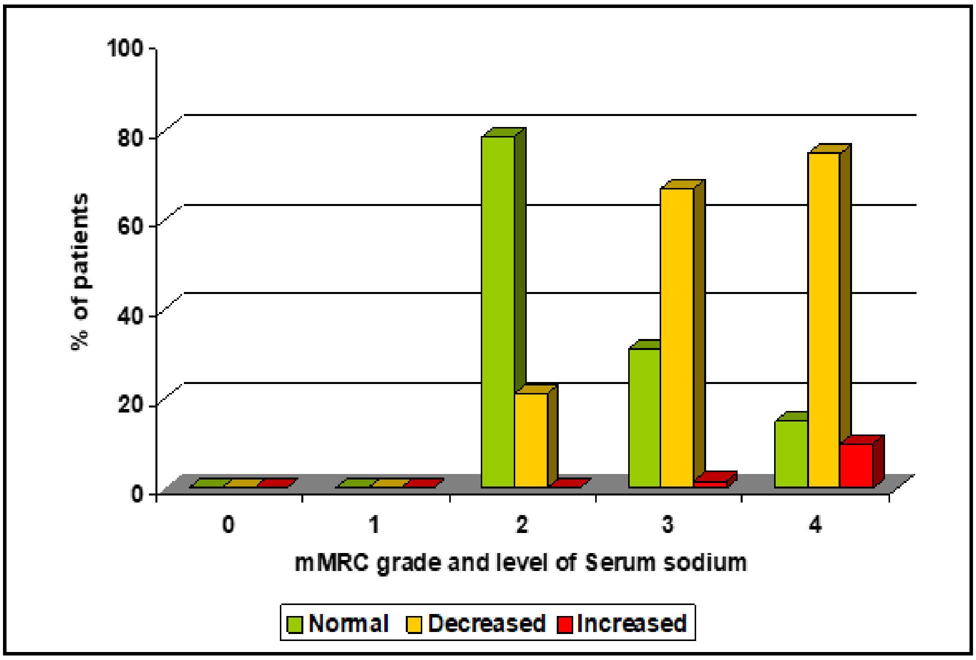

Figure 6: Distribution of Serum sodium levels by mMRC grading in Study Patients

Table 4: qSOFA Score Distribution in Study Patients

qSOFA	Number	%
1	33	29.3%
2	60	53.0%
3	20	17.7%
Total	113	100.0%

Table 5: Distribution of Serum Sodium level by qSOFA score in Study Patients

qSOFA	Normal	Decreased	Increased
1	21 (43.8%)	12 (19.0%)	0 (0.0%)
2	20 (41.7%)	38 (60.3%)	2 (100.0%)
3	7 (14.6%)	13 (20.6%)	0 (0.0%)
Total	48 (100.0%)	63 (100.0%)	2 (100.0%)

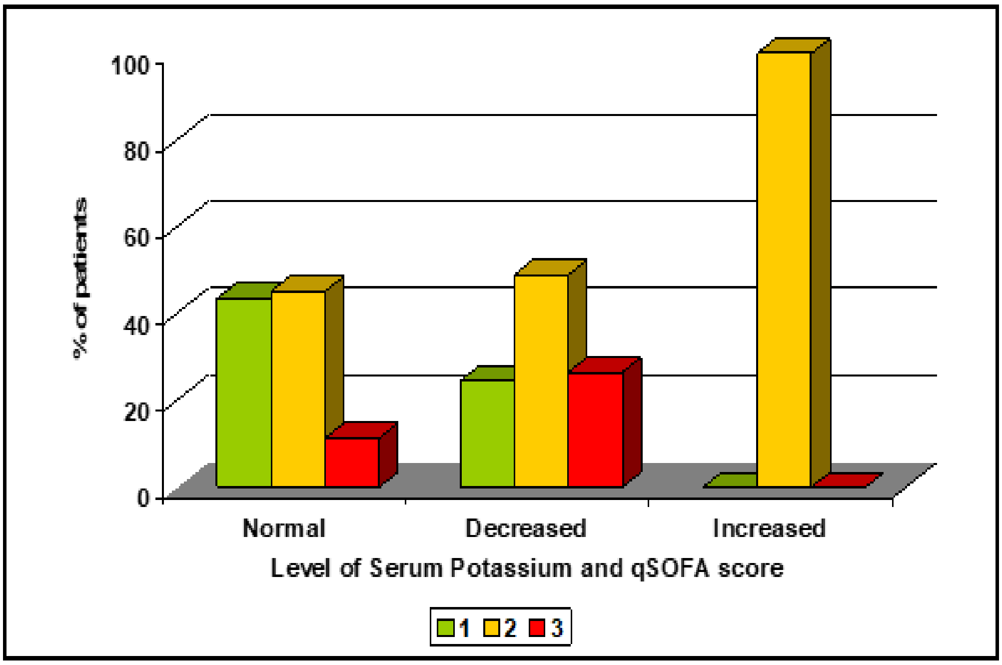

Figure 7: Distribution of Serum Potassium level by qSOFA score in Study Patients

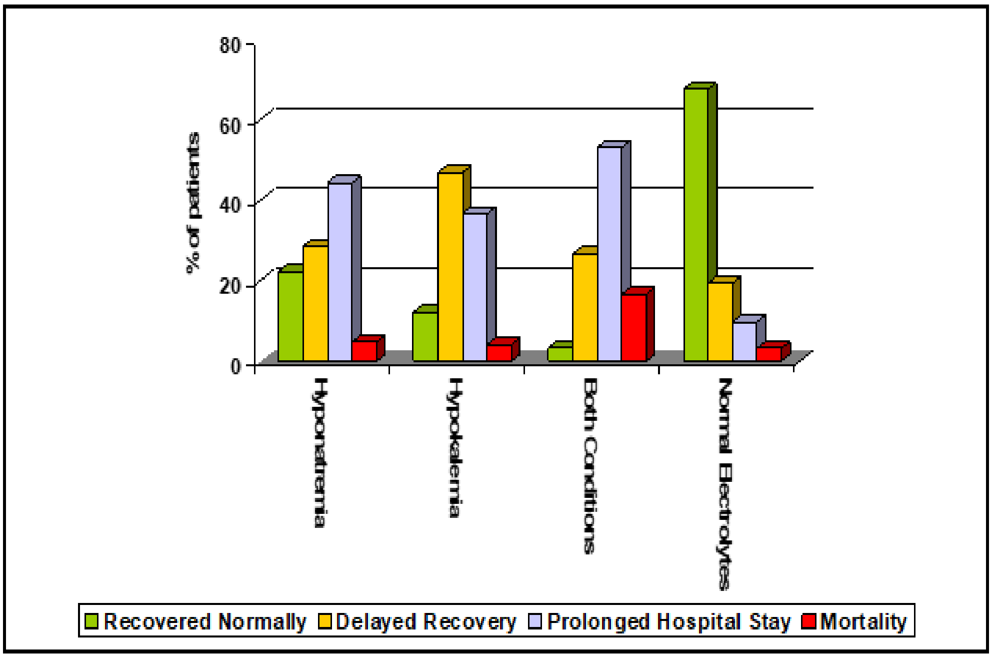

Figure 8: Association of outcomes with Serum level of Sodium and Potassium in Study Patients

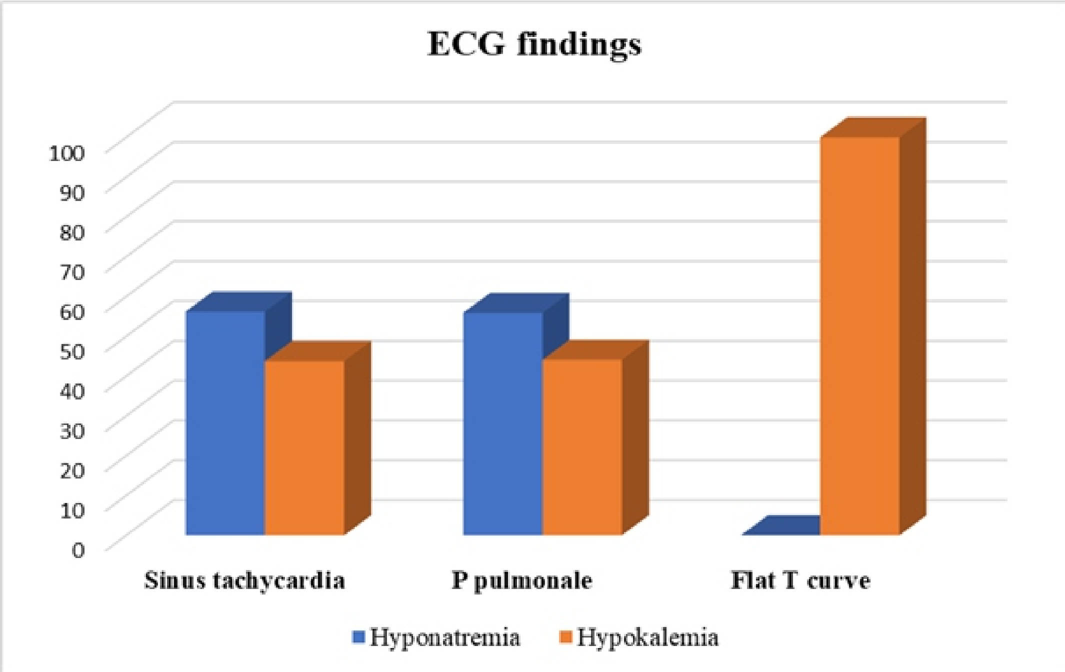

Figure 9: Association of ECG findings with Serum level of Sodium and Potassium in Study Patients

DISCUSSION

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory disorder characterized by irreversible airflow limitation and chronic inflammation of the airways. Acute exacerbations of COPD (AECOPD) are critical clinical events that accelerate lung function decline, increase morbidity and mortality, and impose substantial healthcare burdens [14]. The pathophysiology of AECOPD is complex, involving heightened airway inflammation, oxidative stress, mucus hypersecretion, and infection-triggered immune responses, which collectively contribute to impaired gas exchange and respiratory failure [14]. Electrolyte disturbances, particularly hyponatremia and hypokalemia, are frequently observed in AECOPD and have significant clinical implications. Hyponatremia may result from inappropriate antidiuretic hormone secretion, renal dysfunction, or diuretic use, leading to cellular edema, impaired neuromuscular function, and alter-ations in central nervous system activity [15]. Hypokalemia, often secondary to beta-agonist therapy, corticosteroid use, or metabolic alkalosis, impairs respiratory muscle contractility and conduction of cardiac impulses, increasing the risk of arrhythmias and respiratory compromise [15].

In the present study, the majority of AECOPD patients were elderly, with 45.1% over 70 years, consistent with prior studies reporting mean ages ranging from 58 to 73 years [16]. This supports the concept that advancing age is a major risk factor for both disease progression and susceptibility to exacerbations due to age-related decline in pulmonary reserve and increased comorbidities. Male predominance (79.6%, male:female ratio 3.9:1) was observed, particularly in patients over 70 years, aligning with previous Indian studies, likely reflecting higher tobacco exposure and occupational hazards in men. In our cohort, 61.9% were smokers, reinforcing the established causal role of smoking in COPD pathogenesis and in predisposing to exacerbations [16].

Our findings indicate that hyponatremia and hypokalemia were prevalent in 55.8% and 43.4% of patients, respectively. These disturbances were significantly associated with both higher mMRC grades and qSOFA scores ($p<0.05$), suggesting that electrolyte imbalances are markers of disease severity. Mechanistically, chronic CO_2 retention and compensatory metabolic alkalosis in COPD can exacerbate hypokalemia, while systemic inflammation and neurohormonal dysregulation contribute to hyponatremia [17]. Clinically, patients with these disturbances experienced worse outcomes, including delayed recovery, prolonged hospital stays, and higher mortality, particularly when both hyponatremia and hypokalemia coexisted. These observations are consistent with prior reports highlighting the additive prognostic risk of multiple electrolyte derangements [18-19]. Notably, normal serum electrolyte levels correlated with faster recovery and lower mortality, emphasizing the importance of early recognition and correction of these abnormalities in AECOPD management [20].

Electrolyte disturbances were also reflected in ECG abnormalities. Sinus tachycardia was universally observed in patients with hyponatremia or hypokalemia, P pulmonale in over half, and flat T waves exclusively in hypokalemic patients ($p<0.0001$), highlighting the arrhythmogenic potential of electrolyte imbalances in COPD [21,22]. This underscores the clinical relevance of routine electrolyte monitoring, particularly in patients with cardiovascular comorbidities or those requiring intensive therapy.

The study highlights several mechanistic and clinical insights: electrolyte disturbances in AECOPD may worsen respiratory muscle performance, impair oxygenation, and contribute to cardiovascular instability, ultimately influencing clinical outcomes. Management strategies should, therefore, include regular monitoring of serum sodium and potassium, prompt correction of imbalances, and optimization of pharmacotherapy to minimize iatrogenic disturbances, such as those induced by diuretics, corticosteroids, or beta-agonists [21-22].

Limitations of the study include its single-center design and relatively small sample size, which may affect generalizability. Despite these limitations, the findings provide valuable evidence that serum electrolyte disturbances are prevalent, clinically significant, and prognostically relevant in patients with AECOPD. Future multicenter studies with larger cohorts are warranted to further elucidate the mechanistic pathways linking electrolyte imbalances with clinical outcomes and to develop targeted management protocols aimed at reducing morbidity and mortality [21-22].

CONCLUSION

This study demonstrates that electrolyte imbalances, specifically hyponatremia and hypokalemia, are highly prevalent among patients with acute exacerbation of COPD and are associated with significantly worse clinical outcomes. Either imbalance is strongly correlated with increased dyspnea severity, as reflected by higher mMRC scores, greater systemic compromise indicated by elevated qSOFA scores, delayed recovery, prolonged hospital stays, and increased mortality, with the greatest risk observed in patients presenting with both hyponatremia and hypokalemia. In contrast, patients with normal serum electrolyte levels exhibit markedly better outcomes, emphasizing the importance of routine biochemical assessment. These results highlight the need for early and continuous monitoring of serum sodium and potassium levels in AECOPD management, with prompt correction of abnormalities-particularly in patients with higher severity scores-to enhance clinical outcomes, reduce hospitalization, and potentially lower mortality.

ABBREVIATIONS

AECOPD: Acute Exacerbation of Chronic Obstructive Pulmonary Disease
mMRC: Modified Medical Research Council
qSOFA: Quick Sequential Organ Failure Assessment
ECG: Electrocardiogram

LIMITATIONS & FUTURE PERSPECTIVES

The study was limited by its single-centre design, relatively small sample size, and short duration, which may restrict generalizability. Future research could focus on multicenter studies with larger cohorts to validate findings, evaluate long-term outcomes, and explore innovative diagnostic and management strategies for appendicular perforation, improving patient prognosis and reducing complications.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of translating scientific observations into meaningful improvements in patient care, diagnosis, and treatment outcomes. By highlighting real-world relevance, the study contributes to evidence-based medical practice and supports informed clinical decision-making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

FUNDING

None

ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in thewriting or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research directions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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