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Study of Serum Sodium and Serum Potassium in Acute Exacerbation of Chronic Obstructive Pulmonary Disease and their Correlation with Clinical Outcomes

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Abstract: ***Objectives: To assess serum sodium and serum potassium levels in patients with acute exacerbation of chronic obstructive pulmonary disease (AECOPD) and to evaluate the clinical outcomes. Methods: A prospective observational study was conducted at Sri Siddhartha Medical College Hospital, Tumakuru, over 18 months from March 2024 to September 2025. Sixty-six patients with AECOPD were included using purposive sampling. Clinical evaluation was performed using the Modified Medical Research Council (mMRC) dyspnea scale, and venous blood samples were analyzed with an electrolyte analyzer. Data were statistically evaluated using descriptive statistics and chi-square testing ($p < 0.05$). Results: The mean age of participants was 61.35 ± 6.17 years, with males comprising 75.8% of the cohort. Hyponatremia was present in 34.8% of patients (mean sodium 135.45 ± 3.21 mmol/L), while hypokalemia occurred in 25.8% (mean potassium 4.12 ± 0.65 mmol/L). Overall, 45.5% improved, 37.9% remained stable, and 16.7% were unchanged. A highly significant association was observed between potassium status and clinical outcomes ($\chi^2 = 30.57$, $p < 0.001$), whereas sodium demonstrated only a trend toward association. Conclusion: Electrolyte abnormalities are common among hospitalized AECOPD patients, and hypokalemia is strongly associated with poorer clinical outcomes. Routine electrolyte assessment and early correction, particularly of potassium imbalance, are important for improving recovery and guiding inpatient management.***

Keywords: Acute exacerbation of COPD, serum sodium, serum potassium, hyponatremia, hypokalemia

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) exists as a critical health issue which ranks among the top reasons people experience prolonged health problems and die throughout the globe [1]. The disease represents a preventable medical condition which leads to ongoing breathing problems and increasing airflow restrictions that develop together with permanent airway and lung inflammation caused by harmful substances or gases [2]. The World Health Organization reports that COPD currently ranks as the third biggest global death cause which leads to over 3 million annual fatalities [2]. The upcoming decades will bring an increased COPD burden because people will continue to face risk factors including tobacco smoking and environmental pollution and biomass fuel exposure and because the population will age [2].

COPD leads to lung damage and severe health complications which affect multiple body systems [3]. COPD patients experience system-wide effects because their bodies undergo three simultaneous conditions which include chronic inflammation and oxidative stress and hypoxia and metabolic changes [3]. The body experiences systemic effects which lead to two consequences: skeletal muscle dysfunction and the development of medical conditions which include cardiovascular disease, metabolic syndrome, osteoporosis, and electrolyte disturbances [3]. The disease progression shows that extrapulmonary manifestations significantly affect disease severity which increases hospitalization rates and decreases patient survival rates [3]. The medical community now understands electrolyte imbalance as a major yet frequently undiagnosed systemic complication of COPD which becomes especially dangerous during acute exacerbations [4].

Acute Exacerbation of Chronic Obstructive Pulmonary Disease (AECOPD) is distinct as a sudden worsening of respiratory symptoms beyond normal day-to-day variations that necessitates a change in regular medication [3]. Exacerbations are commonly precipitated by respiratory infections, air pollution, and other environmental triggers. AECOPD contributes significantly to disease progression, decline in lung function, reduced quality of life, and increased mortality. Frequent exacerbations accelerate the natural course of the disease and place a substantial economic burden on healthcare systems due to repeated hospital admissions and prolonged hospital stays [3].

1.1 Pathophysiology and Metabolic Shifts

During acute exacerbations, patients experience severe airflow limitation, increased airway inflammation, worsening ventilation–perfusion mismatch, and impaired gas exchange leading to hypoxemia and hypercapnia [5]. These pathophysiological alterations activate various neurohormonal and metabolic pathways, which can profoundly affect electrolyte homeostasis. Stress response,

increased secretion of antidiuretic hormone (ADH), activation of the renin–angiotensin–aldosterone system, and the use of multiple pharmacological agents contribute to disturbances in serum sodium as well as potassium levels during AECOPD [6].

Sodium functions as the main cation which exists in extracellular areas because it controls plasma osmolality and fluid distribution and it supports nerve and muscle function [7]. Hospitals find hyponatremia to be the most prevalent electrolyte disorder which leads to higher patient death rates and health complications. Patients develop the combination of respiratory disease and hyponatremia because their bodies produce excess ADH which occurs together with hypoxia and systemic inflammation that develops from their use of hypotonic fluids [7]. Multiple research studies have established that both hypoxia and hypercapnia conditions induce ADH secretion which leads to water retention and dilutional hyponatremia [8]. The Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH) has been documented in patients who experience lower respiratory tract infections together with COPD exacerbations [8]. The presence of hyponatremia in AECOPD has been associated with longer hospital stay, increased need for ventilatory support, and higher in-hospital mortality [10].

Potassium acts as the primary intracellular cation which people need to sustain their bodily functions [9]. The normal functioning of resting membrane potential and neuromuscular transmission and cardiac conduction depends on this potassium function. The body experiences severe health problems from minor serum potassium level changes which lead to muscle weakness and arrhythmias and respiratory failure [9]. The respiratory acidosis condition together with their medication treatment and existing health issues makes patients with COPD more likely to experience potassium level fluctuations. Hypokalemia commonly occurs during acute exacerbations because it leads to respiratory muscle weakness which makes respiratory insufficiency worse [9].

The use of β2-agonists, which are cornerstone drugs in the management of AECOPD, is a major contributor to hypokalemia [10]. These agents cause intracellular shift of potassium by stimulating sodium–potassium ATPase activity [10]. Systemic corticosteroids, frequently used during exacerbations, can also promote renal potassium loss. Furthermore, the use of diuretics in COPD patients with associated cor pulmonale or heart failure further increases the risk of potassium depletion. These factors make electrolyte monitoring particularly important during acute exacerbations [10]. Acid–base disturbances commonly encountered in AECOPD also influence potassium balance. Respiratory acidosis tends to cause extracellular shift of potassium, whereas correction of acidosis during treatment may precipitate sudden hypokalemia. Thus, dynamic changes in potassium levels can occur during hospitalization [10].

2. Material and Methodology

We conducted a prospective observational study in patients with diagnosed acute exacerbation of chronic obstructive pulmonary disease at Sri Siddhartha Medical College Hospital, Agalakote, Tumakuru. No intervention was introduced as part of the study protocol. The observations were recorded systematically as per the study objectives. The design allowed assessment of serum electrolyte levels during acute exacerbation of COPD.

2.1 Study Settings and Selection

The research was carried out over an 18-month duration from March 2024 until September 2025. The researchers maintained patient recruitment efforts throughout the entire research duration. The hospital serves as a tertiary care center catering to a large urban and rural population. Patients were recruited from the general medicine ward, pulmonology ward, outpatient department, and emergency department. Purposive sampling was used to select study participants needed for their research project. The standard sample size was calculated as 66 patients based on standard variance and prevalence metrics from prior literature.

Inclusion Criteria: All adult cases of Acute Exacerbation of COPD presenting to the outpatient and inpatient departments of Sri Siddhartha Medical College Hospital who were willing to participate.

Exclusion Criteria: COPD patients admitted for causes other than acute exacerbations; patients with pre-existing renal, hepatic, endocrine, and primary cardiac illnesses; or patients not willing to provide informed consent.

2.2 Study Procedure and Laboratory Testing

The researchers conducted patient interviews to gather medical information after they received patient consent. The researchers used a prepared proforma to document the demographic information of all chosen patients. The Modified Medical Research Council Dyspnea Scale served as the assessment tool for evaluating patient health conditions. The medical team collected 2–3 milliliters of venous blood samples from patients during their first hospital visit. The medical team collected blood samples through venipuncture while maintaining strict aseptic procedures. The medical team processed the collected blood samples to extract serum from the samples. The laboratory technician used centrifugation at 3000 rpm for 10 minutes to separate serum from the blood sample. The laboratory used an electrolyte analyser (ERBA MANNHEIM-EC90) to measure serum electrolyte concentration. The laboratory defined normal serum sodium levels to fall within the range of 135–145 mmol/L. The laboratory defined normal serum potassium levels to fall within the range of 3.50–5.00 mmol/L. The medical team documented patient outcomes after their COPD treatment and electrolyte imbalance treatment.

Short-term clinical outcomes at discharge were categorized into three distinct composite categories based on the duration of hospital stay, oxygen requirements, and clinical status: Improved (<7 days stay with resolved symptoms), Stable (7–14 days stay with partial resolution), and Unchanged (>14 days stay or showing lack of significant response). Statistical evaluation was executed using Epi Info version 3.5.3. Categorical variables were cross-tabulated and analyzed using the chi-square test with significance set at $p < 0.05$.

3. Result and Analysis

A total of 66 patients admitted with acute exacerbation of chronic obstructive pulmonary disease (AECOPD) were successfully evaluated. The mean age of the study participants was 61.35 ± 6.17 years, with 51.5% distributed within the 56–65 year demographic bracket. The gender distribution showed a strong male predominance with 75.8% males (n=50) and 24.2% females (n=16), producing a male-to-female ratio of 3.13:1. This distribution reflects the higher prevalence of COPD among males due to greater historical exposure to smoking and occupational risk factors. Metabolic comorbidities included Diabetes Mellitus in 33.3% (n=22) and Hypertension in 21.2% (n=14), indicating a significant burden of metabolic co-morbidities that may influence electrolyte abnormalities during acute illness. Smoking was documented as a primary modifiable risk factor in 57.6% (n=38) of patients, while alcohol consumption was reported in 22.7% (n=15). Baseline severity staging via standard GOLD classification reported 42.4% (n=28) in Stage 2 (Moderate), 28.8% (n=19) in Stage 3 (Severe), and 28.8% (n=19) in Stage 4 (Very Severe). Functional severity was high, with 42.4% (n=28) presenting with mMRC Grade 4 dyspnea at admission.

The overall cohort mean for serum sodium was 135.45 ± 3.21 mmol/L, with hyponatremia present in 34.8% (n=23) of patients. Within this hyponatremic group, 60.9% (n=14) exhibited mild severity (130-134 mmol/L), 30.4% (n=7) moderate (125-129 mmol/L), and 8.7% (n=2) severe forms (<125 mmol/L). The overall mean serum potassium was 4.12 ± 0.65 mmol/L, with hypokalemia verified in 25.8% (n=17) of patients. Clinical outcomes recorded at discharge showed 45.5% (n=30) improved, 37.9% (n=25) stable, and 16.7% (n=11) unchanged. Baseline chest radiography demonstrated hyperinflation in 89.4% (n=59) and emphysematous changes in 10.6% (n=7).

Table 1: Association of Inpatient Parameter Matrix with Short-Term Clinical Outcome

Parameter Group	Categories	Improved (n=30)	Stable (n=25)	Unchanged (n=11)	Total Matrix (N=66)	Chi-Square (p-value)
Potassium Status	Hypokalemia	2	5	10	17	$\chi^2 = 30.57$
	Normal	28	20	1	49	$p < 0.001$ (HS)
mMRC Scale	Grade 2	5	12	3	20	$\chi^2 = 15.093$
	Grade 3	5	9	4	18	$p = 0.005$ (S)
	Grade 4	20	4	4	28	
Chest X-Ray	Emphysematous	0	7	0	7	$\chi^2 = 12.842$
	Hyperinflation	30	18	11	59	$p = 0.002$ (S)
Sodium Status	Hyponatremia	7	13	3	23	$\chi^2 = 5.269$
	Normal	23	12	8	43	$p = 0.072$ (Trend)
GOLD Stage	Stage 2	12	11	5	28	$\chi^2 = 1.182$
	Stage 3	9	7	3	19	$p = 0.881$ (NS)
	Stage 4	9	7	3	19	

4. Discussion

The aim of the present study was to evaluate serum sodium and serum potassium levels in patients admitted with acute exacerbation of chronic obstructive pulmonary disease and to assess the association of these electrolyte abnormalities with short-term clinical outcomes during hospitalization. Acute exacerbation of COPD represents a period of heightened physiological stress characterized by worsening airflow limitation, hypoxemia, systemic inflammation, and intensive pharmacological treatment, all of which can disturb electrolyte homeostasis. Despite routine biochemical testing in hospitalized patients, the clinical relevance of serum sodium and potassium disturbances during AECOPD has not been consistently emphasized in outcome-based assessments, particularly in resource-limited settings. This study therefore sought to quantify the burden of hyponatremia and hypokalemia in hospitalized AECOPD patients and to examine their relationship with functional severity, radiographic findings, and recovery patterns.

The primary and most clinically decisive finding of this investigation indicates a highly significant association between serum potassium status and hospital outcomes ($\chi^2 = 30.57$, $p < 0.001$). Only 11.8% of hypokalemic patients achieved clinical improvement, while 58.8% remained unchanged throughout their hospitalization. This matches the mortality trends tracked by Ogan (2020) [11], where survivors demonstrated significantly higher potassium lines than deceased cohorts, reinforcing the view that potassium depletion reduces compensatory reserves. Potassium plays a fundamental role in maintaining skeletal muscle contractility and cardiac electrical conduction. Hypokalemia may impair diaphragmatic function, reduce respiratory muscle strength, and increase the risk of respiratory failure in patients already compromised by airflow obstruction. In addition, potassium deficiency predisposes patients to cardiac arrhythmias, particularly in the presence of hypoxemia or underlying cardiovascular disease. Early identification and correction of hypokalemia may therefore contribute to improved respiratory function and reduced complications during hospitalization.

The documented hypokalemia prevalence of 25.8% matches regional findings by Aryal (2025) [14] (29.1%) and Chang (2025) [15] (27.7%). These similarities highlight iatrogenic risk pathways under intensive bronchodilator and corticosteroid dosing. Short-acting beta-agonists cause intracellular shift of potassium by stimulating sodium–potassium ATPase activity in skeletal muscle. Systemic corticosteroids routinely administered during AECOPD further increase distal tubular sodium reabsorption and potassium secretion in the kidneys. When combined with diuretics in patients with cor pulmonale or peripheral edema, the risk of severe potassium depletion increases substantially.

In contrast, serum sodium status demonstrated only a trend toward statistical association ($p = 0.072$). While hyponatremic patients showed lower improvement rates (30.4%) compared to normonatremic individuals (53.5%), it was not statistically robust within this sample size. This mirrors the work of Winther (2016) [10], which highlighted that while non-osmotic ADH release drives high rates of dilutional hyponatremia during acute respiratory distress, it represents generalized systemic illness severity rather than an independent direct driver of short-term prognosis. In COPD, chronic hypoxia and systemic inflammation stimulate non-osmotic release of antidiuretic hormone, leading to water retention and dilutional hyponatremia. Furthermore, impaired oral intake and concurrent medication use may aggravate sodium depletion during acute illness. This explains why patients with lower serum sodium levels in our study experienced a trend toward slower stabilization and less favorable outcomes without hitting true statistical significance thresholds [12], [13].

Furthermore, our data indicate that acute dynamic indicators, such as baseline functional dyspnea severity (mMRC, $p = 0.005$) and imaging phenotype (Chest X-Ray, $p = 0.002$), are significantly associated with short-term clinical outcomes, whereas baseline spirometric staging (GOLD classification, $p = 0.881$) did not significantly predict short-term recovery trajectories during an acute hospitalization. This emphasizes that acute clinical outcomes in AECOPD are more strongly influenced by dynamic severity markers and systemic metabolic changes than by baseline spirometric categories alone. Dyspnea severity assessed by mMRC showed a statistically significant association with clinical outcome ($p = 0.005$), where patients with Grade 4 dyspnea demonstrated higher care-intensity effects and improvement rates within the outcome framework used, possibly reflecting more aggressive therapeutic interventions. Radiographic findings also showed significant value ($p = 0.002$), with emphysematous structural changes associated with a lack of clinical improvement compared to hyperinflation cases, reflecting differences in lung tissue reversibility and functional reserve.

4.2 Strengths, Limitations and Practical Implications

The present study possesses several key strengths. It employed a prospective observational design, thereby reducing recall bias and allowing systematic collection of clinical and laboratory data. All patients were evaluated using standardized clinical assessment, including GOLD staging, mMRC grading, chest radiography, and automated biochemical investigations. The study reflects real-world clinical practice in a tertiary care teaching hospital and highlights the practical utility of routinely available laboratory parameters as prognostic markers. It focuses on two universally available and inexpensive parameters, making the insights directly actionable at the bedside without adding financial burdens to healthcare infrastructure or patients in resource-limited environments.

Certain limitations should be acknowledged while interpreting the findings. It was conducted at a single tertiary care center with a relatively small sample size of 66 patients, which may limit the generalizability of the findings across wider cohorts. Serum electrolyte levels were measured only at admission, and serial tracking during hospitalization was not performed. The observational design precludes establishing an absolute causal relationship between electrolyte abnormalities and clinical outcomes. Additionally, other factors influencing electrolyte balance, including detailed dietary intake, prior medication use, and blood gas parameters, were not completely evaluated. Future multicenter studies involving larger populations and serial electrolyte measurements are warranted to validate these findings and determine whether rapid protocol-driven correction of electrolyte abnormalities can directly improve clinical outcomes in patients with AECOPD.

5. Conclusion

The present prospective observational study highlights the clinical significance of serum sodium and serum potassium abnormalities in patients hospitalized with acute exacerbation of chronic obstructive pulmonary disease (AECOPD). Electrolyte disturbances are highly common among hospitalized AECOPD patients, driven by a combination of severe physiological illness, hypoxemic stress, neurohormonal pathways, and intense pharmacological management. Serum potassium depletion represents the strongest and most robust biochemical predictor of a stagnant inpatient course and delayed recovery in this cohort. Routine evaluation of serum electrolytes at admission, with a specific emphasis on early detection, closer monitoring, and rapid standardized correction of hypokalemia, is supported as a practical strategy to optimize inpatient management, prevent cardiac or neuromuscular complications, and potentially improve clinical recovery rates in patients with acute exacerbations.

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