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Original Research Article

Study of Serum Electrolytes in Acute Exacerbation of COPD: A Cross-Sectional Study Design

Karthik K. H.[1], Nikhil M. B.[2], Adarsh M. M.[3]

[1,3]Senior Resident, Department of General Medicine, Subbaiah Institute of Medical Sciences, Shivamogga, Karnataka, India

[2]Assistant Professor, Department of General Medicine, Subbaiah Institute of Medical Sciences, Shivamogga, Karnataka, India

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Corresponding Author: Dr. Nikhil M. B.

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Abstract

Background: Chronic Obstructive Pulmonary Disease (COPD) is a major global health concern characterized by persistent respiratory symptoms and airflow limitation due to airway and/or alveolar abnormalities. The progression of COPD is often exacerbated by acute events, primarily due to infections and environmental factors, which significantly impact patient morbidity and healthcare resources.

Objective: to assess serum electrolyte levels in patients with acute exacerbations of COPD and investigate the correlation between these imbalances and clinical outcomes

Methods: A cohort of COPD patients experiencing acute exacerbations was examined. Serum electrolyte levels, including sodium, potassium, calcium, and others, were measured and analyzed. Clinical outcomes were recorded, and statistical analyses were performed to establish correlations between electrolyte imbalances and disease severity, exacerbation frequency, and patient mortality.

Result: The study found significant occurrences of electrolyte imbalances, such as hyponatremia and hypokalemia, in patients with acute COPD exacerbations. These imbalances were closely associated with adverse clinical outcomes, including increased risk of cardiac arrhythmias, respiratory muscle weakness, and higher mortality rates.

Conclusion: Serum electrolyte imbalances are prevalent in patients with acute COPD exacerbations and are linked to worsened clinical outcomes. Early detection and correction of these imbalances could play a critical role in managing COPD exacerbations, reducing mortality, and improving overall patient health.

Keywords: COPD, chronic obstructive pulmonary disease, serum electrolyte levels, hyponatremia, hypokalemia, acute exacerbations, inflammation, oxidative stress,

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Introduction

Chronic obstructive pulmonary disease (COPD) is a common and treatable disease characterized by progressive airflow limitation and tissue destruction. It is associated with structural lung changes due to chronic inflammation from prolonged exposure to noxious particles or gases most commonly cigarette smoke. Chronic inflammation causes airway narrowing and decreased lung recoil. The disease often presents with symptoms of cough, dyspnea, and sputum production. Symptoms can range from being asymptomatic to respiratory failure. [1]

The inflammation plays a major role in the pathogenesis of COPD. It is strange that, in the final stages of the disease, long after the cessation of smoking, the inflammation induced by cigarette smoke in early stages of disease will persist [2]. A dose-response relationship between reduced pulmonary function and intensity of smoking explains an increase in COPD as the age increases, and the causal relationship between smoking and COPD is completely approved [3]. Above half of the world's population uses the biomass for cooking, heating, or baking bread, and the epidemiological studies have proven the relationship between biomass smoke, chronic bronchitis, and COPD [4].

An important role is also played by oxidative stress, a condition where reactive oxygen species (ROS) overcome the antioxidant defence systems [5].

Inflammatory cells release ROS that activate proinflammatory molecules, leading to the recruitment of further inflammatory cells. Moreover, ROS activate NF-κB which, in turn, activates several inflammatory genes and impairs

the function of antiproteases, such as α1-antitrypsin, accelerating the breakdown of elastin in the lung parenchyma [6]. The prognosis of patients with COPD is often complicated by the presence of comorbidities [7].

COPD is complicated by acute exacerbations that are associated with healthcare expenditures and high morbidity. Environmental contaminants or a bacterial or viral infection could be the cause. 75% or more of exacerbations are typically caused by infections; around 25% of cases have bacteria, 25% have viruses, and 25% have both bacteria and viruses. During the exacerbation, the inflammation of the airways increases, leading to greater hyperinflation, decreased expiratory [8,9]airflow, and impaired gas exchange.

Electrolyte imbalances can also cause respiratory muscle weakness and impair airway function in this group of patients [10]. Hypercapnia occurs during COPD exacerbations; the sudden decrease in ventilation leads to acute respiratory acidosis or deteriorates pre-existing chronic respiratory acidosis. Owing to the high prevalence of comorbidities [11] and corresponding multi-drug therapies in these patients, mixed acid-base and hydro-electrolyte disorders are becoming increasingly common, particularly in critically ill and elderly populations [12]. This study aimed at evaluating serum electrolyte levels in patients with acute exacerbation of COPD.

Material And Methods

This Cross-sectional study was conducted among all cases of COPD presented to the OPD and emergency department with acute exacerbation of the disease.

Estimation Of Sample Size: On the basis of statistics obtained from hospital, an average of 3 case per month fitting the criteria of the study with study duration of 24 months, we can expect to have N=72. Based on this population size, using YAMANE equation, for a known population size, sample size (n) equal to

$n = N/1+Ne^2$

n=sample size N=population size

e= margin of error (for 95% of confidence level, margin error =0.05)

n=72/1+72*0.05*0.05 = 72/1.38 = 52.17.

Therefore, after approximating, the sample size was fixed at 60.

Inclusion Criteria:

1. Patients willing to give written informed consent.
2. All cases of COPD presented to the OPD and emergency department with acute exacerbation of the disease.

Exclusion Criteria:

3. COPD patients admitted for causes other than COPD exacerbation.
4. Patients infected with COVID-19, ARDS, Viral respiratory diseases, other respiratory diseases responsible for intubation.
5. Patients with pre-existing renal, hepatic, endocrinal or congestive cardiac failure.

Method of study: After obtaining clearance and approval from the institutional ethics committee and written informed consent (Annexure I). Patients with acute exacerbation of COPD fulfilling the inclusion/exclusion criteria was enrolled in the study.

Patient presented to OPD or casualty with acute exacerbation of COPD is selected. Demographic data, medical history, concomitant medications, physical examination, clinical examination including recording of vital signs, systemic examination, laboratory investigations. (CBC, RFT, LFT, SPUTUM C/S, S/E, RBS) , ECG and chest x-ray was done.

Statistical Analysis: The data in this study was assessed using proportion, paired t-test or any other appropriate statistical test as suggested by the biostatistician.

Results

The study population was distributed across various age groups, with the majority falling between 61 and 70 years old (28.3%). This was followed by the 51-60 age group (25.0%), the 41-50 age group (18.3%), and the 71-80 age group (16.7%). The youngest age group, 30-40 years, constituted 11.7% of the participants. The mean age of the participants was 57.87 ± 12.939 years.

In this study, there were 40 male participants, representing 66.7% of the population, while the remaining 20 participants were female, accounting for 33.3% of the study group.

Smoking habits among participants were assessed, with 63.3% (38 participants) reported as smokers, and the remaining 36.7% (22 participants) identified as non-smokers.

The symptoms reported by the participants included breathlessness, experienced by 26.7% (16 participants), chest pain in 20% (12 participants), cough in 18.3% (11 participants), expectoration in 15.0% (9 participants), and hemoptysis in 20.0% (12 participants).

The duration of illness among the participants varied, with a mean duration of 14.27 ± 6.916 years. This indicates that the study population had been dealing with their illness for an extended period, with a significant variation in duration.

The frequency of exacerbations per year was also assessed, with 18.3% (11 participants) experiencing one exacerbation annually, 40.0% (24 participants) experiencing two, 30.0% (18 participants) experiencing three, and 11.7% (7 participants) experiencing four exacerbations per year. The mean body mass index (BMI) of the participants was 22.34 ± 1.76 kg/m²

The participants had an average oxygen saturation (SpO2) of 81.75 ± 10.16%, indicating compromised respiratory function. The mean systolic blood pressure (SBP) was 111.95 ± 9.89 mmHg, and the mean diastolic blood pressure (DBP) was 74.07 ± 7.01 mmHg. The respiratory rate (RR) averaged 25.53 ± 2.95 breaths per minute.

Examination findings revealed that 38.3% of the participants (23 individuals) presented with cyanosis, 36.7% (22 individuals) with clubbing, 81.7% (49 individuals) with wheezing, and 48.3% (29 individuals) with crepitations.

1: Spirometry

Spirometry	Mean	SD
FEV1(% predicted)	50.58	15.510
FEV1/FCV %	51.37	11.966

The spirometry results showed a mean forced expiratory volume in one second (FEV1) percentage predicted of 50.58 ± 15.51%, and a mean FEV1/FVC (Forced Vital Capacity) ratio of 51.37 ± 11.97%, suggesting significant obstructive lung disease.

Table 2: Modified Medical Research Council (MMRC) Dyspnea Scale

MMRC	Frequency	Percent
1	9	15.0
2	14	23.3
3	16	26.7
4	21	35.0

The MMRC scale was used to assess dyspnea, with 15.0% (9 participants) classified at grade 1, 23.3% (14 participants) at grade 2, 26.7% (16 participants) at grade 3, and 35.0% (21 participants) at grade 4, indicating varying degrees of breathlessness.

Table 3: Global Initiative for Chronic Obstructive Lung Disease (Gold) Classification

Gold	Frequency	Percent
1	1	1.7
2	30	50.0
3	12	20.0
4	17	28.3

Participants were classified according to the GOLD criteria, with 1.7% (1 participant) in GOLD stage 1, 50.0% (30 participants) in stage 2, 20.0% (12 participants) in stage 3, and 28.3% (17 participants) in stage 4, reflecting the severity of the chronic obstructive pulmonary disease. The mean serum sodium level was 132.82 ± 3.66 mmol/L, potassium was 3.39 ± 0.37 mmol/L, and magnesium was 1.76 ± 0.08 mmol/L. These values indicate potential electrolyte imbalances commonly seen in chronic illnesses.

Table 4: Association of MMRC Dyspnea Grades With Electrolytes

MMRC		Sodium	Potassium	Magnesium
1	**Mean**	138.962	4.033	1.8822
	SD	3.087	0.3000	0.00833
2	**Mean**	134.385	3.564	1.8214
	SD	0.999	0.0842	0.02770
3	**Mean**	132.45	3.319	1.7544
	SD	0.469	0.0750	0.01861
4	**Mean**	129.42	3.057	1.6686
	SD	1.99	0.1568	0.02869
P Value		**<0.001**	**<0.001**	**<0.001**

The study found a significant association between MMRC dyspnea grades and electrolyte levels. At grade 1, the mean sodium, potassium, and magnesium levels were 138.96 ± 3.09 mmol/L, 4.03 ± 0.30 mmol/L, and 1.88 ± 0.008 mmol/L, respectively. At grade 2, these levels were 134.39 ± 1.00 mmol/L, 3.56 ± 0.08 mmol/L, and 1.82 ± 0.028 mmol/L. At grade 3, they were 132.45 ± 0.47 mmol/L, 3.32 ± 0.08 mmol/L, and 1.75 ± 0.019 mmol/L, and at grade 4, they were 129.42 ± 1.99 mmol/L, 3.06 ± 0.16 mmol/L, and 1.67 ± 0.029 mmol/L. As the severity of dyspnea increased from Grade 1 to Grade 4, there was a noticeable decline in serum sodium, potassium,

and magnesium levels, with P-values of less than 0.001 for all electrolytes. This trend suggests that as respiratory impairment worsens, there is a significant disruption in electrolyte homeostasis, potentially exacerbating the clinical condition.

Table 5: Association of Gold Grades with Electrolytes

Gold		Sodium	Potassium	Magnesium
1	Mean	138.38	3.900	1.8800
	SD			
2	Mean	134.47	3.570	1.8050
	SD	4.05	.4001	.07338
3	Mean	131.87	3.275	1.7383
	SD	1.56	.1765	.05114
4	Mean	130.23	3.129	1.6859
	SD	1.73	.1611	.04770
P Value		<0.001	<0.001	<0.001

The study revealed a significant association between GOLD stages and serum electrolyte levels, highlighting a correlation between the severity of chronic obstructive pulmonary disease (COPD) and changes in sodium, potassium, and magnesium levels. At stage 1, mean sodium, potassium, and magnesium levels were 138.38 mmol/L, 3.90 mmol/L, and 1.88 mmol/L, respectively. At stage 2, these levels were 134.47 ± 4.05 mmol/L, 3.57 ± 0.40 mmol/L, and 1.81 ± 0.073 mmol/L. At stage 3, they were 131.87 ± 1.56 mmol/L, 3.28 ± 0.18 mmol/L, and 1.74 ± 0.051 mmol/L, and at stage 4, they were 130.23 ± 1.73 mmol/L, 3.13 ± 0.16 mmol/L, and 1.69 ± 0.048 mmol/L. As the GOLD stage increased from 1 to 4, indicating more severe disease, serum electrolyte levels showed a marked decline. The P-values for these trends were all <0.001, indicating strong statistical significance. These findings suggest that as COPD severity increases, electrolyte imbalances become more pronounced.

Table 6: Duration of Hospital Stay

Duration of Hospital Stay	Frequency	Percent
< 5 days	27	45.0
6-10 days	26	43.3
>11 days	7	11.7
Mean±SD	6.97±3.02	

The duration of hospital stay varied among participants, with 45.0% (27 participants) staying for less than 5 days, 43.3% (26 participants) for 6-10 days, and 11.7% (7 participants) for more than 11 days. The mean duration of hospital stay was 6.97 ± 3.02 days.

Discussion

This research was conducted to study the serum electrolytes in acute exacerbation of COPD which included 60 patients in our hospital.

The youngest age group, 30-40 years, constituted 11.7% of the participants. The mean age of the participants was 57.87 ± 12.939 years. However, Ogan et al.[13] had an older patient cohort with a mean age of 71.79 years for COPD patients. Also, Deep et al.[14]included 41 AECOPD patients, with a mean age of approximately 69 years, indicating a comparable demographic distribution to our study. Acharya and Paudel's study[9] included 100 AECOPD patients with a mean age of 69.57 ± 9.76 years, closely matching the mean age in our study. Both studies observed that a majority of the patients were over 60 years old, with Acharya and Paudel reporting 83% in this age group.

In this study, there were 40 male participants, representing 66.7% of the population, while the remaining 20 participants were female, accounting for 33.3% of the study group. Similar to our study, Ogan et al.[13]had 82.7% males in their study, showing a higher prevalence of COPD in males. Similarly, the male-to-female ratio was higher in the Deep et al.[14] study (4.25:1 in AECOPD).

Smoking habits among our participants were assessed, with 63.3% reported as smokers, and the remaining 36.7% identified as non-smokers. In concordance to our study, Ogan et al.[13]reported 72.8% among COPD patients.

The symptoms reported by the present study's participants included breathlessness, experienced by 26.7%, chest pain in 20%, cough in 18.3%, expectoration in 15%, and hemoptysis in 20%. Acharya and Paudel[9] reported that the majority of their patients experienced dyspnea (90%) and cough (89%) upon admission, similar to the clinical features observed in our study.

In our study, the duration of illness among the participants varied, with a mean duration of 14.27 ± 6.916 years. The mean duration of hospital stay was 6.97 ± 3.02 days in our study. Similar to our study, in terms of length of stay, the majority of patients (73%)

had been there for five days or longer, while 27% had been there for less time in the Acharya and Paudel[15] study.

The frequency of exacerbations per year was also assessed in our study, with 18.3% experiencing one exacerbation annually, 40% experiencing two, 30% experiencing three, and 11.7% experiencing four exacerbations per year.

In our study, the mean body mass index (BMI) of the participants was 22.34 ± 1.76 kg/m². The participants had an average oxygen saturation (SpO2) of 81.75 ± 10.16%, indicating compromised respiratory function. The mean systolic blood pressure (SBP) was 111.95 ± 9.89 mmHg, and the mean diastolic blood pressure (DBP) was 74.07 ± 7.01 mmHg. The respiratory rate (RR) averaged 25.53 ± 2.95 breaths per minute.

The spirometry results in our study showed a mean forced expiratory volume in one second (FEV1) percentage predicted of 50.58 ± 15.51%, and a mean FEV1/FVC (Forced Vital Capacity) ratio of 51.37 ± 11.97%, suggesting significant obstructive lung disease.

In our study, the MMRC scale was used to assess dyspnea, with 15% classified at grade 1, 23.3% at grade 2, 26.7% at grade 3, and 35% at grade 4, indicating varying degrees of breathlessness. Similar to our study, Ogan et al.[13] observed a median mMRC score of 2 (1–4) in their study.

Our study participants were classified according to the GOLD criteria, with 1.7% in GOLD stage 1, 50% in stage 2, 20% in stage 3, and 28.3% in stage 4, reflecting the severity of the chronic obstructive pulmonary disease. In the Ogan et al.[13] study, a higher proportion of patients were in the more severe GOLD stages - Group C of 35.8% and Group D of 64.2% respectively.

In our study, the mean serum sodium level was 132.82 ± 3.66 mmol/L, potassium was 3.39 ± 0.37 mmol/L, and magnesium was 1.76 ± 0.08 mmol/L. These values indicate potential electrolyte imbalances commonly seen in chronic illnesses. Similar to our study, Ogan et al.[13]found a median Na level of 137.00 mEq/L, median K level of 3.90 mEq/L and a median Mg level of 0.78 mg/dL respectively in COPD patients in their study. Deep et al.[125] highlighted a statistically significant lower mean serum sodium levels in AECOPD patients (129.39 ± 8.654 mmol/L) of their study.

Acharya and Paudel[15] found that hyponatremia was present in 51% of their patients, aligning with our study, which also highlighted the significance of lower sodium levels in deceased AECOPD patients (p=0.0001). Their study reported a mean serum sodium level of 133.8 ± 4.83 mEq/L, with the minimum level at 121 mEq/L, comparable to our findings. In terms of potassium levels, Acharya and Paudel[15] noted that 40% of patients had hypokalemia, 58% had normal potassium levels, and 2% had hyperkalemia. The mean potassium level was 3.6 ± 0.53 mmol/L, with levels ranging from 2.5 to 5.9 mmol/L.

The current study found a significant association between MMRC dyspnea grades and electrolyte levels. At grade 1, the mean sodium, potassium, and magnesium levels were 138.96 ± 3.09 mmol/L, 4.03 ± 0.30 mmol/L, and 1.88 ± 0.008 mmol/L, respectively. At grade 2, these levels were 134.39 ± 1.00 mmol/L, 3.56 ± 0.08 mmol/L, and 1.82 ± 0.028 mmol/L. At grade 3, they were 132.45 ± 0.47 mmol/L, 3.32 ± 0.08 mmol/L, and 1.75 ± 0.019 mmol/L, and at grade 4, they were 129.42 ± 1.99 mmol/L, 3.06 ± 0.16 mmol/L, and 1.67 ± 0.029 mmol/L. As the severity of dyspnea increased from Grade 1 to Grade 4, there was a noticeable decline in serum sodium, potassium, and magnesium levels, with P-values of less than 0.001 for all electrolytes. This trend suggests that as respiratory impairment worsens, there is a significant disruption in electrolyte homeostasis, potentially exacerbating the clinical condition.

The present study revealed a significant association between GOLD stages and serum electrolyte levels, highlighting a correlation between the severity of chronic obstructive pulmonary disease (COPD) and changes in sodium, potassium, and magnesium levels. At stage 1, mean sodium, potassium, and magnesium levels were 138.38 mmol/L, 3.90 mmol/L, and 1.88 mmol/L, respectively. At stage 2, these levels were 134.47 ± 4.05 mmol/L, 3.57 ± 0.40mmmol/L, and 1.81 ± 0.073 mmol/L. At stage 3, they were 131.87 ± 1.56 mmol/L, 3.28 ± 0.18 mmol/L, and 1.74 ± 0.051 mmol/L, and at stage 4, they were 130.23 ± 1.73 mmol/L, 3.13 ± 0.16 mmol/L, and 1.69 ± 0.048 mmol/L. As the GOLD stage increased from 1 to 4, indicating more severe disease, serum electrolyte levels showed a marked decline.

However, in the Haque et al.[16] study, serum sodium levels were significantly lower in very severe GOLD stage patients (mean 128.32 mmol/L) compared to severe GOLD stage patients (mean 131.05 mmol/L) (p = 0.007) and the serum potassium levels were significantly lower in very severe GOLD stage patients (mean 3.11 mEq/L) compared to severe GOLD stage patients (mean 3.28 mEq/L) (p = 0.03) in their study.

Conclusion

We conclude that, this study highlights a significant association between serum electrolyte levels and the severity of chronic obstructive pulmonary disease (COPD) exacerbations. As the severity of dyspnea and COPD increases, there was a notable decline in serum sodium, potassium, and magnesium levels, suggesting that electrolyte imbalances become more

pronounced with worsening respiratory impairment.

Our findings underscore the importance of monitoring and managing electrolyte levels in COPD patients, particularly during exacerbations. However, the limitations of the study, including the small sample size and lack of control for potential confounding variables, suggest that further research with larger, multi-center studies is needed to confirm these results and better understand the mechanisms underlying the observed electrolyte disturbances.

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