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Correlation of Serum Electrolytes with Arterial Blood Gas (ABG) in Acute Exacerbation COPD Patients

Raashika Saxena[1], Arvind Kumar Gupta[2]

[1, 2]PhD Scholar, Department of Biochemistry, K.M. University, Mathura

[2]Corresponding Author Email: *arvindkguptaa12[at]gmail.com*

Abstract: ***Background: Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease characterized by airflow limitation. Acute Exacerbation (AE) COPD is a common cause of morbidity and mortality worldwide, with a significant impact on patient's respiratory and metabolic status. Serum electrolytes and arterial blood (ABG) analysis are essential in managing COPD patients. Objectives: In this study, we aimed to evaluate the correlation between serum electrolytes and ABG in acute exacerbation COPD (AECOPD) patients. These correlations can help clinicians in better managing AECOPD patients, as disturbances in electrolyte balance and acid – base homeostasis are often seen in this condition. Materials and Methods: A prospective observational study was conducted was conducted with a cohort of AECOPD patients. A total number of 90 COPD patients were enrolled in this study. Serum electrolytes (Sodium, Potassium, Chloride, Ionized Calcium and Magnesium) and ABG parameters (pH, pO_2, pCO_2, SO_2, Hct and HCO_3) were measured. Correlation analysis was performed using Pearson's correlation coefficient. Results: A strong positive relations was found between potassium and pCO_2 ($r = 0.55$, $p < 0.001$) that indicates the pCO_2 level rises along with increase in the potassium levels that was seen in respiratory acidosis. Ionized Calcium and SO_2 showed a positive correlation ($r = 0.42$, $p < 0.0002$) that was also linked with acidosis. A weak but significant positive correlation was found between magnesium and pO_2 ($r = 0.33$, $p < 0.012$) which suggests that magnesium may play a role in oxygenation in AECOPD patients. Conclusion: This study highlights the significant correlations between serum electrolytes and ABG parameters in AECOPD patients.***

Keywords: COPD, AECOPD, Hyponatremia, Hypokalemia, Electrolyte imbalance

1. Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory condition characterized by airflow limitation. COPD causes gradual and enduring respiratory symptoms, such as coughing, breathing issues, and phlegm formation. [1] The social and economic burdens formed by acute exacerbations of COPD are very high. Electrolyte imbalances are common in COPD patients. Electrolyte imbalance causes COPD patients to have poor outcomes. The metabolic disturbances and their consequences in COPD are known but still data is limited regarding why considerable ratio of patients with COPD presents with significant electrolyte imbalances (EI) on the basis of severity (as per the GOLD criteria 2023). There are various endothelial factors and impairment of exchange of gas which induces various hormones such as vasopressin and atrial natriuretic peptide that lead to hyponatremia and water retention. [2]

Acute Exacerbation (AE) COPD often lead to significant respiratory compromise, requiring hospitalization and intensive management. AECOPD is frequently associated with disturbances in both serum electrolytes and acid – base balance. Electrolyte imbalances and abnormalities in blood gas parameters can further complicate the clinical course and increase mortality. [3]

Serum electrolytes play an essential role in maintaining cellular function, nerve conduction, while arterial blood gas (ABG) analysis provides valuable information about the patient's acid – base balance, oxygenation, and ventilation. [4] This study aims to explore the correlation between serum electrolytes (sodium, potassium, chloride, ionized calcium and magnesium) and ABG parameters (pH, pO_2, pCO_2, SO_2, Hct and HCO_3) in patients with AECOPD providing insights that can aid in clinical management.

2. Material & Methods

Source of Data and Study Design: It is a hospital based prospective observational study, conducted at NIMS University in the Department of Biochemistry in association with the Department of Respiratory Medicine and General Medicine. Samples were analyzed for biochemical investigations in the Department of Biochemistry, NIMS University in Jaipur.

Inclusion Criteria:

- Clinically diagnosed stable and AECOPD patients.
- Age between 30 to 60 years (both male and female).
- Patients who are willing to participate in the study.

Exclusion Criteria: Patients with Diabetes Mellitus (DM), Hypertension, Cardiovascular Disease, Thyroid Dysfunction, Renal Disease (such as acute renal failure, chronic kidney disease), Pregnant and lactating women, Alcoholic were excluded from the study.

Sample Collection: 5 ml venous blood was drawn from patients; under aseptic precautions with a clot activator tube. Serum was separated by centrifugation and used for the following biochemical analysis. Serum Electrolytes was estimated using Fully Automatic Analyzer and ABG Analysis was estimated using Blood Gas Analyzer.

Statistical Analysis: All the data was presented in number % percentage. Mean and Standard Deviation were used to determine the data. Pearson's correlation was used for the correlation between serum electrolytes and ABG parameters. A p-value less than 0.05 were considered statistically significant.

3. Results

This study included 90 patients of AECOPD (64 males and 26 females) aged 20 to 65 years. The majorities of patients had a history of smoking (80%) and were classified as Gold Stage III or IV in terms of COPD severity. A strong positive relationship was found between potassium and pCO_2 ($r = 0.55$, $p < 0.001$) that indicates the pCO_2 level rises along with increase in the potassium levels that was seen in respiratory acidosis. Ionized Calcium and SO_2 showed a positive correlation ($r = 0.42$, $p < 0.0002$) that was also linked with acidosis. A weak but significant positive correlation was found between magnesium and pO_2 ($r = 0.33$, $p < 0.012$) which suggests that magnesium may play a role in oxygenation in AECOPD patients.

Table 1: Shows Correlation of Serum Electrolytes and ABG Parameters in AECOPD Patients

Variables	Mean ± SD	ABG Parameters	Mean ± SD	Pearson's Correlation	P- Value
Serum Sodium (mmol/L)	137 ± 5	pH	7.35 ± 0.05	- 0.35	0.003
Serum Potassium (mmol/L)	3.8 ± 0.6	pCO_2 (mm Hg)	50 ± 7	0.55	**0.001**
Serum Chloride (mmol/L)	101 ± 4	HCO_3 (mEq/L)	28 ± 3	- 0.47	0.002
Serum Ionized Calcium (mmol/L)	1.1 ± 0.1	SO_2 (%)	85 ± 4	0.42	**0.0002**
Serum Magnesium (mg/dL)	1.9 ± 0.3	pO_2 (mm Hg)	55 ± 10	0.33	**0.012**

Not significant ($p > 0.05$) and **Highly significant** ($p < 0.001$)

4. Discussion

In the present study, we included a total of 90 patients of AECOPD based on inclusion and exclusion criteria. The results of this study demonstrate significant correlations between serum electrolytes and ABG parameters in AECOPD patients. Several electrolyte imbalances are commonly seen in AECOPD and can exacerbate the respiratory and metabolic derangements in these patients. The negative correlation between sodium and pH ($r = - 0.35$, $p = 0.003$) indicates that hyponatremia may contribute to acidosis which is seen in patients with respiratory failure and CO_2 retention. The inverse relationship between chloride and bicarbonate ($r = - 0.47$, $p = 0.002$) is also noticed that supports the concept of a compensatory mechanism in metabolic acidosis, where chloride shifts into the cells to balance the decrease in bicarbonate. As sodium and chloride with ABG parameters such as pH and HCO_3 is less direct, they are still integral in understanding fluid balance and acid-base status. Sodium is the primary extracellular cation and chloride is primary extracellular anion. Alterations in sodium and chloride levels often correlate with changes in acid-base status, especially in conditions such as metabolic acidosis or alkalosis. [5] Wright et al. (2008) suggests that sodium levels tend to shift in response to changes in HCO_3 as seen in the kidney's compensatory mechanisms to regulate acid-base balance. Although sodium's correlation with ABG parameters is less pronounced, its role in maintaining extracellular fluid balance and pH cannot be overlooked. [6]

The positive correlation between potassium and pCO_2 ($r = 0.55$, $p < 0.001$) suggests that Hyperkalemia could be a compensatory mechanism in response to respiratory acidosis. Hyperkalemia is observed in patients with impaired renal function and acidosis. Potassium and pCO_2 plays a crucial role in maintaining cellular function. pCO_2 is a marker of the respiratory component of acid-base balance. Kraut & Madias et al. (2010) also reveal the correlation between potassium levels and pCO_2 with higher levels of potassium associated with acidosis characterized by pCO_2. This is because in acidosis, potassium moves out of cells in exchange for hydrogen ions to buffer the excess acid, leading to Hyperkalemia. [7] In contrast Gennari et al. (2004) marked alkalosis due to reduction in pCO_2 that results in potassium moving into cells causing hypokalemia. This correlation is essential in conditions such as COPD or metabolic disorders where both potassium imbalances and altered pCO_2 levels are often observed. [8]

Ionized Calcium and SO_2 also show a positive correlation ($r = 0.42$, $p < 0.0002$). Ionized Calcium (Ca^{2+}) is the physiologically active form of calcium and plays a pivotal role in numerous biological processes, including muscle contraction, nerve transmission and blood clotting. This relationship has been highlighted in various studies that indicate the role of calcium in oxygen transport and utilization. [10] Zhao et al. (2018) suggests low levels of ionized calcium are linked to decreased SO_2 due to impaired oxygen – binding capacity of hemoglobin and altered cellular function. In critical conditions such as sepsis, trauma or during ICU management, these correlations are valuable in assessing patient status and guiding therapeutic decisions. [11]

The relationship between magnesium and pO_2 ($r = 0.33$, $p < 0.012$) suggests that magnesium may have a role in maintaining respiratory function and improving oxygenation, though the correlation is relatively weak. Magnesium (Mg^{2+}) plays a role in neuromuscular function and the regulation of cardiovascular function. Schanstra et al. (2016) indicate that magnesium levels are inversely related to pO_2 in arterial blood. Magnesium is essential for the functioning of various enzymes involved in oxidative phosphorylation and energy production, which are critical for efficient oxygen utilization. Low magnesium levels can lead to cellular dysfunction, which, in turn, can decrease oxygen delivery to tissues. Furthermore, magnesium deficiency has been associated with poor outcomes in conditions with impaired oxygenation, such as acute respiratory distress syndrome (ARDS) or critical illnesses. [12]

The correlations between serum electrolytes and ABG parameters are essential for clinicians in evaluating patient status and guiding treatment. In patients with respiratory acidosis (elevated pCO_2), clinicians must consider the potential for concurrent Hyperkalemia and electrolyte imbalances. Similarly, in cases of hypoxemia (low pO_2), magnesium and ionized calcium levels should be monitored closely, as both electrolytes play a role in oxygen delivery and utilization. Furthermore, these correlations provide insights into the pathophysiological mechanisms underlying various diseases.

The limitations of the present study is that the sample size is relatively small, which may not be representative of the larger population. The study relies on self-reported data, which may be subject to biases and inaccuracies. This study only examines the correlation between ionized calcium and SO_2 and does not consider other potential factors that may influence this relationship.

5. Conclusion

This study highlights the significant correlations between serum electrolytes and ABG parameters in AECOPD patients. Understanding the interrelationship between serum electrolytes and ABG parameters enhances our ability to diagnose and manage complex medical conditions. Further research is needed to explore these correlations in greater depth, especially in specific patient populations, to optimize clinical decision-making. Clinicians should be aware of these relationships, as disturbances in electrolytes and acid – base balance can worsen the clinical outcome. Monitoring serum electrolytes and ABG levels in AECOPD patients may provide valuable insights into their clinical status and guide therapeutic interventions, including electrolyte correction and ventilation support.

Conflicts of Interest: None

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