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Electrolytes Unchained: The Hidden Threat in Acute Coronary Syndrome

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Abstract: Introduction: Acute coronary syndrome (ACS) encompasses a range of urgent heart conditions characterized by a sudden reduction in blood flow to the heart, potentially causing unstable angina or myocardial infarction. Rapid diagnosis and treatment can restore blood flow, minimizing heart damage.

Rationale of the Study: ACS remains a leading cause of mortality worldwide. Recent evidence suggests that serum electrolyte variability analysis could offer new insights into the pathophysiology of ACS.

Background and Statement of the Problem: Cardiac arrhythmias, common in ACS patients, are often linked to electrolyte imbalances. These abnormalities can exacerbate the severity of the condition, making it crucial to understand their role in patient outcomes.

Aim of Current Study: This study aims to establish the association between various electrolyte abnormalities in patients with ACS, particularly focusing on their potential role in disease severity and prognosis.

Objectives: To determine the relationship between electrolyte imbalances and disease severity in ACS patients and evaluate their potential use as biomarkers for prognosis.

Methodology: The study was conducted on patients diagnosed with ST-elevation myocardial infarction (STEMI) at SBMCH. Serum levels of magnesium, sodium, calcium, chloride, and potassium were analyzed, alongside ECG and Troponin I levels. The study spanned two years from October 2022 to September 2024 and included comparative analysis of electrolyte levels in patients with different forms of ACS.

Results: The study found that electrolyte imbalances are prevalent in ACS patients. Hyponatremia was observed in 45% of STEMI patients, while hypocalcemia and hypokalemia affected 37%. In NSTEMI patients, hyponatremia was present in 41%, with hypocalcemia and hypokalemia affecting 31% and 33%, respectively. These imbalances were associated with worse clinical outcomes, such as reduced ejection fraction and increased mortality rates.

Conclusion: Electrolyte abnormalities, particularly hyponatremia and hypokalemia, are common in ACS and are associated with adverse outcomes. Early recognition and management of these imbalances are crucial for improving patient prognosis. Further studies are needed to enhance the understanding of these complex interactions and develop targeted treatments.

Keywords: hypocalcemia, STEMI, prognosis, ACS, abnormalities

INTRODUCTION

Acute coronary syndrome (ACS) is one of the leading causes of mortality globally, accounting for approximately 7 million deaths annually, alongside 129 million Disability-Adjusted Life Years (DALYs) lost due to coronary artery disease (1,2). This burden represents the largest contributor to global mortality, and in the coming decades, non-communicable diseases,

including ACS, are projected to result in a staggering economic loss of around 47 trillion dollars, with cardiovascular diseases like ACS contributing significantly to these costs (3). In India, ACS is the primary cause of death, with a higher prevalence of ST-segment elevation myocardial infarction (STEMI) compared to high-income countries, where it accounts for a smaller proportion of cases (4). The CREATE registry, a large-scale study of ACS patients across India, reports that STEMI constitutes 61% of cases. Research from South India further highlights a significant in-hospital mortality rate of 17% among STEMI patients, underscoring the urgent need for improved management and treatment strategies (5).

Electrolyte imbalances, particularly hyponatremia (low sodium levels), are increasingly recognized as major contributors to adverse outcomes in ACS patients (6,7). Hyponatremia, defined as a serum sodium concentration below 133 mEq/L, is linked to elevated mortality, especially in patients with heart failure or myocardial infarction (MI) (8). The neurohumoral activation that occurs during ACS mirrors the neurohumoral changes seen in heart failure, which explains the high prevalence of electrolyte imbalances in both conditions (9). While studies have demonstrated that hyponatremia correlates with poor prognosis in chronic heart failure, its role in the acute setting of myocardial infarction is still under-explored, despite its frequent occurrence (10).

Similarly, hypokalemia, defined as serum potassium levels below 3.5 mEq/L, has been shown to increase the risk of in-hospital morbidity in ACS patients, primarily through its association with arrhythmias and larger infarct sizes (11). Guidelines recommend regular monitoring and correction of potassium levels in patients with ACS to prevent life-threatening arrhythmias and other complications (1). In contrast, hyperkalemia, or elevated potassium levels, is also a concern, as it is associated with increased mortality in ACS patients (5). Potassium regulation is primarily mediated by the sodium-potassium ATPase pump and renal excretion, with hormonal influences from aldosterone and vasopressin playing key roles (6).

Sudden cardiac death in the first hour following an MI is often attributed to electrolyte imbalances, particularly disruptions in potassium, sodium, and calcium levels (12). Calcium, a crucial ion in the myocardial contraction process, also plays a significant role in myocardial infarction pathophysiology (4). Disruptions in calcium handling between the sarcoplasmic reticulum and the myofilaments can lead to tissue damage, both reversible and irreversible, during an MI (9). These disruptions also increase the likelihood of atherosclerotic plaque instability and coronary spasms, further complicating the clinical course of ACS (2). Additionally, hypophosphatemia (low phosphate levels) has been linked to left ventricular dysfunction and increased 30-day mortality in ACS patients.

Despite the known importance of electrolyte balance in ACS, the frequency, patterns, and clinical significance of these abnormalities, particularly during the acute intervention period, remain poorly understood (4). This study aims to explore the prevalence and impact of electrolyte imbalances in ACS patients, with the goal of improving patient management and outcomes (10).

MATERIALS AND METHODS

This clinical study included 75 patients diagnosed with acute coronary syndrome (ACS) who were hospitalized in the Department of General Medicine at SBMCH. The study was designed as a prospective, one-dimensional analysis focused on identifying electrolyte abnormalities in patients with myocardial infarction (MI), including both STEMI and NSTEMI cases. Inclusion criteria consisted of patients presenting with NSTEMI, STEMI, and chest pain suggestive of

ACS. Patients with renal failure, chronic liver disease, malignancy, and adrenal insufficiency were excluded.

The methodology involved recruiting individuals with a history of MI who met the inclusion criteria. Each participant underwent detailed clinical assessments, physical examinations, and standard laboratory investigations. The primary aim was to evaluate the prevalence of electrolyte abnormalities, such as hyperkalemia, hypokalemia, hypercalcemia, hypocalcemia, hyponatremia, and hypernatremia, among the MI patients.

We categorized patients into STEMI and NSTEMI groups and analyzed the collected data to determine the frequency of electrolyte imbalances in each category. The study aimed to explore the potential predictive role of these imbalances in the onset and severity of MI. By identifying whether electrolyte disturbances can serve as early markers for MI, this research could enhance risk stratification and lead to more targeted clinical interventions. Future studies are necessary to validate the predictive value of these electrolyte abnormalities in managing MI and improving patient outcomes.

Study Period : 2 years (October 2022 to September 2024)

RESULTS:

Age Distribution

The age distribution among ACS patients showed a notable trend. In the 40–50 age group, 25 cases were reported, while the 51–60 age group had the highest number, with 39 cases. In the 61–70 age group, 32 cases were recorded. However, the number of cases significantly dropped in the 71–80 age group, with only 3 cases, and there was just one case in the 81–90 age group. This trend suggests that ACS primarily affects individuals aged 50 to 60, with a notable decline in older age groups. (Fig.1) (Graph.1)

Table 1 shows the distribution of cases by age group.

Age group	No. of cases	Percentage
40-50	25	25.00%
51-60	39	39.00%
61-70	32	32.00%
71-80	3	3.00%
81-90	1	1.00%

Graph 1 shows the distribution of cases by age group.

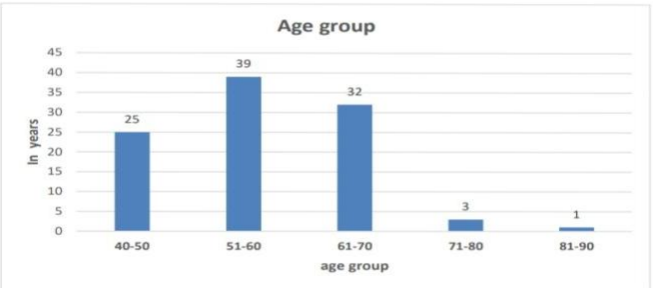

Fig: 1

Gender Distribution

Among the cases, 56% of patients were male, and 44% were female. This indicates that males were more affected by ACS than females in this study population. The gender distribution aligns with existing literature, which often reports higher rates of ACS in males compared to females. (Fig.2)

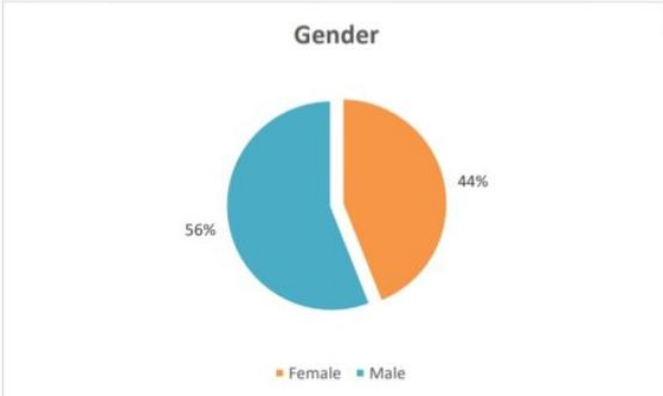

Fig.2

Symptom Presentation

Shortness of breath and chest pain were reported by 59% of patients, while 41% did not experience these symptoms. Palpitations and shortness of breath were reported by 63% of patients, with 37% not reporting these symptoms. These findings highlight the prevalence of these classic ACS symptoms among the study group. (Fig.3)

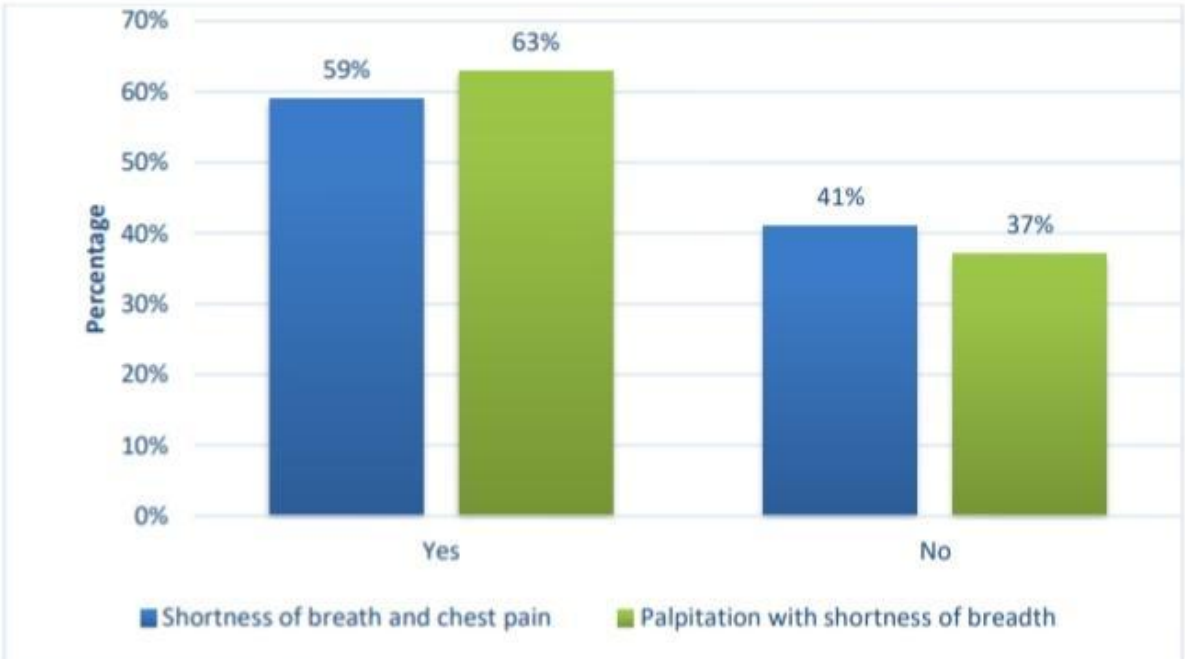

Fig.3

Electrolyte Imbalances in STEMI and NSTEMI Patients

In STEMI patients, 45% had hyponatremia, 37% had hypocalcemia, and 37% had hypokalemia, whereas in NSTEMI patients, 41% had hyponatremia, 31% had hypocalcemia, and 33% had hypokalemia. Despite these differences, there was no statistically significant difference in electrolyte levels between STEMI and NSTEMI patients (p-values: sodium 0.55, calcium 0.89, potassium 0.88). Fig.4)

Pattern of dyselectrolytemia	Hyponatremia	Hypocalcemia	Hypokalemia	Total
STEMI	45 (45%)	37 (37%)	37 (37%)	119
NSTEMI	41 (41%)	31 (31%)	33 (33%)	105

Fig.4

Gender and Electrolyte Imbalances

In terms of gender distribution, 23 females with STEMI had hyponatremia compared to 17 females with NSTEMI, while 22 males with STEMI and 24 males with NSTEMI were similarly affected. The chi-square test revealed no significant relationship between gender and hyponatremia ($p = 0.37$). Similarly, no statistically significant relationship was found between gender and hypocalcemia ($p = 0.60$) or hypokalemia in both STEMI and NSTEMI patients. (Fig.5) (Fig.6) (Fig.7)

Serum electrolytes	STEMI (Mean ± SD)	NSTEMI (Mean ± SD)	p value
Na (mEq/L)	127.19 ± 5.49	127.84 ± 5.49	0.55
Ca (mg/dL)	7.43 ± 1.16	7.40 ± 1.18	0.89
K (mEq/L)	3.37 ± 1.11	3.40 ± 0.936	0.88

Fig.5

Gender	Hypokalemia		Chi square	P value
	STEMI	N STEMI		
Female	18	14	0.27	0.60
male	19	19		
Total	37	33		

Fig.6

Gender	Hypocalcemia		Chi square	P value
	STEMI	NSTEMI		
Female	19	12	1.098	0.29
male	18	19		
Total	37	31		

Fig.7

DISCUSSION:

Acute coronary syndromes (ACS) encompass a spectrum of cardiovascular conditions that include unstable angina, ST-elevated myocardial infarction (STEMI), and non-ST-elevated myocardial infarction (NSTEMI). These conditions occur due to a sudden decrease in blood flow to the myocardium, primarily as a result of blockages in the coronary arteries. The severity of ACS can range from transient ischemic events to complete myocardial infarction, with STEMI typically representing the most severe form due to complete blockage of a coronary artery (11). In this study, we focused on analyzing electrolyte abnormalities in ACS patients,

particularly assessing their correlation with the severity of the condition, and sought to identify patterns across age groups, gender, and presenting symptoms.

The global burden of cardiovascular diseases, as noted by the World Health Organization (WHO), has reached pandemic proportions, affecting millions of individuals worldwide. ACS is among the most common causes of mortality and morbidity in developed and developing nations alike (12). The age distribution in our study revealed the highest incidence of ACS in individuals aged 51–60, with 39 cases recorded in this group. This is consistent with existing literature, which highlights that ACS tends to predominantly affect middle-aged individuals, particularly men. In our study, males accounted for 56% of the cases, aligning with previous findings by Patil et al., where 69% of ACS patients were male with an average age of 62.89±11.85 years (13). The gender disparity in ACS cases is a well-documented phenomenon, often attributed to lifestyle factors, hormonal differences, and a higher prevalence of risk factors such as smoking and hypertension among men.

Our findings further indicated that 59% of patients reported shortness of breath and chest pain as primary symptoms, while 63% reported palpitations accompanied by shortness of breath. These symptoms are characteristic of ACS and are indicative of the significant myocardial strain caused by ischemia (14). The presence of these symptoms often prompts further diagnostic evaluations, such as electrocardiograms (ECGs) and serum biomarkers, which help to differentiate between unstable angina, STEMI, and NSTEMI. The higher prevalence of these symptoms among our patient population underscores the importance of timely recognition and intervention in ACS cases to prevent adverse outcomes.

Electrolyte imbalances are a critical area of concern in patients with ACS, as they can have significant implications for cardiac function and overall prognosis. In our study, we observed that 45% of STEMI patients had hyponatremia, 37% had hypocalcemia, and 37% had hypokalemia. For NSTEMI patients, 41% exhibited hyponatremia, 31% had hypocalcemia, and 33% had hypokalemia. Hyponatremia, in particular, is known to be associated with worse outcomes in myocardial infarction (MI) patients (15). Studies suggest that hyponatremia in MI may be caused by non-osmotic vasopressin secretion, which leads to water retention and dilutional hyponatremia. This condition is often a marker of neurohormonal activation and is associated with reduced left ventricular ejection fraction, indicating a more severe degree of heart failure (16). Flear et al. reported that 45% of patients with MI had hyponatremia, and it was associated with a higher mortality rate, which is consistent with our findings in STEMI patients (14).

Sodium plays a crucial role in maintaining cardiac function by regulating cellular osmolality and the action potentials that facilitate myocardial contraction. During myocardial ischemia, sodium homeostasis can be disrupted, leading to cellular swelling and further exacerbating myocardial damage (17). The findings in our study, which showed no statistically significant difference in sodium levels between STEMI and NSTEMI patients ($p=0.55$), suggest that while hyponatremia is common in both conditions, it may not be a distinguishing factor in terms of severity.

Hypocalcemia, another electrolyte abnormality observed in our study, was present in 37% of STEMI and 31% of NSTEMI patients. Calcium is essential for the excitation-contraction coupling of myocardial cells, and disturbances in calcium levels can impair cardiac contractility (18). Severe hypocalcemia has been linked to cardiomyopathy, and persistent low calcium levels may lead to impaired myocardial performance and increased mortality in MI patients. However, in our study, the average calcium levels between STEMI and NSTEMI patients did not show significant differences ($p=0.89$), suggesting that calcium imbalance, while common,

may not be an acute differentiator between these two types of MI. This observation is supported by previous studies, such as those conducted by Goyal et al., which highlighted the importance of maintaining adequate calcium levels for optimal cardiac function (18).

Hypokalemia was observed in 37% of STEMI patients and 33% of NSTEMI patients in our study. Potassium is vital for maintaining the electrical stability of the heart, and disturbances in potassium levels can predispose patients to life-threatening arrhythmias such as ventricular tachycardia and ventricular fibrillation (17). Skeletal muscle acts as a reservoir for potassium, and stress-related catecholamine responses, particularly epinephrine, can cause a shift of potassium into cells, leading to hypokalemia. This condition is particularly dangerous in MI patients, as it can increase the risk of sudden cardiac death. Although the difference in potassium levels between STEMI and NSTEMI patients was not statistically significant ($p=0.88$), the presence of hypokalemia remains a critical concern in the management of ACS, as maintaining normal potassium levels has been associated with lower mortality rates in MI patients (19).

Gender-based differences in electrolyte imbalances were also examined in our study. We observed that 19 female STEMI patients had hypocalcemia, while 12 female NSTEMI patients exhibited the same condition. Among male patients, 18 with STEMI and 19 with NSTEMI had hypocalcemia. These findings suggest that while both men and women are affected by electrolyte disturbances, there may be subtle differences in the incidence of these imbalances based on gender (13). Previous research has suggested that women with MI may have worse outcomes than men, partly due to underdiagnosis and delayed treatment (19).

In conclusion, our study highlights the prevalence of electrolyte imbalances in ACS patients, with hyponatremia, hypocalcemia, and hypokalemia being common findings. Although these imbalances were observed in both STEMI and NSTEMI patients, there were no statistically significant differences in the average levels of sodium, calcium, or potassium between the two groups. These findings suggest that while electrolyte abnormalities are prevalent in ACS, their presence alone may not be a reliable marker for distinguishing between STEMI and NSTEMI. Further research is needed to better understand the role of electrolyte imbalances in ACS and their potential use as prognostic markers for patient outcomes (11,12).

CONCLUSION:

Electrolyte imbalances, such as low sodium and potassium levels, are commonly observed in patients with acute coronary syndrome (ACS) and are linked to poor clinical outcomes, including higher mortality rates. The causes of these abnormalities are complex, involving factors like neurohormonal activation, myocardial damage, and pre-existing cardiovascular conditions. Timely recognition and treatment of these imbalances are crucial for improving patient care and outcomes in ACS. Future research is necessary to further explore the interplay of these factors to optimize management strategies for ACS patients with electrolyte disturbances.

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