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Clinical profile and prognostic significance of hyponatremia in patients with acute ST-elevation myocardial infarction

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Abstract:
Acute ST-elevation myocardial infarction is frequently complicated by hyponatremia, but its prognostic significance for in-hospital outcomes requires further evaluation. Therefore, it is of interest to assess the incidence and prognostic value of hyponatremia in 100 patients with acute ST-elevation myocardial infarction by comparing clinical outcomes between hyponatremic and normonatremic groups. Hyponatremia was present in 57% of patients, with 29% having moderate hyponatremia and was significantly associated with arrhythmias (73.7% vs. 51.2%; $p = 0.024$), cardiogenic shock (94.7% vs. 30.2%; $p < 0.001$), intensive care unit admission (70.2% vs. 23.3%; $p < 0.001$) and heart failure (63.2% vs. 27.9%; $p < 0.001$). Increasing severity of hyponatremia was associated with progressively worse in-hospital outcomes, although the higher mortality observed did not reach statistical significance. Thus, serum sodium is a simple, inexpensive prognostic marker that can improve early risk stratification and clinical management in acute ST-elevation myocardial infarction.

Keywords: ST-elevation myocardial infarction (STEMI), hyponatremia, prognostic marker, electrolyte imbalance, cardiogenic shock, heart failure

Background:
Cardiovascular diseases (CVDs) are the main cause of death worldwide, responsible for about 17.9 million deaths each year, of which almost 85% are caused by ischemic heart disease and stroke **[1-3]**. Acute coronary syndromes (ACS) are a significant fraction of these deaths, with an estimated 7–8 million new cases annually worldwide **[4, 5]**. CVDs account for almost 28-31% of all deaths in India, resulting in more than 2.5-3 million deaths every year and are seen at a younger age than in western countries **[6]**. The in-hospital mortality rate in STEMI patients was 7.9% and 30-day mortality was 8.6% (higher in resource-limited settings) **[7]** reported from the CREATE registry. The situation is worsened by the high prevalence of risk factors such as hypertension (≈25-30%), diabetes (≈10-12%), tobacco use (≈28%) and the growing urbanization **[8].** One of the most common electrolyte disturbances, hyponatremia (serum sodium <135 mEq/L) occurs in 15–30% of hospitalized patients and up to 20–25% of patients with acute myocardial infarction **[9].** In STEMI, the neurohormonal activation of the renin–angiotensin–aldosterone system and non-osmotic release of vasopressin results in dilutional sodium imbalance **[10]**. There are several studies which have demonstrated that hyponatremia is linked to higher risk of complications, including heart failure, arrhythmias, cardiogenic shock and mortality, with some studies reporting a 2–4 folds increase in mortality risk **[11]**. Current efforts like STEMI India and regional reperfusion programmes are underway to enhance early diagnosis and prompt intervention, but the results are still not satisfactory, especially in semi-urban and rural areas **[12]**. Therefore, it is of interest to evaluate the prevalence of hyponatremia and its association with clinical outcomes in patients with acute STEMI, which will help to enhance risk assessment and management in local healthcare settings.

Materials and Methods:
A cross-sectional observational study was carried out in the Department of General Medicine of Bundelkhand Medical College and Hospital, Sagar, Madhya Pradesh, India for two years from February 2024 to February 2026. One hundred consecutive patients aged ≥18 years with acute ST-elevation myocardial infarction (STEMI) were enrolled in the study. STEMI was diagnosed based on clinical presentation (typical chest pain lasting >20 minutes) along with electrocardiographic evidence of ST-segment elevation in accordance with standard diagnostic criteria. Patients were consecutively sampled and informed consent was obtained. People were excluded if they had a condition that could affect serum sodium levels on its own, such as known renal failure, diabetes mellitus, liver disease, adrenal insufficiency, acute gastroenteritis, or potassium-sparing diuretics. Demographic and clinical information at admission was collected, such as age, sex, clinical symptoms and cardiovascular risk factors. Serum sodium and other biochemical parameters were measured from blood samples. Patients were classified as hyponatremic (serum sodium <135 mEq/L) or normonatremic. Patients were divided into hyponatremic (serum sodium <135 mEq/L) and normonatremic groups. In-hospital complications such as arrhythmias, cardiogenic shock, heart failure, ICU admission and mortality were monitored in all patients during their hospital stay. The data were entered into the Microsoft Excel and analyzed by using the appropriate statistical software. Data for continuous variables were presented as mean ± SD and data for categorical variables were presented as frequencies and percentages. Associations between variables were evaluated using the chi-square test and odds ratios were computed when appropriate. A p value < 0.05 was deemed as statistically significant. The study was approved by the Institutional Ethics Committee before it was started.

Results:
A total of 100 patients with acute ST-elevation myocardial infarction (STEMI) were included in the study. The majority of participants were male (62%) compared to females (38%), as illustrated in **Figure 1**, indicating a higher prevalence of STEMI among males in the study population. The descriptive statistics of continuous variables are presented in **Table 1**. The mean age

of the patients was 60.80 ± 11.38 years, reflecting predominance of elderly individuals. The mean serum sodium at admission was 132.01 ± 7.93 mEq/L, indicating a tendency toward hyponatremia. Other biochemical parameters, including serum potassium (4.54 ± 0.59 mEq/L) and serum creatinine (1.58 ± 0.39 mg/dL), were within expected ranges. The average hospital stay was 7.88 ± 2.66 days. Hyponatremia was observed in 57% of patients, while 43% had normal sodium levels, fulfilling the objective of assessing prevalence. As shown in **Table 2**, hyponatremia was significantly associated with adverse clinical outcomes. Patients with hyponatremia had higher rates of arrhythmia (73.7% vs. 51.2%, p=0.024), cardiogenic shock (94.7% vs. 30.2%, p<0.001), ICU admission (70.2% vs. 23.3%, p<0.001) and heart failure (63.2% vs. 27.9%, p<0.001) compared to normonatremic patients. Although mortality was higher in the hyponatremic group (43.9% vs. 34.9%), this difference was not statistically significant (p=0.34). Further analysis based on severity of hyponatremia **(Table 3)** showed a strong association with worsening outcomes. Severe hyponatremia was associated with the highest mortality (94.4%) and heart failure (94.4%), while mild hyponatremia showed no mortality. All associations were statistically significant (p<0.001), indicating a clear dose–response relationship. Comparison of biochemical parameters **(Table 4)** revealed significantly lower serum sodium levels and higher serum creatinine levels in hyponatremic patients compared to normonatremic patients (p<0.001 and p=0.018, respectively). No statistically significant differences were observed in serum potassium, fasting blood sugar, or post-prandial blood sugar levels.

Table 1: Descriptive statistics of continuous variables

Variable	Mean ± SD
Age (years)	60.80 ± 11.38
Chest Pain Duration (min)	182.57 ± 70.80
Serum Sodium (Admission)	132.01 ± 7.93
Serum Potassium	4.54 ± 0.59
Serum Creatinine	1.58 ± 0.39
Fasting Blood Sugar (FBS)	107.20 ± 20.61
Post-Prandial Blood Sugar	164.90 ± 31.62
Hospital Stay (days)	7.88 ± 2.66

Table 2: Association between hyponatremia and outcomes

Outcome	Normonatremia (n=43)	Hyponatremia (n=57)	p-value
Arrhythmia	22 (51.2%)	42 (73.7%)	0.024
Shock	13 (30.2%)	54 (94.7%)	<0.001
ICU Admission	10 (23.3%)	40 (70.2%)	<0.001
Heart Failure	12 (27.9%)	36 (63.2%)	<0.001
Mortality	15 (34.9%)	25 (43.9%)	0.34

Table 3: Association between severity of hyponatremia and clinical outcomes

Severity of Hyponatremia	Mortality (%)	Shock (%)	ICU Admission (%)	Arrhythmia (%)	Heart Failure (%)
Mild	0	100	100	90	70
Moderate	27.6	93.1	96.6	96.5	82.8
Severe	94.4	94.4	11.1	100	94.4
p-value	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4: Comparison of biochemical parameters between normonatremic and hyponatremic patients

Variable	Normonatremia (n = 43), Mean ± SD	Hyponatremia (n = 57), Mean ± SD	p-value
Serum Sodium (mEq/L)	138.5 ± 3.2	127.4 ± 5.8	<0.001
Serum Potassium (mEq/L)	4.48 ± 0.52	4.59 ± 0.63	0.312
Serum Creatinine (mg/dL)	1.46 ± 0.34	1.67 ± 0.41	0.018
Fasting Blood Sugar (mg/dL)	102.5 ± 18.2	110.8 ± 21.9	0.072
Post-Prandial Blood Sugar (mg/dL)	158.6 ± 28.4	169.8 ± 33.5	0.089

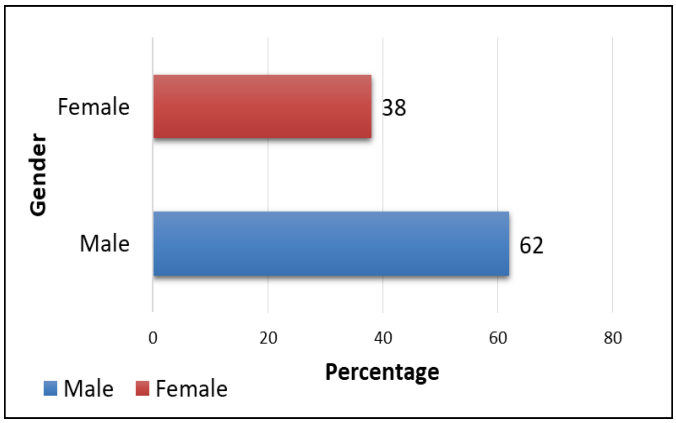


Figure 1: Distribution study participants based on gender

Discussion:

In the present study, the prevalence and prognostic value of hyponatremia in patients with acute STEMI were assessed. Patients were predominantly male (62%) which is similar to previous Indian and global studies where males were more likely to have STEMI, possibly because of increased exposure to cardiovascular risk factors **[12]**. The mean age of 60.8 years in our study is similar to that of the CREATE registry and other Indian cohorts, where STEMI is seen in the sixth decade of life **[13-15]**. The incidence of hyponatremia (57%) was higher than previously reported studies (16–28%). This higher prevalence could be due to delayed presentation, severity of the disease and regional health care disparities. Increased vasopressin release and RAAS activation are known to cause a dilutional sodium imbalance in STEMI **[16, 17]**. Our results show that there is a significant relationship between hyponatremia and poor clinical outcomes. Patients with hyponatremia had significantly higher rates of arrhythmia, cardiogenic shock, admission to the intensive care unit (ICU) and heart failure. Eliasz *et al.* demonstrated that hyponatremia was an independent predictor of in-hospital mortality and complications **[17]**. Similarly, Choi *et al.* reported that hyponatremia was correlated with reduced EF, elevated Killip class and mortality **[13]**. In our study, mortality was increased in the hyponatremic group but not statistically significant, perhaps because of the small number of patients. Importantly, a clear dose–response relationship was found, with

severe hyponatremia being associated with significantly increased mortality (94.4%) and complications. Goldberg *et al.* similarly showed that hyponatremia was independently associated with 30-day mortality in 1,047 patients with acute STEMI, with mortality risk increasing progressively as serum sodium declined, supporting the dose–response relationship observed in our study **[18].** Recent Indian evidence also supports the prognostic significance of hyponatremia in STEMI. Kumar *et al.* and Bheempallinavya reported hyponatremia in 29% of 100 patients with acute STEMI and found markedly higher 30-day mortality among patients with admission or severe hyponatremia. Another Indian study similarly evaluated hyponatremia as a prognostic marker in acute STEMI, emphasizing the potential role of serum sodium in predicting short-term outcomes **[19, 20]**. Biochemically, hyponatremic patients had significantly higher serum creatinine levels, indicative of underlying hemodynamic compromise and renal dysfunction, all of which are known predictors of poor outcomes in STEMI **[21]**.

Conclusion:

Hyponatremia occurred in 57% of patients with acute ST-elevation myocardial infarction and was significantly associated with arrhythmias, cardiogenic shock, intensive care unit admission and heart failure. Increasing severity of hyponatremia showed a clear dose–response relationship with adverse in-hospital outcomes and was associated with higher serum creatinine levels, indicating greater disease severity. Thus, data support routine serum sodium assessment as a simple and cost-effective tool for early risk stratification and timely management of patients with acute ST-elevation myocardial infarction.

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