ORIGINAL ARTICLE

DOI: 10.15713/ins.bhj.123

A Study on the Prognostic Significance of Hyponatremia in Acute Myocardial Infarction - A Prospective Longitudinal Study

ABSTRACT

Background: Hyponatremia, defined as a serum sodium concentration <135 mEq/L, is the most common electrolyte disorder in hospitalized patients. Hyponatremia also increases the morbidity and mortality following myocardial infarction (MI). MI is a major cause of death and is a global health problem reaching epidemic in both developed as well as in developing countries. **Aims and Objectives:** The aim of the study was to study hyponatremia as a prognostic marker in patients with acute MI-ST segment elevation myocardial infarction (STEMI) and non-ST elevation myocardial infarction (NSTEMI). **Materials and Methods:** This prospective, longitudinal observational study was conducted during December 2018–October 2020 in 152 cases of acute MI. **Results:** Male preponderance in the patients hospitalized due to acute MI was 73.03%. The mean age of females was 59.46 ± 9.42 years affected by acute MI was more than males, that is, 53.23 ± 9.92 years. Hyponatremia was present in 39.47% of the cases with acute MI. Mild hyponatremia was the most prevalent 71.67% and severe hyponatremia was the least prevalent 3.33%. Diabetes mellitus was more prevalent in cases of MI with hyponatremia 53.33% versus 25%. The GRACE scores were higher in the cases having hyponatremia and increases with the increase in severity of hyponatremia. The TIMI scores were higher in the cases having hyponatremia and increases with the increase in severity of hyponatremia. The mean duration of hospital stay was 9.99 ± 8.69 days. STEMI was more prevalent 75.66% than NSTEMI. AWMI cases were more in the population with hyponatremia 78% than in the population with normal serum sodium 53.85%. Acute MI cases with hyponatremia had lower mean left ventricular ejection fraction than those with normal serum sodium levels. Primary reperfusion therapy (thrombolysis/primary PCI) was done in 44.08% of the cases and no significant association was found between it and outcomes in the hyponatremia group. Complications were present in 23.03% of the cases in hyponatremia group ($P < 0.05$). Mortality was present in 2.64% of the cases and more common in the cases with hyponatremia ($P > 0.05$). The odds of complications (including death) was 2.91 times in the cases with hyponatremia as compared to cases with normal serum sodium levels, 2.47 times in the cases with mild hyponatremia as compared to cases with normal serum sodium levels, 3.42 times in the cases with moderate hyponatremia as compared to cases with normal serum sodium levels, and 25 times in the cases severe hyponatremia as compared to cases with normal serum sodium levels. **Conclusion:** It can be concluded that the severity of MI is more in cases with hyponatremia and hyponatremia is associated with poorer outcomes in terms of complications post MI and mortality. Although hyponatremia may not be an independent marker of poor outcome, sodium levels in prognostic scoring systems have not yet been used and could be of added value, similar to scoring systems for other diseases such as the MELD score for chronic liver disease.

Key words: Acute myocardial infarction, Hyponatremia, Prognosis

INTRODUCTION

Coronary heart disease (CHD)/myocardial infarction (MI) is a major cause of death and is a global health problem reaching epidemic in both developed as well as in developing countries.[1] Globally, of those dying from cardiovascular diseases, 80% are in developing countries and not in the western world.[2] CHD has been classified as chronic stable angina, acute coronary syndrome (ACS) and sudden death. ACS encompasses different clinical entities associated acute myocardial ischemia including ST segment elevation myocardial infarction (STEMI), non-ST elevation myocardial infarction (NSTEMI), and unstable angina. MI (including NSTEMI and STEMI) is generally caused by an imbalance between the myocardial blood flow and the metabolic demand of the myocardium. Reduction in

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coronary blood flow is related to progressive atherosclerosis with increasing occlusion of coronary arteries.[3]

Coronary artery perfusion depends on the pressure differential between the ostia (aortic diastolic pressure) and coronary sinus (right atrial pressure).[4] Coronary blood flow is reduced during systole because of Venturi effects at the coronary orifices and compression of intramuscular arteries during ventricular contraction. Forty micron collateral vessels are present in all hearts with pressure gradients permitting flow, despite occlusion of major vessels.[5] "Thrombolytic therapy" with agents such as streptokinase or tissue plasminogen activators such as alteplase is often used within the first 12 h following onset of symptoms and with ST-segment elevation to try and lyse a recently formed thrombus.[6] Such therapy with lysis of the thrombus can re-establish blood flow in a majority of cases.

Apart from early diagnosis and prompt initiation of management protocols, there are other factors which are of prognostic significance. Electrolyte imbalance is of particular importance in this regard. Hyponatremia is a well-known electrolyte disorder in hospitalized patients and it can make the prognosis worse depending on their background.[7] Several mechanisms can explain the occurrence of hyponatremia in these patients, such as neurohormonal activation of the renin-angiotensin-aldosterone system as well as sympathetic overstimulation due to reduced stroke volume and subsequent underfilling of arteries.[8] Hyponatremia is associated with exaggerated activation of baroreceptor-mediated hormones, including arginine vasopressin (AVP), catecholamines, and the renin angiotensin-aldosterone system.[9] In particular, the primary mechanism is dilutional hyponatremia triggered by osmolality independent secretion of AVP. Baroreceptor mediated hormonal release reflects the severity of heart failure, worsens cardiac remodeling in itself, and thus could be one of the independent prognostic factor. However, the role of hyponatremia as a prognostic factor in MI still remains understudied. Therefore, this study was conducted to evaluate the prognostic significance of hyponatremia in acute MI- STEMI and NSTEMI.

MATERIALS AND METHODS

This prospective, longitudinal observational study was conducted under the Department of Medicine, MGM Medical College and Hospital, Navi Mumbai from December 2018 to October 2020. Prior approval of the Institutional Ethics Committee was taken before the start of the study. A written signed informed consent was taken from the parents/guardians before enrolling the subjects in the study. A total of 152 cases of acute MI who met the inclusion and exclusion criteria were included in the study.

Inclusion criteria

Patients diagnosed with acute MI (STEMI and NSTEMI) at the time of admission, irrespective of age, sex, and other baseline characteristics.

Exclusion criteria

The following criteria were excluded from the study:

1. Low left ventricular ejection fraction (LVEF) (<35%)
2. Major comorbidities contributing to disease severity or death or hyponatremia - such as chronic renal failure, liver cirrhosis, pulmonary edema, diuretic use, age, and Killip class 3 or 4
3. Mortality due to accident/suicide/non-compliance/causes deemed unrelated to the underlying disease
4. Mortality due to complications due to thrombolysis - such as allergic reaction or micro embolization
5. Participants who do not consent to participate in the study.

Materials used were (1) standard weighing machine, (2) stethoscope, (3) sphygmomanometer for blood pressure measurement, (4) consumables for the estimation of serum sodium levels, CK-MB and Troponin T, and (5) setup for thrombolysis/primary PCI.

Methodology

Detailed history of present illness along with personal and history were taken from all the patients and recorded. General and systemic examinations were carried out. Weight was measured by the standard weighing machine. The left arm supine blood pressure was recorded using sphygmomanometer. It was repeated after 5 min. The average of the two readings was recorded as the patient's blood pressure. Electrocardiogram was done for the diagnosis of acute MI as follows: STEMI -presence of new ST-segment elevation of at least 1 mm (0.1 mV) in continuous leads or new left bundle-branch block on the index or electrocardiogram. NSTEMI - ST-segment depression or T wave inversion with corroborating laboratory evidence of infarction (rising CKMB/Troponin T levels).

Based on the general and systemic examination, the patients were classified as per Killip's classification.

LVEF was measured by 2D ECHO. Patients were grouped into those having LVEF 45% or less and those having LVEF more than 45%.

Various laboratory investigations were carried out viz. Serum sodium levels were assessed at the Central Laboratory using the Beckman Coulter AU480 Photometric Chemistry analyzer; Serum creatinine; CKMB; and Troponin T.

On the basis of serum sodium levels the patients were grouped as Normal: Equal to or more than 135 mmol/L and Hyponatremia: <135 mmol/L the patients having hyponatremia were further classified as mild: 130–134 mmol/L, moderate: 125–129 mmol/L, and severe: <125 mmol/L. GRACE score (Total: 1–372) was also calculated.

Patients requiring reperfusion therapy (thrombolysis/primary PCI) were managed with the appropriate intervention and recorded. Any events during the procedure and complications arising thereafter were recorded. Length of hospital stay was noted. Any mortality occurring during the follow-up period of 30 days was recorded.

Statistical analysis

The data were analyzed using statistical software SPSS v. 20.0. The Numerical/Continuous data were expressed as Mean ± Standard Deviation and the Categorical data were expressed as Percentages. The Numerical/Continuous data were analyzed by the "Unpaired t test" and "One-Way Analysis of variance" and the Categorical data were analyzed by the "Chi-square test" or "Fischer's exact test." $P < 0.05$ was considered as "statistically significant." Odds ratio along with 95% CI was calculated wherever required. Where zeros caused problems with computation of the odds ratio or its standard error, Haldane's correction was applied by adding 0.5 to all cells. A standard normal deviate (z-value) is calculated as ln (OR)/SE {ln (OR)}, and the *P*-value is the area of the normal distribution that falls outside ±z.

RESULTS

Hyponatremia was present in 39.47% of the total cases. The mean age of patients with hyponatremia was 54.50 ± 10.21 with most patients falling between 41 and 70 years, similar to the age distribution of patients with normal sodium levels with no significant statistical difference between the two groups. The study group consisted of 73.03% males. The mean age was higher in females as compared to males and the age difference between males and females was statistically significant.

Table 1 shows the gender-wise distribution of hyponatremia. The differences were statistically insignificant ($P = 0.658$). Further, on the basis of severity, mild cases were the most prevalent (71.67%) and severe cases were the least prevalent (3.33%).

Table 2 shows the distribution of the mean GRACE and TIMI scores according to the presence of hyponatremia. Both the mean scores were higher in cases with hyponatremia ($P < 0.0001$).

Table 3 shows the distribution of the mean GRACE and TIMI scores according to the severity of hyponatremia. Both the scores showed an increasing trend with the increase in the severity of hyponatremia. The difference was statistically significant ($P < 0.0001$ and 0.001, respectively).

Overall, length of hospital stay in the present study was 9.99 ± 8.69 days according to the presence of hyponatremia. In hyponatremia patients, it was 9.27 ± 7.78 days and in normal cases, it was 10.46 ± 9.25 days but the difference was found to be statistically insignificant ($P = 0.411$).

Table 4 shows the distribution of the comorbidities according to the presence of hyponatremia. Statistically significant differences were noted in the prevalence of diabetes mellitus in the two groups.

History of IHD according to hyponatremia in the study population was 6.58%. The difference between the two groups was statistically insignificant ($P = 0.194$). History of PTCA according to hyponatremia was 3.29% insignificant ($P = 0.384$). History of COPD according to hyponatremia was 2.63% ($P = 0.647$). History of hypertension was 48.68% ($P = 0.793$). History of diabetes mellitus was 36.18%. A total of 53.33% of the cases with hyponatremia had diabetes mellitus compared to 25% of cases having normal serum sodium ($P < 0.0001$). Distribution of obese patients according

Table 1: Gender and hyponatremia wise distribution of the study population

	Hyponatremia		Normal		Total		*P*-value (by Chi-square test)
	n	%	*n* n	%	*n*	%	
Females	15	9.86	26	17.11	41	26.97	0.658
Males	45	29.61	66	43.42	111	73.03	
Total	60	39.47	92	60.53	152	100	

Table 2: Distribution of the mean GRACE and TIMI scores in the study population according to the presence of hyponatremia

Scores	Hyponatremia	Normal	Total	*P*-value (by unpaired *t*-test)
GRACE score	110.63±23.04	96.43±17.32	102.04±20.90	<0.0001*
TIMI score	4.05±2.03	2.49±1.35	3.11±1.82	<0.0001*

*significant

Table 3: Distribution of the GRACE and TIMI scores in the study population according to the severity of hyponatremia

Scores	Mild	Moderate	Severe	Total	*P*-value (by unpaired *t*-test)
GRACE score	105.67±18.78	114.67±15.90	187±1.41	110.63±23.04	<0.0001*
TIMI score	3.56±1.48	4.93±2.15	8±5.66	4.05±2.03	0.001*

*significant

Table 4: Distribution of comorbidities according to the presence of hyponatremia

Parameter	Hyponatremia		Normal		Total		*P*-value (by "Chi-square test/Fischer's exact test")
	n	%	*n*	%	*n*	%	
Previous IHD	6	3.95	4	2.63	10	6.58	0.194
Previous PTCA	3	1.97	2	1.32	5	3.29	0.384
COPD	2	1.32	2	1.32	4	2.64	0.647
HTN	30	19.74	44	28.94	74	48.68	0.793
DM	32	21.05	23	15.13	55	36.18	<0.0001*
Obesity	3	1.97	4	2.63	7	4.60	0.999
Dyslipidemia	12	7.89	9	5.93	21	13.82	0.074
Others	11	7.24	11	7.24	22	14.48	0.275
Alcohol	8	5.26	8	5.26	16	10.52	0.362
Tobacco	19	12.50	24	15.79	43	28.29	0.455

*significant

to hyponatremia had overall prevalence 4.61% (P = 0.999). The presence of dyslipidemia according to hyponatremia had overall prevalence 13.82% (P = 0.074).

Table 5 shows the distribution of the type of MI according to the presence of hyponatremia. Overall, more cases of STEMI (n = 115, 75.66%) were present, and there was no significant difference in prevalence of STEMI versus NSTEMI with respect to hyponatremia (P = 0.075).

Type of STEMI according to the presence of hyponatremia showed that overall, there were more cases of AWMI (64.35%) and was seen to be more in cases of hyponatremia (39/50, 78%) as well, the difference between the two groups being statistically significant (P = 0.007). In the present study, hyponatremia was associated with a significantly lower LVEF. The difference between the two groups was statistically significant (P < 0.0001). LVEF according to the severity of hyponatremia was statistically insignificant (P = 0.385).

Distribution of primary reperfusion according to the presence of hyponatremia showed that a total of 67 out of 152 patients underwent primary reperfusion with either primary PCI or thrombolysis, out of which 27 had hyponatremia on admission and 40 had normal serum sodium levels. No significant association was found between intervention with primary reperfusion and presence of hyponatremia (P = 0.853).

In the present study, various complications according to thrombolysis/primary PCI and the presence of hyponatremia showed that 21 out of 60 (35%) patients suffered complications post MI, out of which 12 had undergone primary reperfusion with thrombolysis or primary PCI. The group with normal sodium levels had a total of 14 out of 92 patients (15.21%) with complications post MI and 6 out of them had undergone primary reperfusion. A statistically significant association was seen between presence of hyponatremia and poorer outcome in terms of complications post-MI (P = 0.010). The presence of primary intervention with reperfusion strategies did not seem to improve outcomes in patients with hyponatremia, emphasizing that hyponatremia could be an independent prognostic marker in patients with acute MI.

The most common complications were heart failure, followed by CHB, arrhythmias, and AKI. Heart failure was more common in the group with hyponatremia (13 out of 27, 48.1%) as compared to the group with normal sodium levels (3 out of 14, 21.4%). No significant statistical association was seen between any particular complication and hyponatremia (P = 0.21).

Mortality according to primary reperfusion with thrombolysis/primary PCI and the presence of hyponatremia was associated with higher mortality (3 out of 4); however, there was no significant association between the two (P = 0.262). The presence of primary reperfusion did not affect the outcome in cases with hyponatremia [Table 6].

The odds of complications (including death) was 2.91 times in the cases with hyponatremia as compared to cases with normal serum sodium levels, 2.47 times in the cases with mild hyponatremia as compared to cases with normal serum sodium levels, 3.42 times in the cases with moderate hyponatremia as compared to cases with normal serum sodium levels, and 25 times in the cases severe hyponatremia as compared to cases with normal serum sodium levels. All of these values were statistically significant, further emphasizing the association of hyponatremia with overall higher incidence of complications and higher mortality.

Table 5: Distribution of the study population according to the type of MI and hyponatremia

Type of MI	Hyponatremia		Normal		Total		P-value (by Chi-square test)
	n	%	n	%	n	%	
NSTEMI	10	6.58	27	17.76	37	24.34	0.075
STEMI	50	32.89	65	42.77	115	75.66	
Total	60	39.47	92	60.53	152	100	

DISCUSSION

Hyponatremia, defined as a serum sodium concentration <135 mEq/L, is the most common electrolyte disorder in hospitalized patients.[10] Both admission and hospital acquired hyponatremia are associated with an increased risk for adverse outcomes, including prolonged hospital stay, need for discharge to a short or long-term care facility, and all-cause mortality.[11] Hyponatremia also increases the morbidity and mortality following MI.[12,13]

Table 6: Distribution of odds ratio of complications (including death)

Parameter	Complications	No complications	Odds ratio	P-value#	95% CI	
					Lower bound	Upper bound
Hyponatremia	22	38	2.9719	0.0051*	1.3861	6.3720
Normal	15	77				
Mild	14	29	2.4782	0.0351*	1.0652	5.7651
Normal	15	77				
MOD	6	9	3.4222	0.0396*	1.0602	11.0462
Normal	15	77				
Severe	2	0	25.00	0.0408*	1.1432	546.6893
Normal	15	77				

#P-value calculated on the basis of z value, *significant

In the present study, it was observed that the mean age of the study population was 54.91 ± 10.14 years. A male preponderance was noted (73.03%). The mean age of females (59.46 ± 9.42 years) was more than males (53.23 ± 9.92 years) and the difference was statistically significant ($P = 0.001$). Furthermore, when assessed in terms of hyponatremia, the age and gender-wise differences were statistically insignificant ($P > 0.05$).

In the prospective observational study by Islam *et al*.[14] conducted to study the effects of early development of hyponatremia on in-hospital outcomes in acute STEMI, they included a 100 cases (50 each of hyponatremia and of normal sodium levels). They found that the mean age of the study population was 52.88 ± 11.81 years. They found that the age- and gender-wise differences between the two groups ($P > 0.05$). This was similar to the present study.

In the study by Goldberg *et al*.[15] conducted to assess the prognostic importance of hyponatremia in acute STEMI, they included a total of 1047 patients. They observed a male preponderance (78.03%). They also found that the age- and gender-wise differences between the two groups ($P > 0.05$). This was similar to the present study.

Therefore, it can be effectively concluded that MI shows male preponderance with no significant age and gender differences according to the presence of hyponatremia.

In the present study, it was observed that hyponatremia was present in 39.47% of the cases. When assessed in terms of severity, it was observed that the majority of the cases had mild hyponatremia (71.67%), followed by moderate hyponatremia (25%) and severe hyponatremia (3.33%).

In the study by Tada *et al*.,[16] they evaluated whether early development of hyponatremia implicates short and long term outcomes in acute STEMI. They included a total of 140 cases. They found that the prevalence of hyponatremia was 20.71%. This was almost similar to the present study.

In the present study, it was observed that the history of previous IHD was present in 6.58% of cases, previous PTCA in 3.29% cases, COPD in 2.64% cases, hypertension in 48.68% cases, diabetes mellitus in 36.18% of the cases, obesity in 4.60% cases, and dyslipidemia in 13.82% cases. About 14.48% of the cases had other comorbidities. These included arthritis, asthma, muscular dystrophy, CVA, RHD, atrial fibrillation, hypothyroidism, and muscular dystrophy. The difference in the presence of comorbidities in the populations having hyponatremia and those having normal serum sodium levels was statistically insignificant ($P > 0.05$), except in case of diabetes mellitus ($P < 0.0001$). The prevalence of diabetes mellitus was significantly more in the cases of MI with hyponatremia (53.33%) than in those with normal serum sodium levels (25%).

This was similar to the present study. In another study by Choi *et al*.[17] conducted to assess the prognostic impact of hyponatremia occurring at various time points during hospitalization on mortality in patients with acute MI, they included a total of 1863 patients. They found that the prevalence of hypertension was 48.42%, diabetes mellitus was 27.42%, coronary artery disease was 12.9%, and hyperlipidemia was 4.56%. The prevalence of hypertension and diabetes mellitus was significantly more in the MI cases with hyponatremia than in those with normal serum sodium levels ($P < 0.05$). This was almost similar to the present study, except for the prevalence of hypertension which was higher in the hyponatremia group, although not statistically significant.

Thus, it can be effectively concluded that amongst the various comorbidities, diabetes mellitus is significantly more prevalent in MI cases with hyponatremia than in those with normal serum sodium levels.

In the present study, it was observed that the prevalence of alcohol consumption was present in 10.52% of cases and tobacco consumption was present in 28.29% of the cases. The difference between the populations having hyponatremia and those having normal serum sodium levels was statistically insignificant ($P > 0.05$).

In the study by Islam *et al*.[14] conducted to study the effects of early development of hyponatremia on in-hospital outcomes in acute STEMI, they found that the prevalence of smoking was 46%. They found that the difference between the populations having hyponatremia and those having normal serum sodium levels was statistically insignificant ($P = 0.455$). This was similar to the present study.

In another study by Choi *et al*.[17] conducted to assess the prognostic impact of hyponatremia occurring at various time points during hospitalization on mortality in patients with acute MI, they included a total of 1863 patients. They found that the prevalence of smoking was 60.22%. The difference between the groups was statistically insignificant ($P = 0.158$). Although the prevalence was much higher than the present study, the insignificant difference between the groups was similar to the present study.

Thus, it may be concluded that there is no significant difference between the two populations with respect to personal habits.

In the present study, it was found that the mean score was 102.04 ± 20.90. The mean score was higher in the population with hyponatremia (110.63 ± 23.04) than the population with normal serum sodium (96.43 ± 17.32). The difference between the two populations was statistically significant ($P < 0.0001$). When assessed in terms of severity of hyponatremia, it was observed that the mean scores increased with the increase in the severity of hyponatremia. The difference was statistically significant ($P < 0.0001$).

In the present study, it was found that the mean score was 3.11 ± 1.82. The mean score was higher in the population with hyponatremia (4.05 ± 2.03) than the population with normal serum sodium (2.49 ± 1.35). The difference between the two populations was statistically significant ($P < 0.0001$).

When assessed in terms of severity of hyponatremia, it was observed that the mean scores increased with the increase in the severity of hyponatremia. The difference was statistically significant ($P = 0.001$). No prior studies have been found which assess the correlation of severity of hyponatremia with other prognostic indicators of hyponatremia like TIMI and GRACE scores. A positive correlation between the two could mean that poorer outcomes in cases of acute MI with hyponatremia could be related to the other poor prognostic factors associated with severe acute MI such as higher age, lower LVEF, or presence of other complications such as heart failure, AKI, or arrhythmias. Hence, although hyponatremia can be used as a poor prognostic marker in scoring systems which include other factors as well, using it alone to guess outcome would not be prudent, since it is yet to be understood whether hyponatremia is an independent prognostic marker.

In the present study, it was found that the mean duration of hospital stay was 9.99 ± 8.69 days. The difference between the two populations was statistically insignificant ($P = 0.411$). The length of hospital stay at our institute was influenced by several factors other than the severity of disease, most often due to financial or administrative issues. Therefore, prolonged hospital stay was not used as a marker of outcome in our study and was not found to be associated with severity of hyponatremia or complications.

In the present study, it was observed that the majority of the cases had STEMI (75.66%). The difference between the populations having hyponatremia and those having normal serum sodium levels was statistically insignificant ($P = 0.075$).

Amongst the STEMI cases, AWMI was more prevalent (64.35%). It was also observed that AWMI was more in the population with hyponatremia (78%) than in the population with normal serum sodium (53.85%). The difference between the populations having hyponatremia and those having normal serum sodium levels was statistically significant ($P = 0.007$).

In the study by Devi *et al*.[18] conducted on 100 patients of acute STEMI, they found that the overall prevalence of IWMI was 44%. When assessed in terms of hyponatremia, they found that the prevalence of IWMI was 43.2% in the cases with hyponatremia versus 56.8% in the cases without hyponatremia ($P = 0.002$). Thus, they concluded that hyponatremia was more commonly associated with anterolateral wall, anteroseptal and anterior wall STEMI compared to other sites. This was similar to the present study.

Thus, it can be effectively concluded that STEMI is more prevalent than NSTEMI in hyponatremia and hyponatremia is more commonly associated with AWMI.

In the present study, it was observed that the mean LVEF was 44.64 ± 8.28% (range: 35–60%). Majority of the cases (67.11%) had LVEF <45%. The mean LVEF was found to be lesser in the population with hyponatremia (41.58 ± 7.62%) than the population with normal serum sodium levels (46.63 ± 8.12%), as expected. The difference between the two populations was statistically significant ($P < 0.0001$). When assessed in terms of severity of hyponatremia, the difference between the groups was statistically insignificant ($P = 0.385$).

In the study by Goldberg *et al*.[15] conducted to assess the prognostic importance of hyponatremia in acute STEMI, they found that the mean ejection fraction was 42 ± 13%. The mean ejection fraction was lower in cases of hyponatremia on admission and those developing hyponatremia within 72 h than in the cases with normal sodium level. The difference between the groups was statistically significant ($P < 0.0001$). This was similar to the present study.

In another study by Devi *et al*.,[18] they observed that the patients who presented with or developed hyponatremia more often had lower LVEF (58.88 ± 8.31% vs. 63.15 ± 6.89%, $P = 0.007$). This was similar to the present study.

Thus, it can be effectively concluded that the mean LVEF is significantly lower in cases of hyponatremia than with normal serum sodium levels.

In the present study, thrombolysis/primary PCI was done in a total of 44.08% cases. The difference between the populations having hyponatremia and those having normal serum sodium levels was statistically insignificant ($P = 0.853$). The presence of primary intervention with reperfusion strategies did not seem to improve outcomes in patients with hyponatremia. In the study by Goldberg *et al*.[15] conducted to assess the prognostic importance of hyponatremia in acute STEMI, they included a total of 1047 cases. They found that reperfusion therapy (thrombolysis/primary angioplasty) was done in 52.34% of the cases. This was higher than the present study.

In the present study, it was observed that complications were present in a total of 23.03% of the cases. The spectrum of complications included Acute Kidney Injury, Aortic Regurgitation, Complete Heart Block, Heart Failure, Acute Stent Thrombosis, Cerebrovascular Accident, and with HF being the most common complication in 39.02% of cases. More complications were present in the group with hyponatremia and the difference between the groups was statistically significant ($P = 0.010$).

The proportion of cases having complications among those who underwent intervention versus those who did not were comparable in the population having normal serum sodium levels (14.63% vs. 15.68%). But when assessed in the population with hyponatremia, complications were present in 46.15% of the cases who underwent intervention versus 26.47% of the cases who did not undergo the intervention. This, at the very least, implies that primary reperfusion strategies do not influence outcomes (in terms of complications post MI) in hyponatremia.

Furthermore, it was observed that the odds of complications (including death) was 2.91 times in the cases with hyponatremia as compared to cases with normal serum sodium levels, 2.47 times in the cases with mild hyponatremia as compared to cases with normal serum sodium levels, 3.42 times in the cases with moderate hyponatremia as compared to cases with normal serum sodium levels, and 25 times in the cases severe hyponatremia as compared to cases with normal serum sodium levels.

In the present study, mortality was present in 2.64% of the cases. Of the four cases that expired, three had hyponatremia. When assessed in terms of intervention with primary reperfusion therapies like thrombolysis and PCI, the difference between the populations having hyponatremia and those having normal serum sodium levels, was statistically insignificant (P = 0.262), meaning primary intervention was not associated with improved in-hospital mortality in cases with hyponatremia. In the study by Devi *et al*.,[18] they observed that the mortality rate was 6%, of the six cases that expired four cases had hyponatremia. This was almost similar to the present study.

Limitations of the study

This study is limited by the OPD attendance and attendance of the patients in the Emergency Department due to the COVID-19 pandemic. Therefore, the results may not be generalized to the general population. Furthermore, in the present study serum sodium levels were assessed only at the time of admission. Furthermore, as the patients were followed up only till discharge, the long-term effects of hyponatremia could not be assessed by the present study.

CONCLUSION

It was found in the present study that hyponatremia was present in 39.47% of the cases of acute MI. Mild hyponatremia was more prevalent than severe hyponatremia. The GRACE and TIMI scores were higher in cases with hyponatremia and there was an increase with increase in the severity of hyponatremia. LVEF was also lower in the cases with hyponatremia. The odds of complications (including death) were 2.91 times in the cases with hyponatremia as compared to cases with normal serum sodium levels and an increase in the odds ratio was observed along with the increase in the severity of hyponatremia. Thus, it can be concluded that the severity of MI is more in cases with hyponatremia and hyponatremia is associated with poorer outcomes in terms of complications post-MI and mortality, as observed in previous similar studies. Although hyponatremia may not be an independent marker of poor outcome, sodium levels in prognostic scoring systems have not yet been used and could be of added value, similar to scoring systems for other diseases such as the MELD score for chronic liver disease.

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How to cite this article: Sinha S, Ghanekar J, Farooqui A. A Study on the Prognostic Significance of Hyponatremia in Acute Myocardial Infarction - A Prospective Longitudinal Study. Bombay Hosp J 2022;64(4):1-7.

Source of support: Nil, **Conflicts of interest:** None