Study of Serum Magnesium Levels in Patients with Acute Myocardial Infarction: A Case-Control Study

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Abstract

Background: Magnesium is important in cardiovascular physiology being a cofactor in many enzymatic reactions and also stabilizing myocardial electrical activity. The role of changes in serum magnesium levels in the pathogenesis and complicate acute myocardial infarction (AMI), especially arrhythmias has been contributed. This work was done to determine serum magnesium levels of patients with AMI against healthy controls and investigate its relation to arrhythmias and patient outcomes. **Material and Methods:** It was a tertiary care case-control study that was carried out at a hospital in the Central region of India between the months of December 2022 and December 2024. The cases enrolled were sixty-two patients with a diagnosis of ST-elevation myocardial infarction (STEMI) that presented within 6 hours of the onset of symptoms, and sixty-two healthy age- and sex-matched age-matched controls. Magnesium ion in serum was detected by ion selective electrode technique. Electrocardiographic surveillance has been done to identify arrhythmias. SPSS 22 was used to perform the statistical analysis. **Results:** AMI patients were found to have a statistically lower mean serum magnesium level compared to that of the controls (1.98 ± 0.33 mg/dL versus 2.26 ± 0.18 mg/dL; p < 0.0001). The cases were found to have hypomagnesemia (serum magnesium < 1.6 mg/dL) in 14.5% versus none in controls. Arrhythmic patients had a much lower serum magnesium level (1.57 + 0.44mg/dl) than the nonarrhythmic patients (1.99 + 0.32mg/dl; p = 0.0049). There was no significant relation found between mortality and serum magnesium level. **Conclusion:** Acute myocardial infarction patients have a tremendous decrease in serum magnesium levels which are linked to high risk of arrhythmia. Regular evaluation of serum magnesium can be useful to the risk stratification and management of AMI patients.

Keywords: Acute myocardial infarction, serum magnesium, hypomagnesemia, arrhythmias, STEMI, electrolytes.

INTRODUCTION

AMI is the major cause of morbidity and death in both developed and developing countries across the globe, as it is one of the alarming global public health issues.[1]

Although significant progress has been achieved in clinical practice regarding diagnosis, reperfusion, and pharmacological intervention, such complications as arrhythmias, heart failure, and sudden cardiac death remain a significant challenge to clinical practice.[2]

The prevalence of coronary artery disease in the world has attained epidemic levels with the rising prevalence in the low- and middle-income nations going hand in hand with their wealthier counterparts.[3]

The second best-known intracellular cation is magnesium, which is an essential element in cellular energy metabolism, protein synthesis and membrane stability.[4]

Magnesium plays a crucial role in the cardiovascular system during myocardial contractility, the ability to manage vascular tone as well as the preservation of the normal cardiac rhythm.[5]

The ion has similar effects to physiological calcium channel blockade, which alters the fixed calcium intake into myocardial cells and the duration of the action potential.[6]

The connection between magnesium deficiency and cardiovascular disease is a topic that has been receiving more and more attention over the last few decades.

Hypomagnesemia was cited to cause endothelial dysfunction, increased platelet aggregation, facilitation of coronary vasospasm, and increased atherosclerotic events.[7] Moreover, magnesium deficiency is risky to cardiac arrhythmias, such as ventricular tachycardia and fibrillation, which are significant causes of sudden death of the heart in ischemic heart disease.[8]

A number of studies have shown low levels of serum magnesium after acute myocardial infarction, and later progressively reached normalcy during the rehabilitation process.[9] Research to investigate using the myocardial tissue of the patient having ischemic heart disease has shown that magnesium deficiency is seen which is associated with the predisposition to arrhythmias.[10]

The Leicester Intravenous Magnesium Intervention Trial (LIMIT-2) provided a possible mortality effect of magnesium supplementation in AMI, though later larger studies showed

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opposing results.[11]

Although the overall literature on magnesium in cardiovascular pathophysiology is accumulating, there is still little data on magnesium in tertiary care centers within the Indian subcontinent. Considering the current burden among coronary artery diseases in this area and the possibility of developing therapeutic use on magnesium assessment, there is an urgent need to conduct additional research. The purpose of this study was to compare the serum magnesium levels of patients with acute myocardial infarction to those of healthy individuals and investigate the connection between magnesium levels and the emergence of arrhythmias.

MATERIALS AND METHODS

Study Design and Setting: The study was a two-year hospital-based case-control study that was carried out in a tertiary care teaching hospital in Maharashtra, Central India, during the period between December 2022 and December 2024 in the coronary care unit and the medical wards of this hospital. The institutional ethics committee approved the protocol of the study, and all the participants or representatives of the study gave written informed consent.

Estimating Sample Size: Sample size was calculated based on previous literature reporting mean serum magnesium levels of 1.01 ± 0.94 mg/dL in AMI patients and 2.20 ± 2.23 mg/dL in controls. With an alpha error of 1% and power of 90%, the minimum required sample size was determined to be 62 subjects per group.

Study Population: A total of 124 subjects were enrolled, comprising 62 cases and 62 controls. Patients 18 years of age and older who presented with ST-elevation myocardial infarction (STEMI) within six hours after the onset of symptoms were included in the cases. STEMI was diagnosed according to the 2018 ESC/ACC/AHA/WHF Fourth Universal Definition criteria, requiring new ST-segment elevation at the J-point in two contiguous leads with appropriate cut-point values based on age and sex.

Controls were age- and sex-matched healthy adults without history of cardiovascular disease, recruited from the general population attending the hospital for routine health check-ups.

Exclusion Criteria

Patients with previous history of ischemic heart disease, chronic kidney disease, chronic alcohol abuse, gastrointestinal disorders affecting magnesium absorption (including chronic pancreatitis, celiac disease, and gastrointestinal fistulas), and those on medications known to affect magnesium levels were excluded from the study.

Data Collection and Clinical Assessment: Detailed clinical history was obtained, including demographic data, risk factors (hypertension, diabetes mellitus, smoking, dyslipidemia, obesity, sedentary lifestyle), and presenting symptoms. Physical examination findings including vital signs, jugular venous pressure, and systemic examination were recorded. Twelve-lead electrocardiography was performed at presentation and subsequently for arrhythmia detection.

Laboratory Investigations: Blood specimens in the cases were taken within six hours of symptoms onset and in controls at enrollment. Magnesium ion was determined by ion-selective electrode (ISE) method in a system of automated analyzer. The normal serum magnesium was defined as the range of 1.6 to 2.4mg/dl. Other tests were performed in cases such as complete blood count, renal function and liver function tests, lipid profile, random blood glucose and cardiac enzymes (CK-MB, Troponin I).

Arrhythmia Assessment: All cases were taken through continuous electrocardiographic observation throughout their time of hospitalization. Arrhythmias were classified according to standard electrocardiographic criteria, including ventricular premature complexes, ventricular tachycardia, ventricular fibrillation, sinus tachycardia, sinus bradycardia, and atrioventricular blocks.

Statistical Analysis: Data were entered on Microsoft Excel, version 2016 and analyzed on SPSS version 22. Mean plus standard deviation was used to represent continuous variables and frequency and percentages were used to represent categorical variables. Independent samples t -test of continuous variables and chi-square test of categorical variables were used to compare the groups. The statistically significant p-value was taken to be less than 0.05.

RESULTS

Demographic and Clinical Characteristics.

[Table 1] gives the demographic profile of the study population. The median cases age was 55.7390.27–3370 years (337023), which was similar with control (55.388.9258). The highest number of AMI incidence was identified in the age category of 51-60 years (37.10), and then the age category of 61-70 years (32.26). Males constituted 75.81% of the study population in both groups, with a male-to-female ratio of 3.1:1.

Table 1: Demographic Characteristics of Study Population			
Parameter	Cases (n=62)	Controls (n=62)	p-value
Age (years), Mean ± SD	55.74 ± 9.27	55.38 ± 8.93	0.8286
Age 31–40 years, n (%)	5 (8.06)	5 (8.06)	—
Age 41–50 years, n (%)	14 (22.58)	14 (22.58)	—
Age 51–60 years, n (%)	23 (37.10)	23 (37.10)	—
Age 61–70 years, n (%)	20 (32.26)	20 (32.26)	—
Male, n (%)	47 (75.81)	47 (75.81)	1.000
Female, n (%)	15 (24.19)	15 (24.19)	—

Systemic hypertension was the most prevalent risk factor (40.32%), followed by type 2 diabetes mellitus (32.26%), smoking (9.68%), obesity (6.45%), dyslipidemia (4.84%), and sedentary lifestyle (6.45%). All patients presented with

chest pain (100%), followed by sweating (74.19%), breathlessness (30.65%), vomiting (14.52%), and palpitations (12.90%).

Anterior wall myocardial infarction was the most common presentation (32.26%), followed by inferior wall MI (30.65%), anterolateral wall MI (12.90%), and other territories.

Serum Magnesium Levels: Serum magnesium levels in cases and controls are presented in [Table 2]. AMI patients had a mean serum magnesium level of 1.98 ± 0.33 mg/dL, which was substantially lower than that of controls (2.26 ± 0.18 mg/dL; $p < 0.0001$). Hypomagnesemia (serum magnesium < 1.6 mg/dL) was observed in 9 cases (14.5%) compared to none in the control group ($p = 0.002$). Normal serum magnesium levels were observed in 82.25% of cases and 91.9% of controls.

Table 2: Distribution of Serum Magnesium Levels in Cases and Controls

Serum Magnesium Level	Cases, n (%)	Controls, n (%)	p-value
< 1.6 mg/dL (Low)	9 (14.5)	0 (0)	0.002
1.6–2.4 mg/dL (Normal)	51 (82.25)	57 (91.9)	—
> 2.4 mg/dL (High)	2 (3.2)	5 (8.0)	—
Mean ± SD (mg/dL)	1.98 ± 0.33	2.26 ± 0.18	<0.0001

Correlation with Arrhythmias and Outcomes

Arrhythmias were documented in 6 patients (9.68%), including ventricular premature complexes (n=5), first-degree atrioventricular block (n=1), and junctional rhythm (n=1). The correlation between serum magnesium and arrhythmias is shown in [Table 3]. Patients with arrhythmias had significantly lower serum magnesium levels (1.57 ± 0.44 mg/dL) compared to those without arrhythmias (1.99 ± 0.32 mg/dL; $p = 0.0049$). Among patients with arrhythmias, 66.7% had hypomagnesemia.

Table 3: Correlation of Serum Magnesium with Arrhythmias and Outcomes

Parameter	Serum Magnesium (Mean ± SD)	p-value
With Arrhythmia (n=6)	1.57 ± 0.44 mg/dL	0.0049
Without Arrhythmia (n=56)	1.99 ± 0.32 mg/dL	—
Expired (n=2)	1.80 ± 0.42 mg/dL	0.5287
Survived (n=60)	1.96 ± 0.35 mg/dL	—

Two patients (3.23%) expired during hospitalization. Patients who died had a mean serum magnesium level of 1.80 ± 0.42 mg/dL, while survivors had a mean of 1.96 ± 0.35 mg/dL. There was no statistically significant change ($p = 0.5287$).

Discussion

The present study demonstrates significantly reduced serum magnesium levels in patients with acute myocardial infarction compared to healthy controls, with mean values of 1.98 ± 0.33 mg/dL and 2.26 ± 0.18 mg/dL, respectively. This observation is consistent with several other studies in the past, which have continuously documented the occurrence of hypomagnesemia within acute heart syndrome scenario.[12]

In our cohort study, the frequencies of hypomagnesemia (14.5) demonstrate the clinical importance of magnesium measurement in AMI patients.

The pathophysiology of the decreased serum magnesium in AMI is complex. Acute myocardial ischemia does lead to a shift of intracellular magnesium as a result of catecholamine surge, and lipolysis-induced by stress results in the production of free fatty acids, which chelate magnesium ions.[13]

Also, urinary magnesium loss is higher after AMI, which leads to systemic depletion.[14]

The fact that hypomagnesemia had been found only in cases and not in controls also confirm a pathophysiologic correlation between magnesium status and acute coronary events.

One of the findings of the present study is that there is a high relationship between low levels of serum magnesium and arrhythmias. Patients with arrhythmias had mean levels of serum magnesium of 1.57 ± 0.44 mg/dl compared to 1.99 ± 0.32 mg/dl in the patients with no arrhythmias. This is in agreement with the known electrophysiological impact of magnesium that renders control over potassium and calcium channels, membrane potential relaxation and regulating repolarization.[15]

Hypomagnesemia lengthens the QT interval and predisposes to the activity evoked and re-entry arrhythmias.[16]

We replicate the results of Quader et al. that showed much less serum magnesium in patients with AMI with arrhythmias ($1.63 + 0.27$ mg/dl) than in those without ($2.34 + 0.38$ mg/dl).[17]

Singh et al. have also found the mean serum magnesium levels of 1.73 ± 0.35 mg/dL in arrhythmic patients compared to 2.17 ± 0.38 mg/dL in suppressed arrhythmia patients.[18]

These observations are consistent in various populations thus reinforcing the role of magnesium in arrhythmogenesis in the post-AMI period.

Epidemiological data on the study population, where men were dominant (75.81) and most of the cases occurred between the ages of fifth and sixth decades, is typical of well-known epidemiological trends of coronary artery disease.[19]

The first risk factors were hypertension and diabetes mellitus, which will reflect the increased prevalence of metabolic risk factors among the Indian population.[20]

Even though the mean level of serum magnesium was lower in the patients that died ($1.80 + 0.42$ mg/dL) than in those that survived ($1.96 + 0.35$ mg/dl), the difference was not statistically significant, probably due to the small number of deaths (n=2). Popular larger researches with sufficient power to study

mortality variations are justified to shed light on the prognostic function of serum magnesium in AMI.

These findings have therapeutic implications, which deserve consideration. Condron and MAGIC trials did not show the mortality benefits of routine magnesium supplementation in the attainment of AMI.[21]

Nevertheless, specific therapy in those patients with known hypomagnesemia can be a useful practice, especially in the way of preventing arrhythmia.[22]

Recent evidence suggests the replacement of magnesium in the established deficiency status and in selected arrhythmia like torsades de pointes.[23]

This study has several limitations such as the one-centered design, somewhat small sample, and the failure to measure the intracellular magnesium levels, which can be more appropriate to represent the overall body magnesium state. Furthermore, serial magnesium samples in the hospital would have given information on temporal variation after AMI.

Conclusion

This paper indicates that patients with acute myocardial infarction have much less serum magnesium levels than their healthy counterparts. Moreover, low serum magnesium contents have a strong correlation with the occurrence of arrhythmias during the acute myocardial infarction. This was found not to have a significant correlation with mortality, but this could be due to this small sample size. These results justify the fact that regular measurement of serum magnesium in patients with acute myocardial infarction should be used since the presence of hypomagnesemia can be used to introduce targeted treatment measures that are directed to curb arrhythmic complications. Multicenter studies should be made larger to better understand the prognostic value of serum magnesium, and the possible advantages of using magnesium supplementation in the context of the given clinical scenario.

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Conflicts of interest
There are no conflicts of interest.

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