RESEARCH ARTICLE

DOI: 10.4274/ijca.2024.96268
Int J Cardiovasc Acad 2025;11(1):23-28

A Study of Serum Magnesium Levels in Patients with Acute Myocardial Infarction in the Rural Population of Vijayapura District

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Abstract

Background and Aim: Magnesium is an essential element for the proper functioning and regulation of cardiovascular physiology. It acts as a vital helper molecule in various enzyme systems and is involved in multiple cardiovascular processes. These processes include intracardiac conduction, myocardial contraction, atherogenesis, thrombosis, regulation of vascular tone, and the proliferation and migration of endothelial cells and vascular smooth muscle. The aim of this study was to evaluate the relationship between serum magnesium concentration and their correlation with complications and in-hospital outcomes in acute myocardial infarction (AMI) patients.

Materials and Methods: This observational study included patients who were admitted to a tertiary care centre in India from December 2019 to September 2021. A total of 100 patients with AMI were enrolled in the study. Serum magnesium concentration was assessed using the calmagite method. The patients were followed up for 7 days during their hospitalization to monitor complications and in-hospital outcomes.

Results: The serum magnesium concentration was between 1.1 mg/dL and 4.0 mg/dL. There were 28 patients with hypomagnesemia and 11 patients with hypermagnesemia. The study population consisted of 57% male, and the majority of patients were in the age group of 60-80 years (38%). A typical clinical presentation was observed in 61% of the patients, while 39% of patients displayed an atypical clinical presentation. Higher proportions of patients with typical clinical presentation were significantly observed to have hypomagnesemia ($P = 0.037$). Among the total patient population, 20% experienced QT-prolongation in our study. Patients with hypomagnesemia experienced more complications, but patients with hypermagnesemia were associated with an increased rate of mortality.

Conclusion: In patients with AMI, hypomagnesemia was associated with an increased incidence of complications. Conversely, hypermagnesemia was linked to increased mortality among patients.

Keywords: Hypermagnesemia, hypomagnesemia, mortality, myocardial infarction, outcomes

To cite this article: Bangi SMH, Hidayethulla M, Golla A, Kausar ST, Kadloor P. A study of serum magnesium levels in patients with acute myocardial infarction in rural population of Vijayapura district. Int J Cardiovasc Acad. 2025;11(1):23-28

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Received: 25.10.2024
Accepted: 26.12.2024
Publication Date: 18.03.2025

INTRODUCTION

Ischemic heart disease (IHD) is one of the prominent causes of morbidity and mortality globally. Myocardial ischemia due to atherosclerotic coronary artery disease (CAD) can result in acute myocardial infarction (AMI), unstable angina, or effort angina.[1] Out of all, AMI is the most common and serious event leading to emergency hospital admissions.[1] In the human body, magnesium is an important element following calcium, potassium, and sodium, also it plays a crucial role of being co-factor in numerous enzyme systems holding noteworthy role in production of DNA, RNA, adenosine triphosphate, and in the proper regulation of cardiovascular physiology; such as maintenance of ion channels, energy production, intracardiac conduction, contraction. Additionally, it also helps in atherogenesis, thrombosis, vascular tone regulation, endothelial cell and vascular smooth muscle proliferation, and migration.[2] Hence, the constant supply of magnesium to our body is essential.[3] A normal healthy range of serum magnesium concentration in our body is 0.72-1.15 mmol/L.[4] Persistent deficiency of magnesium leads to various clinical and subclinical conditions, like neuropsychiatric disorders, depression, hypertension, atherosclerosis, cardiac arrhythmias, stroke, type 2 diabetes mellitus, metabolic syndrome, changes in lipid metabolism, osteoporosis.[5] Thus, it is very important to identify how magnesium levels can be correlated with the diagnosis and treatment of cardiovascular disease.[6] Magnesium deficiency is observed in approximately 8% to 30% of in-hospital patients.[7] Patients with AMI often show hypomagnesemia.[1] In AMI, magnesium moves inside the cell compartments from the extracellular compartments because of lipolysis induced by adipocytes, following catecholamine activity, and then magnesium combines with the by-products of lipolysis. The total magnesium levels may not change during AMI, but there is a decline in extracellular magnesium concentration specifically during the first 24 to 48 hours after the onset of MI. This can cause post AMI complications such as ventricular tachycardia, sudden cardiac death (SCD), or even another heart attack.[1] Accordingly, our aim was to study the effect of serum magnesium concentration in patients with AMI and to investigate the associated complications and in-hospital outcomes.

METHODS

Study Design and Population

This is an observational, cross-sectional single-centred study conducted at a tertiary care centre in India from December 2019 to September 2021. A total of 100 patients diagnosed with AMI were included in the study. Eligibility criteria for the study were determined by the inclusion and exclusion criteria. Patients older than 18 years diagnosed with AMI based on their history, clinical examination, electrocardiogram (ECG) changes, and biochemical markers for MI were included in the study. Based on the type of clinical presentation, the patients were divided into typical and atypical types of symptoms. Atypical symptoms usually include epigastric pain, back pain and are characterized by indigestion, burning or stabbing. Typical symptoms are those that include chest pain, arm pain, or pain in the jaws.[8] Patients with history and any cause of hepatitis, history of MI or diagnosed with Crohn's disease, cirrhosis of liver and patients with chronic malnutrition were excluded from the study. Patients on drugs such as thiazide diuretics, and loop diuretics, and antibiotics including aminoglycosides, amphotericin, pentamidine, gentamycin, tobramycin, and other drugs such as digitalis and adrenergics were also excluded from the study. After detailed counseling, all the patients in the study provided written consent in their own language before being included. The study was conducted in accordance with the Declaration of Helsinki, and after receiving approval from the Al-Ameen Medical College Ethical Committee of the institution with (approval number: IEC/AAMC/2019/0098, date: 20.10.2019).

Data Collection

Patients were observed for complications, including conduction abnormalities like sinus bradycardia, bradyarrhythmia (conduction blocks), tachyarrhythmia (ventricular tachycardia, supraventricular tachycardia, atrial fibrillation), ventricular ectopies, and heart failure in the emergency and intensive coronary care unit departments of our institution. A detailed history of patients along with general examination, systemic examination and investigations was performed. The estimated serum magnesium concentration ranged from 1.1 mg/dL to 4.0 mg/dL in the study. The mean serum magnesium level in the present study was 2.1 mg/dL.

Laboratory Investigation

The serum magnesium concentration of patients was collected on the day of admission. Other investigations, including random blood sugar, ECG, cardiac biomarkers, trop-T/CPK-MB, 2D-ECHO/DOPPLER, were also done. The Calmagite method was used to determine the serum magnesium concentration. In this method, the magnesium combines with calmagite in an alkaline medium to form a red complex. By using selected binding agents and detergents, the test eliminates calcium and protein interference. Colour intensity increases in direct proportion to the sample's magnesium concentration.

Follow-up Schedule

The patients were followed up for 7 days during their hospitalization and observed for development of complications before discharge.

Definition

Concentrations of serum magnesium between 1.7 and 2.55 mg/dL are considered normal for all individuals, regardless of age or gender. When a patient's serum magnesium falls below 1.7 mg/dL, it's classified as hypomagnesemia. Conversely, if serum magnesium exceeds 3.0 mg/dL, the condition is termed hypermagnesemia.

Statistical Analysis

SPSS Software v.23 (IBM Statistics, Chicago, USA) was used to analyze the collected data. Mean and standard deviation were used for continuous variables and number and percentage were used for categorical data. For association between two categorical variables, the chi-square (χ^2) test was used. The Fisher-Freeman-Halton exact test was employed in cases of more than 30% cell frequency <5 to determine the significance of the differences among the groups of categorical data. The results were statistically significant if the p-value was <0.05.

RESULTS

A total of 100 patients were included in the study. The gender composition showed a slight male predominance, with 57 male patients and 43 female patients. Age distribution revealed a predominant representation of older patients, with the largest group aged 60-80 years (n=38). There were 3 patients who were less than 20 years old, 14 patients were between the age group of 20-40 years old, 26 patients 40-60 years old, and 19 patients belonged to the age group greater than 80 years old. Serum magnesium level analysis showed that 28 patients had hypomagnesemia (<1.8 mg/dL), 61 patients had normal levels of magnesium (1.8-2.5 mg/dL) and 11 patients had hypermagnesemia (>2.5 mg/dL). Enrolled patients were grouped based on their addictive habits. Thirty patients were observed to have addictive habits. Smoking was found to be the most common of all examined risk factors. Fourteen were smokers, hypomagnesemia was present in 2 (7.1%) patients, 11 (18%) had normal levels of serum magnesium and only 1 (9.1%) had hypermagnesemia. Tobacco chewing was done by 12 patients, of whom 2 (16.7%) patients had hypomagnesemia, 7 (58.3%) (11.5%) patients had normal serum magnesium concentration, and 3 (25%) (27.3%) had hypermagnesemia. Alcohol consumption was seen in 2 patients, of whom 1 (1.6%) had normal serum magnesium concentration and 1 (9.1%) had hypermagnesemia.

Figure 1 illustrates the association between serum magnesium concentration and age.

Based on the clinical presentation, patients were classified into groups exhibiting typical and atypical symptoms. Around 61% of patients showed typical presentation, and 39% atypical presentation. The correlation of clinical presentation and ECG changes with serum magnesium concentration is shown in Table 1. Patients were classified into ST elevation MI (STEMI) and non-STEMI (NSTEMI) based on their ECG changes. The STEMI was found in 67% of the patients and NSTEMI in 33%. Bedside echocardiography was performed to identify which region of the heart was involved. The echocardiographic findings are shown in Figure 2. In our study, echocardiography for three patients was not performed because they died before the procedure could be conducted. Complications were seen in 22 patients over a period of 5 days during their hospital stay. During the course of hospitalization, a total of 9 patients did not survive. Table 2 shows the data of correlation between complications and cause of death in association with serum magnesium concentration in patients. The rate of complications was high in patients with hypomagnesemia, and patients who did not survive had hypermagnesemia.

Among the total patient population, 20% demonstrated QT-interval prolongation on their ECG, with a significant

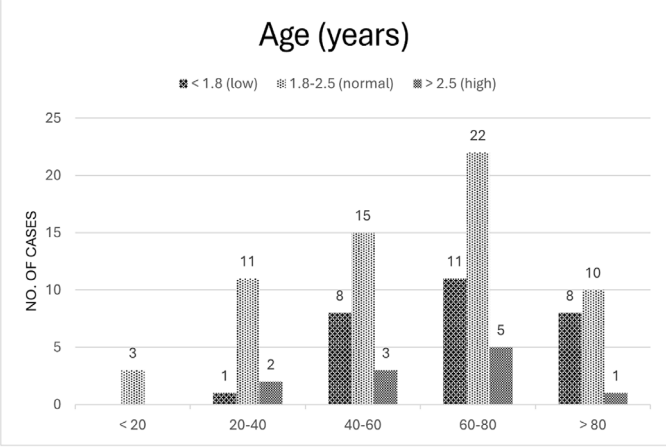

Figure 1: Association among serum magnesium concentration and age

Table 1: Correlation of serum magnesium with clinical presentation and ECG changes

Variables	<1.8 (low) (n=28 patients)	1.8-2.5 (normal) (n=61 patients)	>2.5 (high) (n=11 patients)	*P*-value
Clinical presentation				
Typical	20 (71.4)	38 (62.3)	3 (27.3)	0.037
Atypical	8 (28.6)	23 (37.7)	8 (72.7)	
ECG changes				
STEMI	21 (75)	41 (67.2)	5 (45.5)	0.210
NSTEMI	7 (25)	20 (32.6)	6 (54.5)	

Data are expressed as n (%). *P*-value <0.05 was considered statistically significant.

ECG: Electrocardiogram, NSTEMI: Non-ST segment elevation myocardial infarction, STEMI-ST: Segment elevation myocardial infarction

prevalence observed in patients with STEMI. QT-prolongation was notably associated with several cardiac complications, including sinus bradycardia and ventricular ectopy. Of particular clinical significance, patients experiencing SCD and ventricular tachycardia also exhibited QT-prolongation, which was identified as a potentially contributing factor to patient mortality.

DISCUSSION

This study investigated the relationship between the levels of serum magnesium and its effects on complications and cause of death in patients diagnosed with AMI. Over the past decades, studies have been carried out regarding the role of serum magnesium in the etiology,[9] and the pathophysiology of AMI. It was found that patients with AMI had hypomagnesemia during the first 24 hours of admission to hospital.[10] Even though serum magnesium measurements may not precisely indicate intracellular magnesium content, disturbances in its levels can cause cardiovascular disease.[11] Rahman et al.[12] in their study observed 76% of the patients were male and 70% of patients were smokers in the study group with AMI. In the present study, 57% of patients were male and 14% were smokers. In our study, most of the patient population with AMI belonged to the age group of 60-80 years (38%). In concordance with our study, another study also showed that a majority of the patient population between the ages of 61-70 years (32.5%).[13]

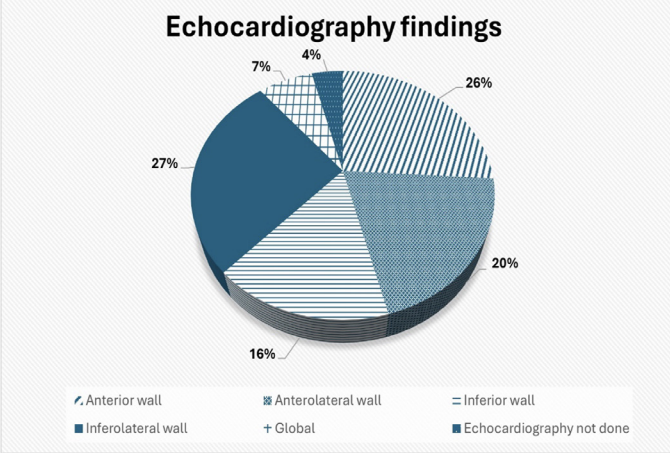

Figure 2: Echocardiographic findings

Table 2: Complications and causes of death in association with serum magnesium concentration

Variables	<1.8 (low) (n=28 patients)	1.8-2.5 (normal) (n=61 patients)	>2.5 (high) (n=11 patients)	*P*-value
Complications				
Bradyarrhythmia	6 (21.42)	2 (3.2)	0 (0.0)	0.802
Tachyarrhythmia	3 (10.7)	3 (4.9)	1 (9.09)	
Sinus bradycardia	0 (0.0)	3 (4.9)	1 (9.09)	
CCF	1 (3.5)	1 (1.6)	0 (0.0)	
Ventricular ectopy	1 (3.5)	0 (0.0)	0 (0.0)	
Cause of death				
Cardiac failure	1 (3.5)	0 (0.0)	0 (0.0)	0.161
VT	0 (0.0)	1 (1.6)	0 (0.0)	
CHB	0 (0.0)	0 (0.0)	2 (18.1)	
Sudden cardiac death	0 (0.0)	2 (3.2)	3 (27.2)	

Data are expressed as n (%). *P*-value <0.05 was considered statistically significant.

CCF: Congestive cardiac failure, CHB: Complete heart block, VT: Ventricular tachycardia

Based on the presenting complaints, patients were classified as having either typical or atypical clinical presentations in our study. Among these, chest pain emerged as the predominant clinical presentation, affecting 61% of the patients. Taha et al.[14] in their study conducted on the prevalence of hypomagnesemia in patients with AMI and its correlation to intra-hospital complications noted that 92% of patients presented with chest pain. In another study, 94% of patients complained about chest pain, which was highest among other presenting complaints.[15] Breining et al.[16] found that 66% of the patients showed a typical presentation. STEMI was diagnosed in 67% of patients while NSTEMI in 33% of patients. A study reported that out of 100 cases, 82% had STEMI and 18% had NSTEMI.[15] In contrast to our study, Singh et al.[13] found that 45% of patients had STEMI and 55% of patients had NSTEMI.

The majority of the patients were affected by inferolateral MI (27%), anterior wall MI (26%), followed by anterolateral MI (20%) which was revealed through echocardiography. While Sharma et al.[15] in their study found that patients were majorly affected by anterior wall MI (34%) followed by (21%) inferior wall MI.

The estimated serum magnesium concentration in the present study ranged from 1.1 mg/dL to 4.0 mg/dL. Among all patients, 28 had hypomagnesemia, 61 had normal levels of serum magnesium, and 11 showed hypermagnesemia. Akila et al.[9] in their study found that 16% of patients with AMI experienced hypomagnesemia with levels less than 1.6 mg/dL during admission and between 1.6-2.4 mg/dL in 34% of patients. Zia Sabah et al.[17] found that out of 160 patients in their study, 52.5% of patients with AMI on admission showed hypomagnesemia.

Out of the total patient groups, 22 experienced complications related to AMI. Half of these patients presented with reduced serum magnesium concentration. The most frequently observed complications in this subgroup were bradyarrhythmia and tachyarrhythmia. A study done by Wahid et al.[18] found that 39% of patients with hypomagnesemia were more prone to develop complications.

The rate of mortality was 9% in our study. Of, 4% of total patients had hypermagnesemia. The cause of death for 2 patients was complete heart block, while 3 patients died of SCD. In contrast to our study, Kieboom et al.[19] reported that there was an association between patients with hypomagnesemia and increased risk of coronary heart disease mortality [heart rate (HR): 1.36, 95% cardiac index (CI): 1.09-1.69] and high risk of SCD (HR: 1.54, 95% CI: 1.12-2.11). In our study, one patient with hypomagnesemia died due to heart failure. Another study found that 2.5% of patients with hypomagnesemia in their study had cardiac failure, which was similar to our findings.[18] Various observational studies have been found to be linked to hypomagnesemia causing adverse form of cardiovascular disease risk factors and events, also it was found that patients were at 2.5 times greater risk of developing heart failure who had hypomagnesemia.[20] Hypomagnesemia is also found to be linked with mortality in elderly people with chronic kidney disease and the overall cause of death in patients admitted to the intensive care unit in the hospital.[21] Additionally, the literature shows that it is linked with increased incidence of hip fracture and progression of Alzheimer's.[22,23]

It has been found in a study that hypermagnesemia can cause cardiovascular symptoms like dysrhythmia suggestive of electrocardiographic imbalances causing bradycardia and malignant ventricular tachycardia.[21] In concordance with that, in our study, the cause of death for 2 patients was complete heart block, whereas 3 patients died of SCD.

Study Limitation

This single-center study has several notable limitations. The relatively small sample size may limit the generalizability of our findings. We did not correlate serum magnesium levels with other biochemical markers, particularly renal function values, nor did we conduct risk factor identification for CAD and IHD. The absence of follow-up data and lack of multivariate analysis for mortality restricted our understanding of patient prognosis. Additionally, the study did not account for patient comorbidities, which could have provided valuable insights into the relationship between serum magnesium concentration and the clinical presentation and course of AMI. To address these limitations, larger multi-center studies with extended follow-up periods and comprehensive patient assessments are needed.

CONCLUSION

The present study examined magnesium levels in patients with AMI and found that increasing age predicted low levels of serum magnesium. Patients with hypomagnesemia had higher complication rates; the majority of them had bradyarrhythmia or tachyarrhythmia. In those with hypermagnesemia, the rate of mortality was high, caused by complete heart block or SCD.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the Declaration of Helsinki, and after receiving approval from the Al-Ameen Medical College Ethical Committee of the institution with (approval number: IEC/AAMC/2019/0098, date: 20.10.2019).

Informed Consent: Written consent in their own language before being included.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S.M.H.B., S.T.K., P.K., Concept: S.M.H.B., M.H., A.G., S.T.K., P.K., Design: M.H., P.K., Data Collection or Processing: S.M.H.B., A.G., S.T.K., Analysis or Interpretation: M.H., S.T.K., P.K., Literature Search: S.M.H.B., M.H., A.G., P.K., Writing: S.M.H.B., M.H., S.T.K., P.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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