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A Study of the Serum Magnesium Levels in St-Elevation Myocardial Infarction and its Correlation to Arrhythmia in Patients Admitted in a Tertiary Care Hospital of South Gujarat

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Abstract: ***Background: Cardiovascular diseases remain one of the leading causes of morbidity and mortality worldwide, with ST-Elevation Myocardial Infarction (STEMI) representing a significant and life-threatening manifestation of ischemic heart disease. STEMI occurs when there is a complete blockage of one of the coronary arteries, leading to severe damage to the heart muscle. Despite advances in diagnostic and therapeutic techniques, the prognosis for STEMI patients continues to depend on a variety of factors, including the occurrence of complications such as arrhythmias. Aims & Objectives: To investigate the relationship between serum magnesium levels and the incidence of various arrhythmia in patients diagnosed with ST-Elevation Myocardial Infarction (STEMI). Methodology: A prospective observational cohort study was conducted among 55 patients who present to the hospital within 12 hours of the onset of symptoms of STEMI at tertiary care center where Magnesium levels were evaluated for the occurrence of arrhythmias. Results: The age of the patients ranged from 35 to 79 years, with the majority being older than 65 years, and an equal distribution of males (50.91%) and females (49.09%). Common risk factors included hypertension (47.27%) and diabetes mellitus (54.55%). The results of the study indicated a statistically significant association between lower magnesium levels and the occurrence of arrhythmias in STEMI patients. Patients with arrhythmias had a mean serum magnesium level of 1.44 mg/dL, compared to 1.89 mg/dL in those without arrhythmias ($p < 0.05$). Conclusion: Patients diagnosed with ST-Elevation myocardial Infarction who had lower magnesium levels (<1.6 mg/dL) demonstrated a higher incidence of arrhythmias, particularly ventricular fibrillation and atrial fibrillation, compared to those with normal magnesium levels (1.6–2.4 mg/dL). This statistically significant association highlights the crucial role of magnesium in maintaining cardiac electrical stability during acute myocardial infarction.***

Keywords: Ischemic heart diseases, STEMI, magnesium levels, arrhythmias

1. Introduction

Cardiovascular diseases remain one of the leading causes of morbidity and mortality worldwide, with ST-Elevation Myocardial Infarction (STEMI) representing a significant and life-threatening manifestation of ischemic heart disease. STEMI occurs when there is a complete blockage of one of the coronary arteries, leading to severe damage to the heart muscle. Despite advances in diagnostic and therapeutic techniques, the prognosis for STEMI patients continues to depend on a variety of factors, including the occurrence of complications such as arrhythmias.

Arrhythmias are common in the setting of STEMI and are a major cause of in-hospital mortality. The role of electrolyte imbalances, particularly magnesium, in the development of arrhythmias has been widely studied. Magnesium, an essential cation involved in numerous biochemical processes, plays a critical role in maintaining normal cardiac rhythm. Hypomagnesemia, or low levels of serum magnesium, has been associated with an increased risk of ventricular arrhythmias, which can further complicate the clinical course of STEMI patients.

India, has a growing incidence of cardiovascular diseases, including STEMI. Identifying key biochemical markers that influence patient outcomes in STEMI is crucial for improving prognosis and management. Serum magnesium levels, given their potential influence on arrhythmic events, may offer valuable insight into risk stratification and therapeutic approaches in this population.

Magnesium, an abundant mineral vital for numerous physiological processes, has long been recognized for its role in maintaining cardiovascular health. It is intricately involved in the delicate dance of myocardial metabolism, facilitating the production of ATP (the energy currency of cells) and modulating the flux of calcium ions critical for heart muscle contraction. Moreover, magnesium exerts a vasodilatory effect, relaxing blood vessels and enhancing blood flow to the heart, while its antioxidant and anti-inflammatory properties provide a shield against cellular damage and promote healing. Think of magnesium ions as tiny guardians, making sure our heart muscle stays in good working order1.

The profound impact of magnesium deficiency on cardiac function is evident in its association with a spectrum of cardiovascular diseases, most notably ST-Elevation

Myocardial Infarction (STEMI), a severe form of heart attack characterized by complete blockage of a major coronary artery. STEMI is frequently accompanied by life-threatening complications, particularly arrhythmias, or irregular heart rhythms. These arrhythmias, such as ventricular fibrillation, atrial fibrillation, and premature ventricular contractions, can disrupt the heart's coordinated pumping action, leading to hemodynamic instability and even sudden cardiac death.
Studies have shown that magnesium levels in the blood take a nosedive in the first couple of days after a heart attack, then slowly climb back to normal over a few weeks. The damaged part of the heart itself is also low on magnesium. This all lines up with those complications, like arrhythmias, that can happen after a heart attack. Sadly, when people die suddenly from heart problems, their heart muscle often shows low magnesium levels too2.

Numerous studies have illuminated the inverse relationship between serum magnesium levels and the risk of arrhythmias following STEMI. The initial insult of a heart attack often triggers a decline in magnesium levels, further compromising the already vulnerable myocardium. This magnesium depletion creates a fertile ground for electrical instability, predisposing the heart to arrhythmogenesis.

While the association between hypomagnesemia (low magnesium levels) and arrhythmias in STEMI patients is well-established, the precise mechanisms underlying this relationship remain an area of active investigation. Potential contributors include magnesium's influence on ion channel function, its role in maintaining cellular membrane stability, and its ability to mitigate oxidative stress and inflammation. Magnesium deficiency seems to make those fatty plaques in our arteries worse, and we know those are trouble3.

This study aims to delve deeper into this critical association by comprehensively examining the correlation between serum magnesium levels and the occurrence of specific arrhythmia types in patients presenting with STEMI. By elucidating this relationship, we hope to gain insights into the potential of magnesium supplementation as a preventive and therapeutic strategy in this high-risk population. Ultimately, this knowledge may contribute to improved patient outcomes and reduced mortality associated with STEMI.

2. Aims & Objectives

To investigate the relationship between serum magnesium levels and the incidence of various arrhythmia in patients diagnosed with ST-Elevation Myocardial Infarction (STEMI).

3. Methodology

A prospective observational cohort study was conducted among 55 Patients who present to the hospital within 12 hours of the onset of symptoms of STEMI at tertiary care centre, Surat. Patients must be older than 18 years and fulfilling all other inclusion criteria and providing written informed consent and Patients who present to the hospital within 12 hours of the onset of symptoms of first episodes of STEMI were included. Patients who had history of CAD or prior myocardial infarction, CKD or undergoing dialysis, electrolyte imbalance, NSTEMI, arrythmias and pregnancy were excluded.

Data Entry & analysis:
Data was entered in MS EXCEL Spreadsheet and Statistical analysis was conducted using SPSS. Descriptive statistics were used to summarize the baseline characteristics of the study population. The primary outcome variables, morbidity, and mortality were analysed using chi-square tests for categorical variables and t-tests for continuous variables. A p-value of less than 0.05 was considered statistically significant.

4. Results

In our study, the age-wise distribution of 55 cases, highlighting a clear trend that the condition under study predominantly affects older adults. No cases were observed in individuals under 35 years, while the majority (47.27%) of cases occurred in patients aged over 65, suggesting a strong association between advancing age and the condition. Middle-aged individuals (35-65 years) accounted for a moderate portion of the cases, with 20% in the 35-45 group and 16.36% each in the 46-55 and 56-65 age groups. The data suggests that the condition is rare in younger populations but becomes increasingly prevalent with age, particularly in those over 65, which may guide clinical focus towards screening and management in older demographics. [Table 1]

Table 1: Distribution of Age in STEMI patients

Age (years)	Cases (No.)	Cases (%)
<35	0	0
35-45	11	20%
46-55	9	16.36%
56-65	9	16.36%
>65	26	47.27%
Total	55	100%

In the study of 55 patients, 28 (50.91%) were Males and 27 (49.01%) were Females. The number of cases between males and females is almost equal, with a slight edge towards males. This balanced distribution suggests that the condition or scenario being analyzed affects both genders almost equally. [Table 2]

Table 2: Distribution of Gender in STEMI patients.

Gender	Cases (No.)	Cases (%)
Males	28	50.91%
Females	27	49.01%
Total	**55**	**100%**

The anterior part has the highest number of infarctions, indicating it might be a critical area to focus on for preventive measures. While the anterior part stands out, other part like inferior and posterior, inferior also have significant percentages, suggesting a similar distribution of infarctions across different parts. Infarctions that affect multiple areas of the heart (like anterior-inferior or posterior-inferior) represent a significant portion of cases, suggesting that a large number of patients might experience more complex forms of heart attacks. [Table 3]

Table 3: Distribution of STEMI patients according to Location of infarction

Location of infarction	Cases (No.)	Cases (%)
Anterior	16	29.09%
Anterior, Inferior	9	16.36%
Inferior	12	21.82%
Lateral	5	9.09%
Posterior	5	9.09%
Posterior, Inferior	8	14.55%

The table presents the distribution of magnesium levels (mg/dL) in patients with Hypertension among 55 cases in which 26 patients with hypertension and 29 with no hypertension. Here 38.46% (10 cases) out of 26 cases have magnesium levels below 1.6 mg/dL. Low magnesium levels are often associated with increased risk for cardiac arrhythmias, particularly in patients with myocardial infarction. The largest 57.69% (15 cases) out of 26 cases have magnesium levels in the normal range (1.6 to 2.4 mg/ dL) which is generally protective against cardiac complications. These patients may have a better prognosis in terms of magnesium-related heart risks. Only **1 patient** falls into this category, indicating that high magnesium levels are rare in this study. Elevated magnesium levels can be harmful.

The p-value is 0.049423 which indicates that there is a statistically significant difference between the two groups at the 5% significance level ($p < 0.05$). In simpler terms, the difference in magnesium levels between hypertensive and non-hypertensive patients is unlikely due to random chance and suggests a possible correlation between hypertension and serum magnesium levels. Magnesium levels are slightly higher in patients with hypertension compared to those without hypertension. [Table 4]

Table 4: Magnesium levels in patients with Hypertension

Magnesium levels (mg/dL)	No. of cases (Hypertensive)	Cases (%)	No. of cases (non - hypertensive)	Cases (%)
<1.6	10	38.46%	16	55.17%
1.6 to 2.40	15	57.69%	12	41.37%
>2.4	1	3.85%	1	3.46%
Total	26	100%	29	100%
P-value	0.049423			

The Figure illustrates the relationship between magnesium levels and the occurrence of arrhythmias. It categorizes patients into three groups based on their magnesium levels: less than 1.6 mg/dL, between 1.6 and 2.4 mg/dL, and greater than 2.4 mg/dL.

For patients with magnesium levels below 1.6 mg/dL, 88.46% (23 out of 26) experienced arrhythmias, while only 11.54% (3 out of 26) did not. In the group with magnesium levels ranging from 1.6 to 2.4 mg/dL, 22.22% (6 out of 27) had arrhythmias, compared to 77.78% (21 out of 27) who did not. Lastly, in patients with magnesium levels above 2.4 mg/dL, none (0 out of 2) experienced arrhythmias, and 100% (2 out of 2) showed no signs of arrhythmias. This suggests a strong correlation between low magnesium levels and a higher incidence of arrhythmias, particularly ventricular fibrillation. Conversely, normal or elevated magnesium levels are associated with a lower risk of arrhythmias.

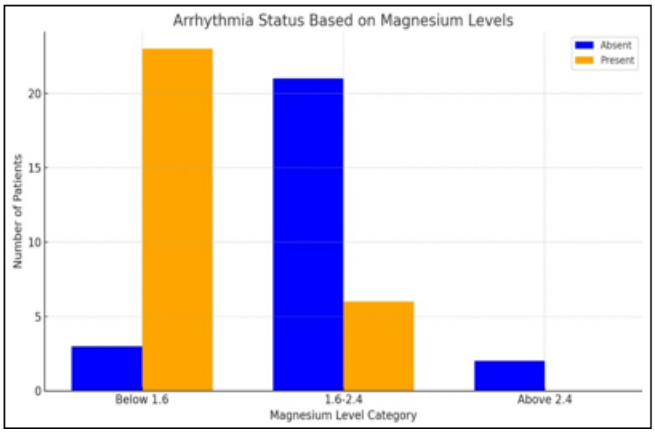

Figure 1: Magnesium levels and prevalence of arrhythmias

Table 5 shows that low magnesium levels (<1.6 mg/dL) are associated with a high incidence of arrhythmias, particularly ventricular fibrillation, with 23 out of 26 patients experiencing arrhythmias. In contrast, patients with normal (1.6–2.4 mg/dL) or elevated (>2.4 mg/dL) magnesium levels mostly exhibit no arrhythmias, suggesting a correlation between low magnesium and increased risk of arrhythmias.

Table 5: Distribution of Arrhythmia Types Across Magnesium Levels

Magnesium levels (mg/dL)	Types of Arrhythmias					
	None	Atrial fibrillation	Atrial flutter	Ventricular fibrillation	Ventricular tachycardia	Any other
< 1.6	3 (11.54%)	5 (62.5%)	4 (100.0%)	7 (70.0%)	4 (100.0%)	3 (100.0%)
1.6-2.4	21 (80.77%)	3 (37.5%)	0 (0.0%)	3 (30.0%)	0 (0.0%)	0 (0.0%)
>2.4	2 (7.69%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Total	26 (100.0%)	8 (100.0%)	4 (100.0%)	10 (100.0%)	4 (100.0%)	3 (100.0%)

Since the p-value is less than 0.05, the difference in serum magnesium levels between patients with and without arrhythmias is statistically significant at a 95% confidence level. This table demonstrates a significant association between low magnesium levels and the presence of arrhythmias in patients. Patients with arrhythmias have an average magnesium level that is notably lower than those without arrhythmias, and this difference is highly statistically significant. [Table 6]

Table 6: Comparison of Magnesium level in patients with Arrhythmias and without Arrhythmias

Group	With	Without
Number of Cases	29	26
Mean	1.44	1.89
Standard	0.38	0.33
t-value		-4.68562
p-value		0.00002

5. Discussion

In our study, patients were categorized by their serum magnesium levels, arrhythmias were observed in 88.46% of those with magnesium levels below 1.6 mg/dL, while only 22.22% of patients with magnesium levels between 1.6 and 2.4 mg/dL experienced arrhythmias. Notably, no arrhythmias were reported in patients with magnesium levels above 2.4 mg/dL. These findings highlight a strong association between lower magnesium levels and the occurrence of arrhythmias, indicating that hypomagnesemia significantly increases the risk of arrhythmias in this patient population. Dyckner and Wester (1980) found that patients with hypomagnesemia had a significantly higher risk of developing ventricular arrhythmias, particularly in the context of acute myocardial infarction. Our study's finding of 88.46% prevalence of arrhythmias in patients with magnesium levels below 1.6 mg/dL aligns with this observation, reinforcing the role of magnesium deficiency as a precipitating factor for arrhythmias in cardiac patients.[4]

In a study by Ganga et al. (2013), hypomagnesemia was identified as a predictor of poor cardiac outcomes, including arrhythmias, particularly in critically ill patients. Our results showing a higher prevalence of arrhythmias in patients with lower magnesium levels (below 1.6 mg/dL) further support this finding. Additionally, the absence of arrhythmias in patients with magnesium levels above 2.4 mg/dL is consistent with studies suggesting that adequate or elevated magnesium levels may exert a protective effect on the myocardium, reducing the risk of arrhythmogenic events. [5]

Singh et al. (1990) demonstrated that magnesium supplementation in patients undergoing cardiac surgery significantly reduced the incidence of arrhythmias, particularly atrial fibrillation. Our study's observation that no arrhythmias were reported in patients with magnesium levels above 2.4 mg/dL suggests that maintaining adequate magnesium levels might be crucial in preventing arrhythmias, especially in high-risk cardiac patients. [6]

The study included a total of 55 patients diagnosed with ST-Elevation Myocardial Infarction (STEMI). The age of the patients ranged from 35 to 79 years, with a mean age of 59.6 ± 12.6 years. The largest proportion of patients (47.27%) were aged between 65 and 79 years, with 26 patients in this age group. This suggests that STEMI predominantly affects older adults, a finding that is consistent with global trends in cardiovascular diseases. A smaller percentage of patients were in the middle-aged groups, with 20% in the 35-45 years range, and 16.36% in both the 46-55 and 56-65 years ranges. In terms of gender distribution, the study consisted of 28 males (50.91%) and 27 females (49.09%), showing an almost equal representation of both sexes, with a slight male predominance. This relatively balanced gender ratio indicates that STEMI affects both males and females within this population at comparable rates, though men remain slightly more affected.

Vaccarino et al. (2003) highlighted that while men tend to experience myocardial infarctions earlier in life, women—particularly postmenopausal women—are at higher risk of mortality and complications such as arrhythmias following STEMI. Our study reflects these findings to some extent, as a significant proportion of older female patients (over 65 years) experienced arrhythmias such as atrial fibrillation and ventricular tachycardia, supporting the increased susceptibility of older women to adverse outcomes post-STEMI. [7]

Shiga et al. (2018) discussed the prevalence of magnesium deficiency in elderly patients, especially those over 70 years, and its correlation with arrhythmias following STEMI. In our study, a high percentage of patients aged 65 to 79 exhibited lower serum magnesium levels, and these patients were more likely to experience arrhythmias. For example, one 75-year-old female with a magnesium level of 1.41 mg/dL developed atrial flutter, underscoring the link between age, magnesium deficiency, and arrhythmic complications. [8]

Rosengren et al. (2004) reported that while men tend to suffer from STEMI at a younger age, women, particularly after menopause, present with more severe cases at an older age. This trend is evident in our study as well, where male patients had a slightly younger mean age compared to females. However, both genders were equally represented in terms of STEMI incidence, which suggests that cardiovascular disease affects both sexes substantially, with women facing increasing risks as they age. [9]

In this study, out of 55 patients diagnosed with ST- Elevation Myocardial Infarction (STEMI), 26 patients (47.27%) had a history of hypertension. This means that nearly half of the STEMI patients were hypertensive, highlighting hypertension as a significant risk factor for STEMI in this cohort. Meanwhile, 29 patients (52.73%) did not report a history of hypertension, showing that STEMI can also occur in normotensive individuals.

Yusuf et al. (2004), in the INTERHEART study, identified hypertension as one of the major modifiable risk factors contributing to myocardial infarction across diverse populations. Their findings indicated that the prevalence of hypertension among myocardial infarction patients was approximately 50%, which closely mirrors the 47.27% prevalence seen in our study. This suggests that the link between hypertension and myocardial infarction is robust and consistent across different settings. [9]

Kannel et al. (1996) found that hypertension was more prevalent among men and strongly correlated with coronary artery disease, particularly myocardial infarction. In our study, 47.27% of STEMI patients were hypertensive, aligning well with Kannel's findings. However, in our cohort, both men and women were similarly affected by hypertension, suggesting that while hypertension is a critical risk factor for myocardial infarction, it affects both genders significantly as they age. [10]

Franklin et al. (2011) emphasized that hypertension, especially isolated systolic hypertension in the elderly, increases the risk of cardiovascular events, including myocardial infarction. In our study, a significant portion of hypertensive patients were older adults, particularly those in the 65-79 age group, further supporting the view that

hypertension in the elderly is a primary contributor to poor cardiovascular outcomes, including STEMI. [11]

Lewington et al. (2002) highlighted the impact of reducing systolic blood pressure on lowering myocardial infarction risk. Our study's findings support this, as a significant proportion of hypertensive patients who experienced STEMI may have benefited from stricter blood pressure control. This underscores the importance of aggressive hypertension management to reduce the risk of STEMI, particularly in populations with multiple cardiovascular risk factors. [12]
Ceremuzynski et al. focused on magnesium's role in preventing arrhythmias in AMI and demonstrated that magnesium therapy reduced arrhythmia-related mortality. Our study supports this, as the patients with normal magnesium levels (1.6-2.4 mg/dL) had fewer arrhythmias, underscoring the need for magnesium as part of arrhythmia prevention strategies in STEMI patients. [13]

6. Conclusion

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide, with complications such as arrhythmia being a significant contributor to mortality in affected patients. In the present study, it was observed that patients with ST-Elevation Myocardial Infarction (STEMI) who had low serum magnesium levels were more prone to developing ventricular arrhythmias compared to those with normal magnesium levels. This statistically significant association highlights the crucial role of magnesium in maintaining cardiac electrical stability during acute myocardial infarction. The findings reveal a statistically significant correlation between hypomagnesemia and the development of arrhythmias in STEMI patients. Patients with lower magnesium levels (<1.6 mg/dL) demonstrated a higher incidence of arrhythmias, particularly ventricular fibrillation and atrial fibrillation, compared to those with normal magnesium levels (1.6–2.4 mg/dL). The findings of this study emphasize the importance of early identification and management of hypomagnesemia in STEMI patients. Magnesium replacement therapy in patients with acute myocardial infarction who have low serum magnesium levels could potentially reduce the incidence of life-threatening arrhythmia, thereby improving patient outcomes. Given the high prevalence of hypomagnesemia in STEMI patients and its clear association with arrhythmic complications, routine serum magnesium monitoring and timely correction should be considered an integral part of the clinical management of acute myocardial infarction.

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