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Evaluation of Prognostic Significance of Serum Magnesium Level in Patients with Acute Myocardial Infarction

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Abstract

Background: Magnesium has been considered an important factor in the pathogenesis of acute myocardial infarction and its complications. Magnesium ions are essential for the maintenance of the functional integrity of the myocardium. It also improves vascular tone, afterload and cardiac output, and decreases peripheral vascular resistance and cardiac arrhythmias. Serum magnesium concentration has great significance in the prognosis of acute myocardial infarction (MI). **Aim and objective:** This study aimed to assess the relation of low serum magnesium levels with post-infarction complications of acute MI. **Methods:** This cross-sectional descriptive study was conducted in the Department of Pharmacology & Therapeutics, Rajshahi Medical College in collaboration with the Cardiology department between July 2019 to June 2020. Assessment and comparison of the serum magnesium level of the patients on the 5th day of post-infarction with the 1st day of admission in 50 patients of acute MI was done in this study. **Results:** The mean magnesium level was 2.25 ± 0.15 mg/dl in patients without any complications which was significantly higher than the patients who had multiple complications. The level of magnesium was 1.79 ± 0.37 mg/dl in complicated cases. (P0.001). These observations suggest that in acute myocardial infarction, patients with low magnesium levels are more prone to develop complications. **Conclusion:** So, it can be concluded that measurement of serum magnesium levels has prognostic significance and magnesium treatment can be implicated in patients of acute myocardial infarction with low magnesium levels.

Keywords: Acute myocardial infarction, Serum magnesium level, Troponin I level.

Introduction

Magnesium is an essential mineral naturally found in human beings. This is the fourth abundant micronutrient which serves as a cofactor in more than 300 enzyme systems in our body.[1] There is around 20-24 gm of magnesium present in an adult human. 60% of total body magnesium is present in bones and one-third of this magnesium acts as a body magnesium reservoir. Almost 35% of total magnesium is located in high metabolic tissues such as muscles, brain, heart, kidneys and liver. Magnesium in the serum represents

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only 1% of the total body magnesium.[2] The plasma concentration of magnesium is maintained within a narrow range of 1.6 to 2.2 mg/dl (0.75-0.95 mmol/l or 1.5-1.9mEq/l).[3] Its diverse action includes regulation of blood pressure, glycaemic control, lipid peroxidation and maintaining cardiac physiology.[4] Magnesium is a well-known mineral for maintaining the normal functional integrity and electrical stability of the myocardium. It plays a vital role in the energy balance of cardiomyocytes. Its beneficial effects also include reducing vulnerability to oxygen-derived free radicals, improving endothelial function and inhibiting platelet aggregation and adhesion Magnesium is beneficial for the cardiovascular system as it improves myocardial lipid metabolism, and reduces cardiac arrhythmias by inhibiting calcium accumulation.[2] Low level of serum magnesium has an association with atherosclerotic acceleration, inducing hyperlipidaemia and subsequent atherogenic deposits in coronary arteries. Low magnesium concentration within the myocardial cell is associated with membrane destabilization and vice versa. Deficiency of magnesium can lead to vasoconstriction and also platelet aggregation as its potent vasodilating role in muscle contraction is hampered.[1] Magnesium deficiency plays a major role in the pathogenesis of cardiovascular diseases both on biochemical and cellular levels. It activates adenosine triphosphatase (ATPase) which is important for proper cell membrane function and also the source of energy for the Na^+-K^+ pump. Low magnesium level causes a decrease in Na^+- K^+ pump activity leading to an increase in intracellular sodium concentrations. This increased sodium concentration in the cell alters the membrane potential resulting in arrhythmia. Additionally, magnesium modulates the potassium-proton exchange mechanism thus it protects the cell from potassium loss. Intracellular hypomagnesaemia may cause increased sodium and calcium concentration in cells predisposing arterial vasospasm, increased catecholamine release and fatty acid.[2] Myocardial contractility is affected by magnesium primarily by exerting calcium mobilization. Magnesium acts as a natural antagonist to calcium by competing with calcium for the binding of troponin C and calmodulin. Intracellular calcium is recognized for cardiac excitation-contraction coupling by binding with troponin. Intracellular and extracellular magnesium both control calcium influx into the cells by inhibiting the L-type calcium channels thus preventing intracellular calcium overload and cell toxicity. In acute myocardial infarction (AMI) increased cytosolic calcium leads to an increased risk for arrhythmia.[5] In myocardial infarction, a functional deficit of available magnesium occurs due to the trapping of free magnesium in adipocytes. Catecholamine-induced lipolysis causes soap formation when free fatty acids are released.[6] Reduction in magnesium concentration would destabilize the membrane potential and make cardiac cells more excitable, thus predisposing them to arrhythmias. Further fall in magnesium levels increases calcium influx resulting in increased systemic and pulmonary vascular resistance.[7] The serum magnesium level was found low in the first 48 hours following an acute myocardial infarction in several investigations. Also, levels were found lower in patients with complications, when compared with acute MI patients without complications.[6] Patients of acute MI who have lower levels of serum magnesium have more chance to develop tachyarrythmias.[7]

So, it is obvious that serum magnesium concentration has great significance in acute myocardial infarction. This study was undertaken to find out the prognostic value of serum magnesium in these complications.

Materials and methods

This study was conducted with a cross-sectional descriptive type design. It was carried out in the Department of Pharmacology and Therapeutics in collaboration with the Cardiology Department of Rajshahi Medical College Hospital. This study was carried out over one year from July 2019 to June 2020. Before the beginning of the study, ethical clearance was obtained from the Ethical Review Committee of Rajshahi Medical College. A total of

50 (age 40-65 years) clinically diagnosed acute myocardial infarction patients admitted to the cardiology department of Rajshahi Medical College Hospital, Rajshahi, were included by convenient and purposive sampling technique as the study population. The inclusion criteria were:

- Patients of acute MI presenting within 24 hours of onset of MI confirmed by clinical features and elevated Troponin I level.
- The age group of 35-65 years.

Also, respondents were excluded from the study according to the following criteria:
- Chronic renal disease.
- Carcinoma.
- Chronic diarrhoea.
- Long-term vomiting.
- On magnesium compound or antacids.

After meeting all inclusion and exclusion criteria and confirmed diagnosis by clinical features, electrocardiography and cardiac enzyme Troponin I; other relevant laboratory investigations were done. With proper consent and necessary permission, 3 ml venous blood was taken from each subject in a test tube without anticoagulant. Serum was collected after centrifuging for 15 minutes at 3000 rpm. Then serum magnesium was measured primarily at admission day. Then on the 5th day of hospital stay again blood sample was collected and serum magnesium level was measured. Measuring of serum magnesium level was carried out by spectrophotometer using Magnesium Kit. All relevant information was collected and compiled. Collected data were processed and analyzed using SPSS (Statistical Package for Social Sciences), version 22.0. The test statistics used to analyze the data were descriptive statistics, unpaired t-test, and Chi-square test. The level of significance was set at 5% and P- value < 0.05 was considered.

Results

The study was anticipated to measure the serum magnesium level and association with the complications among 50 study subjects of acute MI patients. The mean age of the respondents was 54 ± 10.3 years. The highest number of respondents were in the age groups of 51-60 and 60-65 years which occupied 32% each of the total study population. Numbers of male respondents were predominant occupying 84%. The majority (66%) of respondents in this study were smokers. Table 01 shows the demographic characteristics and age distribution of the patients.

Table 01: Demographic characteristics and Smoking history of the respondents.

Age (in years)	Patients (N= 50)	
	Frequency	Percentage
35-40	6	12%
41-50	12	24%
51-60	16	32%
60- 65	16	32%
Sex		
Male	42	84%
Female	8	16%
Smoking history		
Smoker	33	66%
Non-smoker	17	34%

Large numbers of the respondents (66%) were hypertensive and 34% of the respondents were normotensive. The study showed 30% (15) of respondents had a history of ischemic heart disease and the rest (70%) had no history of bad ischemic events. In terms of family history of Ischemic heart disease; positive history of ischemic heart disease was found in 31 (62%) of the respondents. In 19 (38%) respondents there was no family history of ischemic heart disease.

We observed that, in the case of the presence of other diseases, 42% of respondents suffered from concomitant disease and 58% of respondents were free of other diseases.

Table 02: Distribution of the study subjects regarding Hypertension, History of IHD, Family history of IHD and Concomitant disease.

Hypertension	Patients (N= 50)	
	Frequency	Percentage
Hypertensive	33	66%
Normotensive	17	34%
History of IHD		
Present	15	30%
Absent	35	70%
Family history of IHD		
Present	31	62%
Absent	19	38%
Concomitant disease		
Present	21	42%
Absent	29	58%

In the study, we found that 17% of respondents had chest pain, 12% had tachycardia, 8% had bradycardia, 4.5% had heart block and 2.5% had heart failure. 12% of respondents had no MI-related complications. In Table 03 distribution of acute MI-related complications in the study group has been shown.

Table 03: Complications developed after Acute Myocardial Infarction.

Types	Frequency	Percentage
No complications	06	12%
Chest pain	34	17%
Tachycardia	24	12%
Bradycardia	16	08%
Heart block	09	4.5%
Heart failure	05	2.5%

Table 04 shows the serum magnesium level of the study group. We observed higher serum magnesium levels in uncomplicated patients while patients who suffered from multiple complications had lower serum magnesium. In patients with multiple complications, the serum magnesium level was 1.79 ± 0.37 and in patients without complications, magnesium level was 2.25 ± 0.15. On comparison between the two groups, a statistically significant (P-value 0.01) difference was found. (P 0.05 was considered significant throughout the study.

Table 04: Mean serum Magnesium level of complicated and uncomplicated patients in the study population.

Serum magnesium level	(N = 50)			
	n	Mean ± SD	t-value	P-value
Without complications	9	2.25 ± 0.15	- 3.537	0.001
With Complications	41	1.79 ± 0.37	- 3.537	0.001

In this study, a comparison of normal serum magnesium levels between uncomplicated patients with complicated groups was done. 16 patients suffered hypomagnesaemia (<1.6 mg/dl) along with multiple complications whereas 25 complicated patients had serum magnesium ≥ 1.6 mg/dl. Among the 50 respondents, 32% of patients had hypomagnesaemia whereas 68% of respondents had no hypomagnesaemia. A comparison of uncomplicated patients with complicated in regards to hypomagnesaemia is shown in Table 05.

Table 05: Status of hypomagnesaemia in between complicated and uncomplicated groups.

Serum magnesium level	(N = 50)			The reference value of Serum Magnesium
	Without complication (n = 9)	With complication (n = 41)	Total (n = 50)	
<1.6 mg/dl	0 (0.0%)	16 (39%)	16 (32%)	1.6 - 2.2 mg/dl
≥ 1.6 mg/dl	9 (26.5%)	25 (61%)	34 (68%)	

Discussion

The age of the patients included in this study was ranging between 35-65 years. This study showed the highest number of respondents in the age group 51-60 years and age group 61-65 years which occupied 16 (32%) of the population respectively. These results are similar to the findings of Anjum et al. where 43.3% of patients were in the age group 51-60 years.[7] The sex distribution of the study group showed male predominance. There were 42 (84%) male patients whereas 8 (16%) female. Lal and Murmu conducted a study where they observed similar findings showing 29 male and 11 female patients.[1] Akila et al. studied 50 patients with acute myocardial infarction and found smoking was the most common risk factor among 35 patients.[8] In this present study, similarly we found 33 (66%) smokers among the patients and 17 (34%) patients were not smokers. Subramanyam and Vakrani subjected the serum magnesium level in 53 patients of acute myocardial infarction where they showed hypertension as a high-risk factor in their study.[5] Likewise this study also demonstrated that hypertension was present in 33 (66%) of the patients. In this study, a positive history of ischemic heart disease was found in 15 (30%) respondents and 35 (70 %) respondents had no history of ischemic heart disease. In this study, the presence of a family history of ischemic heart disease was found as a risk factor in 31 (62%) patients. In the case of the presence of concomitant disease, this study revealed that 21 (42%) patients were suffering from other concomitant diseases and 29 (58%) patients had no concomitant disease. Patients had a history of diabetes mellitus mostly as the concomitant disease. A similar finding was found in a study conducted by Angeline et al. Where they stated that diabetes patients are more at risk of developing myocardial infarction.[9] Family history of ischemic heart disease was absent in 19 (38%) patients. This resembles the finding of Akila et al. Who also found 10 (20%) patients having a positive family history of ischemic heart disease.[8]

In our study, we found that patients with low serum magnesium levels suffered from several complications. 17% of respondents had chest pain and 12% had tachycardia. The lowest magnesium level of 1.64 ± 0.36 mg/dl was found in 2.5% of respondents with heart failure. 8% of patients developed bradycardia having serum magnesium level of 1.69 ± 0.36 mg/dl. Among the respondents, 12% respondents had no MI-related complications.

In this study mean serum magnesium level was 2.25 ± 0.15 mg/dl in patients without any complications. The patients with multiple complications mean serum magnesium level was 1.79 ± 0.37 mg/dl. On comparison, a statistically significant difference was found.

($P<0.001$). In the comparison of serum magnesium levels between patients without complications and with multiple complications groups, we found 16 patients suffered hypomagnesaemia (<1.6 mg/dl) along with multiple complications. 25 complicated patients had serum magnesium levels ≥1.6 mg/dl. All the uncomplicated patients had serum magnesium levels ≥1.6 mg/dl. Similar findings were found in a study conducted by Nambakam and Girish.[5] In their study they found that in complicated cases serum magnesium levels were 1.38 ± 0.03 mg/dl

and in patients without complications the level was 1.73 ± 0.29 mg/dl which was statistically significant.5 They demonstrated the fact that measuring serum magnesium levels is of prognostic significance in acute MI. In an attempt to find the prognostic value of serum magnesium in various complications, serum magnesium was estimated spectrophotometrically by Govind Mohan et al. in 53 acute myocardial infarction cases.[12] Their study showed lower serum magnesium levels of 1.26 ± 0.19 mg/dl in 42 cases of acute myocardial infarction with complications compared to 1.41 ± 0.13 mg/dl in 11 patients without complications.[12] It was observed that in patients who died due to arrhythmias and cardiogenic shock followed by pump failure, serum magnesium was lowest in them.

A similar study by GQ Khan et al. reported low serum magnesium in 50 patients of acute myocardial infarction with mean serum Mg levels of 2.2 ± 0.24 mg/dl in controls.[13] Further, the serum magnesium level of patients who developed cardiac arrhythmias was found to be comparatively lower. They concluded that the low level of Mg in serum can be taken as a sensitive diagnostic index in cases of acute MI.[13] In the early hours of the infarction period when cardiac enzymes and ECG may not be significant, measuring serum magnesium can be a very informative tool. Another study of serum magnesium in acute MI patients was conducted by Dr. Naseem Hussain where the author found a statistically significant fall in magnesium level in serum in the patients.[14] The study revealed hypomagnesaemia is related to increased risk and poor prognosis in acute MI patients.[14] In summary, this study demonstrated a significant difference in serum magnesium levels in patients with complications and without complications. The serum magnesium level was higher in patients who had no complications than those who suffered multiple complications. Patients who had serum magnesium levels of <1.6 mg/dl developed more complications.

Our findings showed that hypomagnesaemia was associated with an increased risk of developing more adverse sequels after acute MI. Measurement of serum magnesium in early periods of acute MI can be beneficial to detect poor prognosis and take action accordingly.

Conclusion

Hypomagnesaemia is recognized as a significant risk parameter for hypertension, cardiac arrhythmias and other ischemic heart diseases contributing pathogenesis of acute MI. So, along with other biochemical risk parameters, routine assessment of serum magnesium level is advocated which might be useful for avoidance of adverse events and enhanced management of acute MI. Further study with a large population will be helpful to assess the definite role of serum magnesium in acute myocardial infarction.

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