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A cross sectional study on prevalence of hypomagnesemia and hypokalemia in patients with STEMI and its relationship with occurrence of arrhythmias

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Abstract

Background: Cardiovascular disease is one of the leading causes of mortality, morbidity, and increased health-care cost. Magnesium and potassium has been implicated in the pathogenesis of acute myocardial infarction (AMI) and its complications. Magnesium ions and potassium ions are considered essential for the maintenance of functional integrity of myocardium. The serum magnesium and potassium concentration was found to have great significance in AMI. The present study was undertaken to evaluate the prognostic value of serum magnesium and potassium in AMI.

Aim: This study aimed to assess the dynamic changes in serum magnesium and potassium levels in acute STEMI patients and evaluate whether these levels correlate with presence of arrhythmias.

Materials and methods: A comprehensive analysis was conducted over 18 months on 100 patients with acute STEMI. ECG examination was done and blood sample was taken for evaluation of serum magnesium and serum potassium. Statistical analysis was performed to examine correlation with MI and arrhythmias.

Results: In the present study 51-60 years of age were maximum, males were most commonly seen. Mean ±SD of serum magnesium in VPC was 1.900±.3232, sinus tachycardia was 1.850±.1195, maximum in RBBB was 2.200±.000 followed by RBBB/CHB was 2±0, and minimum in 1.288±.5621. Results were found to be significant when comparing type of arrhythmia with serum magnesium. Mean ±SD of serum potassium in VPC was 3.030±.9627, sinus tachycardia was 3.638±.4502, maximum in RBBB was 4.600±.000 and minimum VT/RBBB in 2.850±1.0344. Results were found to be significant.

Conclusion: Patients of AMI with low serum magnesium and potassium levels are found to be more prone to develop arrhythmias as compared to those with normal serum magnesium and potassium levels. Hence, it can be concluded that measurement of serum magnesium and potassium level is of prognostic significance in AMI.

Keywords: Hypomagnesemia; Hypokalemia; ST elevation MI; Arrhythmias

1. Introduction

Cardiovascular disease is one of the leading causes of mortality, morbidity, and increased health-care cost[1]. Magnesium and potassium has been implicated in the pathogenesis of acute myocardial infarction (AMI) and its complications. Magnesium ions and potassium ions are considered essential for the maintenance of functional integrity of myocardium. The serum magnesium and potassium concentration was found to have great significance in AMI.

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Mg is a co-factor in more than 300 enzyme systems in human cells and it has a predominant role in normal myocardial physiology. Magnesium improves myocardial metabolism, inhibits calcium accumulation and myocardial cell death. It improves vascular tone, peripheral vascular resistance, after load and cardiac output, reduces cardiac arrhythmias and improves lipid metabolism. Magnesium also reduces vulnerability to oxygen derived free radicals, improves endothelial function and inhibits platelet function including platelet aggregation and adhesion[2]. Hypomagnesemia is an important risk factor for post AMI complication[3].

K+ serves as the primary ion mediating cardiac repolarization, the hypokalemic state is highly arrhythmogenic, particularly in the presence of digoxin or antiarrhythmic drug therapy. Hypokalemic states produce complex effects on myocardial refractory periods and the potential for triggered arrhythmias[4]. The most concerning and life-threatening arrhythmias associated with K+ deficiency states are tachyarrhythmias, which range from an increase in the frequency of premature ventricular contractions, linearly related to the fall in serum K+ concentrations, to nonsustained ventricular tachycardias and triggering of monomorphic and polymorphic ventricular tachycardias, including torsade de pointes and ventricular fibrillation[5].

There is a significant lower serum Mg and K level in AMI than chronic IHD and fall of these ions immediately after AMI may be due to the catecholamine induced high FFA which causes bindings and precipitation into the cells, resulting in a sudden decrease in total plasma Mg and K level[6].

Thus the present study has been undertaken to evaluate prevalence of hypomagnesemia & hypokalemia in patients with MI.

Objectives

- To estimate the levels of hypomagnesemia and hypokalemia in patients who present with Acute Myocardial Infarction- ST Elevation MI.
- To determine whether the hypomagnesemia and hypokalemic patients are at risk for ventricular arrhythmias or other complication.

2. Material and methods

2.1. Source of data

Patients who were admitted in Intensive Cardiac Care Unit and were diagnosed as acute ST segment elevation myocardial infarction in the medicine department of AL AMEEN MEDICAL COLLEGE AND HOSPITAL, VIJAYAPURA. Cases that satisfied the inclusion and exclusion criteria above were included in the study over a period of 18 months.

- STUDY DESIGN: Cross sectional study.
- STUDY PERIOD: September 2022 to March 2024.
- SAMPLING METHOD: All the patients of STEMI visiting to the hospital satisfying inclusion and exclusion criteria.

2.2. Study instrument and methodology

- Data was collected in a specific proforma by meeting objectives of study. A complete history was elicited from the patient and detailed clinical examination was done. A standard twelve lead electrocardiogram was done in all patients.
- ECG CRITERIA:
  - New onset ST segment elevation more than 1mm in limb leads and or more than 2 mm in precordial leads.
  - The ST segment elevation should be present in two or more leads.
  - The two or more leads should be contiguous with respect to each other. Continuous cardiac monitoring and standard 12 lead electrocardiogram was done to identify any arrhythmias in the first 24 hours since admission.

2.3. Procedure

- Around 3 ml of venous blood sample was collected from the patient.
- The time interval between admission and sample collection did not exceed 6 hours.
- The sample was transferred to a plain tube without any anticoagulants.
- Proper labelling done.

- The proforma for each patient was filled appropriately.
- The sample was sent to the biochemistry laboratory.
- It had to be separated into the serum and fibrin clot.
- The sample was centrifuged at 2000 rpm for the separation of serum from the blood.
- The serum obtained was estimated for its magnesium concentration using Colorimetric method and for its potassium concentration using Ion- selective electrode method.
- Through continuous cardiac monitoring and standard ECG at regular intervals, arrhythmias were identified. A total of 100 patients of STEMI were taken as denominator for prevalence who met the inclusion criteria were investigated for the serum magnesium and potassium levels within six hours since admission and overlooked for the presence of arrhythmias during the first 48 hours and other complications like cardiogenic shock, acute mitral regurgitation and cardiac tamponade.

2.4. Inclusion and exclusion criteria

2.4.1. Inclusion Criteria

- All patients above 18 years who were willing to participate with definite evidence of acute coronary syndrome-STEMI as diagnosed by chest pain<24 hrs., ECG and enzyme assays .
- All patients with definite evidence of arrhythmias as diagnosed by Continuous Cardiac monitoring and standard ECG.
- Significant arrhythmias causing hemodynamic instability, sustained Palpitation, syncope.

2.4.2. Exclusion Criteria

- Use of loop and thiazide diuretics.
- Poor dietary intake/malnourished state.
- Chronic diarrhea/ persistent vomiting.
- Diabetic ketoacidosis.
- Malabsorption syndromes.

2.5. Sample size and estimation

2.5.1. Sample size :100 Cases.

With anticipated Proportion of hypokalemia in patients with STEMI 22% , the study would require a sample size of 100 patients with 95% level of confidence and 8% absolute precision, Using Statulator software (http://statulator.com/SampleSize/ss1P.html)

2.6. Statistical tests

- The data obtained will be entered in a Microsoft Excel sheet, and statistical analysis will be performed using SPSS software (Version 20).
- Data will be presented as Mean ±SD, Median and interquartile range, frequency, percentages and diagrams.
- Association between Categorical variables will be compared using Chi square test.
- Significant difference between two different variables will be analyzed using Chi square test.
- 'p' value <0.05 will be considered statistically significant. All statistical tests will be performed two tailed.

3. Results

Table 1 Comparison of type of arrhythmia with type of MI

Type of arrhythmia	TYPE OF MI							Total	Chi value	Pvalue
	AWMI	ALMI	ASMI	IWMI	IWMI /PWMI	IWMI/ ASMI	AWMI/ IWMI			
VPC	4 9.5%	0 0.0%	2 16.7%	0 0.0%	2 7.7%	0 0.0%	2 100.0%	10 10.0%	163.175	<0.001***
SINUS TACHYCARDIA	0 0.0%	0 0.0%	2 16.7%	6 50.0%	0 0.0%	0 0.0%	0 0.0%	8 8.0%		
CHB/1*/2*BLOCK	2 4.8%	0 0.0%	0 0.0%	0 0.0%	2 7.7%	0 0.0%	0 0.0%	4 4.0%		
VT	8 19.0%	1 25.0%	2 16.7%	1 8.3%	10 38.5%	2 100.0%	0 0.0%	24 24.0%		
RBBB	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 7.7%	0 0.0%	0 0.0%	2 2.0%		
LBBB	6 14.3%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	6 6.0%		
VPC/ST	6 14.3%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	6 6.0%		
VT/RBBB	4 9.5%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	4 4.0%		
Sinus bradicardia/LBBB	0 0.0%	2 50.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 2.0%		
RBBB/CHB	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 7.7%	0 0.0%	0 0.0%	2 2.0%		
SB/CHB	0 0.0%	0 0.0%	0 0.0%	2 16.7%	0 0.0%	0 0.0%	0 0.0%	2 2.0%		
NIL	12 28.6%	1 25.0%	6 50.0%	3 25.0%	8 30.8%	0 0.0%	0 0.0%	30 30.0%		
Total	42 42%	4 4%	12 12%	12 12%	26 26%	2 2%	2 2%	100 100.0%		

Test used- chi square, p<0.001*** very highly significant

Table 2 Comparison of type of arrhythmia with serum magnesium

Type of arrhythmia	S.MG		Total	Chi value	Pvalue
	NORMAL	LOW			
VPC	6 11.1%	4 8.7%	10 10.0%	32.770	0.001**
SINUS TACHYCARDIA	8 14.8%	0 0.0%	8 8.0%		
CHB/1*/2*BLOCK	4 7.4%	0 0.0%	4 4.0%		
VT	6 11.1%	18 39.1%	24 24.0%		
RBBB	2 3.7%	0 0.0%	2 2.0%		
LBBB	2 3.7%	4 8.7%	6 6.0%		
VPC/ST	6 11.1%	0 0.0%	6 6.0%		
VT/RBBB	2 3.7%	2 4.3%	4 4.0%		
Sinus bradicardia/LBBB	2 3.7%	0 0.0%	2 2.0%		
RBBB/CHB	2 3.7%	0 0.0%	2 2.0%		
SB/CHB	0 0.0%	2 4.3%	2 2.0%		
NIL	14 25.9%	16 34.8%	30 30.0%		
Total	54 54%	46 46%	100 100.0%		

Test used- chi square, p<0.01*** highly significant

Table 3 Comparison of type of arrhythmia with serum potassium

Type of arrhythmia	Serum Potassium		Total	Chi value	Pvalue
	NORMAL	LOW			
VPC	4 7.1%	6 13.6%	10 10.0%	30.391	0.001**
SINUS TACHYCARDIA	4 7.1%	4 9.1%	8 8.0%		
CHB/1*/2*BLOCK	2 3.6%	2 4.5%	4 4.0%		
VT	11 19.6%	13 29.5%	24 24.0%		
RBBB	0 0.0%	2 4.5%	2 2.0%		
LBBB	4 7.1%	2 4.5%	6 6.0%		
VPC/ST	6 10.7%	0 0.0%	6 6.0%		
VT/RBBB	4 7.1%	0 0.0%	4 4.0%		
Sinus bradicardia/LBBB	0 0.0%	2 4.5%	2 2.0%		
RBBB/CHB	0 0.0%	2 4.5%	2 2.0%		
SB/CHB	0 0.0%	2 4.5%	2 2.0%		
NIL	17 30.4%	13 29.5%	30 30.0%		
Total	56 100.0%	44 100.0%	100 100.0%		

Test used- chi square, p<0.01*** highly significant

4. Discussion

Cardiovascular disease is one of the leading causes of mortality, morbidity, and increased health-care cost. Magnesium has been implicated in the pathogenesis of acute myocardial infarction (AMI) and its complications. Magnesium ions are considered essential for the maintenance of functional integrity of myocardium. The serum magnesium concentration was found to have great significance in AMI.

Potassium is the major cation inside the cells and is hugely important for regulating heartbeat and muscle function. It forms the other half of the electrical pump that keeps electrolytes in balance and allows conductivity between the cells, also making potassium a critical part of neuron transmission.

4.1. Distribution of arrhythmia with serum magnesium

In the present study, shows Total normal 54(100%) serum magnesium, arrhythmia was present in 40(74.1%) and absent in 14(25.9%). Total low 46(100%) serum magnesium, arrhythmia was present in 30(65.2%) and absent in 16(34.8%). Results were found to be significant.

4.2. Distribution of arrhythmia with serum potassium

We also found significant results with comparison of serum potassium with arrhythmias, shows Total normal 56(100%) serum potassium, arrhythmia was present in 39(69.6%) and absent in 17(30.4%). Total low 44(100%) serum potassium, arrhythmia was present in 31(70.5%) and absent in 13(29.5%).

4.3. Comparison of type of arrhythmia with serum magnesium

In the present study (table 2) Comparison of type of arrhythmia with serum magnesium and we found that Among total 54(100%) normal serum magnesium, 6(11.1%) having VPC type of arrhythmia, 8(14.8%) having sinus tachycardia, 4(7.4%) having CHB/1º/2º block, 6(11.1%) having VT, 2(3.7%) having RBBB and 2(3.7%) having LBBB and 14(25.9%) having nil type of arrhythmia.

Among total 46(100%) low serum magnesium, 4(8.7%) having VPC type of arrhythmia, 18(39.1%) having VT and 4(8.7%) having LBBB and 16(34.8%) having nil type of arrhythmia. Results were found to be significant.

The Mean comparison of type of arrhythmia with serum magnesium shows Mean ±SD of serum magnesium in VPC was 1.900±.3232, sinus tachycardia was 1.850±.1195, maximum in RBBB was 2.200±.000 followed by RBBB/CHB was 2±0, and minimum in 1.288±.5621. Results were found to be significant.

4.4. Comparison of type of arrhythmia with serum potassium

In the present study (table 3) shows Comparison of type of arrhythmia with serum potassium and we found that Among total 56(100%) normal serum potassium, 4(7.1%) having VPC type of arrhythmia, 4(7.1%) having sinus tachycardia, 2(3.6%) having CHB/1º/2º block, 11(19.6%) having VT, 4(7.1%) having LBBB and 17(30.4%) having nil type of arrhythmia.

Among total 44(100%) low serum potassium, 6(13.6%) having VPC type of arrhythmia, 4(9.1%) having sinus tachycardia, 2(4.5%) having CHB/1º/2º block, 13(29.5%) having VT and 2(4.5%) having RBBB and 2(4.5%) having LBBB and 13(29.5%) having nil type of arrhythmia. Results were found to be significant when comparing type of arrhythmia with serum potassium.

The mean comparison of serum potassium with type of arrhythmia shows Mean ±SD of serum potassium in VPC was 3.030±.9627, sinus tachycardia was 3.638±.4502, maximum in RBBB was 4.600±.000 and minimum VT/RBBB in 2.850±1.0344. Results were found to be significant.

4.5. Previous studies

Abraham et al[7] reviewed magnesium level of 65 consecutive patients with an admission diagnosis of acute myocardial infarction. Serum magnesium concentration were low in patient who had AMI (mean 1.70 mg/dl, $p<0.001$)

Bogdan et al.[8] reported lowest serum magnesium and potassium levels on day 1 and day 3 in patients who had AMI.

Singh et al[9]. and Sachdeva et al.[10] also concluded that levels of magnesium and potassium were low on day 1 of MI with progressive rise days later.

Dyckner et al[11] also concluded the role of hypomagnesemia in STEMI in relation to arrhythmias.

5. Conclusion

Magnesium is an underestimated cation and has been implicated in the pathogenesis of AMI and its complications. K+ is critical to the maintenance of CV health and the normokalemic state is vital to the prevention of potentially serious sequelae, especially in the at-risk CV patient. Measurement of serum magnesium and potassium levels is simple and cost effective, and thereby should be done in MI patients along with routine hematological analysis. In the present study, patients of AMI with low serum magnesium and potassium levels are found to be more prone to develop arrhythmias, post-MI complications and death as compared to those with normal serum magnesium and potassium levels.

Hence, it can be concluded that measurement of serum magnesium and potassium level is of prognostic significance in AMI. Magnesium and potassium replacement therapy in patients with AMI with low serum magnesium and potassium levels can be considered to reduce the incidence of arrhythmias and post-MI complications.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The study was approved by the Institutional Ethical Committee.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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