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ORIGINAL RESEARCH

Hypomagnesemia and hypokalemia as a risk factor for arrhythmias in patients of ST segment elevation myocardial infarction (STEMI)

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ABSTRACT

Background- Cardiovascular diseases, especially coronary artery disease (CAD), have reached epidemic proportions worldwide. Potassium plays an important role in relation to electrophysiological functioning of the heart while Magnesium ions are considered essential for the maintenance of functional integrity of myocardium. Both the cations have a significant role in development of arrhythmias in patients of AMI. The present study was undertaken to evaluate the prevalence of arrhythmias in patients of STEMI having electrolyte disturbances at presentation.

Aims and objectives

1. To analyze the levels of Potassium and Magnesium in patients of Acute STEMI.
2. To determine hypokalemia and hypomagnesemia as a potential risk factor for arrhythmias in patients of STEMI.

Materials and methods- This observational cross-sectional study was conducted in the Medicine Department, Guru Nanak Dev Hospital attached to Govt. Medical College, Amritsar. A total of 100 patients of STEMI were enrolled in this study. Serum magnesium and potassium levels were measured in all the patients and their correlation with clinical outcomes was observed. **Results-** The mean serum magnesium in patients with arrhythmia was 1.71±0.38 With a statistically significant p value of 0.031 and without arrhy,thmia 1.88±0.32. Themean potassium concentration in patients with arrhythmias 4.02±0.43 with a statistically significant p-value of 0.006. And without arrhythmiasd 3.59±0.63. It was inferred from this study that patients with STEMI with low serum magnesium and potassium levels are more prone to develop complications such as arrhythmias leadingto sudden cardiac death as compared to patients of AMI with normal serum magnesium and potassium levels. **Conclusion-** Serum magnesium and potassium levels do fall significantly in patients of Myocardial infarction. Patients of Acute myocardial infarction with low serum magnesium and potassium levels are found to be more prone to develop arrhythmias as compared to those with normal levels of these electrolytes. Hence, it can be concluded that measurement of serum magnesium and potassium levels are of prognostic significance in AMI.

INTRODUCTION

Cardiovascular diseases, especially coronary artery disease (CAD,) have reached epidemic proportions worldwide. Acute Myocardial Infarction (AMI), characterized by tissue death of cardiac myocyte, stands as the primary cause of mortality within CAD[1,2]. Notably, a surge in cases has been observed in developing nations like India and this is primarily attributed to the life style changes[3]. In coronary artery disease damage to the coronary arteries occur by pathogenic mechanisms such as atherosclerosis, plaque rupture, thrombosis, and inflammation[4].

The primary cause of CAD is due to development of atheromatous plaque within the vessels supplying the heart[5].

The development of coronary atherosclerosis is significantly increased by both intrinsic and extrinsic risk factors like excessive smoking, poorly controlled diabetes mellitus, hypertension, dyslipedemia, alcohol consumption, and obesity[6,7]. Acute coronary syndrome (ACS) can be subdivided into 3 groups- ST elevation myocardial infarction, Non ST elevation myocardial infarction and Unstable angina[4].

Electrocardiograms (ECGs) play an important role in

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detecting characteristic patterns that suggest myocardial infarction, forming an essential component of the diagnostic process for these patients exhibiting symptoms of MI. Prompt acquisition and interpretation of the ECG, ideally within 10 minutes from the initial medical contact, arerecommended[8]. In order to supplement the ECG and confirm the diagnosis of Acute Coronary Syndromes (ACS), serological proof of myocardial injury is also required. Cardiac biomarkers such as Troponins, CPKMB are the enzymes released from necrotic heart muscle after ACS and can be tested in the peripheral blood. These biomarkers carry both diagnostic and prognostic significance in MI[9].

Different electrolytes such as potassium and magnesium play an important role in the cell metabolism, electrical conduction and membrane excitability. Magnesium has been recently found to be an important cardiovascular cation. Hypomagnesemia following AMI is probably explained by a shift of Mg from extracellular to intracellular compartments in the body with catecholamine over secretion playing a significant role[10]. Magnesium exerts a strong influence in maintaining the homeostasis of cardiac myocytes and maintains a normal action potential.It also acts a natural calcium antagonist which effects the contractility of the myocardium. It has direct electrophysiological effects which affects the conduction of myocardium. Magnesium deficiency especially in initial phase after AMI was therefore linked to occurrence of lifethreatening arrhythmia[11].

Potassium is a major determinant of the electrophysiological properties of the myocardial membrane,and plays an important rote in maintaining resting membrane potential in cardiac myocytes[12]. Low serum potassium levels leads to increase in the rate of spontaneous diastolic depolarization or phase 4 of the action potential which increases the memberane automaticity which ultimately leads to dangerous ventriculararrhythmias[13].

Hence, Abnormalities of these electrolytes due to different causes can lead to a significant cardiac life threatening events.

MATERIAL AND METHODS

This observational cross sectional study was performed in patients admitted to Medicine wards in Guru Nanak Dev Hospital attatched to Government medical college,Amritsar.A total of 100 patients were enrolled for the study. They were diagnosed with ACS-STEMI on basis of clinical symptoms, ECG, cardiac biomarkers and/or echocardiographic findings. For all the patients serum magnesium and potassium levels were done. The end point of the study was to establish hypokalemia and hypomagnesmeia as a risk factor for arrhythmias in patients of STEMI.

INCLUSION CRITERIA

- All patients with definite evidence of acute coronary syndrome – ST elevation MI as diagnosed by chest pain <24 hours, ECG, CPKMB, TropT/I and ECHO.
- Patients with Age>30 years.
- Patients willing to give informed consent in written.EXCLUSION CRITERIA:
- Use of loop and thiazide diuretics.
- Chronic diarrhea/persistent vomiting.
- Diabetic ketoacidosis.
- Patients not giving written informed consent.
- Patients having chronic kidney disease.

ETHICAL CONSIDERATION

Informed written consent was obtained from the participants. Prior approval was obtained from Institutional Ethical Committee.

STATISTICAL ANALYSIS

The data were presented as Mean ± SD (standard deviation). Categorical data were expressed as percentages (%). Numerical variables were normally distributed and were compared using Chi-square test for non-parametric data and Student's "*t*" test for parametric data. The ($P < 0.05$) was considered statistically significant. The analysis was performed on SPSS software (Windows version 22.00).

Reference range for Magnesium: 1.7 - 2.2 mg/dl
Reference range for potassium : 3.5-4.5mg/dl

RESULTS

TABLE 1: AGE WISE DISTRIBUTION OF SUBJECTS

Age (Years)	No. of Patients	Percentage
<40	10	10.0
41-50	25	25.0
51-60	28	28.0
61-70	25	25.0
>70	12	12.0
Total	100	100.0

The above table shows that majority of patients (28%) were between age group of 51-60 years and very few patients (10%) were between age group of <40 years. The minimum age was 35 years and maximum age was 80 years and the mean age was 55.56±11.94 yrs.

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TABLE 2: AGE AND GENDER WISE DISTRIBUTION OF SUBJECTS

Age (Years)	MALES N=85		FEMALES N=15	
	NO.	PERCENTAGE	NO.	PERCENTAGE
<40	8	9.4	2	13.3
41-50	20	23.5	5	38.4
51-60	25	29.4	3	20
61-70	23	27.05	2	13.3
>70	9	10.5	3	20

The above table shows gender wise distribution of subjects. Major proportion of patients who suffered from myocardial infarction were males. Ratio of Male to female was 5.6:1. Incidence of MI was found to be more common in males as compared to females.

TABLE 3: AREA WISE DISTRIBUTION OF SUBJECTS

Area	No. of Patients	Percentage
Rural	16	16.0
Urban	84	84.0
Total	100	100.0

The above table shows area-wise distribution of subjects. Out of 100 patients of STEMI, 84 (84%) patients were from urban background, and remaining (16%) werefrom rural background.

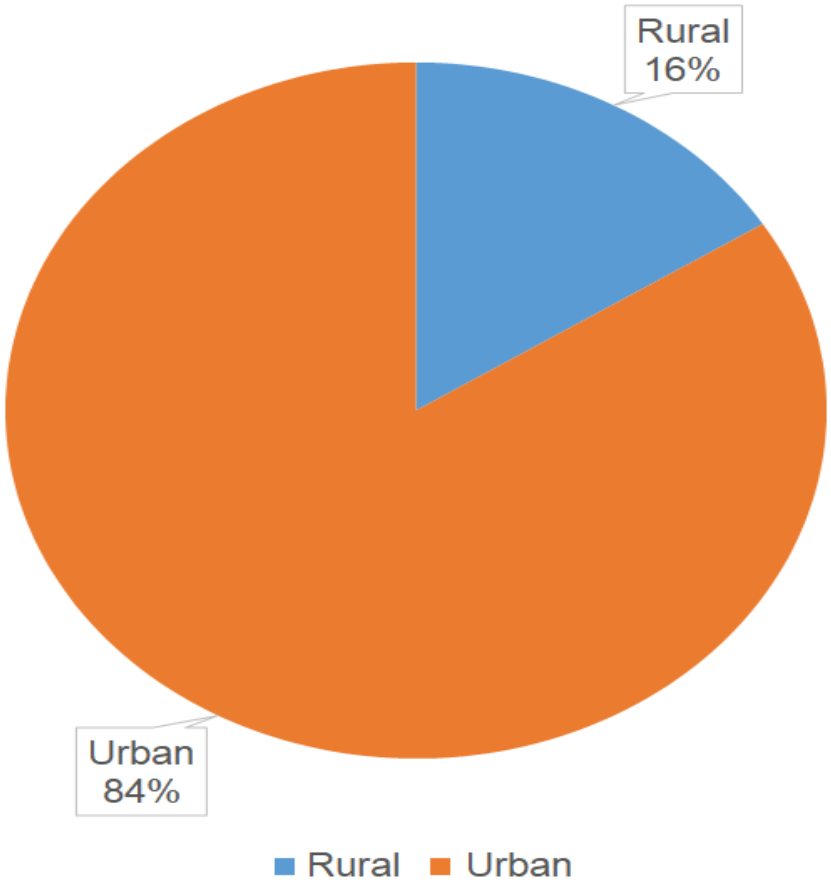

TABLE 4: INCIDENCE OF ARRHYTHMIAS IN SUBJECTS

Arrhythmia	No. of Patients	Percentage
Present	80	80.0%
Absent	20	20.0.%
Total	100	100%

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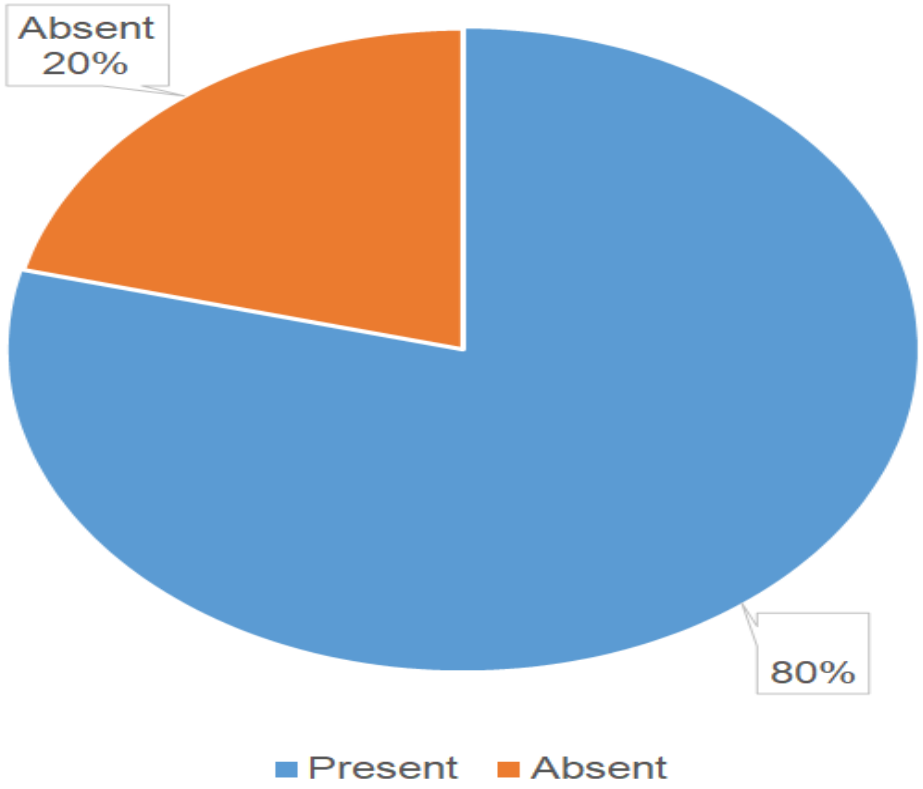

The above table shows incidence of arrhythmias in STEMI patients. Out of 100 patients, 80(80%) patients had arrhythmias and remaining 20 (20%) patients were anarrhythmic.

TABLE 5: VARIOUS TYPES OF ARRHYTHMIA IN SUBJECTS

Arrhythmia	No. of Patients(n=80)	Percentage
Ventricular Tachycardia	25	31.25
Sinus Tachycardia	14	17.50
Ventricular Premature Contraction	11	13.75
Ventricular premature contraction/Sinus Tachycardia	5	6.25
LBBB	5	6.25
Ventricular Tachycardia/RBBB	4	5.00
Sinus Bradycardia	3	3.75
Second Degree Heart Block	4	5.00
Complete Heart Block	3	3.75
Ventricular premature contraction/1st DegreeHeart Block	2	2.50
First Degree Heart Block	2	2.50
RBBB /Complete Heart Block	1	1.25
Ventricular Premature Contraction/VentricularTachycardia	1	1.25

The above table shows that Out of 80 patients of STEMI having arrhythmia, most of the patients had ventricular tachycardia (25%) followed by sinus tachycardia(17.5%) and VPCs (13.75%)

TABLE 6: VARIATION OF SERUM MAGNESIUM LEVELS IN SUBJECTS

Serum Magnesium Level	No. of Patients	Percentage
Normal(1.7-2.2 mg/dl)	57	57.0%
Low (<1.7mg/dl)	43	43.0%
Total	100	100.0%

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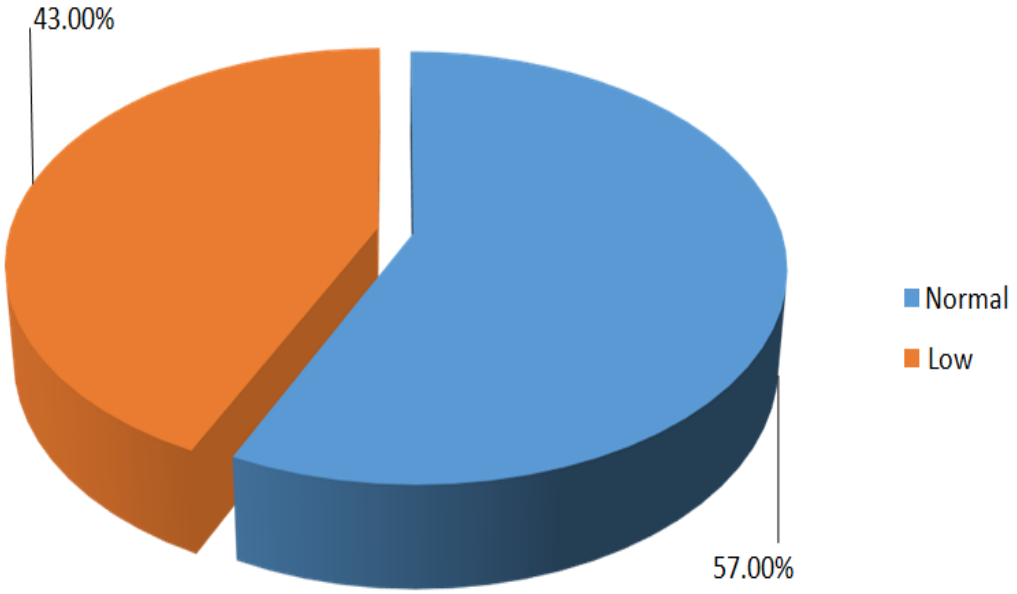
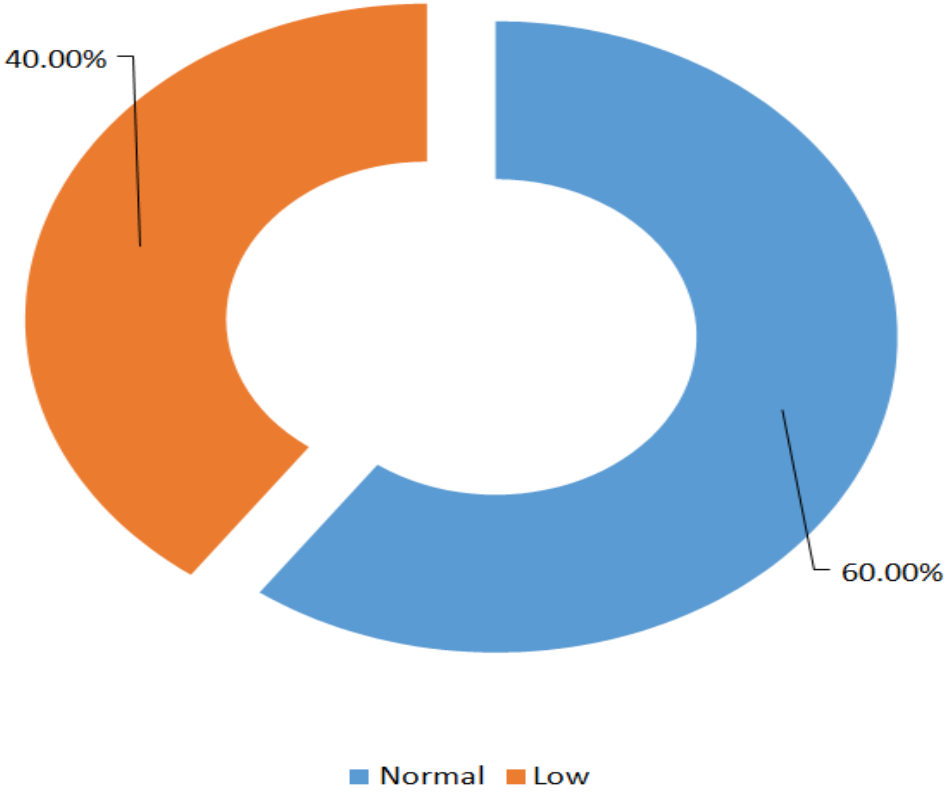


The above table shows that out of 100 patients, 57 (57%) had normal magnesium level and 43 (43%) patients had low magnesium level.

TABLE 7: VARIATION OF SERUM POTASSIUM LEVELS IN SUBJECTS

Serum Potassium Level	Percentage	Percentage
Normal (3.5-4.5meq/lt)	60	60.0%
Low (<3.5meq/lt)	40	40.0%
Total	100	100.0%



The above table shows that out of 100 patients, 60(60%) patients had normal serum potassium level and 40 (40%) patients had low serum potassium level.

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TYPE 8: SERUM MAGNESIUM LEVEL VS ARRHYTHMIA

Serum Magnesium	Arrhythmia	No Arrhythmia
Low (<1.7 mg/dl)	1.40±0.23	1.53±0.10
NORMAL (1.7-2.2 mg/dl)	1.94±0.30	1.98±0.32

The above table shows that Patients with hypomagnesemia had low mean serum magnesium 1.40 ±0.23 and were at high risk of developing arrhythmias with a statistically significant p-value of 0.031($p<0.05$) as compared to the patients with normal magnesium levels.

TYPE 9: SERUM POTASSIUM VERSUS ARRHYTHMIA

Serum Potassium	Arrhythmia	No Arrhythmia
Low (<3.5meq/lt)	2.92± 0.39	3.27±0.23
Normal (3.5-4.5 meq/lt)	4.03±0.31	4.14±0.35

The above table shows that Patients with hypokalemia had low mean serum potassium 1.40 ±0.23 and were at high risk of developing arrhythmias with statistically significant p-value of 0.006 ($p<0.05$) as compared to the patients with normal magnesium levels.

TABLE 10: SERUM MAGNESIUM AND POTASSIUM LEVELS IN VARIOUS TYPE OF ARRHYTHMIA

	Serum Magnesium		Serum Potassium	
	Low	Normal	Low	Normal
Ventricular Tachycardia	15	10	17	8
RBBB	2	2	2	2
Ventricular Premature Contraction	5	6	5	6
CHB/1st Degree AVBlock /2nd Degree AV block	8	5	6	7
Sinus Bradycardia	2	1	1	2
LBBB	2	3	2	3
Sinus Tachycardia	5	14	4	14
NIL	4	16	3	18
Total	43	57	40	60

The above table shows that out of 43 patients of hypomagnesemia,1 5 patients (34.8 %) had VT and out of 40 patients of hypokalemia, 17 patients (42.5%) developed Ventricular tachycardia, hence VT was the most common type of arrhythmia among patients of hypokalemia and hypomagnesmia.

DISCUSSION

Cardiovascular diseases, especially coronary artery disease (CAD), have reached epidemic proportions worldwide. Among the CAD, Myocardial Infarction (MI), which is essentially tissue death (infarction) of the heart muscle, is the commonest cause of mortality. Arrhythmias frequently occur in the early stages of ischemia and continue to be the primary cause of sudden death in cases of STEMI.The guidelines from various renowned associations such as AHA/ACC/ESC emphasize that both hypomagnesemia and hypokalemia are linked to ventricular arrhythmias and sudden cardiac death (SCD) during AMI.

The present study shows that majority of patients (28%) were between age group of 51-60 years and very few patients (10%) were between age group of <40 years. The minimum age was 35 years, the maximum age was 80, and the mean age was 55.56±11.94 yrs. The study population included patients of both sex of different age groups. The predominant age group among men who developed MI was 61-70 yrs which consititutes 39.5% of male population (n=80) and the predominant age group among women who developed MI was 41-50 yrs which constitutes 38.5% of female population.(n=20). According to the American Heart Association, the incidence rate for myocardial infarction in the age group of 50-60 years was higher than of younger adults. Framingham heart study reports that the risk of MI increases progressively with age and patients above 65 years have maximum risk of developing myocardial infarction. Gohel BM et al[15] conducted a similar study in 2020 on 106 STEMI patients and it was observed that maximum number of patients were between age group of 41-50 years with mean age group of 45±11.24 years with male predisposition. Somewhat similar results seen in the study by Ralapanawa et al[16]. had male and female patients with mean age of 61.3 ± 12.6 years and 63.8 ± 2.9 years, respectively.

Ambali et al.[17] proposed that in AMI, serum magnesium levels decrease with increasing age and the elderly (>60 years) are at high risk for hypomagnesemia due to the decreased intake, stress, and chronic medications.

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The present study area-wise distribution of subjects. Out of 100 patients of STEMI, 84 (84%) patients were from urban backgrounds, and the remaining (16%) were from rural background. In concordance to our study, Yusuf S et al[18] in 2004 entitled "Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study)." Lancet, 364(9438), 937-952 concluded that urbanization is a significant risk factor influencing the incidence of MI. Urban populations exhibit higher rates of myocardial infarction due to their sedentary lifestyle, high-fat diet, physical inactivity, etc.

The present study shows incidence of arrhythmias in STEMI patients. Out of 100 patients, 80(80%) had arrhythmias and 20 (20%) were anarrhythmic. Out of 80 patients of STEMI having arrhythmia, 25 patients (31.25%) developed ventricular tachycardia, 14 patients(17.5%) developed sinus tachycardia ,11 patients (13.75%) developed VPCs, , 11 (13.75%) had AV blocks, 3 (3.75%) had RBBB, 4 (5.00%) had LBBB, and 3 (3.75%) patients had sinus bradycardia.

Similar results seen in other research studies like Baset et al.[19] studied 50 MI patients, out of which 6 patients died in their 5 day hospital course. Four patients died of ventricular tachycardia and ventricular fibrillation.

Study also showed that VPC's were the most common arrhythmias among 26 AMI patients with arrhythmias out of a total of 50 patients. A study on 100 MI patients by Ambali et al.[20] reported post MI complications in 20 patients. The complications noted were ventricular ectopic in one patient, congestive cardiac failure in two patients, sinus bradycardia in three patients, tachyarrhythmia (ventricular tachycardia and atrial fibrillation) in seven patients, and bradyarrhythmia (bundle branch blocks, 10, 20, and 30 heart blocks) in seven patients.

The present study shows that Patients with hypomagnesemia had low mean serum magnesium 1.40 ±0.23 and were at high risk of developing arrhythmias with a statistically significant p-value of 0.031($p<0.05$) as compared to the patients with normal magnesium levels.

The present study shows that Patients with hypokalemia had low mean serum potassium 1.40 ±0.23 and were at high risk of developing arrhythmias with statistically significant p-value of 0.006 ($p<0.05$) as compared to the patients with normal magnesium levels.

Kafka et al in 1987[21] conducted a study involving 590 patients admitted to the coronary care unit and measured their serum magnesium and potassium levels over 13 month time period. Hypokalemia is frequently observed in patients with MI.

The study concluded that AMI and is connected to ventricular arrhythmias, regular monitoring of serum potassium levels and prompt treatment are recommended. In a similar study conducted by Asmar et al in 2023[22] on 186 patients of acute STEMI whose serum magnesium and potassium levels were measured at the time of admission. It was concluded that Patients with STEMI who had low serum potassium and magnesium levels were observed to be more likely to develop arrhythmias in comparison to those with normal levels of these electrolytes.

Pophale et al. in 2023[23] conducted a study in 134 individuals who were diagnosed with acute STEMI and brought to the hospital within 24 hours after the development of symptoms of MI. The study concluded that in patients of STEMI with low serum potassium and magnesium levels, the likelihood of arrhythmias leading to mortality was significantly high.

Uddin N et al.[24] in 2020 conducted a study in the Department of Cardiology, DMCH, and concluded that hypomagnesemia was significantly associated with ventricular arrhythmia in patients of STEMI. The above studies revealed very similar results that were comparable to our present study.

Colombo MG et al.[25] in 2018 conducted a study on association of serum potassium concentration with mortality and ventricular arrhythmias in acute myocardial infarction. The study concluded that a serum potassium concentration of <3.5 meq/L was significantly associated with higher incidence of ventricular arrhythmias.

STRENGTHS

The diagnosis of ST-segment elevation Myocardial infarction is very simple. This study needed only serum samples for the estimation of magnesium and potassium which can be estimated relatively easier in central laboratory. Arrhythmias are easily diagnosed by electrocardiogram and continuous cardiac monitoring.

LIMITATIONS

The study population consisted of 100 cases. The study was done over a period of 18 months. It is highly difficult to find out a case of STEMI without the frequent co-morbidities like hypertension and diabetes mellitus which also has an impact over the serum magnesium levels. Since the number of sample is 100. It is non-representative of general population.

CONCLUSION

Magnesium is an underestimated cation which has been implicated in the pathogenesis of AMI. Serum magnesium and potassium levels do fall significantly in patients of Myocardial infarction and low serum magnesium and potassium levels in this subset of patients develop life threatening ventricular arrhythmias in the initial 48 hours of presentation. Hence, early estimation of serum magnesium and potassium levels in Acute MI is recommended as prompt correction when low would be life saving

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