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Evaluation of prognostic role of serum potassium in patients with Acute Myocardial Infarction: A cross-sectional study from a tertiary hospital in northern India

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Abstract

Background: An Acute Myocardial Infarction (AMI) is a subset of a spectrum of IHD that includes unstable angina and AMI with or without ST elevation. Ischemic heart disease (IHD) places a massive health burden on humanity. Sodium (Na^+) and potassium (K^+) have played key roles in the development and maintenance of essential cellular functions throughout more than 2 million years of human evolution. However; there is a lack of current, adequately powered studies that define the optimal range of serum potassium levels with respect to mortality and other important clinical outcomes in patients with AMI. Hence; we planned the present study to evaluate serum potassium levels in AMI and assess its prognostic value in the severity and outcome of AMI.
Material & methods: The present study included 50 patients with AMI who presented to the emergency department of Guru Nanak Dev Hospital. 50 age and sex matched apparently healthy individuals were selected as 'Controls'. Venous blood samples were collected from all the participants. For serum potassium levels, blood was allowed to clot at room temperature for half an hour and then centrifuged at 3000 rpm for five minutes. The serum separated was used for the estimation of serum potassium levels. All the results were analyzed by SPSS software version 17.0.
Results: Maximum number of the patients was in the age group of 51-60 years which is 36% of the total cases followed by 61-70 years which accounted for 34% of the total cases. Hypokalemia was found in 24% cases, hyperkalemia in 6% and 70% were normokalemic. Mean serum potassium levels were higher in the control group in comparison to the study group, the values of which were found to be statistically significant. Arrhythmias were found to be present in 50 % of the hypokalemia patients. 33.3 % of the patients of the hypokalemia group showed presence of heart failure (HF). Mortality was seen in 10 % of the patients of the AMI group. Out of this, 6 % of the patients were hypokalemic while 4 % were normokalemic
Conclusion: Changes in potassium levels, even to a milder extent, might act as a predictor for assessing the prognosis. Hence; the clinicians are advised to closely monitor serum potassium changes and correct them as they seem to have adverse effects on the outcome of AMI and its prognosis.

Keywords: Acute myocardial infarction, Potassium, Prognostic role

Introduction

At the advent of the 21st century, infectious diseases became relatively less of a concern, while chronic diseases continue to plague the global populace. Among the most common chronic diseases that afflict humans worldwide are diabetes, cardiovascular diseases (CVDs), osteoporosis, arthritis, obesity, chronic obstructive pulmonary disease, inflammatory bowel disease, central nervous system degenerative diseases and some cancers.[1] Ischemic Heart Disease (IHD) is one of the predominant types of CVD. The two leading manifestations of IHD are angina and AMI.[2]
An Acute Myocardial Infarction (AMI) is a subset of a spectrum of IHD that includes unstable angina and AMI with or without ST elevation. IHD places a massive health burden on humanity.[3]

Sodium (Na^+) and potassium (K^+) have played key roles in the development and maintenance of essential cellular functions throughout more than 2 million years of human evolution. Because only about 2% of the total body potassium is present in the extracellular fluid, plasma potassium concentration has to be maintained within a narrow range to avoid excessive variations in the membrane voltage and its dangerous consequences.[4]

The critical role of potassium in CVD and the importance of maintaining a normokalemic state are increasingly being recognized, particularly as relates to new and emerging cardioprotective and renoprotective therapies that promote K^+ retention.[5]

Several studies have demonstrated a relationship between low serum potassium levels, usually less than 3.5mEq/L, and the risk of ventricular arrhythmias in patients with AMI. On the basis of these studies, experts and professional societies have recommended maintaining potassium levels between 4.0 and 5.0mEq/L, or even 4.5 to 5.5mEq/L, in AMI patients.[6]

However; there is a lack of current, adequately powered studies that define the optimal range of serum potassium levels with respect to mortality and other important clinical outcomes in patients with AMI.[7] Hence; we planned the present study to evaluate serum potassium levels in AMI and assess its prognostic value in the severity and outcome of AMI.

Materials and Methods

The present study was conducted in the Department of Medicine, Guru Nanak Dev Hospital attached to Govt. Medical College, Amritsar. It was a cross-sectional study with an aim to assess 'serum potassium levels in AMI and its prognostic significance'. 50 patients with AMI who presented to the emergency department of Guru Nanak Dev Hospital and fulfilled the inclusion criteria were selected for the present study as 'Cases'. 50 age and sex matched apparently healthy individuals were selected as 'Controls'. Only those individuals (cases and controls) were included in the study who gave written consent. Written ethical approval was taken from institutional ethical committee and informed written consent was obtained from all the patients after explaining in detail the entire research protocol.

Inclusion criteria:

1. Patients with AMI and who gave written consent for participating in the study.
2. Chest pain lasting more than 20 minutes
3. Diagnostic ECG changes
4. Diagnostic rise in CK-MB

Exclusion criteria:

1. Renal insufficiency (serum creatinine >2.0mg/dl)
2. Old diagnosed case of hypokalemic periodic paralysis
3. Patients on previous diuretic therapy

Control group:

For the control purpose, 50 non-hypertensive and non-diabetic persons with negative history of smoking, and without symptoms of AMI were carefully selected and examined in detail with age and gender matched, who were not obese, non-predisposed and physically active.

Criteria for defining serum potassium level in the subject group:

Normal serum potassium was defined as 3.5 - 5.5 meq/l. Serum potassium values less than 3.5 were categorized as hypokalemia, and values more than 5.5 were categorized as hyperkalemia.[8]

All the patients of AMI fulfilling the inclusion and exclusion criteria were included in the present study. On admission, detailed history and thorough physical examination of the patients was done. An ECG obtained at the time of presentation and serial ECG monitoring was done. Routine baseline investigations i.e. Hemoglobin (Hb), Total leucocyte count (TLC), Differential leukocyte count (DLC), peripheral blood film (PBF), Fasting/ Random blood sugar (FBS/RBS), lipid profile, Serum CK–MB, blood urea and serum creatinine were done. Estimation of levels of serum sodium and serum potassium was done.

Collection of samples:

Venous blood samples were collected from all the participants. Samples were collected on the day of admission within 12 hours from antecubital vein under aseptic precautions. The samples collected were divided into two vials for the purpose of routine baseline blood investigations. For serum potassium levels, blood was allowed to clot at room temperature for half an hour and then centrifuged at 3000 rpm for five minutes. The serum separated was used for the estimation of serum potassium levels.

Statistical analysis

All the results were analyzed by SPSS software version 17.0. Chi-square test, Independent student's t-test and one way analysis of variance were used for assessment of level of significance. P-value of less than 0.05 was taken as significant.

Observations

The present study was conducted in the department of Medicine, Guru Nanak Dev Hospital attached to Govt. Medical College, Amritsar. A total of 50 AMI patients and 50 healthy controls were included and their serum potassium levels were evaluated.

Maximum number of the patients was in the age group of 51-60 years which is 36% of the total cases followed by 61-70 years which accounted for 34% of the total cases. The youngest patient was 32 yrs while the eldest was aged 74 years. Among the 50 patients of AMI, 60% were male and 40% were of female. Hypokalemia was found in 24% cases, hyperkalemia in 6% and 70% were normokalemic. Mean serum potassium levels were higher in the control group (4.41mEq/L) in comparison to the study group (3.97mEq/L0), the values of which were found to be statistically significant (P- value < 0.05).

Table 1: Distribution of AMI subjects on the basis of age group

Age group	Frequency	Percentage
<40	3	6
41- 50	8	16
51- 60	18	36
61- 70	17	34
>70	4	8
Total	50	100

Table 2: Distribution of AMI subjects on the basis of gender

Gender	Frequency	Percentage
Male	30	60
Female	20	40
Total	50	100

22 % patients (11 patients) of the AMI group developed arrhythmias. Arrhythmias were found to be present in 50 % of the hypokalemia patients, while in the normokalemic group, they were found to be present only in 11.4 % of the subjects. One out of 3 (33.3%) hyperkalemic patients also had arrhythmias (P- vale < 0.05).

HF was observed in 16 % of the AMI population in the present study. 11.4 % of the patients of the normokalemia group and 33.3 % of the patients of the hypokalemia group showed presence of HF (P- vale > 0.05). Mortality was seen in 10 % of the patients of the AMI group. Out of this, 6 % of the patients were hypokalemic while 4 % were normokalemic. Non-significant results were obtained while associating the mortality rate in AMI patients on the basis of mean potassium levels (P- vale > 0.05).

Table 3: Distribution of AMI subjects on the basis of serum potassium levels

Parameter	Frequency	Percentage
Hypokalemia	12	24
Normokalemia	35	70
Hyperkalemia	3	6
Total	50	100

Table 4: Comparison of mean serum potassium levels in between the AMI group and the control group

Group	Study group	Control group	P- value
Mean Serum potassium levels (mEq/L)	3.97±0.89	4.41±0.49	0.003 (S)

S: Significant

Table 5: Distribution of subjects with presence of arrhythmias on the basis of serum potassium levels

Arrhythmias	Serum potassium levels			Total	Chi-square value	P-value
	Hypo-kalemia	Normo-kalemia	Hyper-kalemia			
Arrhythmias absent	6	31	2	39	7.986	0.018
Arrhythmias present	6	4	1	11		
Total	12	35	3	50		

Table 6: Distribution of subjects with presence of HF on the basis of serum potassium levels

HF	Serum potassium levels			Total	Chi- square value	P- value
	Hypo-kalemia	Normo-kalemia	Hyper-kalemia			
HF absent	8	31	3	42	3.798	0.15
HF present	4	4	0	8		
Total	12	35	3	50		

Table 7: Distribution of subjects with presence of Mortality on the basis of serum potassium levels

Mortality	Serum potassium levels			Total	Chi-square value	P- value
	Hypo-kalemia	Normo-kalemia	Hyper-kalemia			
Died	2	3	0	5	1.005	0.605
Survived	10	32	3	45		
Total	12	35	3	50		

Discussion

AMI is an event of myocardial necrosis caused by an unstable ischemic syndrome. In practice, the disorder is diagnosed and assessed on the basis of clinical evaluation, the ECG, biochemical testing, invasive and non-invasive imaging, and pathological evaluation.[9]

The usual initiating mechanism for AMI is rupture or erosion of a vulnerable, lipid-laden, atherosclerotic coronary plaque, resulting in exposure of circulating blood to highly thrombogenic core and matrix materials in the plaque.[9]

Potassium (K^+) is a main component of cellular fluid. This positive electrolyte helps to regulate neuromuscular function and osmotic pressure, approximately 98% of this electrolyte is intracellular. Its main regulation is by the renal excretion and shift between the intracellular and extracellular compartments. Potassium is one of the electrolytes that play an important role in cardiac disease specially AMI.[10]

The role of hypokalemia in CVD in general, or in myocardial ischemia and myocardial infarction (MI) in particular, has been under investigation for a long time. Close examination of the literature on hypokalemia in patients with MI reveals the complexity of the matter, with its inherent ample chance for methodologic and clinical pitfalls in the design and implementation of studies.[11] Hence; we planned the present study to assess serum potassium levels in AMI patients.

In the present study, we observed that majority (64%) AMI patients belonged to the age group of 51 to 70 years. While comparing the mean serum potassium levels in between the AMI group and the control group, statistically significant difference was obtained (P- value < 0.05). Our results were in correlation with the results of Wali MV et al and Biyani S et al who observed a significant reduction in the levels of serum potassium levels of AMI patients.[12,13] However; our results were in contrast with the results obtained by Marzoq LFA, who didn't observe any significant difference in the mean value of serum potassium levels in the AMI patients and healthy control.[10]

In our study, we observed that majority of the AMI patients were males (60%). Our results were found to be in correlation with the results obtained by previous authors who have reported a male preponderance in AMI groups of their respective studies.[14, 15]

Hypokalemia was found in 24% cases, hyperkalemia in 6% and 70% were normokalemic. Our results were in correlation with the results obtained by studies of past literature, which have reported that prevalence of hypokalemia in AMI patients varies from 9 % to 25 %.[11,16,17] Our results were also in concordance with the results obtained by Patil S et al, who reported the presence of hypokalemia in 24% of the AMI patients.[18]

The main reason for hypokalemia in the early phase of an AMI is most likely an activation of the sympathetic nervous system leading to an influx of potassium from the extracellular to the intracellular body fluid compartment.[19]Serum potassium levels are maintained within normal limits by renal excretion, and shift between intracellular and extracellular fluid compartments. In the early phases of AMI, the sympathetic nervous system is activated, as reflected by elevated levels of plasma catecholamines and modulation of β adrenergic receptor signalling. This activation leads to intracellular influx of potassium and decrease in serum potassium levels.[20]

Statistically significant association was observed between the prevalence of arrhythmias and serum potassium levels in AMI patients (P- value < 0.05). Our results were in concordance with the results obtained by Clausen TG et al, who also observed significant positive correlation between hypokalemia and the incidence of arrhythmias.[21]

Su J et al, in their study, reported that prevalence of arrhythmias was higher in the hypokalemia group in comparison with that of the normokalemic group (P-value < 0.05).[22]

Low potassium levels have been shown to increase the automaticity and excitability of myocardial cells, leading to the propensity for arrhythmias.[20]

Hypokalemia causes cellular hyperpolarity, increases resting potential, hastens depolarization, and increases automaticity and excitability. Because cardiac repolarization relies on potassium influx, hypokalemia lengthens the action potential and increases QT dispersion (reflecting electrical inhomogeneity). Hypokalemic ventricular ectopy is suppressed by potassium replacement. Thus, hypokalemia increases risk of ventricular arrhythmia and sudden cardiac death.[23]

HF was observed in 16 % of the AMI population in the present study. We also observed a non-significant association between presence of HF and serum potassium levels in AMI group patients. 11.4 % of the patients of the normokalemia group and 33.3 % of the patients of the hypokalemia group showed presence of HF. However, the results were not statistically significant (P- value > 0.05).

Mortality was seen in 10 % of the patients of the AMI group. Out of this, 6 % of the patients were hypokalemic while 4 % were normokalemic. A U-shaped relationship between mean serum potassium concentration and mortality rate has been reported in the past literature.[24] As the mortality cases in our study were too small (5 cases), it is not possible to comment on the correlation of mortality and serum potassium levels. However; we observed that percentage of mortality cases increased from normokalemia group (8.57 %) to hypokalemia group (16.6 %).

Our results were in concordance with results obtained by Goyal et al, who observed mortality in 12.5 % of the patients with hypokalemia, and mortality in 6.4 % of patients with normokalemia.[6]

A U-shaped relationship between the potassium levels at admission and both early and late risk of Cardio-vascular death was also observed by Patel RB et al. They observed lower risk of cardiovascular death in patients with admission potassium levels between 3.5 and 4.5 mEq/l.[24] Previous studies also show higher mortality in hypokalemic AMI patient in comparison to normokalemic AMI patients.[19, 21]

Extracellular (serum) potassium concentration is normally maintained within the approximate reference range which is important for normal cardiac function. Both reduced serum potassium (hypokalemia) and increased serum potassium (hyperkalemia) can, if sufficiently severe, be associated with potentially lethal cardiac arrhythmia. Current guidelines emphasize the importance of avoiding hypokalemia, advising that patients diagnosed with MI should be given potassium supplements, if necessary, to maintain serum potassium in the range of 3.5-4.5 mEq/L.[6]

Conclusion

Cardiac arrhythmias and Congestive heart failure complicating AMI are high-risk conditions associated with high mortality. Hypokalemia was evident in a large number of AMI patients in our study, might be due to sympathetic stimulation and catecholamine surge in such patients. It has been associated with ventricular arrhythmias and increased mortality in AMI patients. Changes in potassium levels, even to a milder extent, might act as a predictor for assessing the prognosis. Hence; the clinicians are advised to closely monitor serum potassium changes and correct them as they seem to have adverse effects on the outcome of AMI and its prognosis.

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