Tabari Biomedical Student Research Journal

OPEN ACCESS

ORIGINAL: Electrolyte Disturbances in Post-Acute Myocardial Infarction Arrhythmias

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ARTICLE INFO

Submitted: 07 Jun 2023
Accepted: 22 Aug 2023
Published: 01 Sep 2023

Keywords:
Acute myocardial infarction;
Calcium;
Electrolyte disturbance;
Magnesium;
Potassium

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Citation:
Seyedi SZ, Zahedi M, Farahani P, Azimi H. Electrolyte Disturbances in Post-Acute Myocardial Infarction Arrhythmias. Tabari Biomed Stu Res J. 2023;5(2):39-44.

10.32598/tbsrj.v5i2.10535

ABSTRACT

Introduction: Electrolyte disturbances are an important predictor for the prediction of arrhythmias after acute myocardial infarction (AMI). This study investigated the prevalence and relationship of various electrolyte disorders with common types of arrhythmias after AMI.

Material and Methods: This cross-sectional study was performed on 153 patients with arrhythmias after AMI. Patient's demographic variables were collected from patient files and required laboratory findings including serum potassium (K), calcium (Ca), and magnesium (Mg) were measured in the first 12 hours after AMI. Any type of serum electrolyte disturbance was defined as a value above or below the reference values. The incidence of any arrhythmias during hospitalization was determined for each group of electrolyte disturbances using chi-square test and fisher exact test. Logistic regression was used in order to evaluate the risk of any arrhythmias in association with serum electrolyte levels.

Results: In this study, the most common arrhythmias after AMI were inappropriate sinus tachycardia (IST) (43.1%), sinus bradycardia (33.3%), and premature ventricular contractions (30.7%), respectively. Majority of subjects had normal levels of serum K and Ca levels (P=0.001). Also, most of the patients with ventricular tachycardia and SB were in the range of normokalemia (P=0.015) and normocalcemia (P=0.035), respectively. The risk of IST increases by 1.911 times for every 0.648 units increase in K (P=0.033). However, no significant relationship was seen between other electrolyte disturbances and any other post-AMI arrhythmias.

Conclusion: Occurrence of IST increases with higher levels of K. lack of association between other serum electrolytes levels and arrhythmias indicate the importance of further studies in this regard with consideration of other affecting factors.

Introduction

According to global burden of diseases, cardiovascular diseases (CVD) caused 18.5 million deaths worldwide in 2019 (1). Ischemic heart diseases (IHD), which can eventually lead to acute myocardial infarction (AMI), was the second leading cause of disability-adjusted life years (DALYs) (2) and first ranked cause of years of life lost (YLLs) globally in 2017 (3). In Iran, with estimated 80 million

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[DOI: 10.32598/tbsrj.v5i2.10535]

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population, 102 thousand deaths happened due to IHD in 2019 (1). Cardiogenic shock, pseudoaneurysm, ventricular septum rupture, acute mitral regurgitation, pericarditis and tamponade, hypertension, and arrhythmias are among the major complications of AMI (4). Although percutaneous coronary intervention has decreased the incidence of AMI complications, but there is still a significant burden due to its increasing incidence (5).

Arrhythmias occur in more than 90% of AMI patients (6) and were the leading cause of death among them before the advent of coronary-care units (7). Although pump failure became the primary cause of mortality currently, but arrhythmia management, which is often leads to left ventricular dysfunction, remains a crucial part of therapy (4). Post AMI arrhythmias can be attributed to some factors such as the electrolyte disturbances, autonomic nervous system dysfunction, pericarditis, ischemic injury to myocardia, hypoxia, as well as persistent pain, left ventricular dysfunction, and medications (8, 9). Sudden cardiac death as a result of ventricular tachycardia (10) and stroke as a result of atrial fibrillation (AF) (11) can be named as the adverse consequences of post AMI arrhythmias. Therefore, early detection of possible future arrhythmias is crucial due to the irreversible and serious complications of it.

Accumulation of various electrolytes in ischemic zone as well as serum electrolyte imbalances are one of the major causes of post AMI arrhythmias (9, 12). Thus, in this study we aimed to investigate the prevalence and association of various electrolyte imbalances with common arrhythmias after AMI in north of Iran.

Methods

Study group

This cross-sectional study was done among 153 patients with arrhythmias after AMI who hospitalized in Shahid Sayad Shirazi referral Hospital in Gorgan (north of Iran) during 2020. Patient's demographic and clinical data were recorded by a trained expert in consultation with the specialist physician. Patients with AMI were included in the study. The simultaneous existence of any other clinical status, which could affect arrhythmia occurrence and electrolyte balances, including structural heart disease, previously known arrhythmia, history of abnormal cardiac electrophysiology study, malignancy, and chronic liver and kidney failures were considered as exclusion criteria. Eventually, patients with AMI who did not meet the exclusion criteria were included in the study.

In order to ensure the observance of ethical considerations, the protocol for this research project was presented in Local Ethics Committee of Golestan University of Medial Sciences and the necessary license was obtained with the code of medical ethics IR.GOUMS.1397.118. All information was kept confidential by the researchers.

Clinical and biochemical measurements

Blood samples were taken to measure electrolytes in the first 12 hours after AMI. In the reference laboratory of the hospital, serum potassium (K), Calcium (Ca), and magnesium (Mg) were measured by flame-photometry with standardized kits (Biorexfars kit), tools and similar methods.

Electrocardiogram (ECG) monitoring were done by CAREWELL standardized machines in cardiac care unit (CCU) or post CCU wards during hospitalization of patients with AMI. In this study, an internal medicine specialist in consultation with a cardiologist in suspicious cases, examined the ECGs and confirmed the diagnosis of AMI and type of arrhythmia based on similar criteria.

Definition

In this study, AMI was diagnosed based on clinical suspicion, ECG series, and serial measurement of specific cardiac enzymes (i.e., troponin) (13).

Inappropriate sinus tachycardia (IST), sinus bradycardia (SB), premature atrial contraction (PAC), atrial fibrillation (AF), supraventricular tachycardia (SVT), junctional

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rhythm, premature ventricular contraction (PVC), ventricular tachycardia (VT), ventricular fibrillation (VF), accelerated idioventricular rhythm (AIVR), atrioventricular block (AV block) were described according to European Society of Cardiology (ESC), the American College of Cardiology (ACC), the American Heart Association (AHA) and the World Heart Federation (WHF).

Electrolyte disturbances were defined separately for each of the serum electrolytes, including K, Ca, and Mg, based on values more or less than the reference value. Electrolyte evaluation standard: normal (normo), blood potassium 3.50-5.50 mmol/L, blood calcium 8.6-10.3 mmol/L, blood magnesium 1.8-2.6 mmol/L; decrease (hypo), blood potassium <3.5 mmol/L, blood calcium <8.6 mmol/L, blood magnesium <1.8 mmol/L; increase (hyper), blood potassium >5.5 mmol/L, blood calcium >10.3 mmol/L, blood magnesium >2.6 mmol/L.

Statistical analysis

Data was analyzed using SPSS version 22. The categorical variables were reported by percentages and measurable variables by mean and standard deviation. Fisher's exact test and Chi-square test were used to compare the frequency of arrhythmias in each group of electrolyte disturbances. The association between serum electrolytes and risk of arrhythmias were evaluated by logistic regression. Analysis with P value <0.05 were considered to be statistically significant in this study.

Results

This cross-sectional study included 153 patients with AMI, who had any arrhythmias during hospitalization with mean age of 62.6 ± 12.4 (range 34 to 92 years). Most of them were female (60.3%). Regarding the arrhythmia prevalence, majority was related to IST (43.1%), followed by SB (33.3%) and PVC (30.7%), respectively (***Table 1***).

K, Ca, Mg measurements were done among 152, 34, 7 of the participants, respectively. Serum K and Ca levels were in the normal range in the majority of subjects (P<0.001) (***Table 2***).

Table 1. Arrhythmias prevalence after acute myocardial infarction

Arrhythmias	No N (%)	Yes N (%)
Inappropriate sinus tachycardia (IST)	87 (56.9)	66 (43.1)
sinus bradycardia (SB)	102 (66.7)	51 (33.3)
Premature atrial contraction (PAC)	135 (88.2)	18 (11.8)
Atrial fibrillation (AF)	138 (90.2)	15 (9.8)
supraventricular tachycardia (SVT)	150 (98)	3 (2)
Junctional rhythm	149 (97.4)	4 (2.6)
Premature ventricular contraction (PVC)	106 (69.3)	47 (30.7)
Ventricular tachycardia (VT)	145 (94.8)	8 (5.2)
Ventricular fibrillation (VF)	150 (98)	3 (2)
Accelerated idioventricular rhythm (AIVR)	150 (98)	3 (2)
atrioventricular (AV) block	141 (92.2)	12 (7.8)

According to chi square and fisher exact test, Serum K levels and VT were reported to be significantly correlated (P=0.015). Accordingly, most of the patients with VT were in normokalemia group. There was no association between K and any other arrhythmias. There was a significant relationship between serum calcium levels and SB (P=0.035). But the most of patients with SB had Ca levels in normal range. Other arrhythmias, however, were not associated with Ca. On the other hand, serum Mg level did not appear to be associated with each of the arrhythmias.

Regression model revealed that a higher serum K level was significantly associated with IST, while no association was found between serum K levels and other arrhythmias. IST is 1.911 times more likely to occur for every 0.648 units increase in K (P=0.033). In this regard, there was not any association between serums Ca and Mg levels with risk of arrhythmias.

Discussion

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Serum electrolyte disturbances have been suggested to be one of the causes of arrhythmias. Considering the high incidence of arrhythmias after AMI and their undeniable complications in some cases; it is crucial to determine the contributing factors including serum electrolyte disturbances.

Table 2. Demographic Characteristics of Participants

Electrolytes	Subgroup	N (%)	Mean ± SD	Minimum	Maximum
Potassium	Hypo (<3.5)	9 (5.9)	4.31 ± 0.56	2.8	6
	Normo (3.5-5.5)	138 (90.8)			
	Hyper (>5.5)	5 (3.3)			
Calcium	Hypo (<8.6)	14 (41.2)	8.7 ± 0.69	7.3	10.4
	Normo (8.6-10.3)	19 (55.9)			
	Hyper (>10.3)	1 (2.9)			
Magnesium	Hypo (<1.8)	1 (14.3)	2.4 ± 0.42	1.7	2.93
	Normo (1.8-2.6)	3 (42.9)			
	Hyper (>2.6)	3 (42.9)			

In line with our study, SB (21.3%), PVC (11.7%), IST (8.5%) reported to be the most common arrhythmias in AMI patients (14). IST occurrence may be due to pain, hypovolemia, left ventricular failure, pulmonary thromboembolism, agitation, and medications (9). Ischemic damage to sinus node and hypo perfusion resulting in decrease cellular oxygenation are the mentioned causes for SB (4, 15). Bundle branch block and atrioventricular block listed as the causes of PVC (4).

Hoppe et al. in a meta-analysis of observational studies demonstrated that hypokalemia was associated with ventricular arrhythmias including VT in AMI patients (16); which was in line with some other studies (8, 17-19). However, in our study, most of patients with VT as one of the ventricular arrhythmias were in range of normokalemia. This could be due to the different designs of studies or different ethnicity of participants.

High levels of serum Ca as well as elevated intracellular Ca by electrical, structural, and mitochondrial dysfunctions can lead to developing AF (20). To the best of our knowledge, serum Ca levels were not reported to be associated to any other arrhythmias. In this study, patients with SB had normocalcemia and Ca disturbances including hypocalcemia or hypercalcemia did not associate with SB prevalence.

In our study we could not find any relationship between serum Mg levels and arrhythmias; Of course, we measured Mg levels in a very small number of patients which could have affected the accuracy of the results. In line with our study, Ambali and Bomann in a cross-sectional study among 100 patients with AMI in 2018, could not find any significant relationship between serum Mg disturbances and cardiac arrhythmias (21). However, Dyckner et al. demonstrated that incidence of PVC, VT, and VF were significantly higher in patients with hypomagnesemia after AMI (22). Furthermore, in a study among 60 patients with AMI, patients with arrhythmias had significantly lower levels of serum Mg compared to patients without (23). Hypomagnesemia was also associated with post-AMI arrhythmias in another study performed among 50 patients (24).

Conclusion

IST, SB, and PVC were the most common post-AMI arrhythmias. In this study risk of development of IST increase with increased serum K levels. But no significant relationship was seen between other electrolyte disturbances and post-AMI arrhythmias. Numerous other factors, including underlying diseases, may be involved in the development of arrhythmias, which are recommended to be explored in future studies.

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[DOI: 10.32598/tbsrj.v5i2.10535]

Ethical standards statement

The study was approved by the Local Ethics Committee of Golestan University of Medial Sciences (Code: IR.GOUMS.1397.118).

Conflicts of interest

The authors declare no conflict of interest.

Authors' contributions

All authors contributed equally to preparing this article.

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