Sudan Journal of Medical Sciences
Volume 19, Issue no. 4, DOI 10.18502/sjms.v19i4.16408
Production and Hosting by KnE Publishing

KnE Publishing

Check for updates

Research Article

Serum Magnesium Level among Acute Myocardial Infarction Patients and Its Correlation with Intra-hospital Complications: A Cross-sectional Single-center Study among Sudanese Patients

Mohammed Taha[1], Ayman Azhary[2,3,4]*, Nooh Mohamed Hajhamed[2,4], Waleed Azhary Sir Alkhatim[5,6], Salahaldeen Ismail Mohammed[2], Abdullah M Bakheit[3,4,7], Abdallah Elssir Ahmed[4], and Abubakar Abdelbagi[8]

[1]Department of Internal Medicine, University of Gezira, Gezira, Sudan
[2]Department of Medical Microbiology, Faculty of Medical Laboratory Sciences, Omdurman Islamic University, Khartoum, Sudan
[3]Department of Microbiology, Faculty of Medicine, Al Mughtaribeen University, Khartoum, Sudan
[4]Molecular Biology Unit, Sirius Training and Research Centre, Khartoum, Sudan
[5]Department of Internal Medicine, University of Sinnar, Sinnar, Sudan
[6]Sudan Medical Specialization Board, Khartoum, Sudan
[7]Department of Pharmaceutics, Faculty of Pharmacy, Al Mughtaribeen University, Khartoum, Sudan
[8]Department of Medical Biochemistry and Biophysics, Umeå University, Umeå, Sweden

Corresponding Author: Ayman Azhary; email: azhryaymn18@gmail.com

Received: 2 June 2024
Accepted: 8 September 2024
Published: 31 December 2024

Production and Hosting by KnE Publishing

Abstract

Background: Patients with acute myocardial infarction (AMI) frequently have hypomagnesemia, although magnesium (Mg) has proven cardioprotective characteristics. Cardiovascular fatality has been linked to low serum Mg levels; however, the exact mechanism is unknown and results are inconsistent. This study aims to measure the level of serum Mg among patients diagnosed with AMI.

Methods: One hundred AMI patients who came to the Wad Madani Heart Center were included in a cross-sectional research study. Demographic data, clinical data (presenting compliance, medical history, and medication history), laboratory examination, electrocardiography (ECG) findings, and echocardiography findings were collected. Serum Mg was measured for all participants, and hypomagnesemia was considered as a serum Mg level <1.6 mg/dl. Version 21.0 of SPSS was used to analyze the data.

Results: The mean age of 100 patients was 60 ± 2 years, with 55 (or 55%) being female and 45 (or 45%) being male. Chest pain (*n* = 92; 92%) was the major presenting complaint. Moreover, the most prevalent heart disease determinants among patients were diabetes mellitus (*n* = 50; 50%) and hypertension (*n* = 50; 50%). The mean of Mg was 2.5 mg/dl, and hypomagnesemia was found in 10 (10%) patients and significantly associated with arrhythmia, namely supraventricular tachycardia, (*P*-value = 0.01). Patients with normal or low Mg levels (98%) were more likely to be discharged in stable condition, whereas all fatalities were among patients with elevated Mg levels (2%).

Conclusion: The frequency of hypomagnesemia among AMI patients was 10%. In addition, hypomagnesemia was significantly associated with arrhythmias (mainly supraventricular tachycardia).

Keywords: acute myocardial infarction, cardiovascular disease, hypomagnesemia, prevalence

1. Introduction

The human body contains magnesium (Mg^{2+}) as the fourth most common mineral, following calcium (Ca^{2+}), potassium (K^+), and sodium (Na^+). It is an important component of cardiovascular homeostasis and a cofactor in over 300 cellular enzyme systems [1]. There is prior research establishing a connection between Mg and the cardiovascular system [2]. Hypomagnesemia affects 2% of the general population, but in certain groups, where there is substantial risk, such as people with congestive heart failure, the prevalence can reach 53%. Serum Mg is still evaluated somewhat rarely, despite the fact that hypomagnesemia can have both short- and long-term consequences [3]. Variations in blood potassium (K^+) levels have an impact on the automation, repolarization, and depolarization of tissues, including the Purkinjie fibers in the heart [4]. Phase 4 of the action potential is raised in Purkinje fibers due to a drop in extracellular K, which results in greater automation. Phase 4 of the action potential occurs when K ions move through Mg-dependent channels inward. When Mg is exhausted, this flow's action ceases [4]. Cardiovascular disease (CVD) is one of the leading causes of disease and death globally. The World Health Organization states that CVD is an epidemic that is currently occurring [5]. AMI patients make up a sizable portion of patients presented to the cardiac intensive care unit, so it is critical to track and stratify their risk. A long-term risk factor for myocardial infarction (MI) and arrhythmia incidents is hypomagnesemia [6]. There are two types of causes for hypomagnesemia – acquired and hereditary. The acquired causes include increased renal loss, redistribution brought on by acute sickness, and decreased oral intake or GI absorption [7]. AMI is a significant health concern in industrialized countries and is growing in significance as a concern in underdeveloped countries. Because free Mg gets trapped in adipocytes after MI, there is a functional shortage of accessible Mg. It was shown that the serum Mg level rises progressively to normal in approximately three weeks after an acute myocardial infarction (AMI), but is low for the first 48 hrs [8]. Hypomagnesemia's clinical manifestations can range from an asymptomatic presentation to potentially fatal arrhythmias [9]. According to clinical investigations, patients with AMI who receive Mg treatment experience about 50% fewer arrhythmias than those who receive a placebo. In another study, Mg supplementation during the first 24 hrs after coronary blockage reduced the index of fatality for the initial year [2]. Mg may be advantageous to MI through a variety of pathways, including effects on intracellular calcium, both aberrant and normal automation, and possibly even coronary tone [10]. A study by Guipeng *et al.* looked into the relationship between major adverse cardiac events (MACEs) following AMI and serum Mg concentrations and concluded that serum Mg was a significant predictor for MACEs of AMI, after adjustment for other confounding factors [11]. Serum Mg levels in individuals with AMI who present within the first 24 hrs were compared by Vedamanickam *et al.* AMI patients had a mean serum Mg level of 1.23 ± 0.98 mg/dL, while the control group had a significantly higher level of 2.12 ± 0.68 mg/dL; therefore, Mg supplementation might improve the patients' outcome [12]. Nasim *et al.* studied the association between hypomagnesemia and acute coronary syndrome. This investigation demonstrated that hypomagnesemia and acute coronary syndrome do not significantly correlate [13]. Mg has been known to have an influence on AMI sequels like arrhythmias; it also has a significant impact on the pathophysiology of other cardiovascular disorders [14]. Serum Mg level, though important, is not a routine investigation done in all patients with AMI in our practice. Therefore, this study was designed to highlight the importance of Mg in the etiology, prognosis, and all-case morbidity and mortality of AMI, and even to prompt the role of early recognition and management of hypomagnesemia in decreasing intra-hospital and overall cardiac deaths secondary to IHD, HF, and arrhythmias. Since there hasn't been a published study that examines hypomagnesemia in Sudanese AMI patients to our knowledge, our goal was to find out how common it is and what impact it has on these individuals.

2. Materials and Methods

This is a cross-sectional study conducted at the Madani Heart Center between December 2018 and May 2019.

2.1. Inclusion criteria

This study included 100 male and female AMI patients aged more than 18 years who attended Madani Heart Center during the study period.

2.2. Exclusion criteria

Alcoholic patients, patients with liver cirrhosis, patients who are known cases of arrhythmias, patients with chronic diarrhea, patients with renal impairment, patients with hypokalemia, and patients on diuretics were excluded.

2.3. Data collection

The lead researcher was in charge of gathering data. Data were gathered using structured questionnaires following the recruitment of study participants. The questionnaires were composed of demographic data, clinical data (presenting compliance, medical history, and medication history), electrocardiography (ECG) findings, and echocardiography findings. To measure serum Mg, 5 ml blood was drawn from study participants in the emergency room (ER). Serum Mg was measured using a Roche Cobas c 311 analyzer. In addition, serum Mg level <1.6 mg/dl was considered hypomagnesemia.

2.4. Statistical analysis

Version 21.0 of the Statistical Package for the Social Sciences (SPSS) was used to analyze the data. Tables and figures are used to display the analyzed data. As a significance test, a Chi-square test was employed. A significance criterion of $P < 0.05$ was established.

3. Results

Ninety percent of the 100 AMI patients who were enrolled in this study lived in central locations, with a mean age of 62 years. Of these patients, 55% were female and 45% percent were male (Table 1). Chest pain (n = 92; 92%) was the major presenting complaint, followed by shortness of breath in 17 (17%) patients and palpitation in 7 (7%) patients (Figure **1**). The most prevalent risk factors for CVD were diabetes mellitus (DM; n = 50) and hypertension (n = 50). A prior history of ischemic heart disease (IHD) was found in 26 patients, and smoking was found in 9 patients (Figure **2**).

Examination results showed that the mean diastolic blood pressure was 71.7 ± 16.3 mmHg, the mean systolic blood pressure was 124.6 ± 20.2 mmHg, and the mean pulse rate was 81.6 ± 20.7 beats per minute. In addition, 35 patients had evidence of heart failure (Table 2). In ECG, 14 patients had arrhythmia – Right Branch Bundle Block (RBBB) in 4, supraventricular tachycardia (SVT) in 4, Left Bundle Branch Block (LBBB) in 3, atrial fibrillation with rapid ventricular rate (A-fib with RVR) in 2, and ventricular tachycardia (VT) in 1 patient (Figure **3**). Figure **4** shows box-plots of Mg levels with different arrhythmia patterns among AMI patients in Sudan. Regarding echocardiography findings, 65 patients had wall motion abnormalities. The mean ejection fraction (EF) was found to be 50.6 ± 10.5%, and 54 patients had reduced EF (Table 3). The mean of Mg was 2.5 mg/dl, and hypomagnesemia was found in 10 patients. Table 4 shows the association between Mg levels and arrhythmias, wherein patients with normal Mg levels are more likely to have no arrhythmias (79.1%), and patients with hypomagnesemia are more likely to have SVT (75%). At *P*-value = 0.01, the difference was significant. Figure **5** shows Mg levels and outcomes, wherein patients with normal or low Mg levels were more likely to be discharged in stable condition (98%), whereas all mortalities were among patients with hypermagnesemia (2%).

Table 1: The demographic characteristics of AMI patients (*N* = 100).

	N	**%**
Age; Mean ± SD	60 ± 2	
Gender		
Female	55	55.0
Male	45	45.0
Residence		
Central	90	90.0
East	9	9.0
West	1	1.0

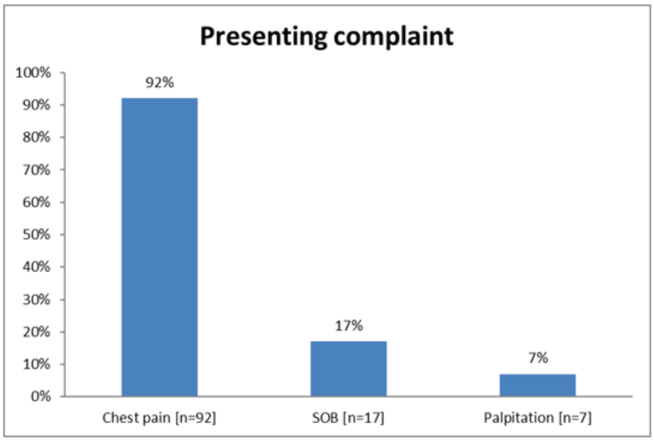

Figure 1: Presenting complaints of AMI patients (*N* = 100). Note: Some patients had more than one dominant symptoms.

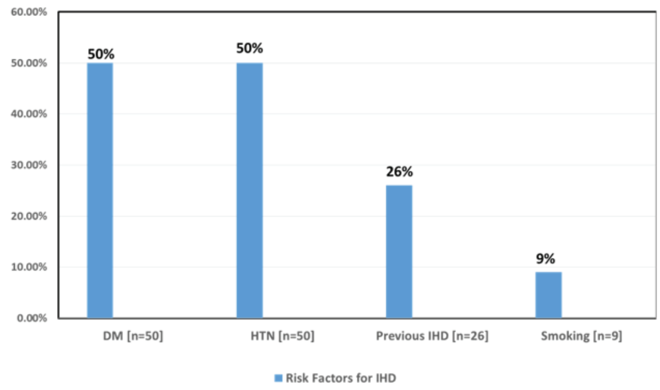

Figure 2: Distribution of risk factors among AMI patients (*N* = 100). Note: Some patients had more than one dominant symptoms.

Table 2: Examinations of AMI patients at presentation (*N* = 100).

	Mean	**SD**
Pulse rate (bpm); mean ± SD	81.6	20.7
SBP (mmHg); mean ± SD	124.6	20.2
DBP (mmHg); mean ± SD	71.7	16.3
Evidence of heart failure (HF); *n* (%)	35 (35%)	

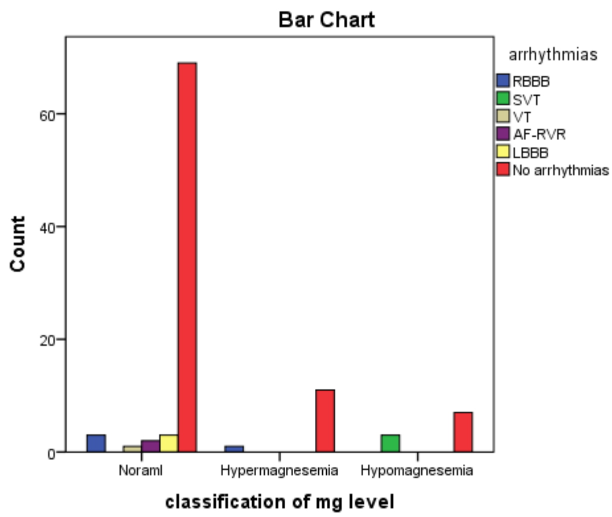

Figure 3: Arrhythmias detected by ECG among AMI patients during hospital admission.

Table 3: Echocardiography findings of AMI patients (*N* = 100).

	N	**%**
Wall motion abnormality	65	65.0
EF (%); mean ± SD	50.6 ± 10.5	
Preserved	46	46.0
Mildly reduced	34	34.0
Moderately reduced	10	10.0
Severely reduced	10	10.0

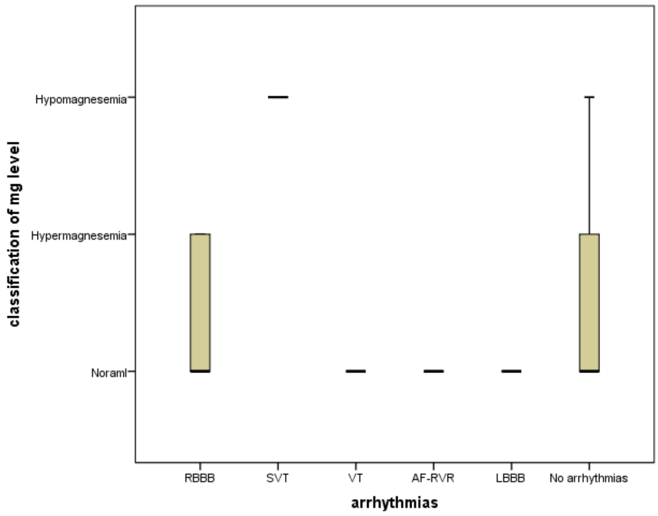

Figure 4: Box-plots of magnesium level with the different arrhythmia patterns among acute myocardial infarction patients in Sudan.

Table 4: Association between magnesium levels and arrhythmias.

ECG	Serum Magnesium category			P-value
	Hypomagnesemia	**Normal magnesium level**	**Hypermagnesemia**	
RBBB	0	3	1	0.604
LBBB	0	3	0	0.647
SVT	3	1	0	0.01
VT	0	1	0	0.867
AF	0	2	0	0.750

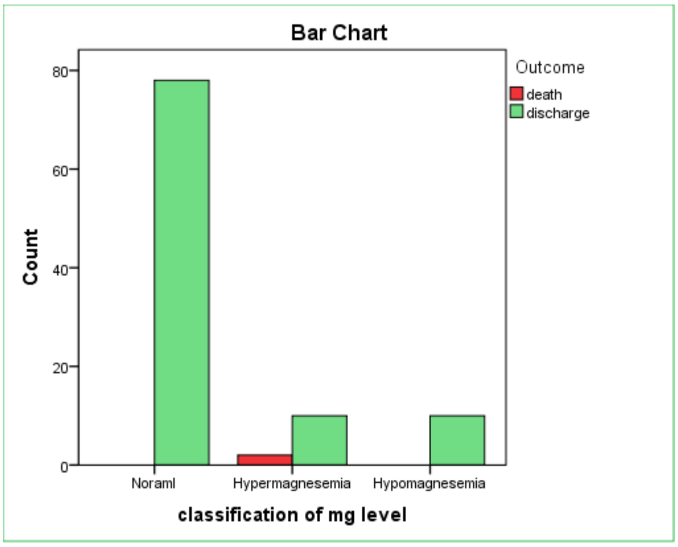

Figure 5: Magnesium levels and patient outcomes.

4. Discussion

Serum Mg concentrations may return to normal while a patient is in the hospital, and hypomagnesemia linked to AMI may only be temporary. Moreover, Mg will immediately exit the ischemic region in an experimental MI caused by coronary artery ligation [12]. Our goal in this study was to assess the prevalence and consequences of hypomagnesaemia in AMI patients. Numerous studies have found a relationship between Mg level and the prognosis of coronary artery disease. Hospitalizations and deaths related to cardiovascular disorder were found to be inversely correlated with serum Mg in the National Health and Nutrition Examination Survey Epidemiologic Follow-up Study (NHANES) [11]. In a population-based sample from northern Germany, hypomagnesemia was revealed to be a reliable indicator of death from heart disease, even after accounting for cardiovascular risk factors including diabetes and hypertension [11]. We found in this study a predominance of females over males (55% vs 45%). Our results corresponds with a review conducted by Brenda *et al.*, who found that 56.8% of AMI patients were females and 43.2% were males [3]. However, Taha *et al.*, in Sudanese ACS patients, found a male predominance [14]. In our study, chest pain (n = 92; 92%) was the major presenting complaint, followed by shortness of breath in 17 (17%) patients and palpitation in 7 (7%) patients. Similarly Taha *et al.*, in Sudanese acute coronary syndrome (ACS) patients, reported that 97% of patients presented with chest pain [14]. Hypertension and DM (50% for each) were the main AMI risk factors among our patients. This aligns with the results of Ghada *et al.*, who reported that the most prevalent risk factors among 40 patients were hypertension (52.5%) and DM (48.7%) [15]. Regarding the examination of AMI patients at presentation, 35 (35%) patients had evidence of heart failure. Hypomagnesemia can negatively impact heart failure by increasing the risk of arrhythmias, hypertension, vasoconstriction, and inflammation, and contributes to metabolic disturbances. It is both a consequence of heart failure treatment and a factor that can exacerbate the condition, leading to a cycle of worsening cardiac function.

In the present study, based on echocardiography findings, wall motion abnormalities constitutes the major finding in 65% of the patients. These results were similar to those of the Iraqi study conducted by Mohammed *et al.*, which found that wall motion abnormality was the main echocardiography finding in 42% of the patients [16]. The mean of EF was 50.6 $\pm$ 10.5%, and the majority of patients (56%) had reduced EF (<50%), mainly in the range of 40–50. In the study of Mohammed *et al.* in Iraq, left ventricular EF was compromised in 74% of LBBB patients with associated CAD [16]. Additionally, Ghaffari *et al.* in Iran showed that left ventricular EF was low in 80% of CAD-diseased patients, while in patients with normal EF, only 37% showed CAD [17]. Mg is the second most abundant ion inside cells and is involved in a wide range of illnesses, such as heart problems [18]. The serum Mg level has been observed to have extraordinary importance in AMI [19]. This study demonstrated that hypomagnesaemia was found in 10 (10%) patients. This hypomagnesemia rate matched the research findings of Cristina *et al.* and Nasim *et al.*, who reported hypomagnesaemia in 9.8% and 5.3%, respectively [13, 20]. However, our prevalence was lower than the findings of Taneva *et al.*, who indicated hypomagnesaemia in 28% [21]. The differences in sample sizes, geographic locations, and methods of use could be the cause of these variations in hypomagnesaemia rates. Considerably, the current study demonstrated a strong correlation between hypomagnesaemia and SVT (*P*-value = 0.01). Hypomagnesaemia was identified in a review by Efstratiadis *et al*. Tachycardia was the primary symptom, which was followed by serious arrhythmia and, ultimately, bradycardia [2]. Our findings showed that lower Mg2+ levels among AMI patients is associated with cardiac arrhythmias.

One of the most interesting findings of this study is that patients with normal Mg levels and those with hypomagnesaemia were more likely to be released in a stable state (98%), whereas patients with elevated Mg levels were the only ones who died (2%). Several factors can contribute to the onset of hypermagnesemia during an MI, including renal dysfunction, cellular Mg release during the infarction, and lactic acidosis due to hypoxia, which can cause Mg to shift from intracellular to extracellular spaces. Hypermagnesemia is associated with conduction abnormalities, such as bradycardia, which can either contribute to or worsen the conditions leading to MI. Additionally, hypermagnesemia may cause excessive vasodilation, leading to hypotension and reduced myocardial perfusion, potentially resulting in ischemia.

Our study contradicts other studies like prospective population‐based Rotterdam studies of Brenda *et al.* [3], Guipeng *et al.* [11], and Vedamanickam *et al.* [12]. which stated that hypomagnesemia was a significant predictor of MACEs and consequently mortality in AMI. On the other hand, Cristina *et al.* do not support a significant role of low Mg as a predictor for prognosis and mortality in AMI [20], which corresponds to the result of our study. The findings of this study indicate that monitoring and testing Mg levels are essential for all AMI patients in order to detect hypomagnesemia, treat it early, maintain cardioprotectivity, and lower the risk of arrhythmia.

5. Limitations

This study's single-center design and small sample size can be considered its limitations.

6. Conclusion

This study concluded that the frequency of hypomagnesemia among AMI patients was 10%. In addition, hypomagnesaemia was significantly associated with arrhythmias (namely, SVT). The study's most intriguing conclusion is that all deceased patients (2%) had hypermagnesemia, and patients with normal Mg levels and hypomagnesaemia had a higher likelihood of being discharged from the hospital (98%). It is advised that more prospective longitudinal multicenter studies be conducted to assess the impact of Mg on the prognosis and mortality of patients with AMI from Sudan.

Acknowledgments

The authors thank all individuals who consented to participate in this study. They are also grateful to the members of the Madani Heart Center.

Ethical Considerations

An ethical approval was obtained from the Sudan Medical Specialization Board (SMSB). Approval and acceptance by the hospital authority were being given. Written consent was obtained from patients.

Competing Interests

The authors declare that they have no competing interests.

Availability of Data and Materials

The data that supports the findings of this study are available in the main manuscript of this article.

Funding

None.

Abbreviations and Symbols

ACS: Acute coronary syndrome

AF: Atrial fibrillation

AMI: Acute myocardial infarction

CAD: Coronary artery disease

CVD: Cardiovascular disease

DM: Diabetes mellitus

ECG: Electrocardiography

EF: Ejection fraction

IHD: Ischemic heart disease

LBBB: Left Bundle Branch Block

MACEs: Major adverse cardiac events

NHANES: National Health and Nutrition Examination Survey

RBBB: Right Branch Bundle Block

SVT: Supraventricular tachycardia

SOB: Shortness of breath

VT: Ventricular tachycardia

References

[1] Chrysant, S. G., & Chrysant, G. S. (2019). Association of hypomagnesemia with cardiovascular diseases and hypertension. *International Journal of Cardiology. Hypertension, 1*, 100005. https://doi.org/10.1016/j.ijchy.2019.100005

[2] Efstratiadis, G., Sarigianni, M., & Gougourelas, I. (2006). Hypomagnesemia and cardiovascular system. *Hippokratia, 10*(4), 147–152.

[3] Kieboom, B. C., Niemeijer, M. N., Leening, M. J., van den Berg, M. E., Franco, O. H., Deckers, J. W., Hofman, A., Zietse, R., Stricker, B. H., & Hoorn, E. J. (2016). Serum magnesium and the risk of death from coronary heart disease and sudden cardiac death. *Journal of the American Heart Association, 5*, e002707. https://doi.org/10.1161/JAHA.115.002707

[4] Humphries, E. S., & Dart, C. (2015). Neuronal and cardiovascular potassium channels as therapeutic drug targets: Promise and pitfalls. *Journal of Biomolecular Screening, 20*, 1055–1073. https://doi.org/10.1177/1087057115601677

[5] Patil, V. N., Ilanchezhian, T., & Aarti, Y. M. (2022). Role of electrolytes in cardiovascular disease (CVD) among Dhule population. *Galore International Journal of Health Sciences and Research, 7*, 46–50. https://doi.org/10.52403/gijhsr.20220107

[6] Hasan, M. Z., Nahar, K., Sharif, J. U., Paul, S. C., Thakur, A. K., Mahmud, A., Siddique, N. A., Islam, M. R., & Paul, G. K. (2023). Serum magnesium level and it's relation in predicting adverse in-hospital outcome in patients with first attack of myocardial infarction. *Mymensingh Medical Journal, 32*, 65–72.

[7] Al Alawi, A. M., Majoni, S. W., & Falhammar, H. (2018). Magnesium and human health: Perspectives and research directions. *International Journal of Endocrinology, 2018*, 9041694. https://doi.org/10.1155/2018/9041694

[8] Sabah, Z., Wani, J., Deajim, M., Al Zomia, A. S., Asiri, A., Alqahtani, A. A., Alansari, W., Alwan, A., Al Qahtani, R. M., & Raj, B. (2023). Serum magnesium in patients with acute myocardial infarction and its

effect on cardiac complications and mortality in myocardial infarction patients. *Cureus, 15*(4), e38147. https://doi.org/10.7759/cureus.38147

[9] Ahmed, F., & Mohammed, A. (2019). Magnesium: The Forgotten Electrolyte-A review on hypomagnesemia. *Medical Sciences*, *7*(4), 56. https://doi.org/10.3390/medsci7040056

[10] Lal, L., & Murmu, H. (2016). Serum magnesium in patients with acute myocardial infarction. *International Journal of Scientific Study, 4*, 167–169.

[11] An, G., Du, Z., Meng, X., Guo, T., Shang, R., Li, J., An, F., Li, W., & Zhang, C. (2014). Association between low serum magnesium level and major adverse cardiac events in patients treated with drug-eluting stents for acute myocardial infarction. *PLoS One, 9*(6), e98971. https://doi.org/10.1371/journal.pone.0098971

[12] Vedamanickam, R., Anandan, P., & Bupesh, G. (2020). Evaluation of hypomagnesemia in acute myocardial infarction patients. *Journal of Clinical and Diagnostic Research: JCDR, 14*(1). https://doi.org/10.7860/JCDR/2020/42568.13455

[13] Nasim, B., Sajjad, A., Khan, Z., Ali, Z., Sheikh, A., Yadgir, T., Khan, W., Sakaf, O., & Naroo, G. (2016). Prevalence of ACS and causal relation of hypomagnesaemia. *British Journal of Medicine and Medical Research, 12*, 1–5. https://doi.org/10.9734/BJMMR/2016/19850

[14] Taha, A., & Mirghani, H. (2017). Basic clinical characteristics and hospital outcomes of acute coronary syndrome Patients-Sudan. *Sudan Journal of Medical Sciences, 12*, 52–62.

[15] Youssef, G., Saad, Z., Ammar, W., & Sharaf, Y. (2018). Assessment of left ventricular regional wall motion abnormalities using regional time-volume curves obtained by real time three-dimensional echocardiography. *The Egyptian Heart Journal, 70*(3), 189–194. https://doi.org/10.1016/j.ehj.2018.02.002

[16] Mutar, M., Merza, M. A., Issa, H. A., & Shaikhow, S. K. (2016). Risk factors and angiographic findings in patients with LBBB who underwent coronary angiography in Duhok Heart Center. *Journal of Medical Science and clinical Research*, *4*(11), 14112–14117. https://doi.org/10.18535/jmscr/v4i11.96

[17] Ghaffari, S., Rajabi, N., Alizadeh, A., & Azarfarin, R. (2008). Predictors of ventricular dysfunction and coronary artery disease in Iranian patients with left bundle branch block. *International Journal of Cardiology, 130*, 291–293. https://doi.org/10.1016/j.ijcard.2007.05.117

[18] Kolte, D., Vijayaraghavan, K., Khera, S., Sica, D. A., & Frishman, W. H. (2014). Role of magnesium in cardiovascular diseases. *Cardiology, 22*, 182–192. https://doi.org/10.1097/CRD.0000000000000003

[19] Singh, H., Khosla, P., & Kaur, J. (2023). A study of serum magnesium levels in acute myocardial infarction and its association with clinical outcome. *National Journal of Physiology, Pharmacy and Pharmacology, 13*(02), 286–291.

[20] Vassalle, C., Battaglia, D., Vannucci, A., Chatzianagnostou, K., Landi, P., Arvia, C., & Carpeggiani, C. (2016). Low magnesium is not a significant predictor of hard events in acute myocardial infarction. *BBA Clinical, 5*, 130–133. https://doi.org/10.1016/j.bbacli.2016.03.003

[21] Taneva, E. (2005). Hypokaliaemia and hypomagnesemia during acute coronary syndrome: A-661. *European Journal of Anaesthesiology, 22*(34), 172. https://doi.org/10.1097/00003643-200505001-00621