

## Electrolyte Abnormalities and Their Impact On ECG- Confirmed Arrhythmias Among Adult Patients in Emergency Department

**Muhammad Arif\*** (Corresponding author)

MS Allied Health science, Faculty of Allied Health sciences, superior university, Lahore Pakistan. [marif.ihsswabi@kmu.edu.pk](mailto:marif.ihsswabi@kmu.edu.pk)

**Dr Maham Qazi**

Assistant Professor Surgery, Faculty of Allied Health sciences, superior university, Lahore Pakistan

**Dr Hafiz Shehzad Muzammil**

Head of the Department, Faculty of Allied Health sciences, superior university, Lahore Pakistan

**Abdullah**

Demonstrator Health Technology, Khyber Medical University

**Dr Sohail Ahmad**

Medical officer, District Headquarter Hospital Battagram

**Zakir Ahmad**

Department of Medical Laboratory Technology, Khyber Medical University Peshawar

**Muhammad Zakaria**

Clinical Technician Cardiology, Mardan Medical Complex Mardan

### Author Details

**Keywords:** Electrolyte imbalance, Arrhythmia, ECG, Emergency department, Potassium, Ventricular fibrillation.

Received on 25 Mar 2026

Accepted on 28 Apr 2026

Published on 5 May 2026

Corresponding E-mail & Author\*:

**Muhammad Arif**

Ms Allied Health science, Faculty of Allied Health sciences, superior university, Lahore Pakistan. [marif.ihsswabi@kmu.edu.pk](mailto:marif.ihsswabi@kmu.edu.pk)

### Abstract

**Background:** Electrolyte disturbances are prevalent in patients of the emergency department and are a major cause of cardiac electrical instability. Potassium, sodium, calcium, and magnesium disruptions may cause typical ECG abnormalities, and lead to life-threatening arrhythmia. But there is limited data on their prevalence and ECG associations in tertiary-care hospitals in Peshawar.

**Objective:** To determine the frequency of major electrolyte abnormalities and evaluate their association with ECG-confirmed arrhythmias in adult emergency department patients

**Methods:** The study was a descriptive cross-sectional study of 385 adult patients who presented ECG-confirmed arrhythmias. Serum electrolytes were used to measure levels within one hour of presentation and ECG findings were recorded. Chi-square and Fisher exact tests were used to analyze associations.

**Results:** The most common electrolyte abnormalities were potassium (78.4%), sodium (32.7%), magnesium (31.9%),

and calcium (15.8%). The most common arrhythmia was ventricular tachycardia

(43.4%), atrial fibrillation (23.1), ventricular fibrillation (13), and supraventricular tachycardia (10.9). Widened QRS (48.6%), prolonged QT (34.5%), peaked T waves (33.2%), and prominent U waves (21.6%), were common ECG findings. There were significant correlations that existed between supraventricular tachycardia and potassium ( $p < 0.001$ ), sodium ( $p = 0.001$ ), and calcium ( $p < 0.001$ ) abnormalities. There was a close relationship between potassium, calcium and magnesium abnormalities and VF ( $p = 0.001$ ). Sodium ( $p < 0.001$ ), magnesium ( $p = 0.002$ ), and potassium ( $p = 0.016$ ) disturbances were associated with complete heart block. There was no significant relationship with atrial fibrillation or ventricular tachycardia. ECGs have been associated with definite electrolyte abnormalities.

**Conclusion:** Electrolyte imbalances are very common among emergency patients with arrhythmia and have a significant association with various tachyarrhythmia and conduction abnormalities. Timely detection and early correction with the use of ECG could help decrease the risk of serious cardiac events.

## Introduction

Electrolyte imbalances are among the most common biochemical disturbances encountered in emergency departments and often reflect underlying renal, endocrine, or metabolic disorders (1). These abnormalities particularly involving sodium, potassium, calcium, and magnesium play a crucial role in maintaining cardiac electrophysiology by regulating resting membrane potential and action potential propagation. Even minor deviations can disrupt myocardial excitability and conduction, predisposing patients to arrhythmias detectable on electrocardiogram (ECG) (2).

Globally, electrolyte disturbances such as hyponatremia, hypernatremia, hypokalemia, hyperkalemia, and hypocalcemia are reported in approximately 20–50% of acutely ill patients. Recent studies indicate that 18–25% of arrhythmic events in emergency settings are associated with electrolyte abnormalities (3). The burden is particularly high in low- and middle-income countries like Pakistan, where delayed presentations, limited diagnostic resources, and absence of standardized emergency protocols contribute to increased morbidity (4).

ECG serves as a rapid and non-invasive tool for identifying electrolyte-related cardiac changes. Characteristic findings include flattened T waves and U waves in hypokalemia, peaked T waves and widened QRS complexes in hyperkalemia, and prolonged QT intervals in hypocalcemia or hypomagnesemia (5). These changes may precede life-threatening arrhythmias such as ventricular tachycardia, torsade's de pointes, and cardiac arrest, emphasizing the importance of early recognition (6).

Among electrolytes, potassium has the most pronounced electrophysiological effects. Hypokalemia prolongs repolarization and increases the risk of ventricular arrhythmias, while hyperkalemia can lead to conduction delays and fatal arrhythmias (7). Calcium influences the plateau phase of the cardiac action potential, with hypocalcemia prolonging the QT interval and hypercalcemia shortening it (8). Magnesium acts as a cofactor in ion transport and its deficiency is strongly associated with torsades de pointes, particularly when combined with hypokalemia. Sodium, although less directly involved in membrane potential, affects osmolar balance and can indirectly contribute to arrhythmogenesis (9).

In Pakistan, tertiary care hospitals frequently receive critically ill patients from rural areas presenting with dehydration, sepsis, and renal dysfunction—conditions that predispose to electrolyte disturbances (10). Studies have reported that up to 40% of emergency patients exhibit electrolyte abnormalities, often accompanied by arrhythmias. Despite this high prevalence, underdiagnosis remains common due to limited point-of-care testing and delayed laboratory reporting (11).

Electrolyte abnormalities are not only associated with arrhythmias but also with increased mortality, prolonged hospital stay, and higher healthcare costs (12). Early detection and prompt correction can significantly improve outcomes, particularly in

emergency settings. Therefore, understanding the relationship between electrolyte imbalances and ECG-confirmed arrhythmias is essential for timely intervention (13)

### **Aim & Objectives**

- To determine the frequency of major electrolyte abnormalities in adult emergency patients.
- To assess the association between electrolyte abnormalities and ECG-confirmed arrhythmias. .

### **Methodology**

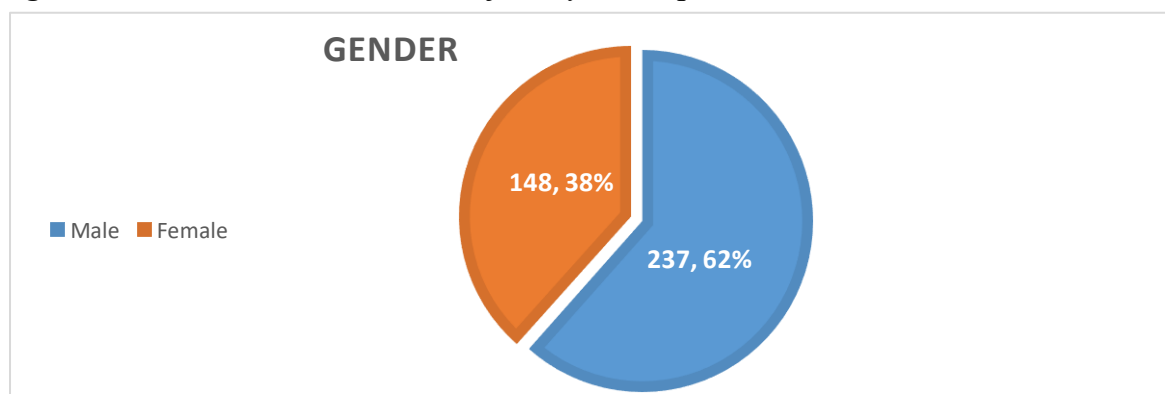
This descriptive cross-sectional study was conducted in tertiary care hospitals in Peshawar over a period of six months. The sample size of 385 patients was calculated using Cochran’s formula for an infinite population with a 95% confidence level ( $Z = 1.96$ ), an assumed prevalence of 50%, and a margin of error of 5%. A consecutive sampling technique was applied, including all eligible adult patients (aged >18 years) presenting to the emergency department with ECG-confirmed arrhythmias until the required sample size was achieved. Patients were included if their serum electrolyte levels (sodium, potassium, calcium, and magnesium) were measured within one hour of presentation, while those with incomplete records, on anti-arrhythmic drugs or electrolyte supplements, or with chronic kidney disease on dialysis were excluded. Ethical approval was obtained from the institutional review committee, and informed consent was secured from all participants. Data were collected using a structured proforma capturing demographic details, clinical presentation, ECG findings (type of arrhythmia and specific changes), and laboratory electrolyte values. Data analysis was performed using IBM SPSS version 26, where descriptive statistics were presented as frequencies and percentages, and associations between electrolyte abnormalities and arrhythmia types were assessed using Pearson’s Chi-square test or Fisher’s Exact test where appropriate, with a p-value of <0.05 considered statistically significant and results reported with 95% confidence intervals.

## **RESULTS**

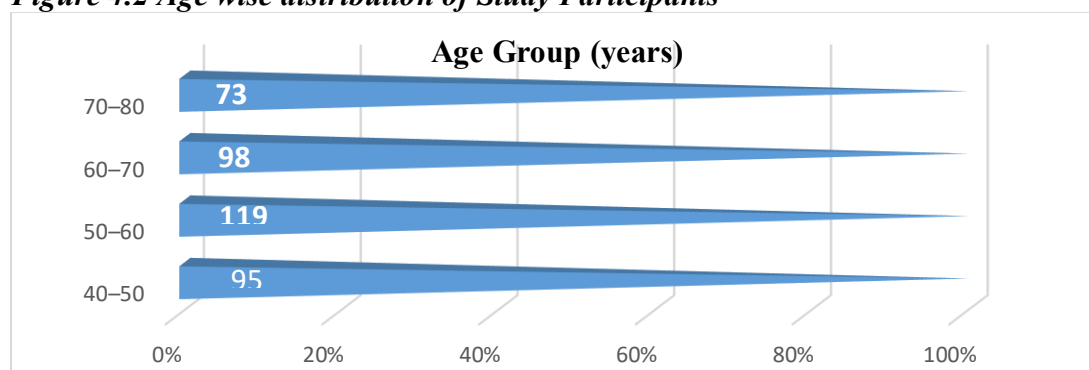
### **4.1. Sociodemographic Characteristics of the Study Participants**

The sociodemographic characteristics of the study participants are presented in figure 4.1 and 4.2. In the study total 385 participants were included. Among them the majority were male participant (237, 61.6%) and female 148(38.4%) participants of the sample. Age wise the largest number of participants were 50-60 years (119, 30.9%), 60 -70 years (98, 25.5%), 40–50 years (95, 24.7%), and 70–80 years (73, 19.0%). This study shows that most participants were middle aged people to older people.

**Figure 4.1 Gender wise distribution of Study Participants**



**Figure 4.2 Age wise distribution of Study Participants**



#### 4.2. Medical History, Presenting Symptoms, and Physical Examination Findings

Table 4.1 summarizes the clinical profile of the participants. Hypertension was the most common comorbidity (60.5%), followed by diabetes mellitus (39.0%), heart failure (36.4%), ischemic heart disease (35.8%), and chronic kidney disease (22.6%), while 10.6% had other conditions. Palpitations were the most frequent presenting symptom (65.2%), followed by shortness of breath (56.9%), dizziness (43.1%), and chest pain (29.6%). On examination, confusion was most common (67.5%), with peripheral edema (34.3%), oliguria (21.3%), pulmonary rales (15.3%), and anuria (1.6%) also observed.

**Table 4.1 Medical History, Presenting Symptoms, and Physical Examination Findings**

| Variable               | Frequency (n) | Percentage (%) |
|------------------------|---------------|----------------|
| Hypertension           | 233           | 60.5           |
| Diabetes Mellitus      | 150           | 39.0           |
| Ischemic Heart Disease | 138           | 35.8           |
| Heart Failure          | 140           | 36.4           |
| Chronic Kidney Disease | 87            | 22.6           |
| Other Conditions       | 41            | 10.6           |
| Chest Pain             | 114           | 29.6           |
| Palpitations           | 251           | 65.2           |
| Shortness of Breath    | 219           | 56.9           |
| Dizziness              | 166           | 43.1           |
| Other Symptoms         | 39            | 10.1           |
| Confusion              | 260           | 67.5           |
| Peripheral Edema       | 132           | 34.3           |
| Pulmonary Rales        | 59            | 15.3           |
| Oliguria               | 82            | 21.3           |
| Anuria                 | 6             | 1.6            |

#### 4.3. Types of Arrhythmias, ECG Changes, and Electrolyte Abnormalities.

Table 4.2 presents the distribution of arrhythmias, ECG changes, and electrolyte abnormalities among participants. Ventricular tachycardia was the most common arrhythmia (43.4%), followed by atrial fibrillation (23.1%), ventricular fibrillation (13.0%), and supraventricular tachycardia (10.9%), while complete heart block (5.2%),

asystole (2.3%), and atrial flutter (1.6%) were less frequent. Regarding ECG findings, a widened QRS complex was most prevalent (48.6%), followed by prolonged QT interval (34.5%), peaked T waves (33.2%), and prominent U waves (21.6%), with third-degree heart block observed in 7.8% of cases. Among electrolyte abnormalities, potassium imbalance was the most common (78.4%), followed by sodium (32.7%) and magnesium (31.9%), while calcium abnormalities were least frequent (15.5%). Overall, ventricular tachycardia, widened QRS complex, and potassium imbalance were the most prominent findings, highlighting the strong association between electrolyte disturbances particularly potassium and cardiac arrhythmias.

**Table 4.2 Types of Arrhythmias, ECG Changes, and Electrolyte Abnormalities.**

| Variable                                  | Frequency (n) | Percentage (%) |
|---|---------------|----------------|
| Atrial Fibrillation                       | 89            | 23.1           |
| Atrial Flutter                            | 6             | 1.6            |
| Supraventricular Tachycardia (SVT)        | 42            | 10.9           |
| Ventricular Tachycardia                   | 167           | 43.4           |
| Ventricular Fibrillation                  | 50            | 13.0           |
| Asystole                                  | 9             | 2.3            |
| Complete Heart Block                      | 20            | 5.2            |
| Peaked T Waves                            | 128           | 33.2           |
| Prolonged QT Interval                     | 133           | 34.5           |
| Prominent U Waves                         | 83            | 21.6           |
| Widened QRS Complex                       | 187           | 48.6           |
| Third Degree Heart Block                  | 30            | 7.8            |
| Potassium Abnormality (K <sup>+</sup> )   | 302           | 78.4           |
| Sodium Abnormality (Na <sup>+</sup> )     | 126           | 32.7           |
| Calcium Abnormality (Ca <sup>2+</sup> )   | 61            | 15.8           |
| Magnesium Abnormality (Mg <sup>2+</sup> ) | 123           | 31.9           |

#### 4.4. Association between Types of Arrhythmias and Electrolyte Abnormalities Using Chi-Square Test:

Chi-square analysis was performed to assess the association between electrolyte imbalances and different types of arrhythmias. No statistically significant relationship was observed between any electrolyte and atrial fibrillation (potassium  $p = 0.811$ , sodium  $p = 0.974$ , calcium  $p = 0.973$ , magnesium  $p = 0.710$ ). In contrast, supraventricular tachycardia showed significant associations with potassium ( $p < 0.001$ ), sodium ( $p = 0.001$ ), and calcium ( $p < 0.001$ ), while magnesium was not significant ( $p = 0.231$ ). Ventricular tachycardia did not demonstrate any significant association with electrolytes (potassium  $p = 0.080$ , sodium  $p = 0.768$ , calcium  $p = 0.897$ , magnesium  $p = 0.143$ ). However, ventricular fibrillation was significantly associated with potassium, calcium, and magnesium (all  $p = 0.001$ ), whereas sodium was not significant ( $p = 0.240$ ). Complete heart block showed strong associations with sodium ( $p < 0.001$ ) and magnesium ( $p = 0.002$ ). Overall, electrolyte imbalances were significantly related to certain arrhythmias particularly supraventricular tachycardia, ventricular fibrillation, and complete heart block while no significant associations were found with atrial fibrillation and ventricular tachycardia.

**Table 4.3 Association Between Types of Arrhythmias and Electrolyte Abnormalities Using Chi-Square Test**

| Arrhythmia Type              | Electrolyte | Arrhythmia Present (n) | Arrhythmia Absent (n) | p-value |
|------------------------------|-------------|------------------------|-----------------------|---------|
| Atrial Fibrillation          | Potassium   | 69                     | 233                   | 0.811   |
|                              | Sodium      | 29                     | 97                    | 0.974   |
|                              | Calcium     | 14                     | 47                    | 0.973   |
|                              | Magnesium   | 27                     | 96                    | 0.710   |
| Supraventricular Tachycardia | Potassium   | 22                     | 280                   | <0.001  |
|                              | Sodium      | 4                      | 122                   | 0.001   |
|                              | Calcium     | 15                     | 46                    | <0.001  |
|                              | Magnesium   | 10                     | 113                   | 0.231   |
| Ventricular Tachycardia      | Potassium   | 138                    | 164                   | 0.080   |
|                              | Sodium      | 56                     | 70                    | 0.768   |
|                              | Calcium     | 26                     | 35                    | 0.897   |
|                              | Magnesium   | 60                     | 63                    | 0.143   |
| Ventricular Fibrillation     | Potassium   | 48                     | 254                   | 0.001   |
|                              | Sodium      | 20                     | 106                   | 0.240   |
|                              | Calcium     | 0                      | 61                    | 0.001   |
|                              | Magnesium   | 26                     | 97                    | 0.001   |
| Complete Heart Block         | Sodium      | 15                     | 111                   | <0.001  |
|                              | Magnesium   | 0                      | 123                   | 0.002   |

#### 4.5. Association Between Types of Arrhythmias and Electrolyte Abnormalities Using Fisher's Exact Test:

Fisher's Exact test was applied to further evaluate associations between selected arrhythmias and electrolyte abnormalities in categories with small sample sizes. The analysis showed that atrial flutter was significantly associated with potassium ( $p < 0.001$ ) and sodium ( $p = 0.001$ ), while no significant association was observed with calcium ( $p = 0.595$ ) or magnesium ( $p = 0.183$ ). Asystole demonstrated a significant relationship only with sodium ( $p = 0.034$ ), whereas potassium ( $p = 0.215$ ), calcium ( $p = 0.365$ ), and magnesium ( $p = 0.063$ ) were not significant. In the case of complete heart block, potassium ( $p = 0.016$ ) and calcium ( $p = 0.046$ ) showed significant associations. Overall, the findings indicate that specific electrolyte disturbances particularly potassium and sodium are significantly linked with atrial flutter and complete heart block, while sodium is also associated with asystole, whereas other electrolyte-arrhythmia combinations were not statistically significant.

**Table 4.4 Association between Types of Arrhythmias and Electrolyte Abnormalities Using Fisher's Exact Test**

| Arrhythmia Type             | Electrolyte | Arrhythmia Present (n) | Arrhythmia Absent (n) | p-value |
|-----------------------------|-------------|------------------------|-----------------------|---------|
| <b>Atrial Flutter</b>       | Potassium   | 0                      | 302                   | <0.001  |
|                             | Sodium      | 6                      | 120                   | 0.001   |
|                             | Calcium     | 0                      | 61                    | 0.595   |
|                             | Magnesium   | 0                      | 123                   | 0.183   |
| <b>Asystole</b>             | Potassium   | 9                      | 293                   | 0.215   |
|                             | Sodium      | 0                      | 126                   | 0.034   |
|                             | Calcium     | 0                      | 61                    | 0.365   |
|                             | Magnesium   | 0                      | 123                   | 0.063   |
| <b>Complete Heart Block</b> | Potassium   | 20                     | 282                   | 0.016   |
|                             | Calcium     | 0                      | 61                    | 0.046   |

## DISCUSSION

There were 385 patients in this study, and 61.6% of the population was male and 38.4% female. This male predominance has been consistently observed in several ED based epidemiological studies investigating cardiac arrhythmias and electrolyte imbalances. For example, Chugh et al. described a greater incidence of sudden cardiac arrhythmias in men, due to differences in myocardial electrophysiology and burden of risks associated with gender differences (29). Similarly, there is literature that has been carried out in South Asia and the Middle East that has reported higher rate male visits to ED in regard to arrhythmia-related complaints as a result of lifestyle, professional stress and delayed healthcare seeking behavior(30).

The age distribution of the present sample was skewed to the middle-aged and older age categories with most respondents in the 50-60 age (30.9%), then 60-70 (25.5%). This age distribution corresponds to the general trends in the epidemiology of the world, as the age increases predisposition to electrolyte derangements, as well as to arrhythmia. Old age is a condition that is characterized by decreasing renal clearance, the use of more drugs including diuretics, structural cardiac remodeling, and an increased occurrence of comorbidities like high blood pressure and diabetes all of which make a person prone to ionic imbalance and electrical instability of the myocardium. A similar study by Kirchhof et al. also emphasized the fact that prevalence of arrhythmia increases rapidly above 50 years, especially in atrial and ventricular rhythm disorders (31). In this way, the demographic data of the study group represent well-known vulnerable groups to the development of electrolyte abnormalities and arrhythmias that support the significance of screening and early treatment in these age and sex groups. The burden of chronic comorbidities in the study population was high, with hypertension (60.5%), diabetes mellitus (39%), heart failure (36.4%), and ischemic

heart disease (35.8%) being the predominant ones. The results are highly related to the earlier literature that has been able to develop a close relationship between chronic diseases and predisposition to electrolyte imbalances. For instance, dysregulated potassium and magnesium levels in patients with heart failure are common because of renal dysfunction, neurohormonal stimulation, and treatment with loop diuretics and others, etc. Equally, sodium and potassium imbalance during hyperglycemia and osmotic diuresis is commonly reported in diabetic patients and is recorded in ED cohorts by Hoorn et al (32).

The existence of chronic kidney disease in 22.6% of patients is a notable risk factor of arrhythmias and electrolyte distortions. The renal failure has a direct impact on the bodies capacity to maintain homeostasis of the electrolytes, especially potassium and magnesium and this increases the arrhythmogenic potential of such patients. In terms of the symptoms, palpitations (65.2%) and shortness of breath (56.9) were found to be the most prevalent presenting complaints. This conclusion is consistent with the clinical results of multiple ED-based research in which palpitations are the typical symptom of arrhythmias, and dyspnea is commonly used to suggest impaired cardiac output during tachyarrhythmia's (33). There was also increased prevalence of dizziness (43.1) and chest pain (29.6) as an indicator of decreased cerebral perfusion and myocardial ischemia respectively. It is interesting to note that the confusion was high (67.5%), which can be attributed to acute metabolic derangements, extreme electrolyte imbalances, or inadequate perfusion during arrhythmic attacks. All in all, the clinical and comorbidity of the patients in the present study is quite consistent with the already established risk pattern that is related to electrolyte-induced cardiac rhythm disturbances.

The most frequent arrhythmia was that of ventricular tachycardia (VT) (43.4). This observation is unlike several reports across the globe with atrial fibrillation (AF) predominating ED cardiac presentations especially in the western population (34). But, South Asian studies have reported an increased prevalence of ventricular arrhythmias, and these findings could be due to delays in healthcare services, uncontrolled hypertension, increased incidence of ischemic heart disease, and weak adherence to medication in these groups(35) .

Atrial fibrillation was also a significant finding (23.1%), which is consistent with the world statistics that reported AF as the most prevalent sustained arrhythmia in the world. Other conditions that were also important were ventricular fibrillation (13%), and supraventricular tachycardia (10.9%). The occurrence of complete heart block and asystole in lesser numbers indicates serious conduction abnormalities that may be related to an advanced disease or serious electrolyte disturbances.

The ECG findings (widened QRS complex (48.6%), increased QT interval (34.5%), elevated T waves (33.2%), and U waves (21.6%) are like typical electrophysiological effects of potassium, calcium, and magnesium imbalance. The original work of Surawicz on the manifestations of electrolytes ECG presented almost the same pattern, the classic peaked T waves of hyperkalemia and the extended QT interval of hypokalemia and hypocalcemia (36). The elevated rate of widened QRS complexes implies either intense hyperkalemia or conduction system disease, which is widespread among the ED population with chronic comorbidities. These ECG patterns do not just confirm the biochemical results, but they also emphasize the role of ECG as a quick screening method of electrolyte imbalance in the emergency room.

The study did not find a statistically significant relationship between the electrolyte disturbances and AF as compared to several previous studies. Increased susceptibility to AF has been linked to hypokalemia and hypomagnesemia as this can affect the duration of atrial action potentials (37). However, AF is a multifactorial disease and structural heart disease, high blood pressure, and aging could have been more relevant in this study than electrolyte status.

SVT showed a lot of correlation with potassium, sodium and calcium imbalances. Such observations are consistent with the electrophysiological studies that revealed that atrial and AV nodal tissues are most sensitive to any fluctuations in extracellular potassium and calcium levels. Mild hypokalemia enhances spontaneous atrial depolarization whereas calcium has a direct effect on AV nodal conduction velocity (38).

The investigation was unable to statistically identify any electrolyte imbalance in the relationship, despite the facts that VT was the most prevalent arrhythmia. This is contrary to classical literature where abnormalities of potassium and magnesium are always mentioned as causative agents. The difference can be attributed to the fact that the sample size of the ischemic heart disease is very high which is a good predictor of VT regardless of the electrolyte status. Therefore, the electrolyte may not dominate structural factors in this population.

The absence of a statistically significant association between electrolyte abnormalities and ventricular tachycardia (VT) in this study is an important and clinically meaningful finding. Unlike supraventricular arrhythmias or ventricular fibrillation, which are often triggered by acute metabolic disturbances, VT is frequently associated with structural heart disease, particularly ischemic heart disease and myocardial infarction. In this study, a high proportion of patients had ischemic heart disease (35.8%) and heart failure (36.4%), suggesting that reentrant circuits and myocardial scarring may have been the dominant mechanisms driving VT rather than transient electrolyte shifts. This finding aligns with established electrophysiological understanding that VT in emergency settings is more commonly related to substrate-based abnormalities rather than purely metabolic causes. Therefore, management strategies in such populations should emphasize structural evaluation alongside electrolyte correction.

## **CONCLUSION**

Electrolyte imbalances are extremely common in adult emergency patients and play a significant role in the development of ECG detectable cardiac arrhythmias. Both atrial and ventricular arrhythmia are closely related to abnormalities in potassium, sodium, calcium, and magnesium. Potassium imbalance especially hypokalemia became a significant predictor of ventricular tachyarrhythmia and conduction delays whereas hypocalcemia and hypomagnesemia were associated with prolongation of the QT and atrial fibrillation.

The findings align with the available literature that electrolyte imbalances are modifiable risk factors in determining acute cardiac outcomes. Laboratory delays and inadequate use of ECG interpretation in resource-limited environments raise the chances of missed diagnosis. This study illustrates the importance of ECG as an early warning sign of electrolyte imbalances.

Electrolyte monitoring and regular ECG analysis are essential in emergency department. Better identification, early correction, and standard management procedures can greatly decrease the complications, ICU hospitalization, and death rates.

### **Limitations:**

- It was carried out in one tertiary-care hospital, it will be limited in terms of generalization.
- Its descriptive cross-sectional design precludes establishing causality despite observed associations.
- Only baseline electrolyte tests were acquired; serial tests were not done thus possibly missing dynamic changes. Magnesium and phosphate levels were unavailable for all patients, possibly underestimating their role.
- Confounding factors like medication intake, kidney function, sepsis, and previous heart disease had not been adequately managed and could have affected electrolyte status and risk of arrhythmia.

## Recommendations:

- Routine screening of electrolytes in all patients with cardiac related complaints presenting to emergency department.
- The ECG-based early detection protocols need to be enhanced because ECG changes usually inform us about laboratory confirmation.
- Rapid correction pathways for critical abnormalities should be established.
- Multicenter longitudinal studies are recommended.

## REFERENCES

1. Ayhan YE, İlerler EE, Sosyal D, Bektay MY, Karakurt S, Daşkaya H, et al. Assessment of drug-induced electrolyte disorders in intensive care units: a multicenter observational study. *Frontiers in medicine*. 2024;11:1343483.
2. Sun J, Liu Q, Seery S, Sun L, Yuan Y, Wang W, et al. The impact of hyperkalemia on ICU admission and mortality: a retrospective study of Chinese emergency department data. *BMC Emergency Medicine*. 2024;24(1):95.
3. Ahmad Z, Khan IA, Ullah N, Khan K, Khan MF, Ashraf A, et al. Association between Serum Potassium and Magnesium Imbalance with In-Hospital Morbidity and Mortality in New-Onset Atrial Fibrillation Patients. *Pakistan Heart Journal*. 2025;58(2):190-6.
4. Winsløw U, Sakthivel T, Zheng C, Philbert B, Vinther M, Frandsen E, et al. The effect of increased plasma potassium on myocardial function; a randomized POTCAST substudy. *The international journal of cardiovascular imaging*. 2023;39(11):2097-106.
5. AL-Obeidallah M. *Myocardial Electrophysiology in Health and Disease*. 2026.
6. Cavusoglu Y, Kaya H, Eraslan S, Yilmaz MB. Hyponatremia is associated with occurrence of atrial fibrillation in outpatients with heart failure and reduced ejection fraction. *Hellenic Journal of Cardiology*. 2019;60(2):117-21.
7. Jones TW. Management of Electrolyte Abnormalities in the Emergency Department. *Lynchburg Journal of Medical Science*. 2025;1(1):13.
8. Khalid S, Hashmi KA, Ramzan H, Hammad M, Shahzad S, Maheshwari M. Persistent QTc Prolongation Due to Hypocalcemia from Hypoparathyroidism in a Heart Failure Patient: A Case Report. *Journal of Islamabad Medical & Dental College*. 2024;13(4):696-700.
9. Morales-Olivas F. Diuretics use in the management of hypertension. *Hipertensión y Riesgo Vascular*. 2024;41(3):186-93.
10. Bartusik-Aebischer D, Rogóź K, Aebischer D. Artificial intelligence and ECG: a new frontier in cardiac diagnostics and prevention. *Biomedicines*. 2025;13(7):1685.
11. Seyfydova M, Rokyta R, Rajdl D, Huml M. Arrhythmias and laboratory abnormalities after an electrical accident: a single-center, retrospective study of 333 cases. *Clinical Research in Cardiology*. 2023;112(12):1835-47.
12. Bachmann KF, Hess B, Koitmäe M, Bloch A, Regli A, Reintam Blaser A. Electrolyte disorders in the critically ill: a retrospective analysis. *Scientific Reports*. 2025;15(1):13943.
13. Khan RN, Saba F, Kausar SF, Siddiqui MH. Pattern of electrolyte imbalance in Type 2 diabetes patients: Experience from a tertiary care hospital. *Pakistan Journal of Medical Sciences*. 2019;35(3):797.
14. Khan Z. ELECTROLYTE IMBALANCES IN KIDNEY DISEASE: HYPONATREMIA HYPERKALEMIA AND HYPOCALCEMIA. *JOURNAL OF POPULATION*. 2024.
15. von Bachmann P, Gedon D, Gustafsson FK, Ribeiro AH, Lampa E, Gustafsson S, et al. Evaluating regression and probabilistic methods for ECG-based electrolyte prediction. *Scientific Reports*. 2024;14(1):15273.

16. Laslett DB, Cooper JM, Greenberg RM, Yesenosky GA, Basil A, Gangireddy C, et al. Electrolyte abnormalities in patients presenting with ventricular arrhythmia (from the LYTE-VT Study). *The American journal of cardiology*. 2020;129:36-41.
17. Makinouchi R, Machida S, Matsui K, Shibagaki Y, Imai N. Severe hypokalemia in the emergency department: A retrospective, single-center study. *Health Science Reports*. 2022;5(3):e594.
18. Bushmen S, Collins E, Kiser AC. A 2025 Literature Review on Arrhythmias: Returning the Focus to Basic Science. *The Journal of Innovations in Cardiac Rhythm Management*. 2026;17(1):6570.
19. Negru AG, Pastorcici A, Crisan S, Cismaru G, Popescu FG, Luca CT. The role of hypomagnesemia in cardiac arrhythmias: a clinical perspective. *Biomedicines*. 2022;10(10):2356.
20. Kohn MA, Kwan E, Gupta M, Tabas JA. Prevalence of acute myocardial infarction and other serious diagnoses in patients presenting to an urban emergency department with chest pain. *The Journal of emergency medicine*. 2005;29(4):383-90.
21. Hooshanginezhad Z, Nemati S, Rezaee M, Rajabi SK. Emergency Department Serum Electrolyte Patterns in Paroxysmal Atrial Fibrillation. *Journal of Clinical Laboratory Analysis*. 2025;39(8):e70030.
22. Birnbaum Y, Rankinen J, Jneid H, Atar D, Nikus K. The role of ECG in the diagnosis and risk stratification of acute coronary syndromes: an old but indispensable tool. *Current cardiology reports*. 2022;24(2):109-18.
23. Durfey N, Lehnhof B, Bergeson A, Durfey SN, Leytin V, McAteer K, et al. Severe hyperkalemia: can the electrocardiogram risk stratify for short-term adverse events? *Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health*. 2017;18(5).
24. Khatib R, Sabir FR, Omari C, Pepper C, Tayebjee MH. Managing drug-induced QT prolongation in clinical practice. *Postgraduate medical journal*. 2021;97(1149):452-8.
25. Rafique Z, Peacock F, Armstead T, Bischof JJ, Hudson J, Weir MR, et al. Hyperkalemia management in the emergency department: an expert panel consensus. *JACEP Open*. 2021;2(5):e12572.
26. Ferreira JP, Butler J, Rossignol P, Pitt B, Anker SD, Kosiborod M, et al. Abnormalities of potassium in heart failure: JACC state-of-the-art review. *Journal of the American College of Cardiology*. 2020;75(22):2836-50.
27. Cabahug MC, Vempati A. Torsade de Pointes due to hypokalemia and hypomagnesemia. *Journal of education & teaching in emergency medicine*. 2022;7(4):S27.
28. Weglicki W, Quamme G, Tucker K, Haigney M, Resnick L. Potassium, magnesium, and electrolyte imbalance and complications in disease management. *Clinical and Experimental Hypertension*. 2005;27(1):95-112.
29. Chugh SS, Havmoeller R, Narayanan K, Singh D, Rienstra M, Benjamin EJ, et al. Worldwide epidemiology of atrial fibrillation: a Global Burden of Disease 2010 Study. *Circulation*. 2014;129(8):837-47.
30. Alosaimi S, Alqarni A, Alkalifah T, Aldaijy M, Alghamdi N, Altalhah A, et al. Gender differences in patient-reported outcomes and cardiac symptoms in patients with acute coronary syndrome in Riyadh, Saudi Arabia. *Saudi Medical Journal*. 2025;46(4):388.
31. Kirchhof P, Benussi S, Kotecha D, Ahlsson A, Atar D, Casadei B, et al. Correction: 2016 ESC Guidelines for the Management of Atrial Fibrillation Developed in Collaboration With EACTS. *Revista Española de Cardiología (English Edition)*. 2017;70(1).

32. Roger VL. Epidemiology of heart failure: a contemporary perspective. *Circulation research*. 2021;128(10):1421-34.
33. Probst MA, Mower WR, Kanzaria HK, Hoffman JR, Buch EF, Sun BC. Analysis of emergency department visits for palpitations (from the National Hospital Ambulatory Medical Care Survey). *The American journal of cardiology*. 2014;113(10):1685-90.
34. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *Journal of the American College of Cardiology*. 2014;64(21):e1-e76.
35. Venkateswaran RV, Moorthy M, Chatterjee NA, Pester J, Kadish AH, Lee DC, et al. Diabetes and risk of sudden death in coronary artery disease patients without severe systolic dysfunction. *Clinical Electrophysiology*. 2021;7(12):1604-14.
36. Jerjes-Sánchez C. *Cardiology in the ER: A practical guide*: Springer; 2019.
37. Wu Y, Kong X-J, Ji Y-Y, Fan J, Ji C-C, Chen X-M, et al. Serum electrolyte concentrations and risk of atrial fibrillation: An observational and mendelian randomization study. *BMC genomics*. 2024;25(1):280.
38. Kingma J, Simard C, Drolet B. Overview of cardiac arrhythmias and treatment strategies. *Pharmaceuticals*. 2023;16(6):844.
39. Kieboom BC, Niemeijer MN, Leening MJ, van den Berg ME, Franco OH, Deckers JW, et al. Serum magnesium and the risk of death from coronary heart disease and sudden cardiac death. *Journal of the American Heart Association*. 2016;5(1):e002707.