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

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CERTIFICATE OF RESEARCH COMPLETION

It is certified that this thesis titled, "**Electrolyte Abnormalities and Their Impact On ECG-Confirmed Arrhythmias Among Adult Patients In Emergency Department**" submitted by **Muhammad Arif** with Roll No: **SU91-MSAHW-S24-051** for MS Allied Health Sciences at Faculty of Allied Health Sciences, Superior University, is an original research work and contains satisfactory material to be eligible for evaluation by the Examiner(s) for the award of the above-stated degree.

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No part of this thesis has been submitted anywhere else to any other degree. This thesis is submitted to the Faculty of Allied Health Sciences, The Superior University, Lahore in partial fulfillment of the requirements for the degree.

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DEDICATION

This thesis is wholeheartedly dedicated to my family, whose unwavering support, constant prayers, and endless encouragement have been my greatest source of strength throughout this academic journey. Their love, sacrifices, and belief in my potential have sustained me during moments of challenge and inspired me to strive for excellence.

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LIST OF ABBREVIATIONS

AF	Atrial Fibrillation
AV	Atrioventricular
Ca^{2+}	Calcium
CHB	Complete Heart Block
CKD	Chronic Kidney Disease
ECG	Electrocardiogram
ED	Emergency Department
HEC	Higher Education Commission
ICU	Intensive Care Unit
K^{+}	Potassium
KPK	Khyber Pakhtunkhwa
LMICs	Low- and Middle-Income Countries
Mg^{2+}	Magnesium
Na^{+}	Sodium
QT	QT Interval
SPSS	Statistical Package for the Social Sciences
SVT	Supraventricular Tachycardia
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia

ABSTRACT

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.

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

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.

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.

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.

Electrolyte imbalance, Arrhythmia, ECG, Emergency department, Potassium, Ventricular fibrillation.

CHAPTER 1

INTRODUCTION

Electrolyte imbalances are the most common forms of biochemical imbalances found in the emergency field and may be indicators of underlying pathophysiologic conditions in the system, including renal, endocrine, or metabolic disorders. Quick correction of these abnormalities is important in acute care setting because temporary alterations in serum electrolytes may have significant influences on the myocardial excitability and conduction. The prevalence of such electrolyte imbalances as hyponatremia, hypernatremia, hypokalemia, hyperkalemia, hypocalcemia and hypercalcemia is also widely reported in the emergency departments, with a range of prevalence rates between 20 and 50 percent among acutely ill adults (1). The electrolyte equilibrium keeps the resting membrane potential and cardiac action potentials propagation intact, and these alterations are important precursors to arrhythmias that can be observed in ECG.

Electrolyte-related cardiac events have increased in frequency across the world in recent years mainly due to the widespread prescription of diuretics and renin-angiotensin-aldosterone system blockers, rising cases of chronic kidney disease and uncontrolled diabetes, among others. A 2024 multi-centered study of Asian tertiary care hospitals reported that electrolyte abnormalities were associated with 18 to25% of arrhythmic events in emergency patients (2). These complications are aggravated in the cases of limited resources, such as in Pakistan, where no standard emergency electrolyte treatment guidelines exist, the waiting time in laboratories is long, and the number of diagnostic resources is scarce.

Electrocardiogram (ECG) is an invaluable diagnostic test that could identify electrophysiological expressions of electrolyte imbalance including flattened T waves and U waves in hypokalemia, peaked T waves and increased QRS in hyperkalemia and long QT intervals in hypocalcemia or hypomagnesemia, are early warning signs of potentially fatal arrhythmias. Epidemiological interrelation of electrolyte imbalances and cardiac crises requires early identification and management that would minimize morbidity and mortality.

Recent cross-sectional reports of tertiary care hospitals in Pakistan and other LMICs have found arrhythmia to be accompanied by hypokalemia and hyponatremia, with a percentage of 40% of

adult emergency-type patients reporting an electrolyte abnormality (3). Such results emphasize the necessity of the regular electrolyte screening in emergency patients who come with presenting with chest discomfort, palpitations, or syncope. This has been reinforced in various studies carried out in different parts of the world. Along with the underlying cardiovascular disease, a large cohort study of Europe showed that hyperkalemia (> 5.5 mmol/L) and hypokalemia (<3.5 mmol/L) increased the risk of ventricular arrhythmia and sudden cardiac death (4). Similarly, the 2025 MDPI review found electrolyte imbalances as foreseeable interventions that could be altered during the peri-emergency environment and suggested that electrolyte imbalance detection by use of ECG monitoring should be a cost-effective intervention to enhance patient outcomes (4).

In the Pakistani healthcare system, seriously ill individuals from rural districts are referred to tertiary hospitals such those in Peshawar, Khyber Pakhtunkhwa (KPK). Here, patients with delayed presentations are frequently concurrent kidney disease, Sepsis, or dehydration all factors which raise the risk of an imbalance in electrolytes. Thus, systemic disparities in healthcare and low public awareness of the signs of imbalances in electrolytes have been linked to the epidemiological burden of these conditions. Electrolytes stabilize the cardiac excitability by influencing the resting membrane potential, action-potential amplitude, and repolarization kinetics (5). Even a slight alteration of the physiological limits disrupts ionic gradients across the cell membrane of the cardiac cell, which predicts conduction delay and arrhythmogenesis. It is especially important in the interactions between sodium, potassium, calcium, and magnesium channel, the dysregulation of which is the basis of many ECG-observable rhythm disorders observed in emergency care.

In volume-dependent neuro-hormonal procedures, sodium indirectly impacts cellular excitability and creates extracellular osmolarity. While hypernatremia causes cellular dehydration and increased automaticity, acute hyponatremia causes neuronal and heart edema, leading to nonspecific abnormalities in the electrocardiogram including ST-segment depression and extended QT. Severe hyponatremia (<125 mmol/L) independently enhanced the incidence of atrial fibrillation on admission ECGs, based on a 2024 multicenter cohort (6) . Sodium's osmotic activity changes transmembrane gradients, making the myocardium more vulnerable to arrhythmogenic stimulation even though it does not directly control membrane potential like potassium does.

Among serum electrolytes, potassium exerts powerful electro physiologic effects. Delayed repolarization triggered by hypokalemia (<3.5 mmol/L) leads to distinct flattened T waves, prominent U waves, and QT prolongation. Ventricular tachycardia and torsade's de pointes are produced more frequently by these alterations. In contrast, hyperkalemia (>5.5 mmol/L) results in peaked T waves, widened QRS, and ultimate sine-wave patterns before cardiac arrest by shortening repolarization time and reducing conduction velocity. The importance of early ECG-based recognition in situations of emergency has been emphasized by a 2025 Frontiers in Physiology study that found a linear association between potassium levels and ventricular arrhythmia burden (7).

Calcium impacts atrioventricular and sinoatrial nodal conduction as well as the plateau phase (phase 2) of the cardiac action potential. While hypercalcemia shortens QT and can lead to junctional rhythms, hypocalcemia prolongs repolarization, which is shown as QT interval getting longer without T-wave flattening. Even after adjusting magnesium and potassium, a 2023 BMC Cardiovascular Disorders study found that patients with ionized calcium <1.0 mmol/L had a two fold increase in prolonged QT > 470 ms, showing its arrhythmogenic potential (8).

Magnesium acts as a potassium cofactor and biological calcium antagonist. Torsade's de pointes and secondary hypokalemia are caused by hypomagnesemia, which decreases Na+/K+-ATPase activity. However less common, hypomagnesemia affects conduction and can cause AV block and PR prolongation. Whereas hyperphosphatemia, usually caused by renal failure, worsens calcium precipitation and QT irregularities, hypophosphatemia reduces cardiac contractility by depletion ATP. Based on a 2024 open-access review published by the Journal of Electrocardiology, 40% of emergency department torsade cases have been triggered by a combination of hypokalemia and hypomagnesemia (9).

The identification of electrolyte-specific ECG appearance facilitates a speedy distinction between primary electrophysiological and metabolic conditions of etiology. In the present day, automated ECG-based electrolyte alerts have been integrated into modern emergency departments, and they associate morphology of the waveforms with live lab values. In a 2023 Sensors study, applying AI-based ECG analysis obtained 88 percent accuracy in forecasting underlying potassium or

calcium imbalance before laboratory validation (10). Such technological advances underscore the increased potential of ECG analytics as a non-invasive electrolyte sensor, particularly in hospitals with limited resources like in Peshawar, KPK, where the availability of rapid biochemical assays may not be available at any given moment

All these mechanisms point to the fact that electrolyte imbalances directly restructure cardiac electrophysiology by providing predictable, frequently reversible, ECG patterns. Early correction is possible through prompt detection, and this helps avoid fatal arrhythmias and enhances the outcomes of emergency-department. The issue of electrolyte imbalances has an immense effect on patient clinical outcomes in the emergency-department setting. Electrical instability can develop due to abnormal concentrations of sodium, potassium, calcium, magnesium and phosphate and increase to life threatening ventricular tachyarrhythmia or cardiac arrest. The prognosis of critical people with illnesses can be significantly altered by significant changes, even if they are mild and temporary. In accordance with a 2023 global observational study published in Frontiers in Cardiovascular Medicine, detectable electrolyte imbalances within 24 hours preceded approximately 30 percent of arrhythmia presentations in critical care centers, emphasizing their direct pathophysiologic role (11) .

Various recent investigations have already identified the electrolyte disorders as self-contained predictors of poor outcomes. Hyperkalemia is the deadliest as it is often accompanied by asystole and pulseless electrical activity. In a study by 2024 with BMC Emergency Medicine on a cohort of more than 5,000 patients, 30-day mortality rates doubled in patients with serum potassium above 5.5 mmol/L, despite controlling renal dysfunction (2) . Hypokalemia, in its turn, puts at risk torsades de pointes and sudden cardiac death; real-time ECG detection allows the correction and enhancing survival chances.

The systemic effects of extreme hyponatremia (less than 125 mmol/L) on hemodynamics and neurological health have been linked to increased rates of ICU admission and extended stay in the hospital. Refractory ventricular arrhythmias, which fail to respond to traditional anti-arrhythmic drugs, are also associated with hypocalcemia and hypomagnesemia. Concurrent hypokalemia and

hypomagnesemia raised the risk of cardiac arrest by almost four times, based on a meta-analysis of the 2025 Scientific Reports (12).

Abnormalities in electrolytes significantly increase hospitalization and consumption of resources. According to a 2023 southeast Asian BMJ Open cohort study, patients who presented to emergency care with any electrolyte derangement incurred a median length of stay of 1.7 days longer and more cardiac monitoring and renal-replacement therapy. The results are in line with the reports of Pakistan Journal of Medical Sciences in which it was also reported that similar patterns were observed in the tertiary hospitals in Karachi and Lahore where as much as 40 percent of medical admissions had to be corrected with electrolytes within the first 48 hours (13).

Electrolyte abnormalities are under known in the tertiary care ecosystem of Pakistan but are very widespread. Dehydrated patients, renal failure, and sepsis are some of the potent triggers of electrolyte change that is handled frequently in the emergency departments under-diagnosis of arrhythmogenic imbalances is caused by limited point of care testing and delayed reporting of laboratories. Only half of KPK's emergency admissions received ECG-based electrolyte testing, and one in three of these individuals had at least one electrolyte imbalance, according to available local statistics (14).

This diagnostic gap could be improved to significantly decrease cardiac arrest and ICU transfers. This research hence seeks to fill this gap by determining the prevalence, pattern, and ECG correlates of electrolyte abnormalities in adult patients in the emergency department of a tertiary-care hospital in Peshawar, KPK. The results are likely to influence the emergency management algorithms, enhance elective recognition with the help of ECG interpretation, and eventually improve patient outcomes in low-resource settings.

Rationale of the Study:

Electrolyte imbalances can disturb the heart's electrical activity thus causing dangerous arrhythmias. In the emergency department, quick detection of electrolyte imbalances and their association with arrhythmias is vital to preventing serious complications or death. However, current literature has deficient comprehensive data on the prevalence of these abnormalities and their specific associations with various arrhythmia. This study aims to address these knowledge gaps, enhancing the speed and safety of emergency care.

AIM & OBJECTIVES

- To determine the frequency of major electrolyte abnormalities
- To determine the relation/impact /association of each electrolyte abnormality and ECG based confirmed arrhythmias in Emergency department.

CHAPTER 2

LITERATURE REVIEW

One of the most prevalent and dangerous abnormalities in adult patients who arrived in emergency departments (EDs) is electrolyte imbalances. Direct alterations of myocardial electrophysiology may result in typical electrocardiogram (ECG) patterns and severe causes of life-threatening arrhythmias, including ventricular tachycardia (VT), torsade's de pointes, and ventricular fibrillation (VF). In the ED, when patients commonly come in acutely with chest pain, syncope and decompensated heart failure, early identification of electrolyte-induced ECG abnormalities is essential to intervene in time and achieve better results (7). The close relationship between the abnormal electrolyte levels and arrhythmia in emergencies and cardiac patients has been highlighted in several studies done in the last ten years. Nonetheless, ED specific data on ECG confirmed arrhythmias directly associated with known electrolyte thresholds in adults, especially in the middle-income environment like that of Pakistan, are still needed.

2.1 Pathophysiology of electrolyte induced arrhythmias

Electrolytes, especially potassium, calcium and magnesium have essential functions in the production and transmission of cardiac action potential. Repolarization of the cardiac action potential is predominantly mediated by outward potassium currents via delayed rectifier potassium channels, including the rapid (IKr) and slow (IKr) components. The inward rectifier potassium current (IK1) further contributes to the terminal phase of repolarization and stabilization of the resting membrane potential. Disturbances in serum potassium levels can significantly affect these channel activities, resulting in altered repolarization, ECG changes, and an increased risk of cardiac arrhythmias. On the other hand, hyperkalemia decreases the resting membrane potential, which slows conduction and reentry based arrhythmias like VT, VF or asystole. Calcium and magnesium regulate inward currents and repolarization. Hypocalcemia and hypomagnesemia

increase the QT interval by delaying the repolarization of phase 3 which promotes torsade de pointes particularly when interacting with other QT-prolonging medications or hypokalemia. In the case of hypercalcemia, it decreases the QT interval due to speeding up the phase 2, however, at the extreme values it may also interfere with conduction and cause VT/VF through enhanced myocardial irritability. The recent literature has strengthened the argument that mixed electrolyte disturbances (e.g., hypokalemia-hypomagnesemia-hypocalcemia) enhance the impact of arrhythmia and death especially in renal and cardiac patients (15).

2.2 ECG changes in major electrolyte disorders.

2.2.1 Hyperkalemia

Hyperkalemia is another known cause of ECG recorded arrhythmias in the ED. Traditionally, the progressive changes entail: Peaked T waves, PR prolongation, QRS widening, and • P waves loss that can be followed by a sine wave pattern that is likely to cause VF or asystole. The review of ED based severe hyperkalemia (>= 6.5 mEq/L) reported that all the adverse events followed the ECG changes, but predates calcium treatment, which means that ECG is likely to predict the lab verification, and it should be used to guide empiric treatment. A different study established that the prevalence of hyperkalemia was reported to be about 85.7 per 1,000 ED patients, the moderate-severe cases of hyperkalemia having a mortality rate up to 14 percent if not corrected promptly (16).

2.2.2 Hypokalemia

Hypokalemia is a commonly underdiagnosed ED condition, but one that has a high risk of arrhythmia. Such correlates of ECG are diffuse ST segment depression, low or inverted T waves, prominent U waves and prolongation of QT. Hypokalemia increases the outward potassium currents, thereby raising transmural dispersion of repolarization and predisposition to torsade de pointes and polymorphic VT. In a dedicated ED-based report, 2020 reported that 30 percent of patients with severe hypokalemia (≤2.5 mEq/L) were not provided with an ECG and 40 percent were not provided with intravenous potassium, despite 77 percent of the patients receiving ECGs having abnormalities of hypokalemia. This highlights the diagnostic utility of ECG as well as the current gap in adhering to guidelines in the practice of Emergency Departments (17).

2.2.3 Hypercalcemia and hypocalcemia

Hypercalcemia generally reduces the length of the QT interval in ECG indicating a hastening of phase 2 of the action potential. But in severe cases it can also lead to QRS widening, AV block, or VT/VF, especially in patients with underlying structural heart disease. Most of the recent observational data indicate that hypercalcemia is commonly secondary to malignancy, hyperparathyroidism, or excess of vitamin D, and is commonly linked to syncope or palpitations in the ED. Hypocalcemia, which is commonly noticed in chronic kidney disease, use of diuretics or perioperative conditions lengthens the QT interval and predisposes to torsade de pointes. A 2025 study of patients with chest pains in the ED observed that hypocalcemia occurred in 18.97 percent of the cases of arrhythmia, and in most cases, they occurred together with hypokalemia and hypomagnesemia, highly associated with polymorphic VT and atrial fibrillation (18).

2.2.4 Hypomagnesemia

Magnesium is one of the most important co factors of potassium and calcium channels; it increases pro arrhythmic impacts of hypokalemia and hypocalcemia. Hypomagnesemia ECG alterations are often not specific and include QT prolongation, T wave distortion and heightened torsade de pointes and VT/VF. In a study of ED based arrhythmia, it was reported that hypomagnesemia occurred in 14.66 percent of adult patients with ECG detected arrhythmia, primarily in patients on diuretics or with heart failure. In patients presenting with sustained VT, observational data of 2020 support that hypomagnesemia is an independent risk factor of ventricular arrhythmias and increased in-hospital mortality (19).

2.3 Epidemiology of ECG confirmed arrhythmias in adults at ED:

Recent research has defined the occurrence and characteristics of the arrhythmia that are associated with electrolyte derangements in adult ED patients. An adult study of patients with chest pain who were in a hospital ED in 2025 identified tachyarrhythmia (64.65%), with atrial fibrillation (36.21) being the most frequent. The prevalence of electrolyte imbalances was high, with the following results: hypokalemia (28.5%), hypocalcemia (18.97), and hypomagnesemia (14.66), and the abnormalities exhibited different arrhythmia patterns: Hypokalemia was considerably associated with VT and complete AV block; Hypocalcemia and hypomagnesemia were more likely to relate to atrial fibrillation (20).

In another 2020 study of patients that presented with sustained ventricular arrhythmias, electrolyte depletion (particularly depletion in potassium and magnesium) was more frequent among patients who were taking diuretics or those with prior cardiac disease. The authors stated that the correction of these electrolytes decreased the rate of the recurrence of VT/VF in ED and inpatient, which indicated a significant changeable risk factor (16).

Another 2020 ED study of patients with paroxysmal atrial fibrillation established that serum sodium, potassium and magnesium abnormalities were closely related to acute events despite controlling other cardiovascular risk factors. This confirms the hypothesis that electrolyte changes may serve as acute triggers of arrhythmia in vulnerable adults not only in chronic conditions (21).

2.4 Role of ECG in detecting and managing electrolyte related arrhythmia

The ECG is a diagnostic and risk stratification instrument of electrolyte induced arrhythmias in the ED. Modern teaching modules, for emergency clinician teaching focus on the use of ECGs (patterns, T wave morphology, QT/PR/QRS) to make a susceptive diagnosis of underlying electrolyte emergency prior to laboratory tests. To illustrate, end-of-range T waves and QRS expansion can be used in hyperkalemia to initiate empiric calcium gluconate and accelerated potassium reduction treatments, before an analysis of the venous blood gas. The recent reports indicate that there is a delay in the treatment of severe hyperkalemia as clinicians await lab confirmation when there are clear ECG changes and thus exposed to preventable arrhythmias (22). A 2017 case series review showed that in those patients having severe hyperkalemia with a normal ECG, the adverse events had preceded the administration of calcium, which highlights the significance of ECG guided therapy. On the same note, ECG directed replacement lowered the occurrence of torsade de pointes and VT in ED groups among patients under severe hypokalemia conditions (23). Moreover, systematic ECG screening rules in the high-risk ED subgroups (e.g., renal failure, heart failure, intensive care patients-transfer patients) have also been suggested to identify subclinical QT prolongation and the emergence of combined electrolyte disturbances. The protocols usually combine point of care electrolyte testing and continuous cardiac monitoring, which enhances the detection and treatment of arrhythmia(24).

2.5 ED-based management protocols and outcomes

Recent ED focused studies are consistent in emphasizing the importance of protocol-based management of electrolyte abnormalities as a rapid process to avoid arrhythmias. In hyperkalemia, initial therapy involves: 1. calcium gluconate (stabilization of the cardiac membranes), 2. Insulin-glucose and beta agonists (change of potassium in the cell), and 3. Potassium excretion and dialysis measures. In extreme situations, empiric calcium is prescribed in case ECG demonstrates any of the typical hyperkalemic changes, even prior to lab verifications(25). In hypokalemia, the replacement is based on the ECG results; oral or intravenous replacement is used, but patients who have prolonged QT or reported arrhythmias are highly aggressive in terms of IV replacement under cardiac monitoring(26). In the case of hypomagnesemia and hypocalcemia, magnesium sulfate and calcium replacement could be applied in EDs in case of QT prolongation or torsade de pointes or in cases of suspected cases(27). In a 2025 ED study, protocol-based magnesium and potassium repletion in patients with hypokalemia-hypomagnesemia decreased the occurrence of torsade de pointes by over 50 percent relative to historic controls. In general, ED based treatment strategies that correlate ECG changes, electrolyte thresholds and empiric treatment have been linked with the low cardiac arrest rates, arrhythmia recurrence, and mortality in patients with severe electrolyte derangements(28).

2.6 Gaps in literature and implications

However, there are still some limitations within the current literature on the topic of electrolyte related, ECG confirmed arrhythmia in adult ED patients. Many studies are: retrospective or single center, specific diagnostic (e.g. ventricular arrhythmias or atrial fibrillation) oriented, or restricted to inpatient or ICU patients, but not unselected ED groups. The definition of clinically significant electrolyte thresholds and the classification of ECG changes is also heterogeneous among studies. In addition, many published data are based on high income economies; there is a lack of strong ED specific data based in middle income economies, e.g., Pakistan the severe electrolyte derangements.

CHAPTER 3

METHODOLOGY

3.1. Research Design:

A Descriptive cross-section study conducted.

3.2. Clinical Settings:

Tertiary care hospitals at Khyber Pakhtunkhwa.

3.3. Sample Size

Sample Size Calculation:

The sample size was calculated using Cochran's formula for an infinite population, with a 95% confidence level (Z = 1.96), an estimated prevalence of electrolyte imbalances in ED patients with arrhythmias of 50% (p = 0.5, q = 0.5), and a 5% margin of error (e = 0.05). The calculated sample size was 385 patients.

3.4. Sampling Technique

A consecutive sampling method was used, where all eligible patients presenting with arrhythmias to the emergency department during the study period were included until the required sample size was completed.

3.5. Duration of Study

The duration of study was 04 months.

3.6. Selection Criteria

3.6.1. Inclusion Criteria

- Age above 18 years.
- ECG-Confirmed arrhythmia on presentation.
- Serum electrolyte levels were obtained within one hour of emergency department presentation.

3.6.2. Exclusion Criteria

- Incomplete laboratory or ECG record.
- Patients on anti-arrhythmic drugs or electrolyte supplements.
- Patients with chronic kidney disease who were on dialysis.

3.8. Ethical Consideration

Ethical approval was obtained from the institutional ethics committee, and informed consent was taken from all the study participants.

3.9. Data Collection Procedure

Data were collected using a structured data collection form that captured participants demographics (Age, gender, medical history), clinical Presentation (symptoms, vital signs, physical examination findings) ECG findings [Arrhythmia type, specific ECG changes (e.g., peaked T waves, prolonged QT)] and laboratory data including serum levels of potassium, calcium, sodium and magnesium.

3.10. Data Analysis

Descriptive statistics were used to summarize the study variables. The demographic profile, the prevalence of electrolytes abnormalities, and the distribution of arrhythmia types were presented as frequencies and percentages. Association between the electrolyte imbalances & arrhythmia type were examined using Pearson's Chi-Square test however, the Fisher's Exact test was applied in instant where the expected cell counts less than 5 in more than 20% of the cells, ensuring the accuracy of statistical inference. Results were reported with 95% confidence intervals, and a p-value of <0.05 was considered statistically significant. All data analyses were performed using IBM SPSS Statistics for Windows, Version 26.

CHAPTER 4

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

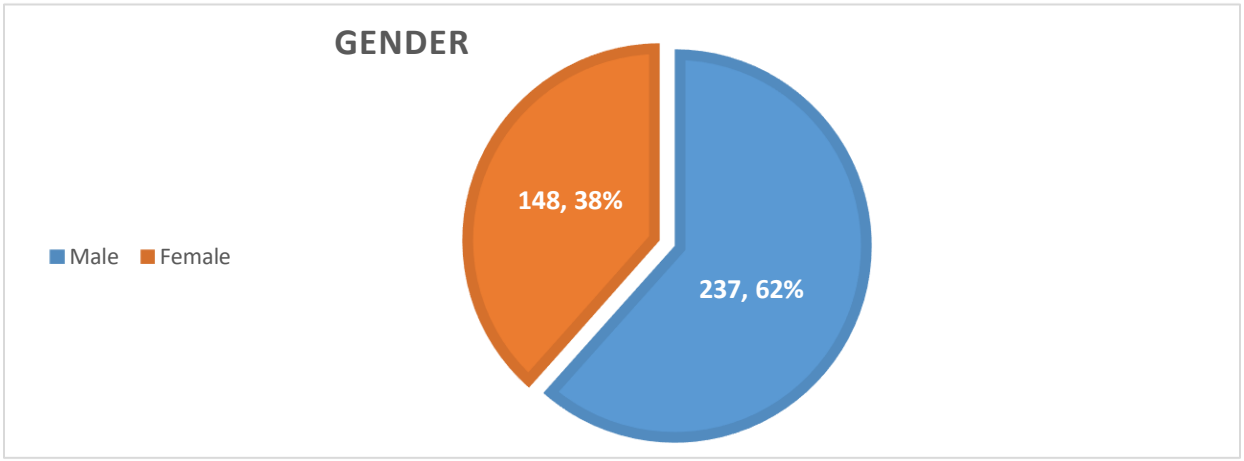
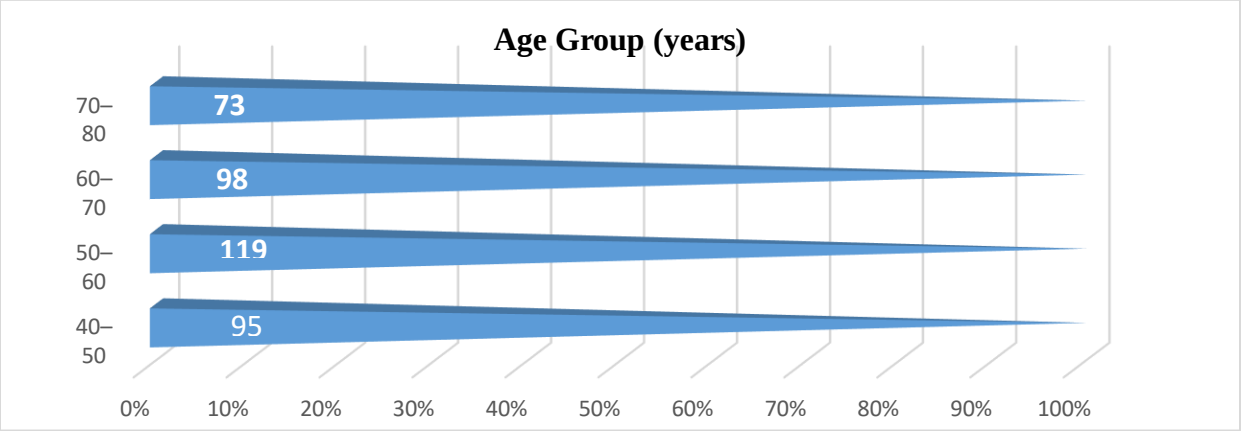


Figure 4.2 Age wise distribution of Study Participants



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

Table 4.1 summarizes the medical history, presenting symptoms, and physical examination findings of the study participants. The most common reported comorbidity was Hypertension (233, 60.5%), followed by Diabetes mellitus (150, 39.0%), heart failure (140, 36.4%), ischemic heart disease (138, 35.8%) and chronic kidney disease was reported in 87 (22.6%) participants, while 41 (10.6%) had other medical conditions.

In terms of presenting symptoms, palpitation was the most common complaint (251, 65.2%), shortness of breath (219, 56.9%), dizziness (166, 43.1%) and chest pain (114, 29.6%).

On physical examination confusion was observed in most people (260, 67.5%), peripheral edema was present in 132(34.3%), pulmonary rales in 59(15.3%), oliguria in 82(21.3%) and anuria in 6(1.6%) participants.

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 shows the frequency distribution of the different arrhythmia, electrocardiographic (ECG) changes, and electrolyte abnormalities. Among the different types of arrhythmias, ventricular tachycardia was the most frequently observed condition, reported in 167 participants (43.4%).It was then followed by Atrial fibrillation identified in 89 participants (23.1%). ventricular fibrillation (n=50, 13.0%), supraventricular tachycardia (SVT) among the participants (42, 10.9%).Other less frequently reported arrhythmias were complete heart block in 20 participants (5.2%), asystole in 9 participants (2.3%) and least common arrhythmia was atrial flutter in 6 participants (1.6%).

In the case of changes in ECG, widened QRS complex, which was the most frequent, was identified in 187 individuals (48.6%). In 133 cases, the prolonged QT interval was observed (34.5%), and the peaked T waves were observed in 128 participants (33.2%). In 83 cases (21.6%), there were prominent U waves. Also, 30 participants (7.8 percent) had third-degree heart block. Concerning the electrolyte abnormalities, the most common abnormality was potassium imbalance with 302 participants (78.4%). Abnormalities of sodium were reported in 126 subjects (32.7%), and magnesium, in 123 (31.9%). Comparatively fewer abnormalities of calcium were present, 61 participants (15.5%).

The results show that ventricular tachycardia was the most observed arrhythmia, a widened QRS complex was the most observed ECG alteration and potassium imbalance was the most observed electrolyte imbalance among the participants of the study. These trends point out the possible

contribution of electrolyte imbalances, especially potassium imbalance, to cardiac rhythm abnormalities and ECG alterations.

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^+)	302	78.4
Sodium Abnormality (Na^+)	126	32.7
Calcium Abnormality (Ca^{2+})	61	15.8
Magnesium Abnormality (Mg^{2+})	123	31.9

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

Chi-square test was used to determine the relationship between the various forms of arrhythmia and the imbalance in the electrolytes. The results showed varying dependencies between electrolyte imbalances and certain types of arrhythmias. In the case of atrial fibrillation, none of the electrolytes studied showed any statistically significant relationship. The abnormality of Potassium ($p = 0.811$), sodium ($p = 0.974$), calcium ($p = 0.973$), and magnesium ($p = 0.710$), did not have a significant relationship, and this implies electrolyte imbalance did not have a significant effect on the prevalence of atrial fibrillation.

In contrast, supraventricular tachycardia (SVT) had considerable correlations with various electrolytes. Potassium had a very strong association ($p < 0.001$) and sodium ($p = 0.001$) and calcium ($p < 0.001$) had a significant relationship with the presence of SVT. Magnesium was, however, not statistically significantly associated with SVT ($p = 0.231$).

In case of ventricular tachycardia, there was no statistically significant association with the electrolytes assessed. The other electrolytes (potassium $p = 0.080$), sodium ($p = 0.768$), calcium ($p = 0.897$), and magnesium ($p = 0.143$) did not produce a significant result, indicating that electrolyte disturbances had no significant relationship with ventricular tachycardia in this data. There were important correlations with some electrolytes as far as ventricular fibrillation is concerned. Significant correlation between ventricular fibrillation and certain electrolytes were found. There were statistically significant correlation between ventricular fibrillation and potassium ($p =0.001$), calcium ($p =0.001$), and magnesium ($p =0.001$).sodium, however, showed no significant correlation ($p = 0.240$).Finally complete heart block showed strong correlation with magnesium ($p = 0.002$) and sodium ($p < 0.001$), suggesting that imbalances in these electrolytes may be associated with the incidence of this arrhythmia.

Overall, it was found that the electrolyte imbalances were strongly related to some arrhythmias, particularly supraventricular tachycardia, ventricular fibrillation, and complete heart block, whereas no significant correlations were found between atrial fibrillation and ventricular

tachycardia and the electrolytes considered. These results show that electrolyte imbalances may be involved in the occurrence of certain abnormalities in cardiac rhythms.

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:

The association between selected arrhythmia types and electrolyte abnormalities was further evaluated using Fisher's exact test, particularly for categories with small sample sizes. The results showed the differences in the associations between specific electrolytes and certain arrhythmias. In the case of atrial flutter, potassium ($p < 0.001$) and sodium ($p = 0.001$) were statistically significant contributors. However, it was not significantly correlated with either calcium ($p = 0.595$) or magnesium ($p = 0.183$), indicating that atrial flutter was more frequently associated with potassium and sodium in the studied population.

Sodium had statistically significant correlation with occurrence of asystole ($p = 0.034$). Potassium ($p = 0.215$), calcium ($p = 0.365$), and magnesium ($p = 0.063$) did not have statistically significant relationships with asystole. For complete heart block, potassium ($p = 0.016$) and calcium ($p = 0.046$) were significant. These finding suggest that disturbances in these electrolytes may be related to the development of complete heart block in certain cases.

Overall, the Fisher's Exact test analysis indicated that specific electrolyte abnormalities particularly potassium and sodium were significantly associated with atrial flutter and complete heart block, while sodium showed a significant relationship with asystole. Others electrolyte and arrhythmia combinations did not show statistically significant associations.

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
Atrial Flutter	Potassium	0	302	<0.001
	Sodium	6	120	0.001
	Calcium	0	61	0.595
	Magnesium	0	123	0.183

Asystole	Potassium	9	293	0.215
	Sodium	0	126	0.034
	Calcium	0	61	0.365
	Magnesium	0	123	0.063
Complete Heart Block	Potassium	20	282	0.016
	Calcium	0	61	0.046

CHAPTER 5

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).

5.1 Demographic Profile of the Study Population

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 \9Bcardiac 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.

5.2 Clinical Characteristics, Comorbidities, and Presenting Symptoms

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.

5.3 Patterns of Arrhythmias and ECG Abnormalities

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.

5.4. Association between Electrolyte Abnormalities and Arrhythmias

Although potassium abnormalities were highly prevalent (78.4%) in this study, this finding should be interpreted cautiously. A considerable proportion of patient had underlying

comorbidities such as chronic kidney disease, heart failure and diabetes mellitus, which are known to influence potassium level. In addition, the use of medication such as diuretics may further contribute to potassium imbalance. Therefore, in this study population, potassium abnormalities may represent secondary effects of underlying condition rather than primary causes of arrhythmias.

5.4.1. Atrial Fibrillation

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.

5.4.2. Supraventricular Tachycardia (SVT).

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).

5.4.3. Ventricular tachycardia (VT)

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 electrolytes abnormalities and ventricular tachycardia (VT) is an important and clinically meaningful finding in this study. Unlike supraventricular arrhythmias or ventricular fibrillation, which are often triggered by acute metabolic disturbances, VT is frequently associated with structural heart diseases, 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 mechanism driving VT rather than transient electrolyte shifts. This finding aligns with established electrophysiological understanding that VT in emergency setting 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.

5.4.4. Ventricular Fibrillation (VF)

Significant correlations were identified between VF and imbalances in potassium, calcium, and magnesium. These results are like a significant amount of research suggesting a link among these deficiencies and severe ventricular arrhythmias. Research by Chugh et al. and Kieboom et al. focused on the fact that any small changes in magnesium or potassium levels can significantly raise the probability of sudden cardiac death (39). The results reaffirm the urgent necessity to correct these electrolytes during the early stage of ED patients under high risk.

5.4.5. Complete Heart Block

Sodium and magnesium abnormality were significantly related to CHB. Past literature indicates that both extreme hyponatremia and magnesium deficiency may cause inhibition of cellular depolarization and AV nodal conduction respectively (19) . Its results are physiologically and clinically coherent.

CHAPTER 6

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.
- Future research should include a larger sample by involving more hospitals across the province, which would enhance the generalizability and robustness of the findings.

CHAPTER 7

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APPENDICES

ENGLISH CONSENT FORM

The study you are about to participate is a Cross Sectional study titled as;

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

"

The study has no potential harm to participants. All data collected from you will be coded in order to protect your identity, and should not be disclosed to anyone. Following the study there will be no way to connect your name with your data. Your answers to the questions will not affect the quality of education given to you. Any additional information about the study results will be provided to you at its conclusion, upon your request.

You are free to withdraw from the study at any time. You agree to participate, indicating that you have read and understood the nature of the study, and that all your inquiries concerning the activities have been answered to your satisfaction.

NAME _____ **SIGNATURE_____**

DATE_____

URDU CONSENT FORM

میں_____ تصدیق کرتا/ کرتی ہوں کہ **محترم Muhammad_Arif**
نے اپنی اس تحقیق

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

.زیرنگرانی **Dr. Maham Qazi** کے متعلق بتا دیا ہے۔ مجھے اس تحقیق کی نوعیت، مقاصد، احداف، توقعات، فوائد اور خطرات کے متعلق ، ۔ساری معلومات فراہم کر دی گئی ہیں

اس تحقیق کے دوران ساری معلومات صیغۃ راز میں رہیں گی اور مریض کا نام اور دیگر معلومات صرف تحقیق کے لیے استعمال ہوں گی۔مجھے یہ بھی بتا دیا گیا ہے کہ میں اس تحقیق سے متعلقہ ہر قسم کے سوال پوچھنے کا مجاز ہوں اور یہ تحقیق صرف ایک شخص ک مفاد میں نہیں ہے بلکہ بحشیت مجموعی انسانیت کا مفاد اس سے وابسطہ ہے۔ تمام تفصیلات جاننے کے بعد یس تحقیق میں شامل ہونے یا نہ ہونے پر کسی کا قائل نہیں ہوں۔ اس تحقیق سے کسی بھی وقت علیحدہ ہونے پر مجھ پر کوئی پابندی نہیں ہو گی۔ میں بذاتِ خود بقائمی حوش و حواس ۔اور رضا مندی سے اس تحقیقاتی عمل میں شامل ہوتی/ ہوتا ہوں

---------- دستخط محقق

---------- دستخط شرکت کار

---------- تاریخ

Data Collection Form

Electrolyte Abnormalities and Their Impact on ECG- Confirmed Arrhythmias among adult's patients in Emergency Department

Patient ID:_____

Date: _____

Demographic and Clinical History

1. **Age (years):** _____
2. **Gender:** ☐ Male ☐ Female ☐ Other
3. **Medical History** (select all that apply):
   ☐ Hypertension ☐ Diabetes Mellitus ☐ Ischemic Heart Disease ☐ Heart Failure ☐ Chronic Kidney Disease ☐ Other: _____
4. **Current Medications** (list all, including dosages): _____
5. **Presenting Symptoms** (select all that apply):
   ☐ Chest Pain ☐ Palpitations ☐ Shortness of Breath ☐ Syncope ☐ Dizziness ☐ Other: _____

Clinical and ECG Findings

6. **Vital Signs**:
   - Blood Pressure (mmHg): _____/ _____
   - Heart Rate (bpm): _____
   - Respiratory Rate (breaths/min): _____
   - Temperature (°C): _____
   - Oxygen Saturation (%): _____
7. **Physical Examination Findings** (select all that apply):
   ☐ Confusion ☐ Peripheral Edema ☐ Pulmonary Rales ☐ Oliguria/Anuria ☐ Other: _____
8. **Arrhythmia Type (ECG-Confirmed)** (select all that apply):
   ☐ Atrial Fibrillation ☐ Atrial Flutter ☐ Supraventricular Tachycardia ☐ Ventricular Tachycardia ☐ Ventricular Fibrillation ☐ Asystole ☐ Other: _____
9. **ECG Changes Suggestive of Electrolyte Imbalances** (select all that apply):
   ☐ Peaked T Waves ☐ Prolonged QT Interval ☐ Prominent U Waves ☐ Widened QRS

Complex ☐ Other: _____

Laboratory Data:

Parameter

Result	Units	Normal Range		Abnormal?
Potassium (K^+)	_____	mmol/L	3.5–5.0	☐ Yes ☐ No
Sodium (Na^+)	_____	mmol/L	135–145	☐ Yes ☐ No
Calcium (Ca^{2+})	_____	mmol/L	2.1–2.6	☐ Yes ☐ No
Magnesium (Mg^{2+})	_____	mmol/L	0.7–1.0	☐ Yes ☐ No

10. **Other Relevant Labs** (e.g., renal function, acid-base status): _____

DEPARTMENT OF CARDIOLOGY

SAIDU GROUP OF TEACHING HOSPITAL

Saidu Sharif Swat

Ph: 0946-9240125

Ref No CRD-SGTH-976 Date 12/11/2025

Subject: Permission for Data Collection

This is to certify that Mr. Muhammad Arif (Registration No. SU91-MSAHW-S24-051), student at Superior University, Lahore, is hereby permitted to collect data from Cardiology department ***Saidu Teaching Hospital, Swat*** for his research study titled ***"Electrolyte Abnormalities and Their Impact on ECG-Confirmed Arrhythmias Among Adult Patients in Emergency Department."***

The permission is granted solely for academic and research purposes, subject to maintaining patient confidentiality and compliance with hospital policies and ethical guidelines.

Signature: KA

Official Stamp: Dr. Khurshid Ali
MBBS, FCPS (Cardiology)
Fellowship in Interventional Cardiology (P.I.C Lahore)
Registrar SGTH Saidu Sharif Swat

Ref.: IRB /FAHS/Allied/10/25/MS/AHS-3821

Date: _10th October 2025_____

Name: Muhammad Arif

Registration: SU91-MSAHW-S24-051

Subject: Ethical Approval Letter

The Research Ethical Committee convened on Dated: **3rd October, 2025** to discuss your protocol titled "**Electrolyte Abnormalities and Their Impact On ECG- Confirmed Arrhythmias Among Adult Patients in Emergency Department**"

No further corrections and recommendations were suggested. The above-mentioned protocol has been approved after considering various research issues including ethical concerns with condition that the researcher will submit completion report at the end of his/her research.

Prof. Dr. Muhammad Naveed Babur
Dean/Convener REC
Faculty of Allied Health Sciences
Superior University, Lahore