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ORIGINAL RESEARCH

Electrocardiographic Abnormalities in Patients with Hyperkalemia: A Retrospective Study in an Emergency Department in Colombia

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Introduction: Hyperkalemia is a prevalent electrolyte disorder related to elevated serum potassium levels, resulting in diverse abnormal electrocardiographic findings and associated clinical signs and symptoms, often necessitating specific treatment. However, in some patients, these abnormal findings may not be present on the electrocardiogram even in elevated serum potassium levels. This study aims to identify electrocardiographic abnormalities related to the severity of hyperkalemia and the clinical outcomes in an emergency department in southwestern Colombia.

Methodology: This is a retrospective cross-sectional descriptive study. We described the electrocardiographic findings, clinical characteristics, treatment, and outcomes related to the degrees of hyperkalemia. The potential association between the severity of hyperkalemia and electrocardiographic findings was evaluated.

Results: A total of 494 patients were included. The median of the potassium level was 6.6 mEq/L. Abnormal electrocardiographic findings were reported in 61.5% of the cases. Mild and severe hyperkalemia groups reported abnormalities in 59.9% and 61.2%, respectively. The most common electrocardiography abnormalities were the peaked T wave 36.2%, followed by wide QRS 83 (16.8%). Only 1.4% of patients had adverse outcomes. The abnormal findings were registered in 61.5%. Mortality was 11.9%. The peaked T wave was the most common finding across different levels of hyperkalemia severity.

Conclusion: High serum potassium levels are related with abnormal ECG. However, patients with different degrees of hyperkalemia could not describe abnormal ECG findings. In a high proportion of patients with renal chronic disease and hyperkalemia, the abnormalities in the ECG could be minimal or absent.

Keywords: hyperkalemia, degree, outcomes, electrocardiographic, ECG, abnormalities

Introduction

Hyperkalemia is a common electrolyte disorder defined as high serum potassium (K+) concentrations[1,2] and it can be classified to the serum concentration defined as a serum level of potassium greater than 5.5 mEq/L.[3–5] Certain conditions can increase serum potassium concentration, such as chronic kidney disease, diabetes, and medications.[6–8]

Clinical manifestations are associated with the grade of hyperkalemia. Some symptoms have been described, as a weakness, paresthesia, and muscular fasciculation in the arms and legs are the most common symptoms, followed by paralysis, nausea, vomiting, and diarrhea. In a few cases, the manifestations could be severe like a mimicking Guillain–Barré syndrome.[9,10] Dysrhythmias, ventricular fibrillation, and asystole manifestations have been described as electrocardiography manifestations. Nevertheless, the majority of patients with hyperkalemia are asymptomatic.[3,11]

Electrocardiographic (ECG) abnormalities have been described, such as the presence of peaked T waves, shortened QT interval, prolonged PR intervals, disappearance or flattening of P waves, sinusoidal wave, and in some cases

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alterations in the cardiac rhythm.[11–16] Nevertheless, the literature describes that ECG findings do not directly correlate with high serum potassium levels,[17–19] and some patients have reported hyperkalemia without electrocardiographic alterations like patients with chronic kidney disease without ECG changes despite elevated potassium levels.[6,20–22]

However, in certain instances, this condition can induce electrocardiographic alterations that may pose potential seriousness, necessitating emergent therapy intervention. Some of these employed to rectify potassium levels encompass the utilization of loop diuretics, beta-agonists, polarizing solutions, hemodialysis, insulin, and ion-exchange resins coupled with a membrane stabilizer featuring calcium gluconate for action potential control. The value of early recognition of hyperkalemia using the ECG has been described.[23]

In our country, only a limited number of case reports have been performed in various contexts. One study described the clinical characteristics of patients with long-term prescriptions for angiotensin-converting enzyme inhibitors or angiotensin receptor blockers despite the absence of electrocardiographic changes.[24] Additional case reports have reported the correlation between medication usage and chronic kidney disease. Nevertheless, there is no comprehensive study with a substantial number of patients reported in the country or southwestern Colombia.

This study aimed to describe the abnormal ECG findings related to serum potassium levels and clinical outcomes in an emergency department of southwest from Colombia.

Methods

Design of the Study

A retrospective cross-sectional descriptive study was performed in an emergency department of a high-complexity university hospital between January 2011 and December 2020.

Population

All patients aged ≥18 years attending the emergency department between 2011 and 2020 with a diagnostic of hyperkalemia intra-hospital (serum potassium concentration is ≥5.5 mEq/L) with an electrocardiogram (ECG) close to the report confirming elevated potassium levels and diagnosing hyperkalemia.

Patients with a history of permanent atrial fibrillation, intracardiac device (pacemaker, cardio-synchronizer, or implantable defibrillator), patients with ECG of poor quality that could not be interpreted or no ECG report, undergoing palliative care treatment, or being pregnant were excluded.

Variables Description

Demographic variables, clinical history, physiological variables, laboratory variables upon admission, symptoms related to hyperkalemia, initial and follow-up ECG findings, initiation of anti-hyperkalemic measures (no treatment, mono-therapy, and combination therapy), and adverse outcomes such as malignant arrhythmias and cardiac arrest were collected from medical history.

ECG abnormalities were defined as at least one of the following findings: shortened QT interval, peaked T waves, reduction of the amplitude or absence of the P wave, QRS prolongation, prolonged PR interval, loss of sinoatrial conduction with the onset of a wide-complex "sine wave" ventricular rhythm, Brugada phenocopy, or any types of block heart (AV block or bundle branch block).

The classification of hyperkalemia was based in European Resuscitation Council Guideline (ERCG) (endorsed by UK Renal Association): mild hyperkalemia (5.5–5.9 mEq/L), moderate hyperkalemia (6–6.4 mEq /L) and severe hyperkalemia (≥6.5 m mEq/L).[25]

Statistical Analysis

The Shapiro–Wilk statistical test was used to assess the distribution of the quantitative variables. These variables were described using measures of central tendency and dispersion. The chi-square test was employed to assess the association between the severity of hyperkalemia and electrocardiographic findings. A multivariate analysis was conducted using logistic regression. Abnormal electrocardiographic findings with a p value <0,2 in the bivariate analysis as independent

variables. The model was adjusted for confounding variables including age ≥60, sex, cardiac arrest rhythms, and renal chronic disease. The goodness-of-fit of the model was evaluated using the Hosmer–Lemeshow test. The analysis was conducted using StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC.

The Biomedical Research Ethics Committee at the University Hospital (Comité de Ética en Investigación Biomédica de la Fundación Valle del Lili) approved this study (Approved No. 280–2021, No. 15 of July 28, 2021). This study adheres to the Helsinki Declaration of Ethical Principles for Medical Research in Human Beings. According to the resolution 8430 of 1993 of the Colombian Ministry of Health, this study did not represent risk and did not require informed consent. This study followed the standards of the STROBE guidelines. The researchers did not expose the patients to biological, psychological, or social risks. Therefore, the ethics committee approved the waiver of informed consent.

Results

A total of 494 patients were included (Figure 1). The median ages were similar among those with mild, moderate, and severe hyperkalemia. The majority of the population were men (57.1%). The most frequent medical history was arterial hypertension (71.7%), followed by chronic kidney disease (63%). The most frequently reported symptom was weakness, followed by nausea/vomiting. Nevertheless, mild and moderate groups were the most common of weakness and respiratory distress. The median serum potassium level was 6.6 mEq/L. The most common cardiac rhythm observed was sinus rhythm. More than half of the cases presented at least one abnormal finding, with a similar distribution across severity groups (Table 1).

Regarding the treatment, the most commonly administered medication was the polarizing solution (insulin/glucose), followed by loop diuretics and beta-agonists (Table 1), and the combined therapy was the most used (Figure 2).

The peaked T wave was the most frequently observed abnormality (36.2%), followed by a Wide QRS complex with bizarre morphologies (16.8%), PR interval elongation (13.6%), and block heart (13.2%). Only five patients experienced cardiac arrest (three patients with pulseless electrical activity, one with asystole, and one with pulseless ventricular tachycardia). The moderate hyperkalemia group documented the most frequent abnormal findings. The distribution of hyperkalemia severity groups for each abnormal finding is illustrated in Figure 3. The relationship between ECG abnormalities and the severity of hyperkalemia was documented in all patients (Table 2) and specifically in patients with chronic kidney disease (Table 3). After running the model, the variable for peaked T waves maintains its statistical significance ($p \leq 0.001$). This suggests that patients who present this finding have 2.4 times the chance of having moderate-to-severe hyperkalemia compared to patients without this feature. The goodness-of-fit test indicates that the model fits the data ($p=0.148$) (Table 4).

Only five patients reported arrest rhythm and the post-discharge mortality rate was 11.9% but decreased with the severity (15.7%, 11.5%, and 10.7%) (Table 5).

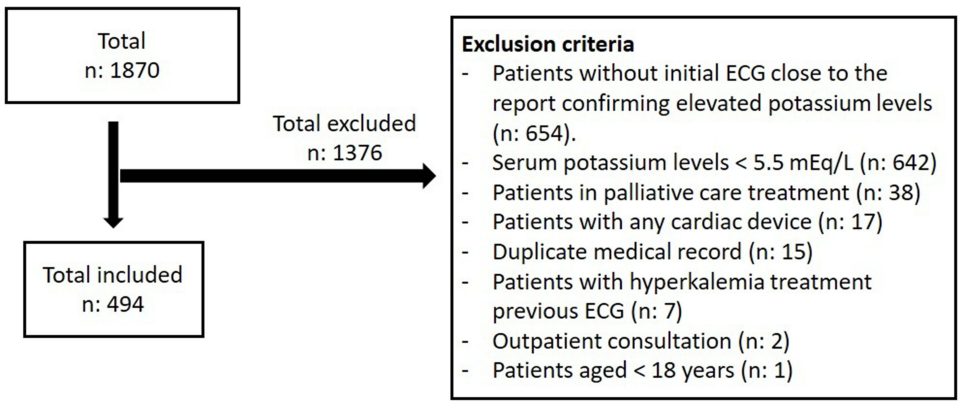

Figure 1 Flowchart.

Table 1 Demographic and Clinical Characteristics of the Study Population

Variables	Available Data	Overall, n: 494	Classification of Hyperkalemia		
			Mild (n: 102)	Moderate (n: 122)	Severe (n: 270)
Age*	494	63 (48–73)	64.5 (53–74)	65 (52–75)	61 (45–72)
Age ≥60 years	494	318 (64.4%)	93 (91.2%)	78 (63.9%)	147 (54.4%)
Gender					
Female	494	212 (42.9%)	48 (47.1%)	58 (47.5%)	106 (39.3%)
Male	494	282 (57.1%)	54 (52.9%)	64 (52.5%)	164 (60.7%)
Background					
Hypertension	494	354 (71.7%)	70 (68.6%)	85 (69.7%)	199 (73.7%)
Chronic kidney disease	494	311 (63.0%)	47 (46.1%)	58 (47.5%)	206 (76.3%)
Diabetes	494	173 (35.0%)	37 (36.3%)	51 (41.8%)	85 (31.5%)
Cancer	494	76 (15.4%)	19 (18.6%)	21 (17.2%)	36 (13.3%)
Heart failure	494	62 (12.6%)	10 (9.8%)	13 (10.7%)	39 (14.4%)
Immunosuppression	494	61 (12.4%)	7 (6.9%)	19 (15.6%)	35 (13.0%)
Autoimmune disease	494	36 (7.3%)	3 (2.9%)	10 (8.2%)	23 (8.5%)
Chronic obstructive pulmonary disease	494	27 (5.5%)	6 (5.9%)	9 (7.4%)	12 (4.4%)
Arrhythmias	494	10 (2.0%)	1 (1.0%)	0	9 (3.3%)
Asthma	494	4 (0.8%)	2 (2.0%)	0	2 (0.7%)
Physiological variables					
Systolic blood pressure *	494	130 (111–152)	130 (114–147)	132.5 (108–152)	130 (112–154)
Diastolic blood pressure*	494	73 (61–86)	72 (64–85)	72 (58–84)	74.5 (60–88)
Heart rate*	494	83.5 (70–98)	84 (70–98)	85 (70–99)	82 (71–98)
Respiratory rate*	494	18 (17–20)	18 (17–20)	18 (17–20)	18 (17–20)
Arterial saturation*	494	97 (95–98)	97 (95–98)	96 (94–98)	97 (95–99)
Temperature, (C°)*	494	36.2 (36–36.5)	36.2 (36–36.5)	36.1 (36–36.5)	36.2 (36–36.5)
Paraclinical					
Creatinine *	443	3.56 (1.9–8.2)	2.6 (1.7–6.6)	2.77 (1.6–5.3)	4.38 (2.5–9.7)
BUN*	470	57.3 (40–78.5)	53 (36.4–68.5)	50.7 (35.3–77.6)	63.1 (42.7–81.6)
Na*	466	136 (133–139)	137 (134–141)	136.9 (132.8–139.9)	135.7 (133–138)
K*	494	6.6 (6.1–7.0)	5.7 (5.6–5.9)	6.2 (6.1–6.3)	6.9 (6.6–7.3)
Mg*	192	2.03 (1.8–2.4)	2.01 (1.6–2.4)	1.92 (1.7–2.2)	2.12 (1.82–2.5)
Ca*	204	8.8 (8.1–9.6)	8.7 (7.6–9.2)	9.2 (8.5–9.8)	8.71 (7.81–9.5)
Cl*	384	101.5 (96.2–107)	102.7 (98–107.2)	101.4 (95.2–106.6)	100.7 (96.2–107)
Glucose*	333	119 (94–158)	129 (90–157)	120.5 (94–170.5)	117 (95–157)
Symptoms related to Hyperkalemia	494	175 (35.4%)	26 (25.5%)	41 (33.6%)	108 (40%)
Weakness	494	105 (21.3%)	18 (17.6%)	20 (16.4%)	67 (24.8%)
Nausea/vomiting	494	51 (10.3%)	6 (5.9%)	11 (9.0%)	34 (12.6%)
Abdominal pain	494	42 (8.5%)	7 (6.9%)	6 (4.9%)	29 (10.7%)
Respiratory distress	494	48 (9.7%)	8 (7.8%)	14 (11.5%)	26 (9.6%)
Slow, weak, or irregular pulse	494	17 (3.4%)	0	5 (4.1%)	12 (4.4%)
Anxiety	494	16 (3.3%)	0	6 (4.9%)	10 (3.7%)
Irritability and restlessness	494	15 (3.0%)	0	3 (2.5%)	12 (4.4%)
Numbness and tingling of the fingertips	494	12 (2.4%)	1 (1%)	1 (0.8%)	10 (3.7%)
Flaccid quadriplegia	494	2 (0.4%)	0	1 (0.8%)	1 (0.3%)
Initial Rhythm					
Sinus rhythm	494	416 (84.2%)	74 (72.6%)	106 (86.9%)	236 (87.4%)
Sinus tachycardia	494	34 (6.9%)	13 (12.8%)	6 (4.9%)	15 (5.6%)

(*Continued*)

Table 1 (Continued).

Variables	Available Data	Overall, n: 494	Classification of Hyperkalemia		
			Mild (n: 102)	Moderate (n: 122)	Severe (n: 270)
Atrial fibrillation	494	16 (3.2%)	6 (5.9%)	3 (2.5%)	7 (2.6%)
Sinus bradycardia	494	12 (2.4%)	3 (2.9%)	3 (2.5%)	6 (2.2%)
Indeterminate rhythm	494	7 (1.4%)	3 (2.9%)	3 (2.5%)	1 (0.4%)
AESP	494	3 (0.6%)	1 (1%)	0	2 (0.7%)
Atrial flutter	494	2 (0.4%)	1 (1%)	1 (0.8%)	0
Idioventricular rhythm	494	1 (0.2%)	0	0	1 (0.4%)
Ventricular tachycardia	494	1 (0.2%)	1 (1%)	0	0
Asystole	494	1 (0.2%)	0	0	1 (0.4%)
Pulseless ventricular tachycardia	494	1 (0.2%)	0	0	1 (0.4%)
Treatment					
Insulin / Glucose	494	281 (56.9%)	44 (43.1%)	69 (56.6%)	168 (62.2%)
Loop Diuretics	494	263 (53.2%)	53 (52%)	69 (56.6%)	141 (52.2%)
Beta agonist	494	231 (46.8%)	36 (35.3%)	58 (47.5%)	137 (50.7%)
Calcium salts	494	209 (42.3%)	22 (21.6%)	50 (41%)	137 (50.7%)
Hemodialysis	494	199 (40.3%)	32 (31.4%)	40 (32.8%)	127 (47%)
Ion exchange resins	494	191 (38.7%)	28 (27.4%)	47 (38.5%)	116 (43%)
Sodium bicarbonate	494	144 (29.25)	33 (32.4%)	26 (21.3%)	85 (31.5%)
No treatment	494	9 (1.8%)	3 (2.9%)	3 (2.5%)	3 (1.1%)
Principal diagnostic					
Renal diseases	494	172 (34.8%	22 (21.6%)	35 (28.7%)	115 (42.59%)
Infectious diseases	494	86 (17.4%)	21 (20.6%)	18 (14.8%)	47 (17.4%)
Cardiovascular diseases	494	57 (11.5%)	16 (15.7%)	21 (17.2%)	20 (7.4%)
Postoperative	494	47 (9.5%)	14 (13.7%)	14 (11.5%)	19 (7%)
Metabolic diseases	494	37 (7.5%)	4 (3.9%)	10 (8.2%)	23 (8.5%)
Neoplasia	494	32 (6.5%)	7 (6.9%)	9 (7.4%)	16 (5.9%)
Digestive diseases	494	22 (4.4%)	4 (3.9%)	7 (5.7%)	11 (4.1%)
Respiratory diseases	494	12 (2.4%)	3 (2.9%)	3 (2.5%)	56 (2.2%)
Neurological diseases	494	11 (2.2%)	7 (6.9%)	3 (2.5%)	1 (0.4%)
Trauma	494	6 (1.2%)	1 (1%)	1 (0.8%)	4 (1.5%)
Immuno-Rheumatology diseases	494	5 (1.0%)	1 (1%)	1 (0.8%)	3 (1.1%)
Hematological diseases	494	2 (0.4%)	1 (1%)	0	1 (0.4%)
Neuromuscular diseases	494	2 (0.4%)	0	0	2 (0.7%)
Toxicity	494	1 (0.4%)	1 (1%)	0	1 (0.4%)
Urological diseases	494	1 (0.4%)	0	0	1 (0.4%)
Vascular diseases	494	1 (0.4%)	0	0	1 (0.4%)
Abnormal ECG findings	494	304 (61.5%)	57 (55.9%)	78 (63.9%)	169 (62.6%)
Hospitalization days**	494	15.33 (± 20.61)	17.5 (± 26.19)	14.2 (± 18.1)	14.9 (±19.26)
Intra-hospital death	494	59 (11.9%)	16 (15.7%)	14 (11.5%)	29 (10.7%)

Notes: *Median (IQR), **Mean (SD).

Discussion

This study describes the frequency of electrocardiographic changes in patients related to the severity of hyperkalemia and the occurrence of clinical outcomes. Over half of the cases exhibited at least one abnormal finding with the highest proportion in the moderate hyperkalemia group. The most common finding was peaked T wave followed by wide QRS. Variables such as age, CKD, and peaked T wave were statistically significant with the severity. The most frequently reported symptom was weakness. The mild hyperkalemia group had the highest percentage of mortality.

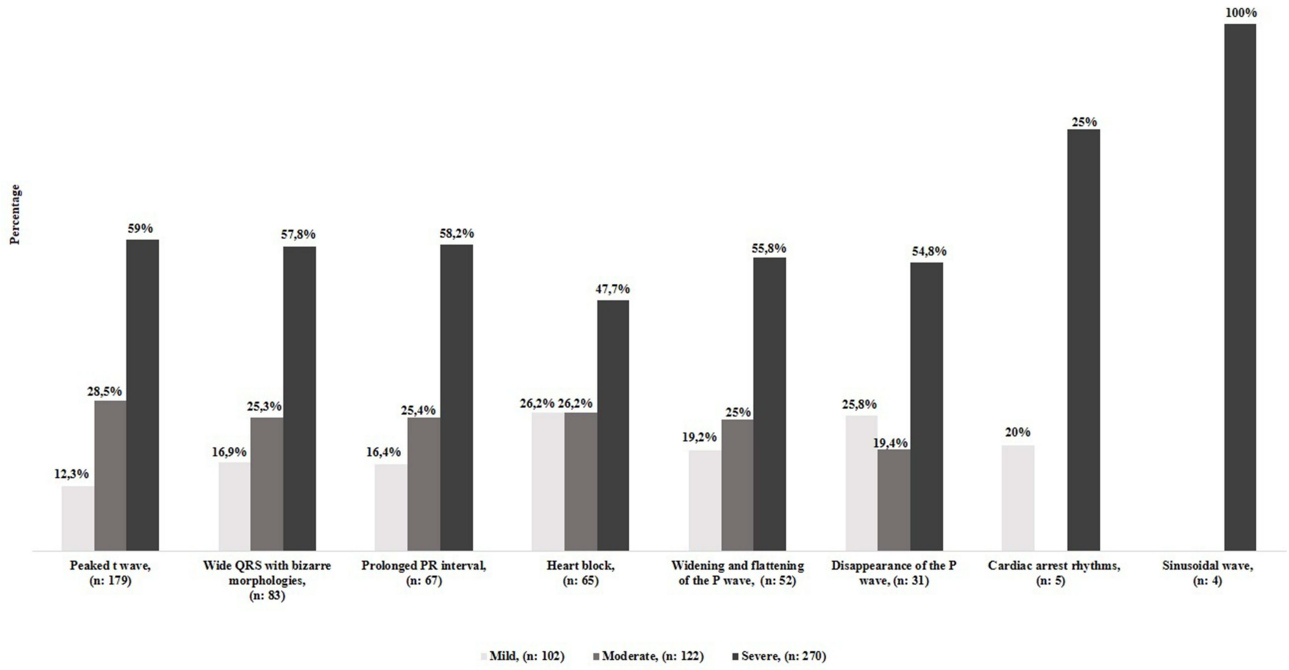

Figure 2 ECG findings and degrees of hyperkalemia.

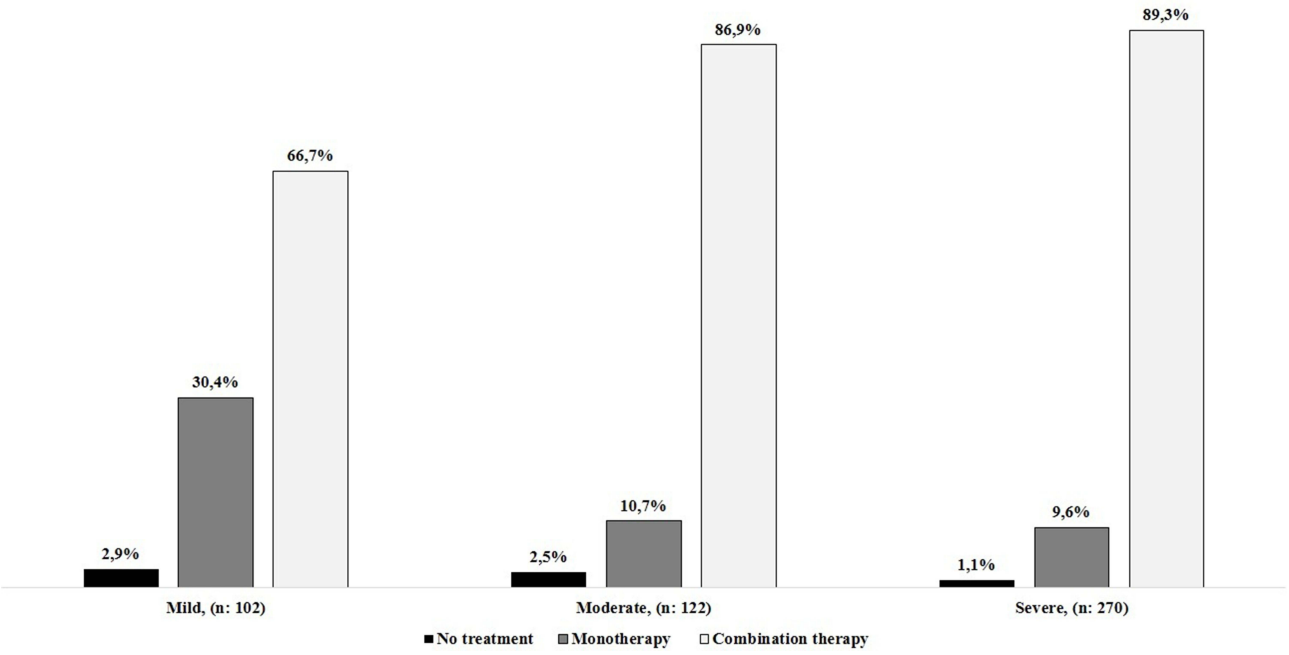

Figure 3 Treatment.

In our study, the most common finding was peaked T wave, followed by wide QRS with bizarre morphologies, prolonged PR interval, and cardiac block rhythm. Previous studies have established the utility of ECG in diagnosing hyperkalemia. Some authors have reported that the ECG exhibits low sensitivity and specificity,[4] but the sensitivity increased in patients with serum potassium ≥6 mEq/l.[19,20,26–28]

Fordjour et al reported that 50% of patients with potassium ≥6.5 meq/L exhibited abnormal ECG results, and the most common finding was the peaked T wave and conduction abnormalities, including prolonged first-degree AV block and

Table 2 Relationship Between Abnormal Electrocardiogram Findings/Demographic Variables and Severity of Hyperkalemia

Variables	Mild, n: 102	Moderate, n: 122	Severe, n: 270	P - value
Age ≥ 60				
No	9 (8.8%)	44 (36.1%)	123 (45.6%)	<0.001
Yes	93 (91.2%)	78 (63.9%)	147 (54.4%)	
Gender				
Female	48 (47.1%)	58 (47.5%)	106 (39.3%)	0.197
Male	54 (52.9%)	64 (52.5%)	164 (60.7%)	
Cardiac arrest rhythms				
No	101 (99.0%)	122 (100%)	266 (98.5%)	0.253
Yes	1 (1.0%)	0	4 (1.5%)	
Renal chronic disease				
No	55 (53.9%)	64 (52.5%)	64 (23.7%)	< 0.001
Yes	47 (46.1%)	58 (47.5%)	206 (76.3%)	
Diabetes				
No	65 (63.7%)	71 (58.2%)	185 (68,5%)	0.134
Yes	37 (36.3%)	51 (41.8%)	85 (31,5%)	
Abnormal electrocardiogram findings				
No	45 (44,1%)	44 (36.1%)	101 (37.4%)	0.406
Yes	57 (55.9%)	78 (63.9%)	169 (62.6%)	
Peaked t wave				
No	80 (78.4%)	71 (58.2%)	164 (60.7%)	0.002
Yes	22 (21.6%)	51 (41.8%)	106 (39.3%)	
Wide QRS with bizarre morphologies				
No	88 (86.3%)	101 (82.8%)	222 (82.8%)	0.641
Yes	14 (13.7%)	21 (17.2%)	48 (17.2%)	
Prolonged PR interval				
No	91 (89.2%)	105 (86.1%)	231 (85.6%)	0.649
Yes	11 (10.8%)	17 (13.9%)	39 (14.4%)	
Heart block				
No	85 (83.3%)	105 (86.1%)	239 (88.5%)	0.401
Yes	17 (16.7%)	17 (13.9%)	31 (11.5%)	
Widening and flattening of the P wave				
No	92 (90.2%)	109 (89.3%)	241 (89.3%)	0.965
Yes	10 (9.8%)	13 (10.7%)	29 (10.7%)	
Disappearance of the P wave				
No	94 (92.2%)	116 (95.1%)	253 (93.7%)	0.667
Yes	8 (7.8%)	6 (4.9%)	17 (6.3%)	
Sinusoidal wave				
No	102 (100%)	122 (100%)	266 (98.5%)	0.188
Yes	0	0	4 (1.5%)	

QRS.[29] Other studies have reported peaked T wave with percentages until 34%.[5,30] Our findings indicated that the peaked T wave was the most prevalent electrocardiographic abnormality in all groups of severity suggesting its increased frequency with the severity of hyperkalemia according to the literature. Recent study has indicated that the T-wave did not significantly correlate to serum potassium levels, and its application in clinical practice could be limited.[11] However,

Table 3 Relationship Between Abnormal Electrocardiogram Findings and Severity of Hyperkalemia in Patients with CKD

Variables	Mild, n: 47	Moderate, n: 58	Severe, n: 206	P-value
Age ≥ 60				
No	3 (6,4%)	22 (37.9)	99 (48.1%)	<0.001
Yes	44 (93.6%)	36 (62.1)	107 (51.9%)	
Gender				
Female	20 (42.6%)	25 (43.1%)	78 (37.9%)	0.197
Male	27 (57.4%)	33 (56.1%)	128 (62.1%)	
Abnormal Electrocardiogram Findings				
No	18 (38.3%)	22 (37.9%)	76 (36.9%)	0.978
Yes	29 (61.7%)	36 (62.1%)	130 (63.1%)	
Peaked t wave				
No	34 (72.3%)	35 (60.3%)	124 (60.2%)	0.288
Yes	13 (27.7%)	23 (39.7%)	82 (39.8%)	
Wide QRS with bizarre morphologies				
No	39 (83%)	47 (81%)	167 (81.1%)	0.953
Yes	8 (17%)	11 (19%)	39 (18.9%)	
Prolonged PR interval				
No	41 (87.2%)	54 (93.1%)	176 (85.4%)	0.305
Yes	6 (12.8%)	4 (6.9%)	30 (14.6%)	
Heart block				
No	40 (85.1%)	51 (87.9%)	182 (88.3%)	0.828
Yes	7 (14.9%)	7 (12.1%)	24 (11.7%)	
Widening and flattening of the P wave				
No	41 (87.2%)	51 (87.9%)	182 (88.3%)	0.977
Yes	6 (12.8%)	7 (12.1%)	24 (11.7%)	
Disappearance of the P wave				
No	41 (87.2%)	54 (93.1%)	194 (94.2%)	0.246
Yes	6 (12.8%)	4 (6.9%)	12 (5.8%)	
Cardiac arrest rhythms				
No	47 (100%)	58 (100%)	203 (98.5%)	0.462
Yes	0	0	3 (1.5%)	
Sinusoidal wave				
No	47 (100%)	58 (100%)	202 (98.1%)	0.356
Yes	0	0	4 (1.9%)	

Table 4 Multivariate Analysis

Variable	Odds Ratio	p value	CI (95%)
Age ≥60	0.123	>0.001	0.588–0.259
Sex	1.517	0.092	0.934–2.464
Diabetes	1.344	0.242	0.818–2.206
Chronic kidney disease	2.082	0.002	1.3–3.335
Peaked t wave	2.355	>0.001	1.36–4,078

Table 5 Description of Deceased Patients

	Mild (n: 16)	Moderate (n: 14)	Severe (n: 29)
Age by groups			
< 60	1 (6.2%)	4 (28.6%)	6 (20.7%)
≥ 60	15 (93.8%)	10 (71.4%)	23 (79.3%)
Principal diagnostic			
Cardiovascular diseases	3 (18.8%)	7 (50%)	4 (13.8%)
Digestive diseases	0	0	1 (3.4%)
Infectious diseases	9 (56.3%)	6 (42.9%)	10 (34.5%)
Metabolic diseases	0	0	1 (3.4%)
Neoplasia	1 (6.2%)	0	3 (10.3%)
Neurological diseases	0	0	1 (3.4%)
Trauma	0	0	1 (3.4%)
Renal diseases	2 (12.5%)	1 (7.1%)	7 (24.1%)
Respiratory diseases	1 (6.2%)	0	1 (3.4%)
Initial rhythm			
AESP	1 (6.2%)	0	1 (3.4%)
Sinus bradycardia	1 (6.2%)	0	1 (3.4%)
Atrial fibrillation	4 (25%)	1 (7.1%)	0
Indeterminate rhythm	1 (6.2%)	0	0
Sinus rhythm	7 (43.8%)	12 (85.7%)	26 (89.7%)
Sinus tachycardia	2 (12.5%)	1 (7.1%)	1 (3.4%)
Abnormal ECG findings	12 (75%)	8 (57.1%)	21 (72.4%)

our results demonstrate statistical significance between the peaked T wave and severity, with a probability of up to 2 times more likely to have this electrocardiographic finding with increased severity.

Heart block rhythm has been documented in several case reports in patients with high serum potassium level which describe AV block or branch block AV node's susceptibility to hyperkalemia.[31–33] Varga et al described AV block in moderate (n: 10/97) and severe (n: 7/38).[13] This finding is more common in severe hyperkalemia. However, the number of patients with this finding in our population was high and could be related to cardiovascular comorbidities.

In CKD group, the interpretation of the ECG could be less specific. Fluctuations in the serum calcium concentration due to exogenous substitution with oral calcium, vitamin D supplementation, and treatment with a dialysate contribute to a higher calcium threshold. This condition could be a cardio-protective factor stabilizing the transmembrane potential. This may explain a greater tolerance to hyperkalemia and fewer abnormal changes in the ECGG.[34,35]

Mulia et al described the most common ECG abnormalities were the prolonged QTc interval (36.6%), fragmented QRS complex (29.8%), poor R wave progression (24.6%), and peaked T wave (22%).[27] Powell et al demonstrated no difference in ECG changes between acute and chronic hyperkalemic groups. This study concluded that increasing age, higher potassium levels, and prior ischemic heart disease predisposed patients to ECG changes, although pharmacologic calcium is known to protect against hyperkalemic arrhythmias.[36]

A recent study showed that a QRS duration of ≥120 ms was the most predictive factor for hyperkalemia in the End-Stage Renal Disease population.[37] Thus, the absence of electrocardiographic changes in patients with hyperkalemia undergoing hemodialysis must be interpreted carefully.[14] In our study, the ECG abnormalities related to hyperkalemia in patients with CKD were above 60%. Peaked T wave and Wide QRS with bizarre morphologies were the most common abnormal ECG findings in the population with CKD. These results are similar to the previous articles cited. Due to these patients exhibiting diverse electrocardiographic findings, it becomes a challenge to characterize them.

Regarding treatment, the use of loop diuretics, beta-agonists, polarizing solutions, hemodialysis, insulin, and ion-exchange resins with an action potential stabilizer membrane with calcium gluconate has been described.[31,37] The alternatives in the treatments are associated with the severity of hyperkalemia, comorbidities, and chronicity.

Insulin/Glucose and Loop Diuretics were the most common treatments in our study. However, most patients received combined therapies, making it impossible to assess the individual efficacy of each of these. Nevertheless, we did not compare the interventions to establish which drug is more effective in reducing potassium levels.

Hyperkalemia is an independent risk factor to increase mortality, cardiovascular events, ≥hospitalizations, and ICU admissions. Cai et al determined that hyperkalemia increases the 90-day mortality in patients with acute and chronic renal disease.[38] Goyal et al reported intra-hospital mortality in 61% of patients with serum potassium levels ≥5.5 6 mEq/l.[39] In our study, the intra-hospital death was 11%, and the mild hyperkalemia group had the higher mortality. One of the potential reasons why the mild hyperkalemia group exhibited higher mortality was associated with age, given that over 90% were aged 60 or older, in contrast to 79% in the more severe group. Another possible explanation was the initial electrocardiographic rhythm, as 56% in the mild severity group showed rhythm abnormalities compared to only 10% in the more severe group. Although both groups had a diagnosis related to infectious disease, there was a higher proportion of patients in the mild hyperkalemia group.

One of the strengths of this study is that it represents a large amount of the population of southwestern Colombia and that until now has not been reported in our region. However, upon reviewing the literature, we found no reported studies in our country with the number of patients comparable to ours. While case reports exist, none provides a detailed description of multiple cases. Despite the existing literature, there is a lack of a comprehensive description of our specific population, hindering the proposal of new hypotheses. Consequently, we aim to present our work, compiling the experiences from this highly complex university hospital leading institution in the Southwest of Colombia. Although our findings align with the literature described previously, we believe it is crucial to address potential future research questions emerging from this study.

This study encompasses a significant number of patients, contributing to the description of the most common findings in the population with hyperkalemia in an emergency department. A more detailed characterization of patients with chronic kidney disease is required to yield additional results of interest.

Conclusion

The high serum potassium levels could cause abnormal ECG findings. However, the severity of hyperkalemia did not consistently exhibit abnormal ECG findings. Age may act as a factor inversely proportional to severity, contrary to what is evident in patients with Chronic Kidney Disease (CKD). Specifically regarding the T wave, it is more commonly observed in patients with moderate and severe hyperkalemia. Therefore, it is imperative to exercise caution in the ECG report, especially in patients with high serum levels of potassium as a chronic or acute kidney disease. Comparative studies to elucidate these findings are necessary.

Data Sharing Statement

The data that support the findings of this study are available from Fundación Valle del Lili but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are, however, available from the corresponding author upon reasonable request and with permission of Fundación Valle del Lili.

Ethics Approval and Consent to Participate

The Biomedical Research Ethics Committee at the University Hospital (Comité de Ética en Investigación Biomédica de la Fundación Valle del Lili) approved this study (Approved No. 280-2021, No. 15 of July 28, 2021). This study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. This study adhered to the standards of the STROBE guidelines. The researchers did not expose the patients to biological, psychological, or social risks. Therefore, the ethics committee approved the waiver of informed consent.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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