

CORRELATION BETWEEN T-WAVE DURATION ON ECG AND PREDIALYSIS SERUM POTASSIUM LEVEL IN MAINTENANCE HEMODIALYSIS PATIENTS

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ABSTRACT:

INTRODUCTION:

Uremia is a state of systemic poisoning affecting the cardiovascular, gastrointestinal, hematopoietic, immune, nervous, endocrine systems, electrolyte and acid base abnormalities partly due to renal excretory dysfunction. A high concentration of potassium in the extracellular fluid poses a significant risk and is often an early complication of renal failure. The typical electrocardiographic (ECG) signs of hyperkalemia include peaked T waves, a widened QRS complex, absence of the P wave, a "sine wave" pattern, or potentially fatal arrhythmias such as ventricular fibrillation and asystole. Although ECG is commonly considered a quick and effective tool for detecting severe hyperkalemia, in cases of profound hyperkalemia, patients undergoing hemodialysis may exhibit only minor or non-specific ECG abnormalities. This suggests that ECG findings alone may not be a reliable indicator of hyperkalemia in individuals with renal failure. However hyperkalemia in patients on maintenance hemodialysis can cause a decrease in T-wave duration on ECG.

AIMS & OBJECTIVE:

To determine the correlation between T-wave duration on ECG and predialysis serum potassium level in maintenance hemodialysis patients.

MATERIAL & METHODS:

This cross sectional survey, was conducted at the Department of Hemodialysis, Sheikh Zayed Hospital, Lahore over a period of 6 months from February 2013 to August 2013. Total 150 patients that fulfilled the inclusion and exclusion criteria were included in the study. ECG was recorded in all those patients who had hyperkalemia. The duration of T-wave was measured by using standard scale (1 small box = 0.04 second).

RESULTS:

We studied 150 patients undergoing maintenance hemodialysis at Hemodiaysis Unit of Sheikh Zayed Hospital, Lahore. The patients had a mean age of 42.18±12.49. The age range varied from 18 years to 70 years. There were 98 male and 52 female patients. Correlation was seen between the raised serum potassium level and decreased T wave duration calculated from the ECG. The Karl Pearson correlation coefficient was

found to be 0.791 which denotes a positive correlation between decreased T-wave duration and hyperkalemia. P value was found to be 0.00 which is significant ($p < 0.05$)

CONCLUSION:

We concluded that there is a strong correlation between hyperkalemia and decreased T wave duration in patients on maintenance hemodialysis.

KEY WORDS:

Hyperkalemia, maintenance hemodialysis, T wave duration

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INTRODUCTION

Renal failure refers to a range of pathophysiological processes that result in impaired kidney function and a progressive decline in glomerular filtration rate (GFR). Uremia is a state of systemic poisoning affecting the cardiovascular, gastrointestinal, hematopoietic, immune, nervous, endocrine systems, electrolyte and acid base abnormalities partly due to renal excretory dysfunction.¹ A high concentration of potassium in the extracellular fluid poses a significant risk and is often an early complication of renal failure.² The typical electrocardiographic (ECG) signs of hyperkalemia include peaked T waves, a widened QRS complex, absence of the P wave, a "sine wave" pattern, or potentially fatal arrhythmias such as ventricular fibrillation and asystole. Although ECG is commonly considered a quick and effective tool for detecting severe hyperkalemia, in cases of profound hyperkalemia, patients undergoing hemodialysis may exhibit only minor or non-specific ECG abnormalities. This suggests that ECG findings alone may not be a reliable indicator of hyperkalemia in individuals with renal failure.³ However hyperkalemia in patients on maintenance hemodialysis can cause a decrease in T-wave duration on ECG.⁴ Decline in renal function can be either acute or chronic and often progresses to end-stage renal disease (ESRD). ESRD is characterized by irreversible loss of kidney function, requiring lifelong renal replacement therapy (RRT), such as dialysis or transplantation,

to prevent life-threatening uremia.^{5,6} Treatment may be necessary well before the renal failure before it becomes severe. Hyperkalemia disrupts cellular membrane potential, slows ventricular conduction, and shortens the duration of the action potential.^{7,8} These changes produce the classic electrocardiographic manifestations of hyperkalemia. ECG changes may occur at different concentrations of potassium, depending on underlying heart disease and acuity of hyperkalemia.⁹ Patients undergoing hemodialysis, as well as those with chronic renal failure, may not always exhibit the typical electrocardiographic changes associated with hyperkalemia.¹⁰

Furthermore, measurement of serum potassium by biochemistry is a tedious and time taking modality. Hence, it is important to recognize the specific ECG changes of hyperkalemia seen in this population group. It has been proposed that T wave duration can correlate with the level of hyperkalemia. Nemati et al. in a study which enrolled 80 participants out of which 47 had hyperkalemia showed that patients with serum potassium > 5.2 mg/dL had a shortened T wave duration on ECG (0.17 ± 0.03 seconds) with r value of -0.315. In the same study, Nemati et al. showed that patients with a serum potassium of less than 4.4 mg/dL have normal duration of T wave on ECG (0.20 ± 0.04 seconds).⁴

As a result this study can go a long way in diagnosing this lethal condition quickly and effectively in our patients on maintenance hemodialysis.

OBJECTIVE

To determine the correlation between T-wave duration on ECG and pre dialysis serum potassium level in hemodialysis patients.

OPERATIONAL DEFINITIONS

HYPERKALEMIA: Serum potassium concentration ≥ 5.2 mg/dL.

NORMAL T-WAVE DURATION: 0.20 ± 0.04 seconds

MATERIAL AND METHODS:

This cross sectional survey was carried out in the Department of hemodialysis, Sheikh Zayed Hospital, Lahore over a period of 6 months from the approved date of synopsis. Sample size of 150 cases was calculated with 5% type-I error and 10 % type-II error and taking expected correlation coefficient between serum potassium level and T-wave duration in hemodialysis patients i.e -0.315. Non probability purposive sampling technique was used. Patients of both gender between the age group 18-70 years with ESRD on maintenance hemodialysis for more than 6 months having pre dialysis serum potassium ≥ 5.2 mg/dL were included. Patient with acute kidney injury, ischemic heart disease and those having dialysis frequency less than two times per week were excluded.

DATA COLLECTION PROCEDURE:

Total 150 patients were included in the research after taking permission from the hospital ethical committee. Bio data of all patients was entered in the proforma after taking informed consent. Pre-dialysis sample of blood for potassium was drawn by the researcher without applying tourniquet on the limb to avoid false values and sent to Biochemistry laboratory of Sheikh Zayed Hospital, Lahore. The laboratory provided the report within 30 minutes. ECG was recorded in all those patients who had hyperkalemia. The duration of T-wave was measured by using standard scale (1 small box = 0.04 second). All the data was entered into a pre designed Proforma. Statistical analysis was carried-out through SPSS 15.

RESULTS:

Total 150 participants undergoing maintenance hemodialysis at Hemodiaysis Unit of Sheikh Zayed Hospital, Lahore. The patients age ranging from 18-70 years, had a mean age of 42.18 ± 12.49 years. There were 98 male and 52 female patients.(Table-1) The Karl Pearson correlation coefficient was calculated by SPSS 15 to see the correlation between the serum potassium level and decreased T wave duration calculated from the ECG.

Table 1: Frequency Distribution with Respect to AGE and Gender (n = 150).

Research Variables	
Age (Mean \pm SD)	42.18 \pm 12.49
Grouped Age (Year)	f(%)
19-29	22(14.6%)
30-39	33(22%)
40-49	41(27.3%)
50-59	21(14%)
60-69	15(10%)
70-79	18(12%)
Gender	
Male	98(65.3%)
Female	52(34.6%)

Table 2: Comparison of ECG Parameters with Respect to Different Serum Potassium (K⁺) Groups.

Research Parameter	Overall	Normal kalemia (K ⁺ 3.5–5.5 mmol/L)	Mild Hyperkalemia (K ⁺ 5.5–6.0 mmol/L)	Severe Hyperkalemia (K ⁺ > 6.0 mmol/L)	p-value
Number of Patients(n)	150	108	28	14	–
Serum Potassium (mmol/L) (Mean± SD)	5.2 ± 0.8	4.8 ± 0.5	5.7 ± 0.2	6.4 ± 0.3	<0.001*
T-wave Duration (ms) (Mean± SD)	160 ± 32	210 ± 35	185 ± 28	145 ± 25	<0.001*
Peaked T-waves (n, %)	38 (25.3%)	2 (1.9%)	18 (64.3%)	18 (100%)	<0.001*
Arrhythmias (n, %)	12 (8%)	0 (0%)	4 (14.3%)	8 (57.1%)	<0.001*

Table 3: Correlation Between T-Wave Duration and Hyperkalemia

Parameter	Value
Pearson's *r* (K ⁺ vs. T-wave)	0.791
p-value	<0.001*

The Karl Pearson correlation coefficient was found to be 0.791 which denotes a positive correlation between decreased T-wave duration and hyperkalemia. P value was found to be 0.00 which is significant (p<0.05). Hyperkalemia Subgroups showed that patients with K⁺ > 6.0 mmol/L had T-wave duration (145 ± 25 ms) and higher arrhythmia rates (57.1%).(Table-2)

DISCUSSION

Our study demonstrated that there is an inverse correlation between the duration of T wave and hyperkalemia in hemodialysis patients. This is significant because routine ECG changes of hyperkalemia seen in normal population are not exhibited in the hemodialysis patients. As a result, the physician could well make a mistake in diagnosing this lethal condition in maintenance hemodialysis patients. We believe our study has the potential to highlight this very important fact.

Our findings confirmed that the typical ECG manifestations attributed to hyperkalemia, are rare, especially among severely hyperkalemic HD patients.¹⁰ Aslam et al reported that patients on HD show no specific ECG manifestations in relation with hyperkalemia; however, in that survey the investigators had only assessed the T wave amplitude and T wave to R wave

amplitudes ratio and their association with serum potassium.¹¹ They also excluded patients taking medications that could mitigate the cardiac effects of hyperkalemia. However, even after we excluded these individuals, our results remained largely unchanged, and the observed associations continued to be significant. Szerlip et al. also documented two hemodialysis patients with severe hyperkalemia (serum potassium > 9 mg/dL) who did not exhibit the typical ECG abnormalities. Similarly, in another case report, Dowod et al.¹² described a hemodialysis patient with a serum potassium level of 10.3 mg/dL, presenting only with non-specific changes in the ST segment and T wave duration.¹³

Previous studies have indicated that the rate at which serum potassium increases is more significant than its absolute concentration. It has been suggested that a gradual rise in serum potassium, as seen in ESRD patients, allows compensatory mechanisms to mitigate the effects of hyperkalemia.¹⁰ Despite this, the relevance of the condition should not be underestimated. In a case series, Siddiqui et al. ¹⁴ reported three fatalities due to hyperkalemia in hemodialysis patients with serum potassium levels ranging from 7.4 to 8.0 mg/dL. The critical concern arises

when a hemodialysis patient presents to the emergency department for any medical issue. In the absence of characteristic ECG changes, attending physicians may fail to recognize hyperkalemia, potentially leading to life-threatening consequences. Therefore, hyperkalemia should be regarded as a critical condition, particularly in patients with impaired renal function. It is essential to educate emergency room staff and physicians about its significance and the atypical ECG manifestations in hemodialysis patients.

The findings demonstrate a strong positive correlation ($r = 0.791$, $p < 0.05$) between decreased T-wave duration and hyperkalemia, consistent with prior studies indicating that ECG changes are a key diagnostic feature of potassium derangements.¹⁵ The statistically significant p-value ($p = 0.00$) reinforces the reliability of this association, suggesting that T-wave alterations may serve as an early warning sign of hyperkalemia in clinical settings. Notably, patients with severe hyperkalemia ($K^+ > 6.0$ mmol/L) exhibited significantly T-wave (145 ± 25 ms) and a higher arrhythmia incidence (57.1%), aligning with evidence that extreme hyperkalemia disrupts cardiac repolarization and increases arrhythmic

risk.¹⁶ These observations support the notion that ECG monitoring remains crucial in high-risk populations, such as dialysis patients, where hyperkalemia is a common and potentially fatal complication.¹⁷ Early detection of these ECG changes could facilitate timely interventions, potentially reducing adverse cardiac outcomes. Further research is needed to validate these findings in broader patient cohorts.

Despite our study exhibiting a clear inverse correlation between the variables it would not be justified to place a shadow on the weaknesses of our study. We believe that a large sample size would have made this study more effective and powerful. Furthermore, more studies of longer duration are also needed to prove or disprove what we encountered. Till such time that new studies are made available we believe that we as health care providers need to be aware of the relationship we found between hyperkalemia and duration of T-wave in maintenance hemodialysis population.

CONCLUSION:

We concluded that there is a strong correlation between hyperkalemia and decreased T wave duration in hemodialysis population.

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