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Association Of Hyperkalemia With T-Wave Changes In Chronic Kidney Disease Patients Versus Hemodialysis Patients.

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Abstract

Sudden death is the leading cause of mortality in individuals with end stage kidney failure (ESKD). Hemodialysis (HD) patients often face hyperkalemia due to various reasons. Level of hyperkalemia and ECG changes may be discordant among HD patients in a significant number of patients, despite its potential life threatening role. This study was conducted to investigate whether or not there is a unique ECG characteristic that predicts hyperkalemia in individuals with both hypertension and kidney disease.

Objective: To determine an association between hyperkalemia (raised serum potassium) and T- (atypical T-wave) changes on ECG in chronic kidney disease (CKD) patients versus HD patients.

Methodology

200 patients on HD and CKD 4 & 5 not on HD, fulfiling the inclusion criteria were enrolled in the study. Sampleing for seum potassium levels were done and ECG obtained.

Results

In the HD group the mean age was 51.46 ± 26.96 years, whereas the mean age in CKD group was 56.16 ± 21.68 years. In HD group there were 61 males and 39 females whereas in CKD group there were 57 males and 43 females. Mean serum potassium levels were 5.20 ± 0.85 (mEq/L) in HD group whereas in CKD group mean serum potassium levels were 5.50 ± 0.62 (mEq/L). The mean T-wave duration in HD group was 168.01 ± 2.94 (msec), while in CKD group the mean T-wave duration was 173.76 ± 2.33 (msec). In HD group Pearson correlation coefficient was -0.779 with a P -value of 0.000, whereas in CKD group Pearson correlation coefficient was -0.02 with P -value was 0.985.

Conclusion

In our study, there was a negative correlation between serum K^+ levels and duration of T-wave in patients on maintenance HD. This negative correlation shows that hyperkalemia is associated with t-wave changes on ECG (i-e shorter duration of T- wave). This correlation was not significant in CKD 4 and 5 patients.

Keywords: Hyperkalemia, T-wave changes, Chronic kidney disease, sudden cardiac death, arrythmia, Hemodialysis, End stage Kidney disease.

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Introduction

Hyperkalemia is often an early complication of chronic kidney disease (CKD).[1] In some patients it requires treatment long before other uremic manifestations become life threatening. Hyperkalemia causes the depolarization of the cell membrane followed by slow ventricular conduction and decrease in duration of the action potential.[2,3] This mechanism is responsible for the production of the classic electrocardiographic manifestations of hyperkalemia including peaked T waves, widening

of the QRS complex, loss or flattening of the P wave, "sine wave" configuration or ventricular fibrillation and ultimately asystole. While laboratory investigations are the definitive means to assess serum electrolyte concentrations, their results are often delayed. Consequently, quick identification of hyperkalemia is vital. While electrocardiography (ECG) is commonly employed for swift diagnosis, it's known that the classic ECG changes associated with hyperkalemia might not always manifest reliably in patients with end-stage kidney disease (ESKD) or CKD.[4]

Recent research suggests a shift towards recognizing atypical changes, such as alterations in T-wave duration on ECG, as potential indicators of hyperkalemia. For instance, a study by Nemati et al. demonstrated that patients with hyperkalemia exhibited shortened T-wave durations on ECG, whereas patients with lower serum potassium levels displayed normal T-wave durations. This indicates that the presence of hyperkalemia could be reflected by distinct ECG patterns beyond the classical manifestations.[5]

Nemati et al. in his study showed that 80 participants were enrolled out of which 47 had hyperkalemia. He showed that patients with serum K+ > 5.2 mg/dL had a shortened T-wave duration on ECG (0.17 ± 0.03 seconds) with r value of -0.315.[6]

In light of this evolving understanding, the present study was conducted to explore the association between hyperkalemia and the atypical ECG change of shortened T-wave duration in HD patients versus CKD 4 and 5 patients.

Methods

The study was approved through IRB Sheikh Zayed hospital via number: 195 dated: 22 August 2016. This study employs a cross-sectional design conducted at the hemodialysis (HD) unit and outdoor/ indoor nephrology department of Shaikh Zayed Hospital, Lahore, Pakistan.

Study Population: The study population consisted of two distinct groups:

CKD Patients: Patients with CKD, stages 4 and 5, who are not yet on dialysis.

HD Patients: Patients with ESKD undergoing maintenance HD for over 6 months.

Duration Of Study: The study is conducted over a period of 1 year, starting from the date of approval of the research synopsis.

Sample Size: A total of 200 cases are included in the study, determined through calculations considering a 95% confidence level and 90% power of the test, with an expected correlation coefficient between serum potassium levels and T-wave duration.

Sampling Technique: Purposive sampling, a non-probability sampling technique, is employed for participant selection.

Inclusion Criteria:

- Patients of both genders aged between 30 and 60 years.
- HD patients with ESKD, receiving maintenance HD for more than 6 months at Shaikh Zayed Hospital.
- CKD patients in stages 4 and 5, not yet on dialysis.

Exclusion Criteria:

- Patients undergoing dialysis for acute kidney injury.
- HD patients receiving less than two dialysis sessions per week.
- Patients with a history of ischemic heart disease.

By adopting this study design and selection criteria, the research aims to contribute valuable insights into the potential correlation between hyperkalemia and atypical ECG changes in the context of CKD and HD patients in Pakistan.

Data Collection Procedure:

200 patients who will fulfilled the inclusion criteria, were enrolled in the study. Informed consent was taken. A 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 Shaikh Zayed Hospital, Lahore. Same procedure was carried out for symptomatic CKD patients coming to the emergency and outpatient department of same hospital. The laboratory provided the report within 3 hours.

ECG recording and interpretation

To check for atypical T-wave changes, specifically a shortened T-wave interval, on the electrocardiogram (ECG) of all patients with end-stage renal disease (ESRD) as well as chronic kidney disease with hyperkalemia whose samples were send to the laboratory for serum potassium levels, the ECG was then conducted.

Standard scale: (1 small box = 0.04 second).

Normal T-wave duration > 170 milliseconds. We used the caliper function on the ECG machine to measure the duration of the T waves. The T-wave duration was typically measured from the baseline (isoelectric line) to the highest point of the T wave, known as the peak. It's important to measure this duration accurately for each lead.

We then Compared the measured T-wave duration in each lead to the established normal values. In the context of atypical T-wave changes associated with hyperkalemia, we looked for significantly shortened T-wave intervals compared to what was expected.

Additional Considerations: Age, ACE inhibitors and calcium channel blockers use and number of dialysis per week were recorded.

Comparison of the duration of T-wave and serum potassium level between CKD-patients and ESRD patients was done by using T-test. All the data was entered into a pre-designed Performa.

Data Analysis Procedure

Data entry and subsequent analysis were conducted using SPSS version 11.5. The dataset encompassed demographic variables, including identification information and various demographic characteristics of the participants. For quantitative variables such as age, T-wave duration, and serum potassium levels, the analysis strategy was tailored based on the distribution of the data. If the data followed a normal distribution, the descriptive statistics of Mean ± Standard Deviation (SD) were computed. Conversely, if the data exhibited a non-normal distribution, the Median along with the Interquartile Range (IQR) was used to provide a robust central tendency and spread measure. To enhance the understanding, graphical representations such as bar charts were employed for these quantitative variables.

Qualitative variables, encompassing attributes like sex and potassium status, were analyzed through frequency distribution and percentages. In cases where the data followed a normal distribution, the Karl-Pearson correlation coefficient was calculated. However, when the data departed from normality assumptions, the Spearman rank correlation coefficient was employed. These correlation

analyses aimed to establish the connection between serum potassium levels and the duration of the T-wave on the ECG. For statistical significance, a p-value threshold of 0.05 was applied. Associations with p-values less than or equal to 0.05 were deemed noteworthy, indicating a relationship worthy of attention and further exploration.

Results

There were 200 patients in the study. Two groups were made comprising of 100 patients of ESKD and 100 patients of CKD. Age and gender distribution is mentioned in Table No 1. Mean serum potassium level was higher in CKD group, Table No 1. The mean T-wave duration in HD group was 168.01 ± 2.94 (msec), while in CKD group the mean T-wave duration was 173.76 ± 2.33 (msec) , Table No 2. In HD group 56 patients used ACE inhibitors out of a total of 100, while in CKD group out of 100, 57 patients used ACE inhibitors. In HD group, out of 100, 77 patients used calcium channel blockers and 23 did not use them, whereas in CKD group 64 patients used calcium channel blockers and 36 did not use them.

Table 1: Characteristics of 200 hemodialysis and chronic kidney disease patients with serum Potassium level >5.5 mmol/L.

	Hemodialysis group	CKD group
Age (mean ±SD)	51.46±26.96	56.16±21.68
Male (n)	61	57
Female (n)	39	43
S Potassium mmol/L±SD	5.20±0.85	5.50±0.62

Table 2: T-wave duration and its correlation with serum potassium levels among 200 hemodialysis and chronic kidney disease patients.

	Hemodialysis group	CKD group
T-wave Mean duration (msec)±SD	168.01±2.94	173.76±2.33
Pearson Correlation coefficient between S Potassium & TW-duration	-0.779 (0.000)	-0.02 (0.99)
Use of ACE-I (n)	56	57
Use of Calcium Channel Blockers (n)	77	64

Patients with a frequency of twice/week HD were 54% and the frequency was 46% for the patients with a HD of thrice /week. In HD group r "Pearson correlation coefficient" was -0.779 with a P -value of 0.000, whereas in CKD group r "Pearson correlation coefficient" was -0.02 with P -value was 0.985.

Figure 1: Scatter plot of serum potassium level among Hemodialysis and chronic kidney disease patients.

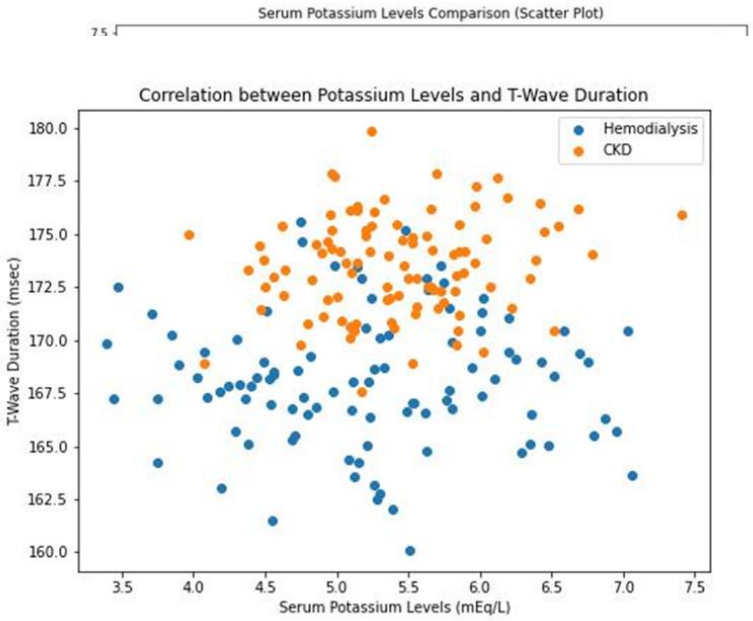

Figure 2: Scatter plot of serum potassium levels in correlation to the T wave duration among 200 hemodialysis and chronic kidney disease patients.

Discussion

The study enrolled a total of 200 patients, divided evenly into two groups: 100 patients receiving maintenance HD and 100 patients with CKD (Stage 4 & 5). The mean age of the HD group was 51.46 ± 26.96 years, while the mean age of the CKD group was 56.16 ± 21.68 years, indicating that patients in the CKD group were older. Gender distribution was comparable between the groups, with 61 males and 39 females in the HD group, and 57 males and 43 females in the CKD group. Serum potassium levels were slightly higher in the HD group (5.50 ± 0.85 mmol/L) compared to the CKD group (5.50 ± 0.62 mmol/L). Additionally, the mean T-wave duration differed between the groups, with 168.01 ± 2.94 msec in the HD group and 173.76 ± 2.33 msec in the CKD group. Notably, the HD group exhibited T-wave durations consistently below 170 msec, while this trend was absent in the CKD group. This observation corroborates findings from earlier research by Nemati et al.[6]

Regarding medication usage, a similar proportion of patients in both groups were on ACE inhibitors, with 56 out of 100 in the HD group and 57 out of 100 in the CKD group. Calcium channel blocker usage was more prevalent in the HD group (77 out of 100) than in the CKD group (64 out of 100). Dialysis frequency was distributed nearly equally, with 54% of patients receiving twice-weekly and 46% receiving thrice-weekly HD. The Pearson correlation coefficient demonstrated a significant inverse correlation between serum potassium levels and T-wave duration in the HD group (correlation coefficient -0.779, p-value 0.000), whereas the CKD group showed a weaker and statistically non-significant inverse correlation (correlation coefficient -0.02, p-value 0.985). This suggests that hyperkalemia leads to distinct T-wave changes on ECG, particularly in the HD group. This finding holds substantial significance, especially in the context of Pakistan's population. Given the high prevalence of chronic kidney disease in Pakistan, the study's results serve as a vital contribution to medical literature, highlighting the unique manifestation of hyperkalemia in

maintenance HD patients. The absence of conventional ECG signs of hyperkalemia in this group could potentially lead to misdiagnosis and inadequate treatment. Recognizing this atypical presentation is crucial for physicians, aiding in timely and accurate intervention. Comparisons to previous research are noteworthy. While Aslam et al's study focused solely on the correlation between T wave amplitude, T wave to R wave amplitude ratio, and blood potassium, our study extends this exploration to the distinct population of maintenance HD patients.[7]
Exclusion of individuals treated with interfering medications did not diminish the significance of our findings, reinforcing their robustness. Additionally, documented cases of hyperkalemia without typical ECG changes by Szerlip et al underline the importance of vigilant consideration in clinical practice. [8]

The study also delves into the intricacies of serum potassium levels and their rate of increase, highlighting their association with compensatory mechanisms in ESKD patients. While the impact of hyperkalemia on patients, especially in the HD group, is evident, this research underscores the potential severity, as exemplified by fatalities resulting from hyperkalemia in HD patients with serum potassium levels ranging from 7.4 to 8.0 mmol/L. Given these findings, the study strongly advocates for heightened awareness of hyperkalemia as a grave concern, particularly in patients with compromised renal function. The absence of typical ECG abnormalities, commonly observed in CKD patients, emphasizes the need for vigilance in the context of HD.[4,8]

In a recent study by Rafique Z et al. QRS duration of >120 msec was sensitive to pick hyperkalemia in hemodialysis patients.[9] In this study the T wave duration was not calculated and a T/R wave ratio using amplitude was evaluated. Furthermore we were looking for ECG changes in patients with hyperkalemia compared to patients with any serum potassium levels. To fortify the study's conclusions, a larger sample size would have been beneficial, as would additional investigations into long-term exposure. Our study not only reveals a unique correlation between serum potassium levels and a shorter T-wave duration in maintenance HD patients but also emphasizes the importance of recognizing atypical ECG manifestations of hyperkalemia.

In the Pakistani setting, where CKD is prevalent and resources may be limited, this study may help to redefine diagnostic approaches, saving lives by preventing the dire consequences of missed hyperkalemia. No previous study exists from Paksitan evaluating ECG in patients with hyperkalemia in CKD patients. We suggest that in the presence of serum potassium levels of >5.5 mmol/L without significant ECG changes, a T-wave duration of 168.5 msec should be taken as indication for initiating the management of hyperkalemia. Further studies are needed with interventions based on this recommendation to solidify our findings.

Conclusion

In conclusion we found a significant inverse correlation between serum K+ levels and T-wave duration in ESKD patients on maintenance HD as compared to CKD patients. Hyperkalemia in such individuals need prompt treatment to avert potential severe cardiac arrhythmias. We suggest that in patients with hyperkalemia and no significant findings on ECG a short T-wave duration $\geq$ 168.5 msec needs initiation of management for hyperkalemia, however, further studies are required to support this recommnedation.

Conflict of interest : None declared.

References:

1. Mount DB, Yu ASL: Transport of inorganic solutes:Sodium, chloride, potassium, magnesium, calcium and phosphorus. In: Brenner' s and Rector the Kidney. 8th Edition. Philadelphia, Saunders,2007,180-183.
2. Faridi AB, Weisberg LS: Acid-base, electrolyte and metabolic abnormalities. In: Critical Care Medicine: Principles of Diagnosis and Management in Adults. Parrillo JE, Dellinger RP. 3rd Edition. Philadelphia, Elsevier, 2008, 1203 – 1243.
3. Montague BT, Ouellette JR, Buller GK: Retrospective review of the frequency of ECG changes in hyperkalemia. Clin J Am Soc Nephrol 2008;3:324 – 330.
4. Tarif N, Yamani H, Bakhsh AJ, Al-Wakeel JS, Sulaimani F, Memon NA et al. Electrocardiography and serum potassium before and after HD sessions. Saudi J Kidney Dis Transpl. 2008;19(1):47-53.
5. Lafrance JP, Nolin L, Senecal L, Leblanc M: Predictors and outcome of cardiopulmonary resuscitation (CPR) calls in a large haemodialysisunit over a seven-year period. NephrolDial Transplant 2006; 21:1006 – 1012.
6. Nemati E, Taheri S. Electrocardiographic manifestations of hyperkalemia in hemodialysis patients. Saudi J Kidney Dis Transpl 2010;21:471-7.
7. Aslam S, Friedman EA, Ifudu O. Electrocardiography is unreliable in detecting potentially lethal hyperkalaemia in haemodialysis patients. Nephrol Dial Transplant. 2002;17(9):1639-42.
8. Szerlip HM, Weiss J, Singer I. Profound hyperkalemia without electrocardiographic manifestations. Am J Kidney Dis. 1986;7(6):461-5.
9. Rafique Z, Hoang B, Mesbah H, Pappal R, Peacock FW, Juarez-Vela R, Szarpak L, Kuo DC. Hyperkalemia and electrocardiogram manifestations in end-stage renal disease. Int J Environ Res Public Health. 2022;19(23):16140.