https://doi.org/10.48047/AFJBS.6.15.2024.13991-14000

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

ASSOCIATION BETWEEN SERUM POTASSIUM LEVELS AND ELECTROCARDIOGRAM FEATURES IN NON-DIALYSIS STAGE 5 CHRONIC KIDNEY DISEASE PATIENTS

Arief Kamil[1], Pendrik Tandean[1], Haerani Rasyid[1], Syakib Bakri[1], Sudirman Katu[1], Arifin Seweng[2]

[1]Department of Internal Medicine, University of Hasanuddin, Makassar, South Sulawesi, Indonesia
[2]Department of Public Health and Community Medicine, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

Corresponding author: Arief Kamil
Email : Ariefkamil19@gmail.com

Volume 6, Issue 15, Oct 2024

Received: 15 Aug 2024

Accepted: 25 Sep 2024

Published: 21 Oct 2024

doi: 10.48047/AFJBS.6.15.2024.13991-14000

Abstrak

Background: Potassium abnormalities are common in chronic kidney disease patients due to low glomerular filtration rate (GFR) and tubular abnormalities. Electrolyte imbalance across the membrane potential can manifest as ECG changes. It is found that patients with hyperkalemia in chronic kidney disease had ECG changes. Therefore, we conducted this study to investigate the association between serum potassium levels and electrocardiogram of hyperkalemia patients in stage 5 non-dialysis chronic kidney disease.

Methods: A cross-sectional study conducted at Wahidin Sudirohusodo Hospital, Makassar, Indonesia in January 2024. We included all patients aged ≥18 years with stage 5 chronic kidney disease who had never undergone hemodialysis. Then, the serum potassium level and electrocardiogram examination were performed. The data then analyzed with Chi-Square.**Results:** This study consisted of 101 subjects who were mostly male (53.5%) and aged ≤60 years (71.3%). Elevated serum potassium levels were found in 59.4% subjects. ECG abnormalities were found in 45.5% and most ECG abnormalities were tall T (58.2%). We found a significant association between hyperkalemia and ECG abnormalities ($p<0.001$). We also found a significant association between hyperkalemia and the appearance of tall T ($p<0.001$).**Conclusion:** We found significant association between hyperkalemia with ECG abnormalities, especially tall T, in non-dialysis stage five chronic kidney disease patient. ECG abnormalities were mostly found in severe hyperkalemia.

Keywords: *Potassium, electrocardiogram, End stage renal disease*

INTRODUCTION

Chronic kidney disease (CKD) is an abnormality of the kidney structure and function that persists for more than 3 months.[1,2] The global prevalence of chronic kidney disease is approximately 8%-16%.[1]

Potassium abnormalities are common in chronic kidney disease patients due to low glomerular filtration rate (GFR) and tubular abnormalities.[3] As many as 67.9% of chronic kidney disease patients experience hyperkalemia.[4,5] The risk of hyperkalemia in chronic kidney disease is increased by the use of potassium inhibitors, renin-angiotensin-aldosterone system (RAAS) and potassium-sparing diuretics, in addition to comorbidities, such as diabetes and heart failure.[5]

Hyperkalemia is elevated serum potassium levels greater than 5 mmol/L. The human body uses a combination of renal and extrarenal mechanisms to maintain extracellular potassium levels. The distal tubule of the kidney is critical in maintaining potassium homeostasis through the renin-angiotensin-aldosterone system. However, in patients with chronic kidney disease, impaired renal function leads to a reduced ability to excrete excess potassium, resulting in hyperkalemia. Hyperkalemia can have fatal consequences, such as abnormal heart rhythm disturbances and potentially lead to heart attack. Therefore, it is important to closely monitor serum potassium levels in patients with chronic kidney disease.[6]

Increased extracellular potassium reduces the concentration gradient across the cell membrane and lowers the overall resting membrane potential. Electrolyte imbalance across the membrane potential can manifest as ECG changes that include changes in tall T wave, PR interval prolongation, P wave loss, R wave loss, conduction delay, QRS complex widening, ST segment elevation, and sine-like wave patterns. The use of ECG in the diagnosis of hyperkalemia also only appears in less than 50% of patients.[7] In addition, there is a lack of consensus on what constitutes severe and mild potassium elevation and the role of ECG in its diagnosis and treatment.[8]

Raffe et al (2022) found that 74.6% of patients with hyperkalemia in chronic kidney disease had ECG changes. T tall was significantly more common in severe hyperkalemia (87.5%) than mild and moderate hyperkalemia.[9] Currently, research on serum potassium levels and electrocardiogram of hyperkalemia patients in stage 5 non-dialysis chronic kidney disease is still

very limited. Therefore, we conducted this study to investigate the association between serum potassium levels and electrocardiogram of hyperkalemia patients in stage 5 non-dialysis chronic kidney disease.

METHODS:

This study was a cross-sectional study conducted at Wahidin Sudirohusodo Hospital, Makassar, Indonesia in January 2024. We included all patients aged ≥18 years with stage 5 chronic kidney disease who had never undergone hemodialysis in our hospital with a consecutive sampling technique. The sample size in this study was calculated by the two-group proportion comparison test and obtained a minimum sample size of 68 people.

Samples that meet our eligibility criteria will be performed serum potassium levels and electrocardiograms examination. Serum potassium levels were checked with ELISA kit and classified into normal (3.5-5.5 mmol/L), mild hyperkalemia (5.5-5.9 mmol/L), moderate hyperkalemia (6.0-6.4 mmol/L), and severe hyperkalemia (≥6.5 mmol/L). In addition, electrocardiogram examination to calculate the parameters of P wave, PR interval, QRS complex, and T wave. Abnormalities in these parameters are no P wave (amplitude <0.25 mV), prolonged PR interval (>200ms), wide QRS complex (>120ms), and tall T (amplitude >5 mm in precordial leads and >10 mm in limb leads).

The result data will be displayed in proportion and percentage. The statistical test used was Chi-Square. Statistical test results were considered significant if the p value was found to be <0.05.

RESULTS:

This study consisted of 101 subjects who were mostly male (53.5%) and aged ≤60 years (71.3%). Elevated serum potassium levels were found in 59.4% subjects, consisting of mild and moderate hyperkalemia (38.3%), and severe hyperkalemia (23.3%). ECG abnormalities were found in 45.5% and most ECG abnormalities were tall T (58.2%). Other ECG abnormalities were shortened P wave and prolonged PR interval found in mild hyperkalemia (71.4% and 14.3%, respectively). Wide QRS complex was found in moderate hyperkalemia (16.7%). We found a significant association between hyperkalemia and ECG abnormalities (p<0.001). In addition,

there was a significant association between hyperkalemia severity and ECG abnormalities ($p<0.001$). We found a significant association between hyperkalemia and the appearance of tall T ($p<0.001$). In addition, there was a significant relationship between hyperkalemia severity and the presence of tall T ($p<0.001$).

Table 1. Subjects' characteristics.

Variables	Category	n (101)	%
Sex	Male	54	53.5
	Female	47	46.5
Age	≤60 years old	72	71.3
	>60 years old	29	28.7
Serum Kalium Level	Normokalemia	41	40.6
	Hyperkalemia	60	59.4
Hyperkalemia Severity	Mild	23	38.3
	Moderate	23	38.3
	Severe	14	23.3
ECG abnormalities	Yes	46	45.5
	No	55	54.5
ECG Features	Short P wave	14	25.5
	Long PR interval	2	3.6
	Wide QRS complex	7	12.7
	Tall T	32	58.2
ECG Abnormalities Count	0	21	35.0
	1	31	51.7
	>1	8	13.3

Table 2. Association between ECG Features and Hyperkalemia Severity

ECG Features	Hyperkalemia Severity			Total
	Mild	Moderate	Severe	
	n (%)	n (%)	n (%)	
Short P wave	5 (71.4)	5 (27.8)	4 (28.6)	14
Long PR interval	1 (14.3)	0 (0)	1 (7.1)	2
Wide QRS complex	0 (0)	3 (16.7)	2 (14.3)	5
Tall T	2 (28.6)	14 (77.8)	11 (78.6)	27

Table 3. Association between ECG Abnormalities and Serum Kalium Level

Serum Kalium Level	ECG Abnormalities				Total	p
	Yes		No			
	n	%	n	%		
Normokalemia	7	17,1%	34	82,9%	41	0.000
Hyperkalemia	39	65,0%	21	35,0%	60	
Total	45	45,5%	55	54,5%	101	

Table 4. Association between ECG Abnormalities and Hyperkalemia Severity

Hyperkalemia Severity	ECG Abnormalities				Total	p
	Yes		No			
	n	%	n	%		
Mild	7	30,4%	16	69,6%	23	0.000
Moderate	18	78,3%	5	21,7%	23	
Severe	14	100,0%	0	0,0%	14	
Total	39	65,0%	21	35,0%	60	

Table 5. Association between Tall T Appearance and Serum Kalium Level

Serum Kalium Level	Tall T				Total	p
	Tall T (+)		Tall T (-)			
	n	%	n	%		
Normokalemia	5	12,2%	36	87,8%	41	0,001
Hyperkalemia	27	45,0%	33	55,0%	60	
Total	32	31.70%	69	68.3	101	

Table 6. Association between Tall T Appearance and Hyperkalemia Severity

Hyperkalemia Severity	Tall T				Total	p
	Tall T (+)		Tall T (-)			
	n	%	n	%		
Mild	2	8,7%	21	91,3%	23	0.000
Moderate	14	60,9%	9	39,1%	23	
Severe	11	78,6%	3	21,4%	14	
Total	27	45,0%	33	55,0%	60	

DISCUSSION

This study aims to investigate the assoication between serum potassium levels with electrocardiogram abnormalities of hyperkalemia patients in stage 5 non-dialysis chronic kidney disease. Chronic kidney disease (CKD) is one of the many risk factors and is associated with hyperkalemia. The reduction in urinary potassium excretion that occurs in CKD can lead to an inability to maintain potassium homeostasis.[10] Abnormalities can be detected on the electrocardiogram (ECG) that can develop as the severity of hyperkalemia increases, such as shortened P wave, prolonged PR interval, widen QRS complex, and tall T wave.[11] Betts et al (2008) found that 6.35% of CKD patients suffer from hyperkalemia each year.[12] Alrashidi et al

(2020) found that 47.3% of patients suffered from hyperkalemia.[13] Mulia et al (2021) found the most common ECG abnormalities were prolonged QT interval (36.6%), fragmented QRS complex (29.8%), poor R wave progressivity (24.6%), and tall T (22%).[14]

Not all hyperkalemia conditions give a specific ECG picture. However, patients with hyperkalemia should have an ECG examination to determine whether there is a heart rhythm disorder. Research by Raffee et al (2022) on 67 hyperkalemia patients in the emergency department in Jordan concluded that not all hyperkalemia conditions give a specific picture on the ECG.[8] Montague et al (2008) concluded that the electrocardiogram is not sensitive to the diagnosis of hyperkalemia.[15]

This study found a significant association between ECG abnormalities and hyperkalemia, especially severe hyperkalemia. Quintero et al (2024) found a significant association between serum potassium levels and ECG abnormalities, especially tall T. In that study, Tall T and wide QRS complexes were the most common abnormal ECG findings in the CKD patient population.[16] Varga et al (2019) also found that hyperkalemia was significantly associated with ECG abnormalities, such as wide QRS complexes and tall T.[17]

In this study, ECG abnormalities were found in 45% of patients with hyperkalemia. This finding is in line with Regolisti et al (2019) who found ECG abnormalities related to hyperkalemia were found in 50% of patients where tall T wave was the most common ECG abnormality (34.5%).[18]

CONCLUSIONS

We found significant association between hyperkalemia with ECG abnormalities, especially tall T, in non-dialysis stage five chronic kidney disease patient. ECG abnormalities were mostly found in severe hyperkalemia.

ACKNOWLEDGEMENT

This research was supported by the Department of Internal Medicine, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia

FUNDING

None.

ETHICS COMMITTEE APPROVAL

This research was approved by the Ethics Committee for Biomedical Research on Humans, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia. Based on recommendation letter Number: 782/UN4.6.4.5.31/PP36/2024, with protocol number: UH24080652

STATEMENT OF CONFLICT OF INTEREST

Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interests, patent/licensing arrangements, etc.) that might give rise to a conflict of interest with respect to the submitted article.

REFERENCES

1. Chen TK, Knicely DH, Grams ME. Chronic Kidney Disease Diagnosis and Management: A Review. JAMA. 2019;322(13):1294–1304.
2. Vaidya SR, Aeddula NR. Chronic Renal Failure. StatPearls Publishing LLC. 2022;
3. Morales E, Cravedi P, Manrique J. Management of Chronic Hyperkalemia in Patients With Chronic Kidney Disease: An Old Problem With News Options. Frontiers in Medicine. 2021;8(June):1–13.
4. Kashihara N, Kohsaka S, Kanda E, Okami S, Yajima T. Hyperkalemia in Real-World Patients Under Continuous Medical Care in Japan. Kidney International Reports. 2019;4(9):1248–60.
5. Watanabe R. Hyperkalemia in chronic kidney disease. Revista da Associacao Medica Brasileira. 2020;66(1):31–6.
6. Nagasu H, Tokuyama A, Kanda E, Itano S, Kishi S, Sasaki T, et al. The Impact of Potassium Binders on Mortality in Patients with Hyperkalemia: A Single-Center Study. Kidney and Dialysis. 2023;3(3):244–54.
7. Zhao R, Hao X, Wang F, Feng J, Pan J, Jing C, et al. The characteristic and dynamic electrocardiogram changes on hyperkalemia in a hemodialysis patient with heart failure: A case report. Journal of Geriatric Cardiology. 2022;19(2):163–6.
8. Rafique Z, Hoang B, Mesbah H, Pappal R, Peacock FW, Juarez-Vela R, et al. Hyperkalemia and Electrocardiogram Manifestations in End-Stage Renal Disease. International Journal of Environmental Research and Public Health. 2022;19(23).
9. Raffee LA, Alawneh KZ, Ababneh MJ, Hijazi HH, Al abdi RM, Aboozour MM, et al. Clinical and electrocardiogram presentations of patients with high serum potassium concentrations within emergency settings: a prospective study. International Journal of Emergency Medicine. 2022;15(1):1–14.
10. Sarnowski A, Gama RM, Dawson A, Mason H, Banerjee D. Hyperkalemia in Chronic Kidney Disease: Links, Risks and Management. International Journal of Nephrology and Renovascular Disease. 2022;15(June):215–28.
11. Nyirenda MJ, Tang JI, Padfield PL, Seckl JR. Hyperkalaemia. Bmj. 2009;339.
12. Betts KA, Woolley JM, Mu F, McDonald E, Tang W, Wu EQ. The prevalence of hyperkalemia in the United States. Current Medical Research and Opinion. 2018;34(6):971–8.
13. Alrashidi TN, Alregaibah RA, Alshamrani KA, Alhammad AA, Alyami RH, Almadhi MA, et al. Hyperkalemia Among Hospitalized Patients and Association Between Duration of Hyperkalemia and Outcomes. Cureus. 2020;10(9).
14. Mulia EPB, Nugraha RA, A'Yun MQ, Juwita RR, Yofrido FM, Julario R, et al. Electrocardiographic abnormalities among late-stage non-dialysis chronic kidney disease patients. Journal of Basic and Clinical Physiology and Pharmacology. 2021;32(3):155–62.

15. Montague BT, Ouellette JR, Buller GK. Retrospective review of the frequency of ECG changes in hyperkalemia. Clinical Journal of the American Society of Nephrology. 2008;3(2):324–30.

16. Quintero JA, Medina CA, Penagos F, Montesdeoca JA, Orozco GA, Saavedra-Castrillón J, et al. Electrocardiographic Abnormalities in Patients with Hyperkalemia: A Retrospective Study in an Emergency Department in Colombia. Open Access Emergency Medicine . 2024;16(June):133–44.

17. Varga C, Kálmán Z, Szakáll A, Drubits K, Koch M, Bánhegyi R, et al. ECG alterations suggestive of hyperkalemia in normokalemic versus hyperkalemic patients. BMC Emergency Medicine. 2019;19(1):1–9.

18. Regolisti G, Maggiore U, Greco P, Maccari C, Parenti E, Di F, et al. Electrocardiographic T wave alterations and prediction of hyperkalemia in patients with acute kidney injury. Internal and Emergency Medicine. 2019;