ASSOCIATION BETWEEN CHRONIC KIDNEY DISEASE AND CHANGES IN THE T PEAK-T END INTERVAL AMONG HEMODIALYSIS PATIENTS AT RAA SOEWONDO PATI REGIONAL HOSPITAL

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ABSTRAK

Secara global, prevalensi penyakit ginjal kronis (PGK) mencapai 359 juta kasus pada tahun 2021, dengan kematian terkait PGK meningkat sebesar 176% dalam periode yang sama, mencapai 1,53 juta kematian. Interval *T peak-T end* (TpTe), yang mewakili dispersi repolarisasi transmural, telah muncul sebagai penanda elektrokardiografi (EKG) kritis untuk aritmogenesis ventrikel. Penelitian telah menunjukkan bahwa perpanjangan interval TpTe secara substansial terkait dengan peningkatan risiko kematian jantung mendadak. Penelitian ini bertujuan untuk mengetahui hubungan antara CKD dan perubahan interval TpTe pada pasien hemodialisis. Sebuah penelitian observasional dengan desain potong lintang dilakukan di RSUD RAA Soewondo Pati pada September-November 2024. Pengumpulan data menggunakan teknik pengambilan sampel secara konsekutif. EKG dilakukan pada pasien selama hemodialisis. Kami menggunakan uji-T tidak berpasangan untuk pengujian statistik. Lima puluh pasien memenuhi kriteria inklusi dalam penelitian ini, berusia 43-65 tahun. Sebanyak 48% pasien PGK mengalami pemanjangan interval TpTe pada EKG selama hemodialisis dengan nilai rata-rata 98,2 ± 12,7 ms. Komorbiditas seperti hipertensi dan diabetes mellitus meningkatkan risiko PGK masing-masing sebesar 1,9 kali lipat dan 1,87 kali lipat. Pasien dengan PGK ≥ 6 bulan memiliki pemanjangan TpTe rata-rata yang signifikan lebih besar, yaitu 11 ms, dibandingkan dengan pasien dengan PGK < 6 bulan.

Kata kunci : diabetes mellitus, gagal ginjal kronik, hemodialisis, hipertensi, interval TpTe

ABSTRACT

Globally, chronic kidney disease (CKD) reached 359 million cases of prevalence in 2021, with CKD-related deaths increasing by 176% over the same period, reaching 1.53 million deaths. The T peak-T end (TpTe) interval, which represents transmural repolarization dispersion, has emerged as a critical electrocardiographic (ECG) marker for ventricular arrhythmogenesis Prolongation of TpTe intervals has been shown in studies to be substantially linked to an elevated risk of sudden cardiac death (SCD). This study aims to determine the relationship between CKD and changes in the TpTe interval in hemodialysis patients. An observational study with a cross-sectional design was conducted at RSUD RAA Soewondo Pati from September to November 2024. Data collection used a consecutive sampling technique. ECGs were performed on patients during hemodialysis. We used an unpaired T-test for statistical testing. Fifty patients, aged 43-65 years, met the inclusion criteria in this study. A total of 48% of CKD patients experienced a prolonged TpTe interval on the ECG during hemodialysis with a mean value of 98.2 ± 12.7 ms. Comorbidities such as hypertension and diabetes mellitus increased the risk of CKD by 1.9-fold and 1.87-fold, respectively. Patients with CKD ≥ 6 months had a significantly greater mean TpTe prolongation, namely 11 ms, compared to patients with CKD < 6 months.

Keywords : chronic kidney disease, TpTe interval, hemodialysis, diabetes mellitus, hypertension

INTRODUCTION

Recent comprehensive analyzes from the Global Burden of Disease (GBD) 2021 study reveal alarming trends in the worldwide chronic kidney disease (CKD) epidemic. Globally,

CKD reached 359 million cases of prevalence in 2021, representing a staggering 92% increase since 1990. This dramatic rise accompanies equally concerning mortality statistics. CKD-related deaths increasing by 176% over the same period, reaching 1.53 million deaths (Guo J et al., 2025). According to projections, the age standardized prevalence and death rates will continue to rise, reaching 8.773.85 and 21.26 per 100.000 people, respectively, by 2032 (Xie K et al., 2025).

The T peak-T end (TpTe) interval, representing transmural dispersion of repolarization, has emerged as a critical electrocardiographic (ECG) marker for ventricular arrhythmogenesis in this vulnerable population. TpTe interval prolongation is defined as >100 ms (Torres YC et al., 2015; Koca H & Koc M, 2020). Prolongation of TpTe intervals has been shown in studies to be substantially linked to an elevated risk of sudden cardiac death (SCD), with the mean interval measuring 89.4 ms in patients who experienced SCD compared to 76.1 ms in controls (Panikkath R et al., 2011). Globally, ventricular arrhythmias in CKD patients are substantial, with 24-hour ECG monitoring revealing prevalence rates ranging from 19% to 72% in dialysis patients (Bonato FOB & Canziani MEF, 2017). This increased arrhythmogenic risk translates into devastating clinical outcomes, as ventricular arrhythmias account for 78.6% of cardiac arrests in hemodialysis patients (Wan C et al., 2013). This situation makes SCD responsible for 25-29% of all-cause mortality in this population (Turakhia MP et al., 2018)

Several studies reveal consistent patterns of TpTe interval prolongation across different populations with CKD. Research from European centers demonstrates that the TpTe interval are significantly elevated in hemodialytic end-stage renal disease patients compared to controls (Mulia EPB et al., 2022). A comparative study of hemodialysis and hemodiafiltration patients showed that conventional hemodialysis specifically increased TpTe intervals from 102.64 ± 22.16 msec to 135.32 ± 29.08 msec (p <0.001) by the 240th minute of treatment (Pall A et al., 2017). Studies from Cairo University Hospital demonstrate similar patterns of cardiac repolarization abnormalities, with TpTe intervals significantly increased in CKD patients in hemodialysis (Yehia H et al., 2023). The consistency of these findings across diverse populations underscores the fundamental pathophysiological relationship between declining kidney function and cardiac repolarization abnormalities, independent of genetic or environmental factors.

The Asia-Pacific region carries a disproportionate burden of CKD, with around 434.3 million people. Regional variations in CKD prevalence range substantially, from 7.0% to 34.3%, with China and India accounting for up to 299.9 million cases (Liyanage T et al., 2022). In this region, CKD affects younger populations compared to Western countries, with > 50% of prevalent cases occurring in people < 50 years of age. The regional data reveals concerning mortality trends, CKD causes years of life lost (YLL) of approximately 400-600 per 100.000 population (Makmun A et al., 2025). These disparities highlight the urgent need for enhanced cardiovascular risk stratification and monitoring in Asian CKD populations, where the combination of younger age at presentation and limited healthcare resources creates particularly challenging clinical scenarios.

Indonesia faces a significant and growing CKD burden, with national prevalence increasing from 0.2% in 2013 to 0.38% in 2018 according to the Basic Health Research (Hidayangsih PS et al., 2023). The CKD prevalence is 1.8% in patients with diabetes, with gender being identified as the dominant risk factor (aPR = 3.24) (Zahra ASA & Simanjorang C, 2024). The number of individuals undergoing renal replacement therapy (RRT) has increased, exceeding 132,000 in 2018, representing an 84% increase over five years since the implementation of National Health Coverage in 2014 (Indonesian Society of Nephrology, 2018). The aim of this study was to determine the relationship between CKD and changes in the TpTe interval in hemodialysis patients at RAA Soewondo Hospital, Pati.

METHODS

An observational study with a cross-sectional design was conducted at RAA Soewondo Pati Regional Hospital during September-November 2024. Inclusion criteria were all CKD patients undergoing hemodialysis at RAA Soewondo Pati Regional Hospital during the study period. The exclusion criteria were patients with a history of previous heart infarction, chronic heart failure, congenital heart disease, heart valve abnormalities, patients undergoing treatment (amiodarone, verapamil, propanolol, or phenobarbital), ECG results with flat or biphasic T waves that make TpTe assessment difficult. Data collection used a consecutive sampling technique. ECGs were recorded during hemodialysis. TpTe was measured using lead V5. If V5 was not suitable, leads V4 or V6 were used. A total of 50 patients were analyzed. Data normality was assessed using the Shapiro-Wilk test, and differences were analyzed with the unpaired t-test using SPSS version 25.

RESULTS

Table 1.　　Characteristics of Study Subjects

Characteristics	Amount (N = 50)	Mean (± SD)	Median (Min-Max)
Age	-	51,1 (± 6, 02)	50 (43-65)
Sex			
Male	29 (58%)	-	-
Female	21 (42%)	-	-
Comorbid			
Hypertension	15 (30%)	-	-
DM Type 2*	19 (38%)	-	-
Hypertension and DM Type 2*	8 (16%)	-	-
Didn't have Hypertension /DM Type 2*	8 (16%)	-	-
Duration of CKD			
≥ 6 months	26 (52%)	-	-
< 6 months	24 (48%)	-	-
TpTe Interval	-	98.2 (± 12.7)	99.5 (67-130)
TpTe Interval Prolongation			
Yes	24 (48%)	-	-
No	26 (52%)	-	-

Fifty patients met the inclusion criteria in this study, aged 43-65 years. This study was dominated by men, at 58%. Diabetes mellitus was the most common comorbidity experienced by CKD patients, at 38%, followed by hypertension at 30%. Patients with a duration of CKD ≥ 6 months were 52%. A total of 48% of CKD patients experienced a prolonged TpTe interval on the ECG during hemodialysis procedures. The TpTe interval ranged from 67 to 130 ms with a mean value of 98.2 ± 12.7 ms (see table 1).

Table 2.　　Data Normality Test

Kolmogorov-Smirnov		Shapiro-Wilk	
Statistics	Sig.	Statistics	Sig.
0,096	0,2	0,982	0,649

The subjects of this study were 50 people, so we used Shapiro-Wilk as a data normality test with a significance of 0.649, which stated that the data was normally distributed (see table 2).

Diabetes mellitus was found in 66.7% of CKD patients ≥ 6 months. CKD and diabetes mellitus were substantially correlated (p = 0.049). Compared to those without concomitant

diabetes mellitus, those with diabetes mellitus had a 1.9-fold increased risk of developing CKD (see table 3).

Table 3.   Association between Diabetes Mellitus and CKD

Variable	CKD		Total	p-value	PRR (95% CI)
	≥ 6 months	< 6 months			
Diabetes Mellitus				0,049	1,917 (1,031-3,563)
Yes	18 (66,7%)	9 (33,3%)	27 (100%)		
No	8 (34,8%)	15 (65,2%)	23 (100%)		
Total	**26 (52%)**	**24 (48%)**	**50 (100%)**		

Table 4.   Association between Hypertension and CKD

Variable	CKD		Total	p-value	PRR (95% CI)
	≥ 6 months	< 6 months			
Hypertension					
Yes	16 (69,6%)	7 (30,4%)	23 (100%)	0,044	1,878 (1,072-3,292)
No	10 (37%)	17 (63%)	27 (100%)		
Total	**26 (52%)**	**24 (48%)**	**50 (100%)**		

Hypertension was found in 69.6% of CKD patients ≥ 6 months. CKD and hypertension were substantially correlated (p = 0.044). Compared to those without concomitant hypertension, those with hypertension were 1.87 times more likely to have CKD (see Table 4).

Table 5.   Association between the Duration of CKD and the Prolongation of the TpTe Interval

Duration of CKD	TpTe Interval Mean (± SD)	p-value	Mean Difference (95% CI)
≥ 6 months	103 (± 11.3)	0,001	11 (4.5 – 17.7)
< 6 months	92 (± 11.8)		

An unpaired t-test was performed to analyze the association between CKD duration and TpTe interval prolongation. The analysis revealed a statistically significant relationship (p = 0.001). Furthermore, patients with CKD ≥ 6 months had a significantly greater mean TpTe prolongation of 11 ms compared to patients with CKD < 6 months (see Table 5).

DISCUSSION

The statistically significant relationship (p = 0.001) between CKD duration and TpTe interval prolongation represents a crucial finding with important clinical implications. Patients with CKD ≥6 months demonstrated a mean TpTe prolongation of 11 ms compared to those with shorter disease duration. These findings align with a study by Mulia et al. showing that hemodialysis patients experience increased ventricular repolarization abnormalities with a prolonged TpTe interval of 10 ms compared to pre-dialytic patients with a significant p = 0.025 (Mulia EPB et al., 2022). Kollu et al. reported that stages 3-5 CKD patients had a prolonged TpTe interval of 5.2 ms compared to healthy patients with a significant p = 0.001 (Kollu K et al., 2018). Guclu et al. revealed that, with a significant p = < 0.001, the TpTe interval is prolonged by 13.63 ms and 15.87 ms for hemodialysis and peritoneal dialysis patients, respectively, in comparison to the control group (Guclu A et al., 2016). Yehia et al. reported that ventricular repolarization abnormalities worsen with advancing CKD and longer exposure to uremic conditions (Yehia H et al., 2023). The mechanism behind this relationship

involves multiple factors including uremic toxin accumulation, electrolyte imbalances, chronic inflammation, and structural cardiac changes that develop over time in CKD patients (Yehia H et al., 2023; Kollu K et al., 2018). Progressive prolongation of TpTe interval correlates with increased risk of ventricular arrhythmias and SCD, making this a valuable prognostic marker in CKD management (Panikkath R et al., 2011; Guclu A et al., 2016).

Our study revealed that 48% of CKD patients experienced prolonged TpTe interval during hemodialysis procedures, with values ranging from 67 to 130 ms and a mean of 98.2 ± 12.7 ms. This finding is consistent with previous research demonstrating that CKD patients, particularly those on hemodialysis, exhibit significant prolongation of ventricular repolarization parameters (Mulia EPB et al., 2022). Guclu et al. showed that TpTe interval prolongation during hemodialysis and peritoneal dialysis with mean values of 95.11 ± 16.87 ms and 97.35 ± 12.10 ms, respectively, compared to the mean value for the control group, 81.48 ± 5.54 ms (Guclu A et al., 2016). Saour et al. reported that 45.85% of hemodialysis patients experienced TpTe interval prolongation with a mean value of 103.5 ms (Saour BM et al., 2019). The TpTe interval represents transmural dispersion of repolarization and serves as a marker of arrhythmogenesis, with normal values typically ranging from 50-90 ms in healthy populations (Koca H & Koc M, 2020). The prolonged TpTe intervals observed in our patients exceeded the normal range and approach values associated with increased SCD risk, where intervals >100 ms have been linked to significantly elevated mortality (Panikkath R et al., 2011; Torres YC et al., 2015).

Our analysis revealed that diabetes mellitus was present in 66.7% of patients with CKD duration ≥ 6 months, demonstrating a 1.9-fold higher risk of getting CKD in comparison to people without diabetes (p = 0.049). This finding corroborates extensive literature demonstrating that globally diabetes is the primary cause of CKD and that longer duration of diabetes significantly increases nephropathy risk. The pathophysiology involves persistent hyperglycemia causing glomerular hyperfiltration, albuminuria, and progressive decline in glomerular filtration rate (Siddiqui K et al., 2022). Research has indicated that those who have had diabetes for more than 15 years are 1.75 times more likely to develop high-risk CKD, emphasizing the importance of glycemic control and early intervention to prevent or slow kidney disease progression (Siddiqui K et al., 2022). Damtie et al. reported that patients with diabetes duration ≥ 10 years have a 3.38-fold increase in risk of CKD with a significant p = 0.007 (Damtie S et al., 2018).

Hypertension was found in 69.6% of patients with CKD duration ≥ 6 months, showing a significant association (p = 0.044) with a 1.87 times greater likelihood of developing CKD. This relationship reflects the complex bidirectional nature of hypertension and kidney disease, whereas deteriorating kidney function causes hypertension through a variety of pathways, such as volume expansion and renin-angiotensin-aldosterone system activation, high blood pressure speeds up kidney deterioration (Ameer OZ, 2022). Research demonstrates that patients with systolic blood pressure (SBP) ≥ 140 mmHg are 3.6 times more likely to develop CKD (Damtie S et al., 2018). Lee et al. also reported that SBP ≥ 140 and ≥ 160 mmHg increased the risk of developing CKD by 1.79 and 3.22 times, respectively (Lee H et al., 2021). Aggressive blood pressure treatment is crucial to slowing the progression of the disease and lowering cardiovascular consequences, as seen by the high frequency of hypertension in patients with longer durations of CKD.

The TpTe interval measurements during hemodialysis procedures in our study highlight the acute electrophysiological stress imposed by dialysis therapy. Hemodialysis induces rapid shifts in electrolytes, particularly potassium, calcium, and magnesium, which directly affect cardiac ion channel function and repolarization dynamics. Research demonstrates that post-hemodialysis TpTe intervals are significantly increased compared to pre-dialysis values, with changes correlating inversely with calcium shifts and directly with phosphorus changes

(Candemir M et al., 2021). These electrolyte fluctuations, combined with volume shifts and autonomic dysfunction, create a vulnerable period for arrhythmogenesis during and immediately after hemodialysis sessions (Noppakun K et al., 2021). The interdialytic period, particularly the longer weekend interval, has been associated with higher rates of SCD, emphasizing the clinical significance of these electrophysiological changes (Foley RN et al., 2011).

Our study's findings have significant clinical ramifications for CKD patient care and risk assessment. Patients with diabetes, hypertension, and longer disease duration, identifies a high-risk subset requiring enhanced cardiovascular monitoring and potentially prophylactic interventions. The TpTe interval measurement represents a simple, non-invasive tool that can be easily incorporated into routine ECG assessment during hemodialysis sessions to identify patients at increased arrhythmic risk. Future research should focus on establishing TpTe interval cutoff values specific to CKD patients for optimal risk prediction and investigating interventions such as electrolyte optimization, dialysis prescription modifications, and antiarrhythmic strategies to reduce sudden cardiac death in this vulnerable population. Long-term prospective research is required to confirm the prognostic significance of TpTe interval prolongation and its utility in guiding clinical decision-making for CKD patients undergoing hemodialysis therapy.

CONCLUSION

This study concluded that there was an association between CKD and TpTe interval prolongation in patients undergoing hemodialysis, with patients with CKD $\geq$ 6 months having a longer TpTe interval than those with shorter durations. Furthermore, diabetes mellitus and hypertension are risk factors that can raise the chance of developing CKD.

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