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Original Article

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Investigation of QT Dispersion in Hemodialysis and Peritoneal Dialysis Patients and Determining the Effects of Variables

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Abstract

Objective: This study aimed to investigate the status and pathogenesis of the increase in QT dispersion (QTd), which allows predicting the occurrence of cardiac arrhythmia, in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD) owing to end-stage renal disease.

Materials and Methods: A total of 32 patients undergoing HD, 22 patients undergoing PD, and 20 healthy individuals were included in this study. The difference between the longest QT distance and the shortest QT distance on electrocardiography was calculated, and the corrected QT dispersion (QTcd) was calculated using QTd and corrected QT distances using the Bazett's formula. Blood samples taken 1 day after routine HD in patients undergoing HD and blood samples taken on the day of follow-up after 12 hours of fasting in patients undergoing PD were evaluated.

Results: Corrected QT (QTc) was calculated as 54.25±22.4 ms in the HD group, 54.13±18.06 ms in the PD group, and 38.7±8.11 ms in the control group, and these values were statistically significant ($p<0.01$). However, there was no significant difference between the HD and PD groups regarding the QTc. There was no significant relationship between QTcd and serum electrolytes, age, sex, and duration of dialysis in patients undergoing HD and PD.

Conclusion: Although there are sudden electrolyte changes during HD, this does not occur during PD. However, long QTcd monitoring in both the groups suggests that the prolongation of QTcd may depend on the current uremia rather than electrolyte changes.

Keywords: Hemodialysis, peritoneal dialysis, QT dispersion, corrected QT dispersion

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INTRODUCTION

Cardiovascular diseases are common in patients with end-stage renal disease (ESRD). The main causes of death in these patients with cardiovascular disease are congestive heart failure and coronary artery disease as well as sudden death because of arrhythmia after possible hyperpotassemia (1, 2). Arrhythmia occurs partly owing to changes in the sympathetic autonomic tonus and partly owing to the metabolic abnormalities in the ventricular structure. Different electrocardiography (ECG) scales have been developed to predict the occurrence of ventricular arrhythmias in clinical practice, and it has been reported that the prolonged QT interval in conventional ECG is consistent with the arrhythmogenic status of some cardiac diseases (3, 4).

Sudden death owing to arrhythmias was found to be the cause of death in 30% of patients with ESRD (5). ECG abnormalities in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD) vary widely, and both these procedures could themselves be the cause of ECG changes and arrhythmias. Complex arrhythmias often occur after the patient is connected to HD and can persist for at least 5 hours after dialysis. This implies that arrhythmias may be associated with HD and PD (6).

This study aimed to evaluate the effects of HD and PD on QT and corrected QT (QTc) dispersion and their relationship with metabolic variables by measuring QT dispersion in patients with ESRD undergoing HD and PD.

MATERIALS AND METHODS

A total of 54 patients aged 19-70 years were included in this study among the patients who were followed up in the nephrology clinic with a diagnosis of ESRD. A total of 20 healthy individuals were selected as the control group. All the patients included in the study were evaluated by anamnesis, physical examination, and ECG. Dialysis entry times were recorded. The patients who were diagnosed with heart failure or ischemic heart disease by exercise test or coronary angiography, had arrhythmias such as bundle branch block, had atrial fibrillation on ECG, had bradycardia or tachycardia, and those who were using any drugs affecting the QT interval were not included in the study.

To ensure that laboratory tests and ECG parameters were not affected by the acute metabolic effects of dialysis, blood samples taken 1 day after routine HD in patients undergoing HD and blood samples taken on the day of follow-up after 12 hours of fasting in patients undergoing PD were evaluated. The results of the hemogram test and serum iron, total iron-binding capacity, ferritin, creatinine, blood urea nitrogen, sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), parathyroid hormone (PTH), C-reactive protein (CRP), and bicarbonate levels of patients undergoing HD and PD, which were obtained during the routine follow-ups, were analyzed retrospectively. The same procedure was repeated for the control group.

Ethics committee approval was received for this study from the Ethics Committee of İstanbul Training and Research Hospital (Approval Date: January 10, 2020; Approval Number: 2147).

Main Points

- ECG abnormalities in patients undergoing hemodialysis (HD) and peritoneal dialysis (PD) vary widely. It is known that the corrected QT distance (QTcd) is long in patients undergoing dialysis and that the prolongation of the QTcd is related to ventricular premature complexes.
- In our study, while an increase in QT and QTcd was observed in HD and PD patients, no statistically significant difference was found between the 2 groups in terms of QTc and QTcd.
- If it was owing to the sudden electrolyte change, prolonged QTcd was not expected after PD treatment based on the idea of continuously replacing renal function with a natural membrane without the need for any force or apparatus.
- Therefore, the result of our study can be explained by the current uremic state rather than the effect of sudden electrolyte changes.

QT and QTc Dispersion Measurement Method

The distance from the beginning of the Q wave to the end point where the T wave returned to the isoelectric line was measured in milliseconds as the QT interval. In ECGs with U waves, the lowest point between the T and U waves was accepted as the end of the T wave. Derivations of which the end of the T wave could not be determined were not analyzed. QTc interval was calculated using the Bazett's formula (QTc=measured QT interval [seconds]/√R-R interval [seconds]) (7). The QTc interval of 3 consecutive beats in each lead was regarded as the QTc interval of that lead. The patients with the QTc interval calculated in at least 9 leads were included in the study. The QTc dispersion (QTcd) was determined by calculating the difference between the longest QTc interval and the shortest QTc interval. Individuals with QTcd above 50 ms were considered abnormal.

Statistical Analysis

Number Cruncher Statistical System 2007 and PASS 2008 statistical software (Number Cruncher Statistical Systems; Keysville, Utah, USA) program were used for statistical analysis. To evaluate the study data, descriptive statistical methods (mean, standard deviation, and ratio), one-way analysis of variance test for intergroup comparisons of normally distributed parameters, and Tukey's honestly significant difference (HSD) test for determination of the group causing the difference (post hoc) were used. The Student's t test was performed for the comparisons between 2 groups. The Kruskal-Wallis test was performed for the comparison of non-normally distributed parameters between groups, and Mann-Whitney U test was used for the determination of the group causing the difference and evaluations according to the 2 groups. The chi-squared test and Fisher's exact chi-squared test were used to compare the qualitative data. The Pearson correlation and Spearman's correlation analyses were used to analyze the relationship between the parameters. Significance was set at $p<0.05$.

RESULTS

A total of 32 patients undergoing HD, 22 patients undergoing PD, and 20 healthy individuals as the control group were included in this study. The ages of the patients ranged from 19 to 70 years, and the mean age was 44.45±13.10 years.

There was a statistically significant difference between the QT dispersion levels according to the groups ($p<0.01$). The results of the post hoc Tukey's HSD test performed to determine the group causing the difference showed that the QT dispersion levels of the HD and PD groups were significantly higher than those of the control group ($p=0.001$; $p=0.001$) (Table 1).

There was also a statistically significant difference between the QT dispersion classes according to the groups ($p<0.01$). The rates of patients with long QT dispersion levels in HD and PD groups were significantly higher than those of the control group ($p<0.01$) (Table 1).

There was no statistically significant relationship among age; dialysis duration; K, Ca, P, Mg, PTH, and CRP levels; and QT dispersion levels in the HD and PD groups (p>0.05). Similarly, there was no statistically significant relationship among age; K, Ca, P, Mg, PTH, and CRP levels; and QT dispersion levels in the control group (p>0.05) (Table 2).

There was no statistically significant difference with regard to age, sex, and duration of dialysis between the groups (p>0.05) (Table 3).

In the HD and PD groups, there was no statistically significant difference in terms of the number of patients with long QT dispersion according to sex (p>0.05) (Table 4).

In both the HD and PD groups, there was no statistically significant difference with regard to dialysis durations and serum K, Ca, P, Mg, PTH, and CRP levels between patients with elongated and normal QT dispersion (p>0.05) (Tables 5 and 6).

DISCUSSION

Patients with chronic renal failure are a high-risk group for coronary artery disease, peripheral vascular disease, cerebrovascular disease, and congestive heart failure (7). In patients with uremia, increase in sympathetic autonomic tonus, ventricular dilatation, hypertrophy, structural changes in the myocardium such as fibrosis, wall stress differences caused by increased circulation volume, and metabolic factors may cause cardiac arrhythmias (8, 9).

QTcd was first described by Cowan et al. (10) as the difference between the longest QTc distance and the shortest QTc distance in a standard 12-lead ECG. Day et al. (11) reported that increased QT dispersion in patients with long QT syndrome may indicate ventricular tachycardia risk. In addition, QTcd has been shown to be associated with hypertrophic cardiomyopathy, myocardial infarction, electrolyte imbalance, heart failure, valve diseases, and life-threatening arrhythmia (12).

Table 1. Assessment of QT dispersion levels by groups

	Hemodialysis (32)	Peritoneal dialysis (22)	Control (20)
	Mean±SD	**Mean±SD**	**Mean±SD**
QT dispersion (msec)	487.25±28.40	487.13±24.06	426.70±8.11
	n (%)	**n (%)**	**n (%)**
Normal	15 (46.9)	12 (54.5)	20 (100)
Elongated	17 (53.1)	10 (45.5)	0 (0)

SD: standard deviation; msec: milliseconds

Table 2. Evaluations regarding QT dispersion levels

	QT dispersion					
	Hemodialysis		Peritoneal dialysis		Control	
	r	p	r	p	r	p
Age (years)	-0.196	0.281	0.069	0.759	0.282	0.229
Dialysis duration (years)	-0.061	0.738	0.062	0.785	-	-
Potassium (mmol/L)	-0.034	0.853	0.065	0.773	0.131	0.581
Calcium (mg/dL)	0.228	0.209	-0.033	0.885	-0.106	0.655
Phosphorus (mg/dL)	-0.108	0.556	0.148	0.510	-0.174	0.463
Magnesium (mg/dL)	0.194	0.288	0.210	0.349	0.440	0.052
Parathyroid hormone (pg/mL)	0.185	0.310	-0.213	0.341	0.054	0.820
C-reactive protein (mg/dL)	0.054	0.771	0.195	0.384	-0.155	0.514

Table 3. Age, sex, and dialysis duration assessments by groups

	Hemodialysis	Peritoneal dialysis	Control
	Mean±SD	**Mean±SD**	**Mean±SD**
Age (years)	42.96±10.55	45.50±14.48	45.70±15.47
Dialysis duration (years)	5.65±4.14	6.50±3.88	-
	n (%)	**n (%)**	**n (%)**
Sex			
Women	12 (37.5)	14 (63.6)	9 (45)
Men	20 (62.5)	8 (36.4)	11 (55)

SD: standard deviation

Table 4. Assessment of QT dispersion levels by sex in groups

		Sex		
		Women	Men	
Group	**QT dispersion**	**n (%)**	**n (%)**	**p**
Hemodialysis	Normal	5 (41.7)	10 (50)	0.647
	Elongated	7 (58.3)	10 (50)	
Peritoneal dialysis	Normal	8 (57.1)	4 (50)	1.000
	Elongated	6 (42.9)	4 (50)	

Table 5. Evaluation of QT dispersion levels in hemodialysis group

	QT dispersion level		
	Normal	Elongated	
Hemodialysis group	**Mean±SD**	**Mean±SD**	**p**
Dialysis duration (years)	5.75±4.71	5.60±3.56	0.944
Potassium (mmol/L)	4.96±0.96	5.52±1.36	0.185
Calcium (mg/dL)	8.80±0.73	8.78±0.80	0.961
Phosphorus (mg/dL)	4.88±1.21	5.30±1.07	0.321
Magnesium (mg/dL)	2.46±0.28	2.42±0.50	0.792
Parathyroid hormone (pg/mL)	496.41±386.24	564.96±480.76	0.763
C-reactive protein (mg/dL)	1.31±1.72	4.63±2.19	0.910

SD: standard deviation

QTcd shows regional heterogeneity in myocardial repolarization. Delay in action potential duration as a result of regional conduction deceleration or conduction change in the myocardium causes regional heterogeneity in repolarization. It was reported that the higher the QTcd, the lower the homogeneity of ventricular repolarization, and hence greater the ventricular in-

Table 6. Evaluation of QT dispersion levels in peritoneal dialysis group

	QT dispersion level		
	Normal	Elongated	
Peritoneal dialysis group	Mean±SD	Mean±SD	p
Dialysis duration (years)	6.40±3.02	6.58±4.62	0.915
Potassium (mmol/L)	4.38±0.69	4.32±0.74	0.861
Calcium (mg/dL)	8.68±1.03	9.10±0.44	0.254
Phosphorus (mg/dL)	5.78±1.92	5.33±1.58	0.557
Magnesium (mg/dL)	2.29±0.78	2.25±0.49	0.885
Parathyroid hormone (pg/mL)	1352.35± 981.64	883.09±873.2	0.147
C-reactive protein (mg/dL)	0.72±0.68	1.28±1.51	0.509

SD: standard deviation

stability (13, 14). Individuals with QTcd longer than 50 ms have an increased risk of severe ventricular arrhythmias and sudden cardiac death through the heterogeneous ventricular repolarization re-entry mechanism (15).

The main advantage of QT dispersion is that it is an easy and noninvasive method to demonstrate the risk of ventricular arrhythmia. Therefore, it can be used as a predictor of cardiac arrhythmia, especially in non-cardiac diseases, such as ESRD.

It is known that the QTc distance is long in patients undergoing dialysis and that the prolongation of the QT distance is related to ventricular premature complexes (16). In addition, it is known that electrolyte imbalance plays a role in the pathogenesis of cardiac arrhythmias. Accordingly, in a study of 68 patients with ESRD, it was stated that QTc interval increased in association with rapid electrolyte level changes during HD, but there was no correlation between HD and QTcd (17). In the study of Kantarcı et al. (18), it was reported that QTcd significantly increased in both HD and PD groups than in the control group. In addition, Howse et al. (19) also showed that HD increases both QTc interval and QTcd. In our study, a statistically significant elongation in QTc was seen in the HD and PD groups in all 54 patients in accordance with the literature (HD group: 54.25±22.4 ms; PD group: 54.13±18.06 ms).

It has been reported that the increase in QTc and QTcd may be because of sudden electrolyte changes during HD and PD (16, 20). In these studies, electrolyte follow-up was performed before and after HD and PD, and it was reported that prolongation of QTcd could be owing to the difference between the intracellular potassium and serum potassium levels or a sudden decrease in the serum potassium levels; changes in serum Ca, Mg, P levels; rapid correction of metabolic acidosis; or increase of PTH and free fatty acid levels (16, 20). Covic et al. (17) emphasized that QTc interval was associated with rapid changes in electrolyte levels during dialysis, but QTcd was of less clinical importance in the absence of a significant concomitant heart disease. However, in our study, no significant relationship was found between QTcd and serum electrolyte levels in patients undergoing HD and PD. Although there was no sudden electrolyte change during PD, the prolongation of QT distance, which we found in our study, suggests that current urea may be the main reason rather than electrolyte changes. There have been studies suggesting the role of changes in serum electrolyte levels in increasing QTcd in patients undergoing dialysis as well as authors claiming the opposite. In a study including 31 patients with ESRD, it was reported that serum PTH, Ca, Mg, and K levels did not correlate with the increase in QTcd during HD (19). In our study, no statistically significant relationship was found between serum Ca, K, P, and Mg levels and QTcd in all patients. Moreover, no correlation was found between the increase in PTH levels and the increase in QTcd, as in the literature.

There are large-scale epidemiological studies showing that plasma CRP level is an independent factor for the risk of developing cardiovascular diseases (21-23). CRP has been accepted as an easily measurable inflammation and cardiovascular risk index. QTcd is a simple, inexpensive, and noninvasive method that can be used to determine the risk of ventricular arrhythmias in patients with cardiovascular diseases. However, in our study, no correlation was found between CRP levels and QTcd.

In our study, no statistically significant relationship was found between QTcd and age, sex, and duration of dialysis in the entire patient group. This finding is consistent with the previous literature (17).

CONCLUSION

The increase in QTc and QTcd was present in patients undergoing HD and PD, but the absence of a statistically significant difference between the 2 groups in terms of QTc and QTcd could be explained by the present uremic state rather than the effect of sudden electrolyte changes. If it was owing to the sudden electrolyte change, prolonged QTcd was not expected after PD treatment based on the idea of continuously replacing renal function with a natural membrane without the need for any force or apparatus. As a predictor of sudden deaths and severe arrhythmias, the use of QT dispersion may be applicable to the patients undergoing HD and PD as well as post-myocardial infarction, ischemic heart disease, left ventricular hypertrophy, and long QT syndrome.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of İstanbul Training and Research Hospital (Approval Date: January 10, 2020; Approval Number: 2147).

Informed Consent: Informed consent was not obtained due to the nature of this study.

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REFERENCES

1. Leiver CV, Boudolulas H. Renal disorders and heart disease. Braunwald E (ed). Heart Disease: A Textbook of Cardiovascular Medicine. 5th ed. Philadelphia: WB Saunders, 1997; p. 1914-38.
2. Chazan JA. Sudden death in patients with chronic renal failure on haemodialysis. Dial Transplant 1987; 16: 447-8.
3. Day CP, Mc Comb JM, Cambell RWF. QT dispersion: An indication of arrhythmia risk in patients with long QT intervals. Br Heart J 1990; 8: 342-4. [Crossref]
4. Foley RN, Parfrey PS, Harnett JD, Kent GM, Murray DC, Barre PE. The prognostic importance of left ventricular geometry in uremic cardiomyopathy. J Am Soc Nephrol 1995; 5: 2024-31.
5. Avram MM, Edson J, Gan A, Edson NJ. Continuous monitoring of cardiac rhytym in haemodialysis patients. Dial Transplant 1978; 7: 516-9.
6. Gruppo Hemodialisie Patologie Cardiovascular. Multicentre cross-sectional study of ventricular arrhythmias in chronically haemodialysed patients. Lancet 1988; 2: 305-9. [Crossref]
7. K/DOQI Clinical Practice Guidelines for bone metabolism and disease in chronic kidney disease. Am J Kidney Di 2003; 42: S1. [Crossref]
8. Morrison G, Michelson EL, Brown S, Morganroth J. Mechanism and prevention of cardiac arrhythmias in chronic haemodialysis patients. Kidney Int 1980; 17: 811-8. [Crossref]
9. Kimura K, Tabie K, Asano Y, Hosoda S. Cardiac arrhythmias in haemodialysis patients: A study of incidence and contributory factors. Nephron 1989; 53: 201-5. [Crossref]
10. Cowan JC, Yusoff K, Moore M, Amos PA, Gold AE, Bourke JP, et al. Importance of lead selection in QT interval measurement. Am J Cardiol 1988; 61: 83-7. [Crossref]
11. Day CP, McComb JM, Campbell RW. QT dispersion: An indication of arrhythmia risk in patients with long QT intervals. Br Heart J 1990; 63: 342-4. [Crossref]
12. Helming H, Holm E, Jun L, Torp-Pedersen C, Køber L, Kircshoff M, et al. The prognostic value of QT interval and QT dispersion in all cause and cardiak mortality and morbidity in a population of danish citizens. Eur Heart J 1998; 19: 1391-400. [Crossref]
13. Astor BC, Muntner P. Association of kidney function with anemia: The Third National Health and Nutrition Examination Survey (1988-1994). Arch Intern Med 2002; 162: 1401-8. [Crossref]
14. Higham PD, Campell RW. QT dispersion. Br Heart J 1994; 71: 508-10. [Crossref]
15. Aparicio M, Gin H, Merville P, Combe C, de Precigout V, Lafage MH, et al. Parathormone activity and rate of progression of chronic renal failure in patients on low- protein diet. Nephron 1990; 56: 333-4. [Crossref]
16. Gin H, Combe C, Rigalleau V, Delafaye C, Aparicio M, Aubertin J. Effects of a low-protein, low-phosphorus diet on metabolic insulin clearance in patients with chronic renal failure. Am J Clin Nutr 1994; 59: 663-6. [Crossref]
17. Covic A, Diaconita M, Gusbeth-Tatomir P, Covic M, Botezan A, Ungureanu G, et al. Haemodialysis increases QT(c) interval but not QT(c) dispersion in ESRD patients without manifest cardiac disease. Nephrol Dial Transplant 2002; 17: 2170-7. [Crossref]
18. Kantarcı G, Ozener C, Tokay S, Bihorac A, Akoglu E. QT dispersion in hemodialysis and CAPD patients. Nephron 2002; 91: 739-41. [Crossref]
19. Howse M, Sastry S, Bell GM. Changes in the corrected QT interval and corrected QT dispersion during haemodialysis. Postgrad Med J 2002; 78: 273-5. [Crossref]
20. Beaubien ER, Pylypchuk GB, Akhtar J, Biem HJ. Value of corrected QT interval dispersion in identifying patients initiating dialysis at increased risk of total and cardiovascular mortality. Am J Kidney Dis 2002; 39: 834-42. [Crossref]
21. Peuchant E, Delmas-Beauvieux MC. Antioxidant effects of a supplemented very low protein diet in chronic renal failure. Free Radic Biol Med 1997; 22: 313-20. [Crossref]
22. Ridker PM, Cushman M, Stamfer MJ, Tracy R, Hennekens CH. Inflammation, aspirin and the risk of cardiovascular disease in apperantly healthy men. New Engl J Med 1997; 336: 973-97 [Crossref]
23. Ridker PM, Cushman M, Stampfer MJ, Tracy R, Hennekens CH. Plasma concentration of C-reactive protein and risk of developing peripheral vascular disease. Circulation 1998; 97: 425-8. [Crossref]