Improvement of Maximum Corrected QT and Corrected QT Dispersion in Electrocardiography After Kidney Transplantation

Ali Monfared,[1] Ahad Jafari Ghods[2]

[1]Department of Internal Medicine and Urology Research Center, Guilan University of Medical Sciences, Rasht, Iran
[2]Department of Nephrology and Transplantation, Hasheminejad Hospital, Iran University of Medical Science, Tehran, Iran

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Introduction. The electrocardiography (ECG) markers of corrected QT interval (QTc) and QTc dispersion are prolonged in patients on hemodialysis. This study was carried out to investigate if changes in these markers will reverse by successful kidney transplantation.
Materials and Methods. Twenty-six kidney allograft recipients with functioning grafts, 26 patients on maintenance hemodialysis, and 22 healthy individuals were underwent a 12-lead ECG and laboratory studies for electrolytes and arterial blood gas. In the patients on dialysis, ECG and laboratory studies were performed prior to the start of a hemodialysis session. Both QT dispersion and maximum QT were corrected for heart rate (QTc dispersion and maximum QTc). The results were compared between the three groups.
Results. The mean QTc dispersion was 30.3 ± 15.2 ms, 27.6 ± 8.3 ms, and 24.5 ± 9.0 ms, and the mean maximum QTc was 464.7 ± 23.0 ms, 436.3 ± 19.0 ms, and 415.0 ± 85.0 ms in the patients on dialysis, transplant recipients, and controls, respectively. The QTc dispersion value was lower in the transplant group than in the hemodialysis group, but the differences were not statistically significant. Whereas, the maximum QTc was significantly shorter in the transplant recipients as compared with the patients on hemodialysis ($P < .02$). There was a significant correlation between the maximum QTc and serum calcium level ($P < .001$), serum magnesium level ($P < .001$), and pH ($P < .001$).
Conclusions. Prolonged maximum QTc decreases towards normal by successful kidney transplantation. These corrections are most likely due to normalization of electrolytes and the acid-base status from a uremic state to the normal kidney function.

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INTRODUCTION

The risk of developing cardiovascular diseases is higher in patients on hemodialysis than in the general population. Electrocardiography (ECG) findings, particularly the QT interval and its dispersion (QTD), the QT interval corrected (QTc) for heart rate according to Bazett formula, and the QTc dispersion, can be considered to be direct indicators of risk of developing arrhythmia in patients on hemodialysis.[1] QT dispersion is a crude and approximate measure of general abnormality of repolarization, reflects regional differences in ventricular recovery time, and has been linked to the concurrence of malignant arrhythmia in different cardiac diseases.[2,3] In patients on hemodialysis, QTD is significantly greater compared with that in healthy individuals,[4] and it rises significantly after hemodialysis; however, it has not been previously

assessed in patients after successful kidney transplantation. To the best of our knowledge, no study has been done on QTD changes after kidney transplantation. Thus, we designed a study to compare the QTC and QTc dispersion in patients with end-stage renal disease (ESRD) and kidney allograft recipients with a normal serum creatinine level.

MATERIALS AND METHODS

In Shaheed Hasheminejad Hospital, we evaluated 26 consecutive kidney transplant recipients with functioning graft (14 men and 12 women with a mean age of 37.7 ± 8.7 years (range 20 to 57 years). The mean duration from transplantation was 33.0 ± 12.2 days (range, 15 to 60 days), and the mean serum creatinine level was 1.3 ± 0.7 mg/dL (range 0.6-2 mg/dL). We also recruited 26 patients on maintenance hemodialysis and 22 healthy individuals with the same age and sex distribution from the preoperative assessment clinic. The duration of dialysis was 3 months to 10 years in the hemodialysis group. In all the three groups, chronic heart failure and coronary artery disease were screened by ECG and echocardiography and those with these heart diseases were excluded. In addition, we excluded patients who were receiving class I or class III antiarrhythmic drugs. Informed consent was obtained from all the participants in the three groups of the study.

Plasma levels of electrolytes (sodium, potassium, magnesium, calcium, and phosphorous), blood urea nitrogen, serum creatinine, and arterial blood gas were tested in the patients of hemodialysis and transplant groups. In the former group, samples were taken before the dialysis session. Calcium and magnesium levels were corrected based on the serum albumin levels. A 12-lead ECG was performed by a single nurse in the participants of all the three groups. The measurement of QT in all possible leads was performed by a single observer. The QT interval was taken from the onset of the QRS complex to the end of the T wave. Then, QTc was calculated according to the Bazett formula. The QTc dispersion was determined as the difference between the maximum and minimum values of QTc in different leads.

We also measured 2 left ventricle hypertrophy ECG indexes of cornell voltage criteria (Ravl+SV3) and Sokolow voltage criteria (SV1+RV5 or RV6) and calculated the cardiac axis, as well. The correlation between electrolytes and ECG indexes was evaluated in the whole group of the patients (hemodialysis and transplant).

Results of quantitative variables were reported as mean ± standard deviation. Statistical analyses were performed using the *t* test to compare the continuous-scale data between the groups. Pearson correlation test was used to assess the correlation between serum electrolyte levels and the QT interval. Significant levels were considered if *P* value was less than .05.

RESULTS

The mean ages were 37.7 ± 10.1 years, 39.9 ± 19.2 years, and 38.2 ± 15.1 years in the subjects of the transplant, hemodialysis, and control groups, respectively. Other main clinical characteristics are demonstrated in Table 1.

There were no significant differences in the average results of the QTc dispersion and QT dispersion between the three groups, whereas the maximum QTc was significantly lower in the control group than in the hemodialysis group ($P = .001$) and in the transplant group than in the hemodialysis group ($P = .02$). Table 2 demonstrates ECG results

Table 1. Clinical and Demographic Characteristics of Healthy Controls, Patients on Hemodialysis, and Kidney Allograft Recipients

Characteristic	Control Group	Hemodialysis Group	*P**	Transplant Group	*P*†
Age, y	38.1 ± 25.1	39.9 ± 19.2	.06	37.7 ± 10.1	.06
Sex					
Male	12	14		14	
Female	10	12	.07	12	.06
Blood urea nitrogen, mg/dL	14.70 ± 7.40	68.65 ± 20.50	< .001	28.19 ± 15.20	< .001
Serum creatinine, mg/dL	1.10 ± 0.31	12.10 ± 2.92	.01	1.30 ± 0.60	.001
Heart rate, /min	76.1 ± 12.7	78.5 ± 14.2	.06	75.8 ± 8.6	.06

*Independent *t* test between hemodialysis and control groups.
†Independent *t* test between transplant and hemodialysis groups.

Table 2. Electrocardiography Results in Healthy Controls, Patients on Hemodialysis, and Kidney Allograft Recipients

Parameter	Control Group	Hemodialysis Group	*P**	Transplant Group	*P*†
Maximum QTc, ms	415.0 ± 85.0	464.7 ± 23.0	.001	436.3 ± 19.0	.02
QTD, ms	15.1 ± 3.1	18.1 ± 5.5	.06	19.2 ± 6.4	.05
QTc dispersion, ms	24.5 ± 9.0	30.3 ± 15.1	.06	27.6 ± 8.0	.06
Axis	30.1 ± 25.5	17.6 ± 27.7	.07	30.0 ± 24.9	.07
Sokolow, ms	20.5 ± 5.2	22.2 ± 5.4	.05	24.8 ± 8.9	.05
Cornell, ms	10.3 ± 4.4	14.8 ± 5.2	.06	13.1 ± 6.1	.06

*Independent *t* test between hemodialysis and control groups.
†Independent *t* test between transplant and hemodialysis groups.

Table 3. Electrolytes and Arterial Blood Gas Results in Patients on Hemodialysis and Kidney Allograft Recipients

Parameter	Hemodialysis Group	Transplant Group	*P*
Potassium, mEq/L	5.21 ± 1.22	4.32 ± 0.44	.001
Sodium, mEq/L	134.00 ± 8.40	135.00 ± 2.90	.07
Magnesium, mEq/L	2.85 ± 0.38	1.95 ± 0.38	< .001
Calcium, mg/dL	7.77 ± 1.25	8.25 ± 0.97	.07
Bicarbonate, mEq/L	15.96 ± 2.21	21.86 ± 2.10	< .001
pH	7.31 ± 0.05	7.40 ± 0.05	< .001

and the comparisons between the controls and the hemodialysis and transplant groups.

Significant differences were observed in the levels of potassium, magnesium, bicarbonate, and pH, but not in the levels of sodium and calcium between the patients of hemodialysis and transplant groups (Table 3).

In the patients who received either hemodialysis or transplant, there was a significant correlation between the maximum QTc and serum calcium level ($P < .001$), serum magnesium level ($P < .001$), and pH ($P < .001$). But, there was no significant correlation between the maximum QTc and serum potassium level.

DISCUSSION

Patients on hemodialysis present different cardiovascular diseases and have a higher mortality rate. This is often due to the higher incidence of events such as arrhythmia which can cause sudden death.[1] Indexes of the ECG are among the studied parameters for evaluation of the cardiac rhythm status of patients with ESRD. It is suggested that markers such as QT, QTD, QTc, and QTc dispersion, like ejection fraction, heart rate variability, and heart rate, are good predictors of pathologic cardiac events, and that their limitation depends on the variability of the measuring techniques used (manual or automated).[1] The initial concept that QTD as an index of inhomogeneity was supported by link between the dispersion of ventricular recovery times and the genesis of arrhythmias.[5] It was generally believed that the standard 12-lead ECG contained information about regional ventricular repolarization; thus, when increased QTD was seen in cardiac diseases with heterogenous ventricular recovery times, it was assumed that increased QTD was a direct reflection of the disparity of ventricular recovery times.[6] Experimental studies using arterially perfused ventricular wedge prepare times have shown that the risk of drug-induced torsade-de-pointes is closely related to enhancement of the normally existing transmural dispersion of repolarization rather than of prolongation of ventricular repolarization.[7-9] This shows the relation between QT changes and repolarization time with arrhythmia.

In the present study, we demonstrated that the maximum QTc in cases of successful transplantations with normal graft function was significantly lower than that in patients on hemodialysis. However, the mean QTD obtained in the transplant group was not significantly lower than that obtained in the hemodialysis group. This finding was detected in patients with ESRD on maintenance hemodialysis and those with a kidney allograft with no clinical cardiac disease. We showed that the maximum QTc and QTc dispersion, two markers of risk for arrhythmia and sudden death, were elevated in patients on hemodialysis (even before

dialysis), and that they decreased after successful transplantation.

In a study that evaluated ECG changes during hemodiafiltration with different potassium removal rates, a correlation between repolarization indexes and plasma potassium changes was found for all the indexes, but with a different level of significances.[10] In another study, no correlation was observed between the increasing of QTc dispersion and the degree of electrolytes changes after hemodialysis.[3] Our study showed that reduction of maximum QTc in kidney allograft recipients markedly correlated with serum electrolytes magnesium, calcium, bicarbonate, and pH, but not with potassium concentration. The responsible mechanism is unclear, but slow equilibration of the extracellur concentration of potassium, magnesium, calcium, and bicarbonate can be the main cause of decreased maximum QTc and QT dispersion. To define the pathogenesis of the decrease of these markers, a well-designed study and more patients are needed. Our few number of cases and the study design performed on two different groups instead of a cohort study on a same group of patients with ESRD are our study limitation.

In summery, the QTc dispersion and maximum QTc which decrease in kidney transplant recipients may be theoretically regarded as one of the factors contributing to reduce the risk of arrhythmia and cardiac death due to heterogeneity in the ventricular recovery time.

CONCLUSIONS

Prolonged maximum QTc in patients on hemodialysis decreases toward normal by successful kidney transplantation. This corrections is most likely due to normalization of electrolytes and acid-base status from uremic state in patients on hemodialysis to normal condition in kidney transplant patients.

CONFLICT OF INTEREST

None declared.

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Correspondence to:
Ali Monfared, MD
Urology Research Center, Razi Hospital, Srdar-e-Jangal St, Rasht, Iran
Tel: +98 131 553 0169
Fax: +98 131 553 0169
E-mail: urc1384@yahoo.com

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