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ORIGINAL ARTICLE

Can hemodialysis change QRS axis in patients without cardiovascular disease?

Hemodiyaliz kardiyovasküler hastalığı olmayan hastalarda QRS aksını değiştirebilir mi?

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ABSTRACT

Objective: Due to rapid changes in volume and electrolyte concentration during hemodialysis (HD), some electrocardiographic (ECG) changes or arrhythmias can be seen. The aim of this study was to assess ECG QRS axis changes and other ECG parameters after HD in patients with end-stage renal disease (ESRD).

Methods: A total of 46 patients (65% male, mean age 52±15 years) with a sinus rhythm and without cardiovascular disease who were undergoing chronic HD treatment were included to the study. Blood samples, 12-lead electrocardiograms, and echocardiograms were recorded immediately before and at the end of an HD session. The QRS axis and other electrocardiographic, echocardiographic, electrolyte parameter, and volume changes were analyzed.

Results: The serum urea, creatinine, potassium, and B-type natriuretic peptide concentrations significantly decreased after HD, and the serum calcium levels significantly increased after HD. Body weight significantly decreased after HD. There was no significant difference in the QRS duration, PR interval, P-wave axis, QRS axis, or QT and QTc interval following HD. Based on a comparison of variables according to the any QRS axis change after HD treatment, there was no significant difference in biochemical values, HD time, ultrafiltration volume, left ventricular ejection fraction, or other echocardiographic findings.

Conclusion: ESRD and HD are complex and dynamic processes, and the change in the QRS axis is rarely emphasized in these patients. In our study, there was no significant change in the QRS axis with HD in patients without cardiovascular disease.

ÖZET

Amaç: Hemodiyaliz (HD) sırasında hacim ve elektrolit konsantrasyonlarındaki hızlı değişimlere bağlı olarak, bazı elektrokardiyografi (EKG) değişiklikleri veya aritmiler görülebilir. Bu çalışma, son dönem böbrek yetersizliği (SDBY) olan hastalarda HD sonrası elektrokardiyografik QRS aks ve diğer EKG parametreleri değişikliklerini değerlendirmeyi amaçlamaktadır.

Yöntemler: Kardiyovasküler hastalığı olmayan, sinüs ritmi olan ve kronik HD tedavisi gören 46 hasta (%65 erkek, ortalama yaş 52±15 yıl) çalışmaya dahil edildi. Kan örnekleri, 12-derivasyonlu EKG ve ekokardiyogramlar HD'den hemen önce ve sonra kaydedildi. QRS aksı ve diğer elektrokardiyografik, ekokardiyografik, elektrolit parametreleri ve hacim değişiklikleri analiz edildi.

Bulgular: Serum üre, kreatinin, potasyum ve BNP konsantrasyonları HD'den sonra anlamlı olarak azaldı ve HD'den sonra serum kalsiyum düzeyleri anlamlı olarak arttı. HD sonrası vücut ağırlığı anlamlı olarak azaldı. HD sonrası QRS süresi, PR intervali, P dalga aksıı, QRS aksıı, QT ve QTc aralığı açısından istatistiksel olarak anlamlıı değişiklik gözlenmedi. Hemodiyaliz sonrası QRS aksındaki herhangi bir değişime göre değişkenler karşılaştırıldığında, biyokimyasal değerler, HD süresi, ultrafiltrasyon hacmi, sol ventrikül ejeksiyon fraksiyonu ve diğer ekokardiyografi bulguları arasında anlamlı bir farklılık yoktu.

Sonuç: Son dönem böbrek yetersizliği, HD karmaşık ve dinamik süreçlerdir ve bu hastalarda QRS aksındaki değişim nadiren vurgulanmaktadır. Bizim çalışmamızda, kardiyovasküler hastalığı bulunmayan hastalarda HD ile QRS aksında anlamlı bir değişiklik olmadı.

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The potential to determine the electrical axis is essential in the identification of subtle early caution indicators of any cardiovascular alterations of the patient. Atypical or changed electrocardiographic axis patterns may result from changes in physical circumstances such as increased ascites, conduction disturbances (e.g., fascicular or bundle branch blocks), or biochemical imbalances (e.g., hypokalemia).[1] The detection of the electrical axis may distinguish uncharacteristic paroxysmal supraventricular tachycardia from ventricular tachycardia.[1] In essence, the QRS electrical axis could be useful to determine the position of the heart in the chest, the patency of the electrical pathways, and the integrity of the muscle mass. By itself, the QRS electrical axis is not diagnostic, but it promotes the clinician to suspect from such clinical conditions.

It is known that the mortality rate of patients who undergo HD is high. The most widespread causes of morbidity and mortality in HD patients are cardiovascular events.[2] Several studies have demonstrated that HD affects a variety of electrolyte, fluid, and acid–base parameters, as well as electrocardiography (ECG) results.[3–6] However, data on the QRS axis change in patients with end-stage renal disease (ESRD) who are undergoing dialysis are still not available.

In this study, we aimed to evaluate any changes and possible influencing factors in the QRS axis measured by both pre- and post-dialysis ECG.

METHODS

A total of 46 chronic HD patients participated in this study. The mean duration of dialysis history was 73±40 months. All of the patients who underwent chronic HD for more than six months were included in this study and dialysis was performed 3 times per week. Serum potassium, sodium, urea, creatinine, and calcium concentrations were measured immediately before the dialysis treatment. The serum concentration of these components was also evaluated immediately post hemodialysis in accordance with the Guidelines of Dialysis Outcome Quality Initiative.[7,8] Laboratory measurements were carried out using automated analyzers within 1 hour of the sample collection.

The patients, who were lying in the left lateral decubitus position, were evaluated with transthoracic echocardiography. The left ventricle (LV) dimensions and wall thicknesses were imaged using an M-mode cursor from the parasternal long axis view. The LV end-diastolic (LVEDD) and end-systolic diameters (LVESD), and the left atrial (LA) dimension and right heart dimensions and functions were all evaluated by a single reader following the standards set by the American Society of Echocardiography.[9,10] The LV ejection fraction (LVEF) was measured using Simpson's method.[11]

Abbreviations:

CAD	*Coronary artery disease*
ECG	*Electrocardiography*
ESRD	*End-stage renal disease*
HD	*Hemodialysis*
LA	*Left atrium*
LV	*Left ventricle*
LVEDD	*LV end-diastolic diameter*
LVEF	*LV ejection fraction*
LVESD	*LV end-systolic diameters*
RA	*Right atrium*
RV	*Right ventricle*
SPAP	*Systolic pulmonary artery pressure*

Simultaneous, standard surface 12-lead ECGs were performed immediately before and after HD. ECGs were performed with the patients lying in the supine position, with the ECG electrodes put on the patients during the HD session to avoid alterations in their location. The QT interval, QTc interval, QRS duration, PR interval, P wave, and QRS axis measurements were determined from the computer printout.

Despite the lack of real consensus on the normal values of the QRS axis, the American College of Cardiology and American Heart Association ECG guidelines modernized the accepted values of a normal QRS axis to -30 and +90° in 2009.[12] The QRS axis is computed using the hexa-axial reference system, although there are several ways of doing this. In addition to computer software, studies have identified a high correlation between the QRS axis computed by inspection, computer, or vector method.[13] In the present study, the computer software in the ECG machine was chosen for reasons of practicality.

Patients with pacemakers, undetectable T-waves, atrial fibrillation, bundle branch block, LV hypertrophy, and those taking class I or class III antiarrhythmic drugs were excluded from this study. Any drugs that may affect the QT interval, such as antiarrhythmics (class Ia or III), antidepressants, antibiotic/antifungal drugs, antihistamines, inotropic drugs, or cisapride were avoided by the patients. Patients with an LVEF <50%, systolic pulmonary artery pressure (sPAP) >50 mm Hg, history of coronary or other peripheral artery disease, acute coronary syndrome, severe cardiac valve disease, pericardial effusion, pulmonary embolism, cor pulmonale, body mass index >30 or <18 kg/m^2, pregnancy, or malignancy were also excluded from this study. The local ethics committee approved the study protocol, and informed consent was obtained from all of the patients.

Statistical analysis

Statistical analyses were performed using SPSS Statistics for Windows, Version 18.0 (SPSS Inc., Chicago, IL, USA). All of the parameters were evaluated for normal distribution. If the data were normally distributed, the Students' t-test was used; otherwise, the Mann-Whitney U-test was used to compare the non-normally distributed data, and a chi-square test was preferred for categorical variables. Electrocardiographic and echocardiographic data pre and post HD were compared in a paired samples t-test or a Wilcoxon signed ranks test, according to the normality test results. For all tests, a 2-tailed $p<0.05$ was considered significant.

Table 1. Demographic and clinical characteristics of the study population

Variables	n	%	Mean±SD
Gender			
Male	30		
Female	16		
Age (years)			51.13±15.85
Hemodialysis time, hours			4.70±0.50
Ultrafiltration level (mL)			2371±988
Average time on dialysis (months)			73±40
Diabetes mellitus	12	26	
Hypertension	21	46	
Body mass index (kg/m^2)			25.50±5.29

SD: Standard deviation.

RESULTS

A total of 46 patients with ESRD who were undergoing hemodialysis participated in this study. The percentage of male patients in the study was 65%, and the mean age was 52±15 years. Both the baseline demographic and clinical features of the study population are provided in Table 1. The results of the assessment of biochemical values before and after HD are presented in Table 2. It can be seen that serum urea, creatinine, potassium and B-type natriuretic peptide concentrations were significantly decreased after HD, while serum calcium levels were significantly increased after HD. Body weight decreased significantly following HD.

The results of the comparison of ECG parameters and echocardiographic results pre and post HD are demonstrated in Table 3. There was no significant difference in QRS duration, PR interval, P wave axis, QRS axis, or QT and QTc interval with HD. The mean change in QRS axis was recorded as 5.4±3.80°. The LVEDD, LVESD, LA size, area of the right atrium (RA) and right ventricle (RV), and sPAP values were found to decrease significantly after HD, whereas the LVEF and tricuspid annulus plane systolic excursion values increased significantly after HD.

An abnormal QRS axis shift was defined as >10°; however, as no patient fell into this category, the patients were evaluated regarding any QRS axis shift of ≥1° in the biochemical, HD, and echocardiographic

Table 2. Comparison of renal functions and electrolyte levels measured before and after hemodialysis

Variables	Before hemodialysis	After hemodialysis	*p*
	Mean±SD	Mean±SD	
Urea (mg/dL)	149.44±31.47	37.77±15.37	<0.001
Creatinine (mg/dL)	8.50±2.20	3.63±1.28	<0.001
Serum sodium (mEq/L)	136.21±2.73	137.90±2.20	0.102
Serum potassium (mEq/L)	5.15±0.72	3.35±0.31	<0.001
Serum calcium (mg/dL)	8.05±0.41	8.29±0.53	<0.001
Brain-type natriuretic peptide (pg/mL)	1207±952	920±673	<0.001
Weight (kg)	67.74±15.94	65.48±15.41	<0.001

SD: Standard deviation.

Table 3. Comparison of electrocardiographic and echocardiographic parameters before and after hemodialysis

Variables	Before hemodialysis	After hemodialysis	*p*
	Mean±SD	Mean±SD	
Electrocardiographic findings			
Heart rate (bpm)	84±14	90±16	0.088
QRS duration (ms)	81.43±12.01	82.85±11.52	0.156
QT interval (ms)	378.21±44.34	374.24±38.63	0.223
Corrected QT (ms)	443.87±40.90	435.36±36.85	0.106
PR interval (ms)	151.43±14.78	145.00±25.92	0.083
P wave axis	49.89±16.98	52.48±17.29	0.306
QRS axis	24 (2.5–36.5)	23 (5.7–35.2)	0.112
Change in QRS axis	–	5.4±3.8	–
Echocardiographic findings			
Left ventricular end diastolic diameter (cm)	4.86±0.57	4.61±0.56	<0.001
Left ventricular end systolic diameter (cm)	3.30±0.49	3.00±0.45	<0.001
Left ventricular ejection fraction (%)	59.08±7.14	62.73±6.56	<0.001
Left atrium size (cm)	3.83±0.51	3.70±0.53	<0.001
Right atrium area (cm^2)	14.51±3.52	12.73±3.26	<0.001
Right ventricle area (cm^2)	17.7±4.98	16.85±4.86	<0.001
Systolic pulmonary artery pressure (mm Hg)	35.82±14.21	30.16±12.69	<0.001
Tricuspid annular plane systolic excursion (mm)	18.54±3.73	20.06±2.38	<0.001

SD: Standard deviation.

Table 4. Comparison of variables according to QRS axis change after hemodialysis

Variables	No QRS axis shift (n=9)	Left QRS axis shift (n=17)	Right QRS axis shift (n=20)	*p*
	Mean±SD	Mean±SD	Mean±SD	
Hemodialysis time (hours)	5.00±0.01	4.58±0.57	4.76 ±0.52	0.173
Urea (mg/dL)	164.00±34.74	149.08±38.09	135.08±31.99	0.107
Creatinine (mg/dlL)	9.24±2.00	8.98±3.34	7.62±1.77	0.119
Sodium (mEq/L)	134.00±3.21	136.85±2.58	136.08±2.40	0.085
Potassium (mEq/L)	5.20±1.03	5.04±0.65	5.08±0.69	0.885
Calcium (mg/dL)	8.04±0.23	8.09±0.26	8.08±0.53	0.959
Left ventricular ejection fraction (%)	59.88±4.36	61.62±6.68	57.52±8.10	0.250
Ultrafiltration (mL)	2325.00±1270.26	2261.54±898.65	2.445.83±971.32	0.860
LVEDD (cm)	5.03±0.58	4.63±0.44	4.86±0.58	0.253
Left atrium size (cm)	3.75±0.49	3.84±0.53	3.72±0.59	0.740
Right atrium area (cm^2)	13.36±3.94	14.62±2.60	14.64±3.67	0.643
Right ventricle area (cm^2)	18.42±6.92	17.68±3.25	17.03±4.19	0.744
TAPSE (mm)	16.70±6.61	19.46±2.85	18.68±2.63	0.243

LVEDD: Left ventricular end diastolic diameter; TAPSE: Tricuspid annular plane systolic excursion; SD: Standard deviation.

findings. The comparison of the variables related to the QRS axis change after HD is presented in Table 4. No significant difference was identified in biochemical values, HD time, ultrafiltration volume, LVEF, or any other echocardiographic finding according to QRS axis change.

DISCUSSION

In this study, the findings showed that electrolyte, volume, and hemodynamic changes induced by HD did not seem to affect the QRS axis in hypervolemic patients with regular LV and RV systolic functions, a normal-sized heart cavity, and without coronary artery disease (CAD). No significant axis shift was noted after HD.

The effects of volumetric and electrolyte changes that arise from ultrafiltration during HD were investigated not only in the QRS axis, but also in the echocardiographic and electrocardiographic parameters in this study. First, the effect of volume change on cardiac function was investigated with an echocardiographic examination. The findings indicated that the mean LVEF value increased after HD , whereas the diameter of the LV and the volume of the LA (left atrium) decreased. In earlier studies, Ozdemir et al.[14] found that LVEF increased after HD, while Drighil et al.[15] detected that the LV decreased in diameter. In the present study, however, it was observed that these changes did not affect the QRS axis. These findings could be attributed to the fact that many myocardial cells are depolarized in the same direction at the same time, creating a larger vector, and so the mean cardiac axis may be present in the same direction.

We also found a decrease in the RA area and improvement in RV function in our analysis, similar to previous studies, although these changes did not affect the QRS axis in our study.[16,17] There is a possible explanation for this. In a healthy adult heart, the larger muscle mass of the LV cancels out the detection of the electrical activity of the RV in what can be described as a "tug of war," leaving approximately 20% of the LV electrical activity for the ECG to sense.[18] This is why the normal QRS axis is directed downward, toward the left and in the same direction.

Electrolytes that affect depolarization can influence the mean electrical cardiac axis.[19] Potassium, calcium, and also ultrafiltration may be the most important determinants of the ECG parameters of HD patients and HD-induced repolarization abnormalities, and these factors may also affect the QRS axis. In our study, the PR, QRS, QT and QTc intervals did not change before or after HD. Previous studies have reported similar findings in different outcomes, which may be due to differences in the baseline characteristics of patients and hemodialysis.[6,20,21,22] Calcium levels increased while serum potassium levels decreased in our study, although these changes did not result in any electrocardiographic changes. The QRS axis, which has not been assessed previously, was evaluated, and no significant change was seen in the QRS axis. The absence of any change in the QRS axis may be attributed to the characteristics of the selected study group.

When studies related to the QRS axis are evaluated, in clinical practice, a QRS axis shift may point to CAD. Recent reports have shown that an exercise-induced QRS axis shift may be related to CAD.[23–28] In a different study, the role of QRS axis change was evaluated in an assessment of the efficacy of thrombolytic therapy and the determination of the prognostic infarct size.[29] In another study, a change in the QRS axis after a mitral balloon valvuloplasty was found to be associated with hemodynamic improvement.[30] We believe that a QRS axis change before and after HD in cardiovascular patients may indicate the presence of cardiovascular problems. The lack of cardiac problems in our study population and the absence of significant QRS axis changes after HD support this hypothesis.

Limitations

There are some limitations to this study. First, our study was a small sized single center study. Further large scale studies are needed to confirm our findings. The second limitation of our study is related to the lack of data about the course of electrolytes other than potassium, sodium, and calcium. The third limitation is that to estimate the QRS axis of patients, an ECG machine software program was used, and the final limitation is that only 1 HD session was evaluated.

Conclusion

In conclusion, as ESRD and HD are complex and dynamic processes, changes in the QRS axis are rarely emphasized in such patients. In our study, no significant change was seen in the QRS axis with HD in patients without cardiovascular disease.

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Keywords: End-stage renal disease; hemodialysis; QRS axis

Anahtar sözcükler: Son dönem böbrek yetersizliği; hemodiyaliz; QRS aksı.