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Assessment of aortic stiffness, myocardial performance index and cardiac functions in patients with end-stage renal disease

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Abstract

Aim: Chronic renal failure is a prevalent health disorder in which risk for cardiovascular disease is increased. Cardiovascular diseases (CVDs) are one of the leading causes of mortality in this patient population. Aortic stiffness is an early and independent marker for CVDs. We aimed to investigate aortic stiffness in patients with end-stage renal disease (ESRD).

Material and Methods: This study was conducted on patients who underwent hemodialysis with ESRD in Hemodialysis Unit of Nephrology Department of Goztepe Teaching Hospital between July, 2009 and November, 2009. The study included 65 patients with ESRD and 20 healthy controls. Systolic and diastolic functions of left ventricle, aortic stiffness and TEI index were evaluated in all subjects by using echocardiography.

Results: Systolic and diastolic blood pressures were higher in the patient group compared to the control group ($p<0.05$). Having compared the patient and control groups, it was found that diastolic ventricular functions and TEI index were significantly impaired in the patient group. The aortic strain and distensibility were decreased while aortic stiffness index was increased in the patient group compared to the control group ($p<0.05$).

Conclusion: We observed impaired cardiac functions , increased aortic stiffness and myocardial performance index (MPI) in patients with ESRD. However, we believe that this area needs more study.

Keywords: Aortic Stiffness; End-Stage Renal Disease; Myocardial Performance Index.

INTRODUCTION

Chronic renal failure is a common public health issue worldwide with increased cardiovascular risk in this patient population (1).

Approximately 50% of deaths related to en-stage renal disease ESRD result from cardiovascular causes and the pathophysiological mechanism is complex. In this process, left ventricular dilatation and myocardial fibrosis, termed as uremic cardiomyopathy, develop as a result of events including increased arterial stiffness, chronic inflammation and autonomic equilibrium (2). Aortic stiffness is an early and independent marker for cardiovascular diseases and can be assessed by measurement of pulse wave velocity in vivo. It is observed to be increased in elder individuals (3).

Despite challenges in the measurement of aortic stiffness, it is able to show cardiovascular risk factors as a single value (4). Here, we investigated cardiac functions and aortic stiffness.

MATERIAL and METHODS

This study was conducted on patients who underwent hemodialysis with ESRD in Hemodialysis Unit of Nephrology Department of Goztepe Teaching Hospital between July, 2009 and November, 2009. Before the study, demographic data and history including cardiac risk factors as well as data regarding dialysis were recorded for all patients.

Echocardiographic measurements

In all subjects, echocardiography was performed by a single operator via General Vivid 3 Pro device. All measurements were taken by a single operator on parasternal long-axis, short-axis, apical four-chamber and five-chamber images

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via 2-dimensional M-mode continuous wave Doppler and pulsed wave Doppler sonography while patient was at left lateral decubitus position. The M-mode measurements (left ventricular diastolic and systolic diameters, left atrial systolic diameter and aortic diameter) were performed in accordance with recommendations by American Society of Echocardiography. Systolic and diastolic aortic diameters were measured from trace obtained after placing M-mode probe 3 cm distal to ascending aorta. Systolic diameter was measured from area with maximum anterior movement while diastolic diameter from area corresponding to R peak of ECG.

Mitral early diastolic velocity (E), deceleration time (DT) and late diastolic velocity (A) were obtained by placing sampling volume to the level of mitral annulus on apical four-chamber image. Isovolumic relaxation time (IVRT) was defined as time from the end of aortic flow trace to the initiation of mitral trace by placing sampling volume to left ventricular outlet on apical long axis image. Em and Am flow velocities were measured from septal portion of mitral annulus by using tissue Doppler.

Estimation of Aortic Elasticity Markers

Aortic elasticity markers were calculated by using following formula:

Aortic strain (%) = [(systolic aortic diameter-diastolic aortic diameter) x 100]/ diastolic aortic diameter

Distensibility (cm2/dyn/103) = (2 x aortic strain) (systolic blood pressure-diastolic blood pressure)

Aortic stiffness index= ln (SBP-DBP)/Aos-AoD/AoD

Estimation of Myocardial Performance Index

Cardiac time intervals can be obtained by using pulsed wave Doppler echocardiography (PWDE) techniques. Myocardial performance index (MPI) is a numeric value obtained by using cardiac time intervals. This numeric value is calculated by dividing the sum of isovolumic contraction time (IVCT) and isovolumic relaxation time (IVCT) by ejection time (ET).

MPI can be calculated separately for each ventricle. By using PWDE techniques, time interval from end to initiation of mitral flow (a) was measured after placing sampling volume to tips of mitral leaflets on apical four-chamber images. Left ventricular ejection time (LVEZ) (b) was measured by placing sampling volume just below aortic valves at left ventricular outlet on apical five-chamber images. Left ventricular total isovolumic time (IVCT+IVRT) can be calculated by subtracting LVEZ from time between the end and the initiation of mitral flow (a-b). Thus, MPI can be readily calculated (a-b/b).

Statistical analysis

All statistical analyses were performed by using NCSS 2007 and PASS 2008 Statistical Software. Data were assessed by using descriptive statistics (mean, standard deviation, frequency).

Student's t test and Mann Whitney U test were used to compare quantitative data. Spearman's correlation coefficient was used to assess relationships among parameters. Chi-square test was used to compare qualitative data. A p value<0.05 was considered statistically significant.

RESULTS

There was no significant difference in age and gender between patient and control groups (Table 1). Table 2 shows causes of renal failure in the patient group.

Table 3 presents heart rate and blood pressure values in patient and control groups.

Systolic and diastolic blood pressures were higher in the patient group than those in the control group (p<0.05). No significant difference was found in heart rate between patient and control groups (p=0.904).

When patient and control groups were compared, it was found that left ventricular diastolic function, Left ventricular ejection fraction (LVEF), intraventricular septum thickness in diastole (IVSd), the thickness of the rear wall of the left ventricle (LVPWDs), DT, IVRT, E/E1 and TEI index were significantly impaired in the patient group. The left ventricular diastolic diameter was smaller in the patient group as compared to the control group but the difference wasn't statistically significant (Table 4).

It was found that aortic strain and distensibility were decreased while aortic stiffness was increased in the patient group (p<0.05) (Table 5).

Table 1. Demographic characteristics of subjects included

		Patients	Controls	P value
Age		54.74±13.84	50.10±8.82	0,082*
Gender n (%)	Female	27 (41.5)	10 (50)	0,504**
	Male	38 (58.5)	10 (50)	

*Student's t test, **Chi-square test

Table 2. The causes of chronic renal failure in the patient group

Disease	N	%
DM	9	13.8
Hypertension	16	24.6
DM-hypertension	11	16.9
Polycystic kidney	5	7.7
Pyelonephritis	5	7.7
Amyloidosis	2	3.1
Glomerulonephritis	3	4.6
Post-renal causes	2	3.1
No cause	12	18.5

Table 3. Heart rate and blood pressure values in patient and control groups

	Patient	Control	P value*
HR	75.61±6.94	75.40±7.00	0,904
SBP (mmHg)	140.15±17.16	120.50±8.25	0,001
DBP (mmHg)	79.61±8.54	69.00±7.88	0,001

*Student's t test, (HR) heart rate, (SBP) systolic blood pressure, (DBP) diastolic blood pressure

Table 4. Assessment of echocardiographic results

	Patient	Control	P value*
LVEF (%)	65.86±12.35	70.15±5.68	0.035
Left atrial diameter (cm)	3.71±0.53	3.39±0.44	0.015
Systolic aortic diameter (mm)	32.30±3.41	28.72±1.78	0.001
Diastolic aortic diameter (mm)	31.51±3.33	25.91±1.91	0.001
LVIDd (mm)	45.05±7.31	46.66±2.93	0.155
LVPWDd (mm)	12.19±1.89	10.03±0.85	0.001
IVSd (mm)	12.54±2.22	10.54±0.80	0.001
E (cm/sn)	68.11±20.68	85.65±13.40	0.001
A (cm/sn)	88.75±26.35	65.00±10.69	0.001
E/A	0.83±0.38	1.32±0.19	0.001
E/E'	8.03±3.43	6.68±1.51	0.011
DT (ms)	252.81±46.90	199.25±16.35	0.001
IVRT (ms)	104.00±12.07	77.20±5.96	0,001
ET (ms)	251.25±33.39	278.35±14.76	0,001
TEI index	0.67±0.13	0.45±0.05	0,001

*Student's t test

Table 5. Assessment of aortic strain, distensibility and stiffness according to groups

Parameters	Patient Mean± SD (Median)	Control Mean+ SD (Median)	P value*
Aortic strain (%)	2.88±1.59 (2.13)	10.25±1.71 (10.73)	0,001
Distensibility (cm2/dyn/103)	1.09±0.53 (1)	4.73±0.88 (4.83)	0,001
Aortic stiffness index	0.021±0.014 (0.023)	0.0079±0.002 (0.079)	0,001

*Mann Whitney U test

DISCUSSION

In uremic patients, macro-vascular disorders can result in ischemic heart diseases, left ventricular hypertrophy, congestive heart failure or sudden death. Complication may develop even in the absence of clinically apparent atherosclerosis in most patients with ESRD. Here, the primary mechanism is arterial dilatation and arterial stiffness related to hypertrophy (5).

In patients with ESRD, two major mechanisms, atherosclerosis and arteriosclerosis, play role in the development of cardiovascular disease. The arteriosclerosis is the predominant mechanism in cardiovascular events (6). Age, hypertension and diabetes mellitus are main risk factors for aortic stiffness (7,8). There are publications suggesting that aortic stiffness is related to an inflammatory process; thus, inflammatory disorders could be the cause of aortic stiffness (9). It has been found that diseases progressing with inflammation such as systemic lupus erythematosus (10), systemic vasculitis (11) and inflammatory bowel diseases(12) lead to increased arterial stiffness.

In a study on 241 patients, Blacher et al. showed that increase in aortic stiffness is an independent predictor for cardiovascular mortality in patients with ESRD (5). Again, in a study by Zapolkski et al., it was seen that aortic stiffness, atherosclerotic plaques in aorta and large vessel calcification were increased in patients with ESRD. It was found that the degree of aortic stiffness wasn't related to calcification in mitral leaflets or extra-valvular calcification (13).

The MPI is a parameter that assesses systolic and diastolic components of left ventricle together (14). The MPI, also known as TEI index, is calculated by dividing sum of isovolumic contraction time and isovolumic relaxation time by ejection time. It can be readily calculated by using echocardiography. It is a widely accepted parameter which isn't influenced by factors such as heart rate and ventricular structure of preload (15).

It was found that MPI is an independent risk factor for mortality in acute myocardial infarction (16). In a study by Nizamuddin et al., the MPI worsening within first 24 hours after ICU admission was found to be related to 90-days mortality in patients with severe sepsis (17). It was also found to be increased in subclinical hypothyroidism (15) and lichen planus (18). We also observed significant increase in MPI in our study.

In this study, it was found that cardiac functions were impaired with decreased aortic elasticity and increased thickness of left ventricular wall. We think that the MPI can be used as a parameter in the assessment of cardiac functions in patients with ESRD.

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