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ARAŞTIRMA / RESEARCH

The presystolic wave was not sufficient for diagnosing subclinical left ventricular diastolic dysfunction in hemodialysis patients

Hemodiyaliz hastalarında subklinik sol ventrikül diyastolik fonksiyon bozukluğu tanısında prestostolik dalga yetersiz kalmıştır

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Abstract

Purpose: In hemodialysis patients, detection of left ventricul diastolic dysfunction as early as possible is critically important. The presystolic wave occurs in the left ventricul outflow tract and it's associated with left ventricul stiffness and compliance. The aim of this study was to evaluate the clinical significance of presystolic wave in the detection of diastolic dysfunction in hemodialysis patients.
Materials and Methods: In this cross-sectional study, eighty hemodialysis patients and 88 healthy controls were included in the study. The laboratory parameters were tested before the dialysis. The conventional B-mode, pulsed doppler parameters, doppler tissue-imaging, and presystolic wave measurements were performed at echocardiography.
Results: Presystolic wave was detected in 46.0% of patients and 18.1% of the control group. There was no statistically significant difference between patients in terms of MPI, mitral E and A wave velocity, E/A and e'/a' ratio, deceleration time, septal a' and e' wave velocity, and Sao in either presence or absence of presystolic wave. In the univariate model, higher Eao velocity and septal E/e' ratio, and reduced duration of hemodialysis were determined as risk factors for the presence of presystolic wave.
Conclusion: The assessment of presystolic wave on echocardiography examination may provide important information about the left ventricul diastolic function. But we have demonstrated in this study that presystolic wave is not entirely associated with left ventricul diastolic dysfunction in hemodialysis patients.
Keywords: Diastolic dysfunction, heart failure, hemodialysis

Öz

Amaç: Hemodiyaliz hastalarında, sol ventrikül diyastolik fonksiyon bozukluğunun mümkün olduğu kadar erken saptanması kritik öneme sahiptir. Presistolik dalga sol ventrikül çıkış yolunda saptanmaktadır ve sol ventrikül sertliği ve uyumu ile ilişkilidir. Bu çalışmanın amacı, hemodiyaliz hastalarında presistolik dalganın diyastolik fonksiyon bozukluğunun saptanmasında yardımcı olup olamayacağını değerlendirmektir.
Gereç ve Yöntem: Bu kesitsel çalışmada, 80 hemodiyaliz hastası ve 88 sağlıklı kontrol çalışmaya dahil edildi. Laboratuvar parametreleri diyalizden önce test edildi. Ekokardiyografide konvansiyonel B mod, darbeli doppler parametreleri, doppler doku görüntüleme ve presistolik dalga ölçümleri yapıldı.
Bulgular: Presistolik dalga hastaların % 46.0'sında ve kontrol grubunun % 18.1'inde tespit edildi. Hastalarda miyokard performans indeksi, mitral E ve A dalga hızı, E / A ve e '/ a' oranı, deselerasyon zamanı, septal a' ve e' dalga hızı ve Sao açısından presistolik dalga olan ve olmayan arasında istatistiksel olarak anlamlı fark yoktu. Univariate analiz sonucunda, yüksek Eao hızı ve septal E / e 'oranı ve kısa hemodiyaliz süresi presistolik dalga varlığı için risk faktörü olarak belirlendi.
Sonuç: Ekokardiyografik olarak presistolik dalganın değerlendirilmesi sol ventrikül diyastolik fonksiyonu hakkında önemli bilgiler sağlayabilir. Ancak çalışmamızda presistolik dalganın hemodiyaliz hastalarında sol ventrikül diyastolik fonksiyon bozukluğu ile ilişkili olmadığını gösterdik.
Anahtar kelimeler: Diyastolik fonksiyon bozukluğu, hemodiyaliz, kalp yetmezliği

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INTRODUCTION

Cardiovascular diseases are the most common cause of mortality in patients with chronic renal failure[1]. Left ventricular (LV) hypertrophy, cardiac arrhythmia, systolic, and diastolic LV dysfunction are frequently seen in the patients with chronic renal failure[2]. However, hemodialysis itself may also contribute to the high prevalence of cardiac morbidity and mortality[3]. Early detection of an increased cardiovascular risk in hemodialysis patients is essential in improving patient survival[4]. The incidence of heart failure (HF) with preserved LV systolic function has increased in recent years[5]. It has been shown that HF with preserved ejection fraction (EF) in the patients with end-stage renal disease, however, its diagnosis is challenging because it manifests similar symptoms with fluid overload[6]. The prevalence of diastolic dysfunction in hemodialysis patients ranges from 25%-87%[7]. As in the population without renal dysfunction, diastolic dysfunction is associated with adverse cardiovascular events in hemodialysis patients[8]. Hemodialysis may also itself contribute to the development of diastolic dysfunction as well as uremic myocardial disease, atherosclerosis, and cardiac remodeling[9,10]. In hemodialysis patients, detection of LV diastolic dysfunction as early as possible is critically important in predicting high-risk patients for the development of HF.

The blood that enters the LV during atrial systole creates a countercurrent blood flow towards the aortic valve along the septum. As a consequence, a presystolic wave (PSW) occurs in the LV outflow tract at the late diastolic period[11]. Other probable factors for the occurrence of PSW are LV stiffness and impaired LV compliance12,13. However, no data on its prevalence, its relationship with echocardiographic parameters and clinical significance in hemodialysis patients been reported. Many diastolic function parameters which complicate diagnosis have been determined to detect diastolic dysfunction in hemodialysis patients. Therefore, we have investigated whether PSW may indicate diastolic dysfunction in hemodialysis patients taking into consideration that PSW contributes to ventricular stiffness and LV compliance.

MATERIALS AND METHODS

This prospective cross-sectional study included nondiabetic and nonhypertensive 80 hemodialysis patients and a control group comprised of 88 age- and gender-matched healthy control participants. When selecting the control group, they were paid attention to be completely healthy individuals. It was proved that the control group did not have chronic diseases such as diabetes mellitus (DM), coronary artery disease and hypertension which are known to cause diastolic dysfunction. The participants were selected from the patients who have been undergoing regular dialysis treatment in the dialysis unit of Cukurova University Hospital in Turkey. One hundred-eight dialysis patients were approached, but exclusion criteria were taken into consideration, 28 patients were excluded from the study and finally 80 dialysis patients were included in the study. Exclusion criteria were as follows; i) systolic heart failure (EF<50%), ii) coronary artery disease (clinical and ECG evidence of myocardial ischemia), iii) diabetes mellitus (fasting blood glucose>125 mg/dl or HbA1C>6.5% or on antidiabetic medication), iv) hypertension (history of HT or ongoing antihypertensive medication), v) chronic atrial fibrillation or other known arrhythmia, and vi) current smokers. This study was approved by the Medical Ethics Committee of Cukurova University under the protocol number 79 at July of 2018. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013.

Procedure

The baseline characteristics and clinical data of the study population were documented. A cardiologist performed cardiovascular assessment and a nephrologist examined the patients with end-stage renal disease. The patients continued to receive regular hemodialysis treatment. No specific intervention was performed before the dialysis session to change patient habits of regarding their adherence to fluid restriction or drug regimen. Systolic and diastolic blood pressure were measured before the dialysis section. Laboratory tests, including serum creatinine, albumin, hemoglobin (Hb), calcium, and phosphorus levels were obtained by standard enzymatic procedures using fasting blood before the dialysis. We calculated body mass index (BMI) on the next day after dialysis in our study.

Echocardiographic evaluation

The echocardiographic examination was performed by an experienced cardiologist who was blinded to

the patients' clinical and demographic data using the Vivid S5 cardiovascular ultrasound system with a 3S 1.5 - 3.6 MHz transthoracic probe (GE Medical Systems, Buckinghamshire, UK). Echocardiographic data were recorded during end-expiratory apnea. Conventional B-mode and pulsed Doppler parameters were measured according to the guideline of the American Society of Echocardiography [14]. Volume reduction typically affects mitral inflow and annular early diastolic velocities in the patients who receive hemodialysis. Hence, we performed echocardiography on the next day after dialysis to minimize the effect of the change in the filling volume on Doppler parameters in our study.

Left ventricular EF was calculated using the modified Simpson's formula [14]. The LV indices (end-diastolic and end-systolic internal volumes, LV mass indexed to body surface area, interventricular septal and posterior wall thickness were measured according to the guidelines of the American Society of Echocardiography and European Association for Cardiovascular Imaging 15. Aortic root analyses were performed at the annular plane in all cases. All measurements were performed on M-mode images.

The tissue doppler imaging (TDI) program was set to the pulsed-wave doppler mode. The Nyquist limit was adjusted to a velocity range of 15 cm/s - 20 cm/s and filters were set to exclude high-frequency signals. The transthoracic echocardiographic parameters used to assess diastolic LV function included peak early filling velocity (E-wave) divided by late diastolic filling velocity (A-wave), and isovolumetric relaxation time (IVRT). Then we recorded the tissue Doppler velocity analysis of the lateral and septal parts of the mitral annulus. Septal e' velocity and septal a' velocity were measured, then e'/a' ratio was calculated to estimate LV filling pressure.

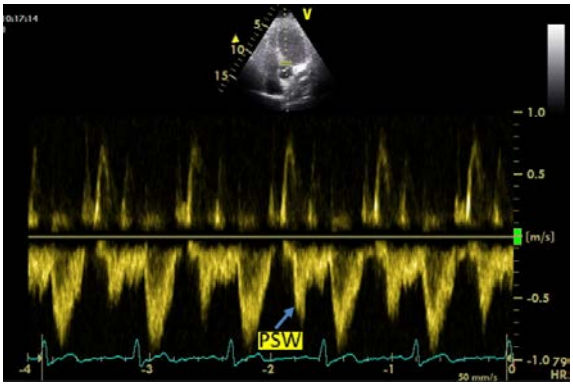
The E/e' ratio, which is obtained by calculating early diastolic transmitral flow velocity (E) and mitral annular velocity at the early diastolic session on tissue Doppler (e'), was reported as a useful indicator for reflecting the LV filling pressure [16]. In healthy individuals, E/e´ ratio is <8. In the presence of diastolic dysfunction/impaired relaxation, e´ will be rather low. In contrast, the E-wave increases with high filling pressures. Thus the E/e´ ratio will increase in diastolic dysfunction [17].

The myocardial performance index (MPI) is a parameter for global ventricular performance. The MPI consists of 3 variables derived from the doppler spectrum. The formula is MPI= ((Isovolumic contraction time (IVCT) + IVRT/ Ejection time (ET)). Isovolumic contraction time will increase when systolic dysfunction is present in patients [18].

The wall motion velocities of ascending aorta were measured by TDI at the same point as in the M-mode measurements. The TDI of expansion peak aortic wall systolic velocity (Sao, cm/s) and aortic wall early diastolic retraction velocities (Eao, cm/s) were obtained with a 1-mm sample volume size. The resulting velocities were recorded for 5–10 cardiac cycles and stored for future reviews and analyses.

Pulse-wave spectral Doppler of the left ventricular outflow tract (LVOT) was evaluated by placing the pulse-wave sample volume in the LVOT, approximately 1 cm from the aortic valve in the apical five-chamber window. PSW preceding the LVOT flow was also investigated (Figure 1).

Figure 1. Typical appearance of a PSW on pulse-wave Doppler examination of the LVOT.



Statistical analysis

The statistical analysis was performed using IBM SPSS Version 20.0 software package (SPSS Inc., Chicago, IL, USA). Conformity of the data to normal distribution was checked using the Shapiro−Wilk test. Descriptive statistics were used to determine the median value (interquartile range) of the parameters. Intergroup and inter-subgroup comparisons in terms of clinical and echocardiographic variables were analyzed for continuous and categorical variables using the Mann−Whitney U and the Chi−square test, respectively. Binary logistic regression analysis was used to determine the risk factors for the presence of PSW. The relationship between the clinical variables and ECHO parameters was assessed with Spearman's

correlation analysis. The strength of the correlation was graded as very weak (r_s=0−0.19), weak (r_s=0.20−0.39), moderate (r_s=0.40−0.59), strong (r_s=0.60−0.79), or very strong (r_s=0.80−1.0). The level of statistical significance was accepted as $p<0.05$.

RESULTS

Eighty patients and 88 healthy controls were included in the study. Baseline characteristics and clinical variables of the study population were given in Table 1.

Table 1. Baseline characteristics and clinical variables of the study population

	Patients (n=80)	Healthy controls (n=88)	p value
Age (years)[a]	51.4±13.0	52.4±7.9	**0.691**
BMI (kg/m^2)[a]	26.4±2.7	25.6±3.5	**0.169**
Gender (Male[b])	47(58.7)	50(56.8)	**0.227**
Systolic BP (mmHg)	132.7±9.2	118.7±10.2	**<0.001**
Diastolic BP (mmHg)	79.8±6.8	77.4±7.3	**0.076**
Heart rate (/min)	81.3±6.6	80.4±7.9	**0.529**
Creatinine (mg/dl)	9.8±1.6	0.7±0.1	**<0.001**
Hemoglobin (g/dl)	11.2±0.9	13.5±0.7	**<0.001**
Albumin (g/dl)	3.6±0.3	4.1±0.3	**<0.001**
Calcium (mg/dl)	9.2±0.2	8.8±0.6	**<0.001**
Phosphorus (mg/dl)	4.9±0.7	3.2±0.3	**<0.001**

[a]Values are given as mean±standard deviation; [b]Values are given as n (%); BMI: Body Mass Index, DM: Diabetes Mellitus, HT: Hypertension.

There was no statistically significant difference between the two groups with respect to age, BMI, gender, heart rate, and diastolic blood pressure. Accordingly, the mean age of the patients and the control subjects were 51.4 and 52.4 years (p=0.691), respectively. PSW was encountered in 31.5% of the study population. Therefore, PSW was detected in 46.0% and 18.1% of the patients, and control subjects (x^2=0.01), respectively. The etiology of renal failure was unknown in 15 (19%) patients while chronic glomerulonephritis, polycystic kidney disease, toxic nephropathy and vesicoureteral reflux were found in 29 (36%), 11 (14%), 8 (10%), 10 (12%) and 7 (9%) patients, respectively.

The patients and control groups were divided into two subgroups based on the absence and presence of PSW (table 2); septal E/e' ratio was statistically significantly higher in the presence of PSW in both groups (15.4 vs 10.7, p=0.002 for patients; 17.4 vs 12.4, p=0.006 for controls), IVCT was statistically significantly higher in the presence of PSW (107.0 vs 92.0 ms, p=0.015) in patients; EAo was statistically significantly higher in the presence of PSW (5 vs 4 m/s, p=0.003) in patients. LV mass index was statistically significantly higher in the presence of PSW in controls (103.5 vs 88 g/m2, p=0.035) (Figure 2).

The duration of hemodialysis treatment was shorter in hemodialysis patients with PSW than those without PSW (respectively 28.0 vs 50.0 months, p= 0.001). Interestingly, there was no statistically significant difference between patients in terms of LA anteroposterior diameter, LVOT diameter, MPI, mitral E wave velocity, mitral A wave velocity, E/A ratio, deceleration time, septal a' wave velocity, septal e' wave velocity, e'/a' ratio and Sao in either presence or absence of PSW.

Multivariate analysis was performed to identify the variables that were important with respect to the presence of PSW in hemodialysis patients. Multivariate logistic regression analysis showed that higher Eao velocity [Odds ratios (OR) 15.344; with a 95% confidence interval (CI): 2.582-91.167, p=0.003], higher septal E/e' ratio (OR 1.554; with a 95% CI: 1.167-2.069, p =0.003), and reduced duration of hemodialysis (per year) (OR 0.375; with a 95% CI: 0.180-0.782, p=0.009) were the independent determinants of PSW (Table 3). Each decrease in the hemodialysis duration per year caused a 2.66-fold increase in risk for the presence of PSW. An increase of 0.1 unit in Eao velocity caused a 15.344-fold increase in risk for the presence of PSW. On the other hand, E/e' ratio was found as the most significant risk for presence of PSW according to the multivariable model. An increase of 0.1 unit in septal E/e' ratio caused a 1.55-fold increase in risk for presence of PSW.

Table 2. The comparison of the ECHO parameters between groups according to the absent or present of PSW

	Patients (n=80)		p	Controls (n=88)		p
	PSW absent (n=43)	PSW present (n=37)		PSW absent (n=72)	PSW present (n=16)	
EF (%)	60.0 (51.0-68.0)	60.0 (52.0-67.0)	0.960	65.0 (60.0-70.0)	65.0 (60.0-66.0)	0.054
IVS (mm)	11.0 (8.0-15.0)	12.0 (8.0-15.0)	0.531	9 (8.0-12.0)	9.5 (8.0-12.0)	0.697
PW (mm)	11.0 (8.0-15.0)	11 (8.0-14.0)	0.813	9 (8.0-12.0)	9.0 (8.0-10.0)	0.620
LVDD (mm)	48.0 (39.0-57.0)	48.0 (38.0-55.0)	0.914	44 (35.0-50.0)	46.0 (36.0-53.0)	0.072
LV mass index (g/m2)	125.0 (87.0-144.0)	125.0 (83.0-148.0)	0.868	88 (72.0-110.0)	103.5 (72.0-117.0)	0.035
LVSD (mm)	30 (24-39)	30 (22-38)	0.953	30 (22-35)	32.0 (22.0-36.0)	0.104
LA anteroposterior diameter (mm)	41.0 (26.0-53.0)	37.0 (28.0-48.0)	0.482	33 (24.0-37.0)	33.5 (24.0-35.0)	0.925
LVOT diameter (mm)	25.6 (20.0-34.3)	26.4 (19.0-32.3)	0.579	24 (18.2-31.1)	23.0 (20.0-26.0)	0.324
AoS (mm)	30.1 (18.1-47.0)	30.1 (26.4-37.0)	0.922	44 (35.0-49.0)	46.0 (36.0-48.0)	0.097
AoD (mm)	29.2 (22.1-40.3)	29.2 (24.8-36.4)	0.785	30 (22.0-35.0)	32.0 (22.0-36.0)	0.104
Aortic root (mm)	26.0 (21.0-30.0)	26.0 (20.0-31.0)	0.499	28 (21.0-31.0)	27.0 (21.0-30.0)	0.864
MPI	0.44 (0.28-1.4)	0.54 (0.26-1.40)	0.302	0.40 (0.20-0.66)	0.43 (0.27-0.62)	0.130
E (cm/s)	78.28 (25.8-90.3)	92.4 (32.51-177.41)	0.139	80 (35.3-120.3)	80 (45.2-110.5)	0.822
A (cm/s)	88.0 (60.7-120.0)	93.0 (60.20-130.0)	0.275	80 (50.5-120.4)	80 (60.4-120.3)	0.558
E/A ratio	1.02 (0.3-1.73)	1.17 (0.54-1.57)	0.311	1.12 (0.29-1.71)	1.06 (0.50-1.33)	0.542
Septal E/e' ratio	10.7 (5.0-16.4)	15.4 (6.3-20.4)	0.002	12.4 (6.0-22.8)	17.4 (7.4-22.4)	0.006
LVOT VTI (cm)	18.2 (13.3-32.0)	19.0 (12.5-36.0)	0.838	20.6(13.2-38.5)	18.4 (11.2-23.1)	0.087
DT (ms)	203.1 (171-217)	188.3 (154-209)	0.074	217.1 (171-228)	196.3 (164-209)	0.084
IVCT (ms)	92.0 (55.0-134.0)	107.0 (77.0-167.0)	0.015	95 (37.0-128.0)	100 (58.0-170.0)	0.665
IVRT (ms)	102.0 (174.0-180.0)	116.0 (76.0-190.0)	0.239	112 (69.0-199.0)	110 (84.0-190.5)	0.955
Septal e' (cm/s)	7.9 (3.0-13.0)	8.0 (5.0-14.0)	0.552	7.4 (3.6-14.0)	7 (4.6-11.8)	0.839
Septal a' (cm/s)	8.0 (4.5-14.0)	8.0 (5.0-11.5)	0.359	7(4.7-11.7)	8.4 (6.0-11.2)	0.141
e'/a' ratio	0.95 (0.2-1.7)	1.09 (0.7-2.0)	0.307	1 (0.32-2.17)	0.8 (0.51-1.4)	0.223
SAo (m/s)	5.8 (3.6-6.8)	5.8 (4.0-7.1)	0.915	6 (3.1-7.5)	5.3 (3.7-7.3)	0.374
EAo (m/s)	4.0 (3.1-5.7)	5.0 (3.6-5.7)	0.003	4.3 (3.2-5.6)	4.65 (3.60-5.40)	0.431
Hemodialysis time (per months)	50.0 (5.0-69.0)	28.0 (4.0-49.0)	0.001			

Values are given as median (interquartile range); AoD: Ascending aorta diastolic diameter; AoS: Ascending aorta systolic diameter; DT: Deceleration time; EAo: Aortic wall early diastolic retraction velocity; EF: Ejection fraction; IVCT: Isovolumic contraction time; IVRT: Isovolumetric relaxation time; IVS: Interventricular septum; LA: Left atrium; LV, left ventricular; LVDD: Left ventricular end-diastolic diameters; LVOT VTI: Left ventricular outflow tract velocity time integral; LVSD: Left ventricular end-systolic diameters; MPI: Myocardial performance index; PW: Posterior wall, Sao: Aortic wall systolic velocity.

Table 3. Modeling association of risk factors of the presence of PSW in hemodialysis patients

Variables	OR (95% CI)	p value
Eao velocity (m/s)	15.344 (2.582-91.167)	0.003
Septal E/e' ratio	1.554 (1.167-2.069)	0.003
Hemodialysis time (per year)	0.375 (0.180-0.782)	0.009

EAo: Aortic wall early diastolic retraction velocity

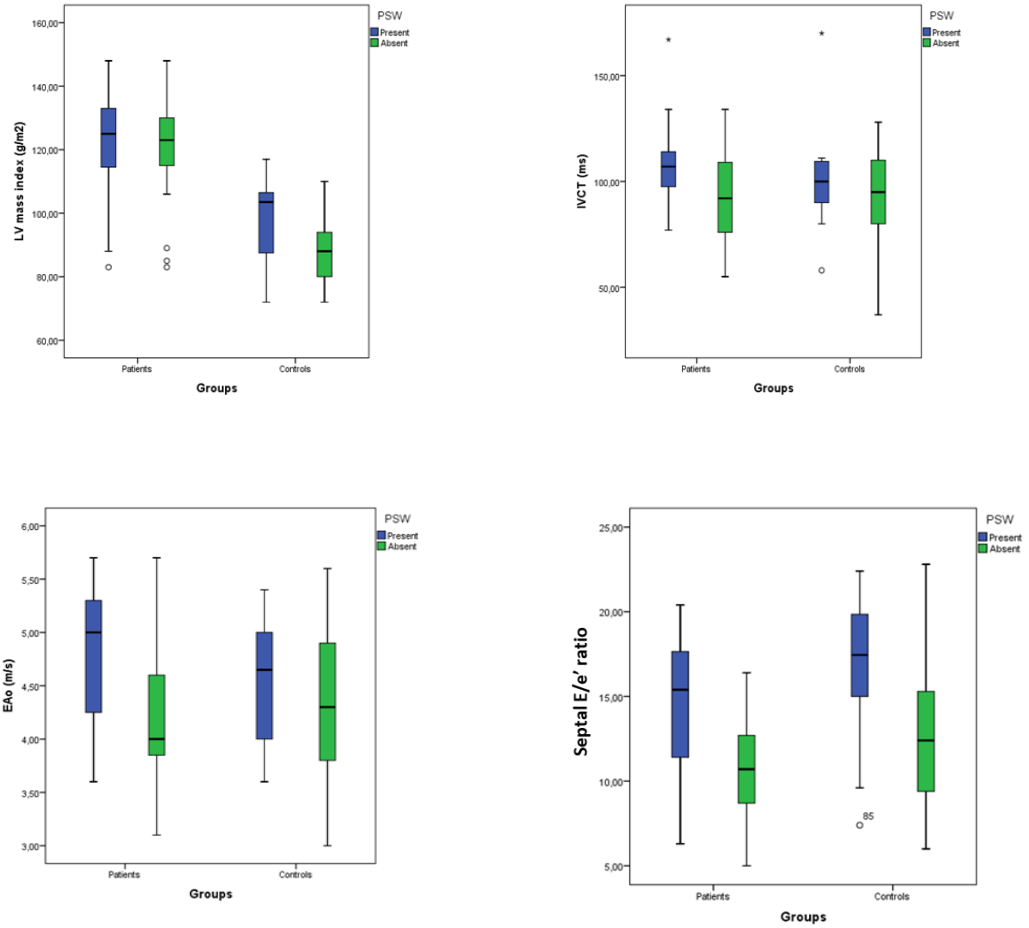


Figure 2. The comparison of the ECHO parameters according to the absent and present of PSW between hemodialysis patients and controls

EAo: Aortic wall early diastolic retraction velocity; IVCT: Isovolumic contraction time; LV, left ventricular

DISCUSSION

We have found in our study that PSW is not associated with LV diastolic dysfuntion assessed by various imaging techniques in the nonhypertensive and nondiabetic hemodialysis patients. As far as we know, this is the first study which investigated the relationship between PSW and LV diastolic dysfunction in hemodialysis patients.

The presence of PSW was encountered in 46% of the study patients. A vortex results from a countercurrent blood flow towards the aortic valve along the septum at late diastole probably in the noncompliant late ventricle. This flow pattern is the probable mechanism of PSW [19]. Another mechanism of PSW is associated with mitral transmission time. Mitral transmission is affected by contraction function of the left atrium at late diastole [12]. Therefore, PSW can be associated with atrial contraction [20]. Additionally, the relationship between PSW and other echocardiographical Doppler parameters in hemodialysis patients is not yet clearly know.

There is a limited number of studies on the clinical and echocardiographical importance of PSW. Mittal SR et al. [12] have detected that PSW is associated with

LV diastolic dysfunction. Joshi KR et al. [20] have found that the absence of PSW is associated with increased frequency of adverse event and one study have shown that PSW is an indicator of impaired compliance of LV [21]. Kul S. et al. [22] have found that PSW is associated with subclinical LV diastolic dysfunction in patients with DM. Akyuz AR et al. [23] have detected that PSW is an independent predictor of subclinical LV dysfunction in patients with HT. In the light of all these data; an occurrence of PSW is estimated in the patients with subclinical diastolic dysfunction.

Prolonged relaxation time and impaired LV compliance are the two major components of diastolic dysfunction. According to the recent definition and consensus of European Society of Cardiology; diagnosis of diastolic HF is based on clinical signs and symptoms of HF as well as the echocardiographic parameters [24]. Mitral E-wave velocity reflects transmitral pressure gradient in early diastole and is affected by changes in LV relaxation and preload. Mitral A-wave velocity indicates transmitral gradients at late diastole and is affected by LV compliance [25]. The presence of PSW was considered to be related with transmitral wave velocities in a study [20]. On the other hand, Pai RG et al. [26] have reported that PSW is not affected by A-wave velocity in the CAD (coronary artery disease) patients in another study. We have found in our study that PSW was not affected by mitral A-wave velocity. No statistically significant relationship was found between the presence of PSW in hemodialysis patients and septal a' wave. A study has shown that the presence of PSW is related to septal velocities [27]. However, our study included only hemodialysis patients differently from other studies. This difference between the study populations may have affected the outcomes of our study.

Isovolumetric relaxation time depends on active relaxation rate, and mean left atrial pressure. E-wave deceleration time depends on mean atrial filling pressure, left atrial compliance and LV compliance during early filling [28]. In our study, we have detected no statistically significant difference between the patients with and without PSW in terms of deceleration time and IVRT. Hence, our data indicated that PSW is not affected by active IVRT and left atrial pressure during early filling. It may be considered theoretically that PSW should be affected by the blood volume pushed into the LV during atrial systole and also LV compliance during this process. However, the absence of such effect can be explained by the fact that there may be many factors which may affect the diastolic function and consequently PSW in hemodialysis patients.

The patients with DM, hypertension and coronary artery disease were excluded from our study taking into consideration that diastolic functions may be affected in the clinical course of these diseases. Another factor which may affect diastolic dysfunction is age. Incidence of diastolic dysfunction increases as age advances and diastolic dysfunction was been reported to be more prevalent especially after the age of 45 years [29]. In our study, no statistically significant difference was found between the patient and control groups in terms of age. Anemia is an important component of CRF. It has been previously reported that anemia is associated with HF and LV hypertrophy in chronic renal failure patients [30]. As expected, hemodialysis patients were more anemic than control groups patients in our study. Various mechanisms irrelevant to blood volume may also cause impaired LV relaxation and consequently LV diastolic dysfunction. The changes in the plasma calcium concentration may affect LV relaxation [31]. In our study, we have determined statistically significant difference between the patients and control group subjects with respect to calcium levels.

The myocardial performance index is an easily performable, and reproducible echocardiographic Doppler parameter and it provides data on both systolic and diastolic functions of LV. The myocardial performance index increases by the development of systolic and/or diastolic ventricular dysfunction as a result of prolonged IVRT and also shortening ET. Thanks to this technique, impaired LV function can be identified early before the development of overt HF. However, we have encountered in our study that the MPI was not associated with PSW.

Abbasnezhad M et al. [32] have found that diastolic dysfunction is found more commonly in the patients who received dialysis treatment and that it is associated with the increase in the duration of hemodialysis treatment. We have interestingly encountered in our study by multivariate logistic regression analysis that prolonged hemodialysis duration reduced the risk for the presence of PSW. Suh SY et al. [33] have determined that abnormal LV diastolic filling pattern is significantly associated with elastic features of the aorta and that reduction in the

EAo velocity may be a useful parameter in the evaluation of LV diastolic function. However, multivariate logistic regression analysis has interestingly shown in our study that high EAo velocity is the independent determinant of PSW. According to these two findings of our study that PSW can not be accepted as an indicator of diastolic dysfunction in hemodialysis patients.

E/e' has been found associated with LV diastolic pressure which is an important indicator of diastolic dysfunction [34]. Therefore, a high E/e' ratio is one of the most essential diagnostic parameters used by many researcher study groups for diagnosis of diastolic dysfunction [35,36]. However, multivariate logistic regression analysis indicated in our study that high E/e' ratio reduced the risk for the presence of PSW. All these data have demonstrated that diastolic dysfunction can not be detected by presence of PSW in hemodialysis patients.

Some limitations of our study should be taken into account in the interpretation of this study outcomes. First of all, our study was a single-center prospective study, and the number of study patients was relatively low while diastolic dysfunction was detected noninvasively. Secondly, our study included numerous CRF patients with unknown etiology. A probable consequence of this fact may be overlooking a hypertensive patient. However, normotensive patients with a history of HT were also excluded from the study. Thirdly, the patients with clinical CAD were excluded from the study. However, coronary angiography was not performed in all these patients. Finally, the effects of the factors such as volumetric overload, neurohormonal profile, inflammation, and parathyroid hormone on LV diastolic function were not evaluated in our study.

In conclusion, we have demonstrated in the present study that PSW is not entirely associated with LV diastolic dysfunction in hemodialysis patients. We have also shown that diastolic dysfunctions are not related to the presence of PSW and that diastolic dysfunction can not be predicted based on the detection of PSW. Further studies are needed to identify the clinical importance of these findings.

Yazar Katkıları: Çalışma konsepti/Tasarımı: ÇÖ, BK; Veri toplama: ÖT, REA; Veri analizi ve yorumlama: AD, ÇÖ; Yazı taslağı: ÇÖ, BK; İçeriğin eleştirel incelenmesi: AU; Son onay ve sorumluluk: ÇÖ, BK, REA, ÖT, AD, MK, MD, AU; Teknik ve malzeme desteği: ÇÖ; Süpervizyon: MK; Fon sağlama (mevcut ise): yok.
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