Left ventricular myocardial performance index in prehypertensive patients with normal coronary arteries

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Objectives **Prehypertension, which may be the precursor of hypertension, is an important public health problem in the community. Myocardial performance index (MPI) is a noninvasive Doppler measurement of global ventricular function. Thus, our aim was to evaluate left ventricule (LV) functions with the MPI in prehypertensive patients with normal coronary artery angiography.**

Patients and materials **Forty prehypertensive patients (21 women and 19 men), with blood pressures between 120/80 and 139/89 mmHg, and 40 normotensive controls (18 women and 22 men), with blood pressures under 120/80 mmHg, were included in the study. Patient population comprised those who underwent coronary angiography because of typical angina and had normal coronary arteries. The MPI was calculated and compared between the two groups.**

Results **No statistically significant differences were found between the two groups in terms of age, sex, or other demographic characteristics ($P > 0.05$). Moreover, LV ejection fraction, late diastolic flow, deceleration time, isovolumetric contraction time, and ejection time values were not significantly different between the two groups ($P > 0.05$). However, early diastolic mitral inflow velocity, *E/A* ratio, isovolumetric relaxation, and MPI were all significantly higher in the patient group than in the control group.**

Conclusion **The MPI was increased in prehypertensive patients. This result demonstrates that LV diastolic and systolic functions may be negatively affected in patients with prehypertension. The advantages of our method are as follows: it is simple, it does not demand special equipment, and it is not time consuming.** *Blood Press Monit* **22:149–153**

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Introduction

Hypertension is an important disease that threatens public health due to its complications, and its prevalence has been increasing in our country, as well as in the world [1,2]. Prehypertension, which is the precursor of hypertension, has been defined as having a systolic blood pressure of 120–139 mmHg and a diastolic blood pressure of 80–89 mmHg [3]. Increased morbidity and mortality have been shown in patients with prehypertension, as in hypertensive patients [4].

The myocardial performance index (MPI), which can be used to analyze systolic and diastolic performance, has a prognostic value in a number of cardiac diseases [5]. The MPI for the right ventricle (RV) and the left ventricle (LV) may be calculated accurately using 'Pulsed' wave Doppler echocardiography of the mitral and tricuspid valves and tissue Doppler echocardiography techniques [6]. The MPI is higher in hypertensive individuals than in nonhypertensive ones [7].

The LV's global functions in prehypertensive patients with normal coronary arteries have not been analyzed before using the MPI. Thus, our aim was to use the MPI to analyze these functions.

Patients and methods

A total of 80 individuals, consisting of 40 consecutive prehypertensive patients (18 women and 22 men) who had undergone coronary angiography because of typical and quasitypical symptoms of angina, with normal coronary arteries, and 40 normotensive individuals, were included in this study. All controls had no history of cardiovascular disease and normal echocardiographic and exercise histories. Patients with prehypertension had a systolic blood pressure of 120–139 mmHg and/or a diastolic blood pressure of 80–89 mmHg, as mentioned in the JNC VII report [3]. The control group consisted of normotensive (< 120/80 mmHg) individuals. All patients provided written informed consent. The study protocol was approved by the local Ethics Committee, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Data as regards age, sex, and other cardiac risk factors were obtained from all participants. Presence of an

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occlusive coronary artery disease in at least one coronary artery, cardiac valvular disease, blood pressure over 140/90 mmHg, nonsinus rhythm, heart block, congestive heart disease, cardiomyopathy, chronic liver or kidney disease, diabetes mellitus, chronic obstructive lung disease, congenital heart disease, and comorbid systemic disease were considered as exclusion criteria.

The BMI was calculated as weight in kilograms divided by height in square meters (m^2). The patients rested for 5 min before blood pressure measurement. They were asked whether they had drunk tea or coffee or smoked in the past 30 min. Blood pressure was measured from both arms, and the following measurements were performed on the arm with a higher blood pressure according to the European Society of Hypertension/European Society of Cardiology Guidelines for the management of arterial hypertension [8]. At least two measurements were made, and, in each, a total of three blood pressure measurements were performed in all participants, with 15 min intervals, and their average was calculated. All blood pressure measurements were performed using an aneroid manual sphygmomanometer (ERKA, Berlin, Germany).

All standard transthoracic echocardiographic and tissue Doppler measurements were performed while the patient was lying on his/her left side. All echocardiographic examinations were carried out using a Philips İE33 (Philips Medical Bothell, Bothell, Washington, USA) device. The images were saved on parasternal long and short axes, with apical two, four, and five chambers, and in subcostal windows. Doppler records were obtained with a recording rate of 100 mm/s. All measurements were performed in three consecutive cycles, and their averages were recorded. All Doppler measurements were performed during expiration to prevent the effect of respiration on the measured parameters.

The early and late diastolic flow rates of the mitral valve (*E*/*A* ratio) were measured as centimeter/second using a pulse wave Doppler (PWD) method on an apical four-chamber image by placing the sample volume on the edge of the mitral valve leaflets. Later, tissue Doppler imaging was used to measure left ventricular isovolumetric relaxation time (IVRT), isovolumetric contraction time (IVCT), and ejection time (ET) on an apical four-chamber image by placing the sample volume on the point where the LV wall joined with the mitral annulus. IVRT was obtained by measuring the time between the midpoint of aortic closure click and appearance of E wave, which appeared by the opening of the mitral valve, in milliseconds. IVCT was calculated by measuring the time between the end of mitral A wave and the start of ejection by the opening of the aortic valve, in milliseconds. ET was obtained in milliseconds by measuring the duration of the starting and ending points of the Sm wave, which showed the ejection period. The isovolumic relaxation time + isovolumic contraction time/ET formula was used to determine MPI value. The ejection fraction of the LV was calculated using the Simpson method.

All patients underwent standard coronary angiography procedures using a Philips coronary angiography device (Philips Integris 5000; Philips, Amsterdam, The Netherlands) through femoral or radial arteries. The artery used in the angiography was determined by the practitioner's preference. Any narrowing in a coronary artery at any level on coronary angiography was determined as an exclusion criterion.

Statistical analysis

The statistical analysis of the data was performed using the SPSS 17.0 (SPSS Inc. Chicago, Illinois, USA) package program. Numerical (quantitative) variables were presented as mean ± SD, and categorical variables were presented as *n* (%). The normality of the parameter distribution was tested with the Shapiro–Wilk test when comparing the study and control groups. An independent samples *t*-test was used to compare quantitative variables, and Yates' correction χ^2-test was used for comparison of the categorical variables. The level of significance was set at 0.05.

Results

The comparison of participants' demographic characteristics is presented in Table 1. The study and control groups were compared for age, sex, fasting glucose level, blood urea nitrogen, creatinine, hemoglobin, white blood cell count, total cholesterol, low-density lipoprotein, high-density lipoprotein, triglyceride, BMI, and smoking; there were no differences between the groups ($P > 0.05$). However, the mean systolic and diastolic blood pressures were higher in the prehypertensive group than in the control group, and the difference between the groups was statistically significant ($P < 0.001$).

Table 1 Demographic and clinical characteristics of study groups ($n = 40$)

	Mean ± SD		
Variables	Patient group	Control group	*P* value
Age (years)	50.0 ± 11	48.5 ± 10	0.540
Sex (male) [*n* (%)]	19 (47.5)	22 (55)	0.650
Cigarette smoking [*n* (%)]	23 (57.5)	17 (42.5)	0.070
BMI (kg/m^2)	27.2 ± 5.2	28.4 ± 4.1	0.262
Systolic blood pressure (mmHg)	131.1 ± 4.1	112.5 ± 3.6	**< 0.001**
Diastolic blood pressure (mmHg)	86.8 ± 2.7	73.3 ± 3.1	**< 0.001**
Fasting blood sugar (mg/dl)	92.1 ± 7.4	89.5 ± 9.8	0.181
Creatinine (mg/dl)	0.72 ± 0.12	0.70 ± 0.05	0.520
Total cholesterol (mg/dl)	197.9 ± 33.5	191.9 ± 37.3	0.444
LDL cholesterol (mg/dl)	122.8 ± 28.6	113.8 ± 33.7	0.205
HDL cholesterol (mg/dl)	40.8 ± 8.7	38.8 ± 7.4	0.271
Triglycerides (mg/dl)	145.8 ± 33.4	140.8 ± 37.1	0.535
Hemoglobin (g/dl)	13.6 ± 1.6	14.1 ± 1.5	0.178
White blood count (10^3/ml)	7.4 ± 1.8	8.2 ± 2.3	0.085

HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Bold values indicate statistically significant ($P < 0.05$).

Table 2 Comparison of echocardiographic variables of the study population ($n = 40$)

	Mean ± SD		
Variables	Patient group	Control group	*P* value
Ejection fraction (%)	60.8 ± 2.4	60.6 ± 3.4	0.772
E (cm/s)	65.4 ± 16.4	74.8 ± 15.7	**0.011**
A (cm/s)	67.8 ± 12.3	66.4 ± 15.7	0.654
E/*A* ratio	0.9 ± 0.2	1.1 ± 0.3	**0.009**
Deceleration time (ms)	198.1 ± 48.4	194.9 ± 49.3	0.771
Ejection time (ms)	293 ± 39	302 ± 30	0.067
IVRT (ms)	78.9 ± 13	71.7 ± 9.3	**< 0.001**
IVCT (ms)	75.0 ± 11	72.6 ± 12	0.383
MPI	0.55 ± 0.09	0.47 ± 0.05	**< 0.001**

A, mitral inflow contraction velocity; DT, deceleration time; *E*, mitral velocity of early diastolic filling; IVCT, isovolumetric contraction time; IVRT, isovolumetric relaxation time; MPI, myocardial performance index.
Bold values indicate statistically significant ($P < 0.05$).

The comparison of participants' two-dimensional and Doppler echocardiographic measurements is presented in Table 2. The mean EF values of the prehypertension and control groups were not statistically significant ($P > 0.05$).

Mitral *E* velocity was higher in the prehypertension group than in the control group, and the difference was statistically significant ($P = 0.011$). The mean mitral *A* velocity was 67.8 ± 12.3 cm/s in the prehypertension group and 66.4 ± 15.7 cm/s in the control group, but the difference between the groups was not statistically significant ($P > 0.05$). The *E*/*A* ratio was decreased in the prehypertension group when compared with the control group, and the difference was statistically significant ($P = 0.009$). The mean mitral deceleration time was 198.1 ± 48.4 m/s in the prehypertension group and 194.9 ± 49.3 m/s in the control group, without any statistically significant difference ($P > 0.05$).

The IVRT values were higher in the prehypertension group than in the control group, and the difference between the groups was statistically significant ($P < 0.001$). There was no significant difference between the groups for IVCT ($P > 0.05$). The MPI value was also higher in the prehypertension group than in the control group, and the difference between the groups was statistically significant ($P < 0.001$).

Discussion

The main results of the study were as follows: (i) mitral *E* velocity and *E*/*A* ratio were significantly decreased in the prehypertension group when compared with the control group; and (ii) the MPI values were significantly increased in the study group when compared with the control group.

Recent studies have suggested that prehypertension might increase the risk for cardiovascular diseases and cause injury in the target organs [3,9]. In addition, prehypertension is an important public health problem due to its high prevalence and increasing frequency. Previous studies have compared the mean ages of prehypertensive and normotensive individuals [9–11]. Grotto *et al.* [10] found a higher mean age in prehypertensive patients; however, Erdoğan *et al.* [11] did not find any significant difference between the groups. In our study, we did not find any significant difference between hypertensive and normotensive individuals as regards age.

Recent studies have indicated that prehypertension was correlated with obesity and being overweight, and that the prevalence of prehypertension would increase if the frequency of obesity also increased [12]. A number of studies found higher mean weight, BMI, and waist circumference in the prehypertensive group than in the normotensive group [11,13]. In our study, we did not find any significant difference between the groups with regard to BMI, which may be due to the small number of patients included in our study.

The studies that compared the lipid profiles of the prehypertensive and normotensive groups revealed significantly higher total cholesterol, low-density lipoprotein cholesterol and triglyceride, and lower mean high-density lipoprotein cholesterol levels in the prehypertensive group [11,13]. Similar to other studies, we found higher total cholesterol, low-density lipoprotein cholesterol, and triglyceride levels in the prehypertension group, but the differences between the groups were not significant.

Significant structural and functional cardiac changes occur because of hypertension. Hypertrophy and diastolic function impairments, which develop because of increased vascular resistance, are the most frequently encountered disorders [14]. Diastolic abnormalities include abnormal LV relaxation and/or filling. Myocardial relaxation, LV sucking, viscoelastic properties of the myocardium, ventricular compliance, atrial contraction, interaction of the left and right ventricles, pericardial restraint, and heart rate affect the diastolic performance directly or indirectly. The impairment of myocardial function without development of hypertrophy in hypertensive patients was supposedly due to structural changes, such as increased after load, increased LV mass (even in the absence of hypertrophy), increased collagen density in the myocardium, and disruption of LV geometry [15]. In normal conditions, left atrial volume and pressure increase as the ventricle does not fill with low pressure. In this case, a decrease in E wave due to decreased fast filling and an increase in A wave due to increased passive stiffness are observed [16].

Drukteinis *et al.* [13] found a significantly decreased mitral inflow, early diastolic flow velocity (*E*), and *E*/*A* ratio in the prehypertension group when compared with the normotensive group. Similarly, in our study, we found a significantly higher mitral *E* velocity, *E*/*A* ratio, and IVRT in the prehypertension group than in the control group. Furthermore, the impairments observed in

prehypertensive patients also supposedly appear with the mechanisms seen in hypertensive patients.

The MPI is a relatively new index that may be used to analyze systolic and diastolic functions together and has a prognostic value in a number of cardiac diseases. The MPI value is higher in hypertensive individuals than in nonhypertensive ones [17]. In patients with hypertension, MPI increases because of changes in LV geometry [18]. A study indicated significantly higher LV mass index and MPI dipper in nondipper hypertensive patients [19]. Akintunde *et al.* [20] showed a significantly higher MPI value and diastolic dysfunction in hypertensive individuals than in normotensive ones. Strain and strain rate measures reflect regional systolic function, which is used to detect subclinical myocardial dysfunction and may provide a novel tool for LV risk assessment in patients with hypertension [21]. Poulsen *et al.* [22] showed that reduced longitudinal strain is associated with the degree of myocardial fibrosis in hypertensive patients and highlights the potential utility of regional deformation measures in hypertensive heart disease. Previously, the MPI was found to be associated with both systolic and diastolic myocardial function assessed using conventional and newer echocardiographic measures. In addition, the MPI was especially associated with the systolic measures LVEF and global longitudinal strain using speckle-tracking echocardiography. In their study, Di Bello *et al.* [23] found that longitudinal two-dimensional strain, an early abnormality of LV longitudinal systolic deformation, was significantly lower in both the prehypertension and the hypertension group than in the control group. On the basis of our study design, we did not perform speckle-tracking echocardiographic measurements. However, we think that the advantage of our method is that it can be performed in every echo-laboratory because it does not demand special equipment and is not time consuming.

Although various studies have investigated LV dysfunction in hypertensive patients, only a few studies have investigated the effects of prehypertension, a precursor of hypertension, on the heart. In our study, we aimed to show the effects of prehypertension on LV using the MPI, an echocardiographic measurement that has not been used on this subject before. As the effect of the coronary artery disease on the MPI is known, we aimed to exclude patients with a narrowing at any level in their coronary arteries to increase the accuracy of our results. In our study, we found that MPI value was higher in the prehypertensive group than in the normotensive group, which was due to the elongation of IVRT in this group. The elongation of IVRT may reflect the elongation of diastolic filling time, increased LV end-diastolic pressure, or impairment in diastolic relaxation. In addition, it may be an early finding of LV diastolic dysfunction in prehypertensive patients.

In our study, we did not support our results with invasive methods, which is an important limitation of our study. However, studies have shown good correlations of tissue Doppler parameters, which are used to evaluate cardiac functions with invasive parameters [24]. The small number of patients included in our study is another important limitation, which decreases the statistical power of our study. In addition, the cross-sectional design of our study is a limitation. As we did not perform a follow-up, the effects of lifestyle measures, such as weight reduction, regular exercise or a low-salt diet, and/or medical treatment could not be measured. Therefore, the results of our study should be supported with further, randomized, large-scale cohort studies.

Conclusion

The results of this study showed that prehypertension can negatively affect the LV diastolic and systolic functions. In addition, high-risk individuals with prehypertension (and that could progress to hypertension or end in organ injury) may be identified early by using noninvasive methods, such as Doppler echocardiography and MPI. Thus, by using these methods, the lifestyles of those individuals may be changed, and medical treatment may be used to prevent blood pressure from reaching hypertensive levels and/or to slow down the progression of the disease. Moreover, the advantage of our method is that it could be simply performed in clinical practice because it does not demand special equipment and is not time consuming.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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