Diastolic functions and myocardial performance index in obese patients with or without metabolic syndrome: a tissue Doppler study

Metabolik sendromun eşlik ettiği veya etmediği obez hastalarda diyastolik fonksiyonlar ve miyokart performans indeksi: Doku Doppler çalışması

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Objectives: This study was designed to evaluate left ventricular (LV) diastolic functions and myocardial performance index (MPI) in obese individuals with or without metabolic syndrome (MetS).

Study design: The study included 44 obese subjects with MetS (16 men; 28 women; mean age 46±7 years) and 32 obese subjects without MetS (16 men, 16 women; mean age 43±9 years). Diagnosis of MetS was based on the ATP III criteria. Obesity was defined with a body mass index (BMI) of ≥30 kg/m^2. All the subjects underwent echocardiography and tissue Doppler imaging to determine LV diastolic functions and MPI. Clinical and echocardiographic characteristics of obese subjects were compared with those of a control group consisting of 21 healthy, nonobese individuals (10 men, 11 women; mean age 42±4 years).

Results: Waist circumference, weight, and BMI were similar in the two obese groups. Control subjects and obese subjects without MetS had similar systolic and diastolic blood pressures, fasting blood glucose, triglyceride, and HDL cholesterol levels, but all these significantly differed in patients with MetS. Left ventricular mass, mass index, and diastolic parameters were similar in the two obese groups, but differed significantly from the controls (p<0.05). Body mass index was correlated with the LV mass (r=0.42, p=0.001) and mass index (r=0.33, p=0.001). Left ventricular MPI was similar in the two obese groups with (0.59±0.10) and without (0.59±0.11) MetS, but was higher compared to the control group (0.48±0.06, p<0.05). Left ventricular MPI was correlated with BMI, waist circumference, LV mass, and mass index (r=0.24, p=0.02; r=0.30, p=0.005; r=0.31, p=0.002; r=0.21, p=0.04, respectively).

Conclusion: Our findings demonstrate that obesity with or without MetS affects LV MPI. In addition, LV MPI showed significant correlations with BMI, waist circumference, and LV mass.

Key words: Echocardiography, Doppler; metabolic syndrome X/complications; myocardial contraction; obesity/complications; ventricular function, left.

Amaç: Bu çalışmada, metabolik sendromun (MetS) eşlik ettiği ya da etmediği obez bireylerde sol ventrikül (SV) diyastolik fonksiyonları ve miyokart performans indeksi (MPİ) değerlendirildi.

Çalışma planı: Çalışmaya MetS tanısı konan 44 obez hasta (16 erkek, 28 kadın; ort. yaş 46±7) ve MetS olmayan 32 obez kişi (16 erkek, 6 kadın; ort. yaş 43±9) alındı. Metabolik sendrom tanısı ATP III ölçütlerine göre kondu. Obezite, beden kütle indeksinin (BKİ) ≥30 kg/m^2 olması olarak tanımlandı. Tüm katılımcılar, SV diyastolik fonksiyonları ve MPİ'nin belirlenmesi için ekokardiyografi ve doku Doppler görüntüleme ile değerlendirildi. Obez grupların klinik ve ekokardiyografik özellikleri, obez olmayan 21 sağlıklı kişiden oluşan kontrol grubuyla (10 erkek, 11 kadın; ort. yaş 42±4) karşılaştırıldı.

Bulgular: Bel çevresi, ağırlık ve BKİ iki obez grupta benzer idi. Metabolik sendrom bulunmayan obez grupta sistolik ve diyastolik kan basınçları, açlık kan glukozu, trigliserit ve HDL kolesterol düzeyleri kontrol grubuyla benzer bulunurken, bu değerler MetS'li obez grupta anlamlı farklılık gösterdi. Sol ventrikül kütlesi, kütle indeksi ve diyastolik parametreler kontrol grubu ile obez gruplar arasında farklıyken (p<0.05), iki obez grubunda benzer bulundu. Beden kütle indeksi, SV kütlesi (r=0.42, p=0.001) ve kütle indeksi (r=0.33, p=0.001) ile anlamlı ilişki gösterdi. Sol ventrikül MPİ, MetS olan ve olmayan obez gruplarda benzer bulunurken (sırasıyla 0.59±0.10 ve 0.59±0.11), kontrol grubundan (0.48±0.06) anlamlı derecede yüksek idi (p<0.05). Sol ventrikül MPİ, BKİ, bel çevresi, SV kütlesi ve kütle indeksi ile ilişkili bulundu (sırasıyla, r=0.24, p=0.02; r=0.30, p=0.005; r=0.31, p=0.002; r=0.21, p=0.04).

Sonuç: Bulgularımız obezitenin, beraberinde MetS olsun veya olmasın, SV MPİ üzerinde etkili olduğunu göstermektedir. Ayrıca, SV MPİ, BKİ, bel çevresi ve SV kütlesi ile anlamlı ilişki göstermiştir.

Anahtar sözcükler: Ekokardiyografi, Doppler; metabolik sendrom X/komplikasyon; miyokart kontraksiyonu; obezite/komplikasyon; ventrikül fonksiyonu, sol.

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Obesity and insulin resistance are closely associated with hyperinsulinemia, glucose intolerance, dyslipidemia, hypertension, premature atherosclerosis, and increased risk for coronary artery disease. The coexistence of these abnormalities is called insulin resistance syndrome or metabolic syndrome (MetS).[1] Metabolic syndrome is associated with a five-fold increase in the risk for diabetes mellitus and a 2-3 fold increase in the risk for cardiovascular disease.[2] The incidence of MetS dramatically increases in those with a high body mass index (BMI).[3] Obesity leads to impairment in cardiac structure and function.[4] Obesity has been reported to be correlated with left ventricle (LV) mass, systolic and diastolic dysfunction, and coronary artery disease.[4,5] Impairment of diastolic functions in obese and hypertensive patients has been demonstrated in many trials.[4] However, data on myocardial performance index (MPI), which is helpful in evaluating systolic and diastolic function together, are quite limited. Several studies reported that MPI in obese patients and healthy controls differed significantly.[6-8] These studies mainly included patients who were both obese and had MetS. In our study, the obese group consisted of only patients with or without MetS.

The aim of this study was to evaluate LV diastolic functions and MPI in obese patients with or without MetS using tissue Doppler-derived parameters.

PATIENTS AND METHODS

Study population. A total of 97 individuals were enrolled in the study, including 44 obese patients with MetS (group 1; 16 men, 28 women; mean age 46±7 years), 32 obese patients without MetS (group 2, 16 men, 16 women; mean age 43±9 years), and 21 healthy individuals as controls (10 men, 11 women; mean age 42±4 years). Approval was obtained from the local ethics committee. Diagnosis of MetS was established based on the ATP III (National Cholesterol Training Program-Adult Treatment Panel) criteria.[9] Patients who met at least three of the MetS criteria, with a BMI ≥30 kg/m^2 were included in group 1. Those who were obese, but did not meet the MetS criteria were in group 2. Body mass index was calculated by dividing the patient's weight (kg) by the square of their height (m^2). Those with a BMI ≥30 kg/m^2 were considered obese. All controls in the healthy volunteer group had a BMI of less than 30 kg/m^2. Waist circumference was measured on standing subjects, with a soft tape midway between the last rib and the iliac crest. Exclusion criteria included the presence of the following: history of coronary artery disease, moderate or severe valvular heart disease, cardiomyopathy, chronic lung disease, diabetes mellitus, antihypertensive drug use, atrial fibrillation, frequent atrial or ventricular extrasystole, creatinine >2.0 mg/dl, malignancy, and poor echogenicity.

Blood pressure was measured on both arms in the sitting position after 15 minutes of resting and the mean value of three consecutive measurements was calculated. Following 12 hours of fasting, venous blood samples were obtained from all subjects for fasting blood glucose and lipid panel tests.

Echocardiography. Echocardiographic examination was performed using an ATL-5000 echocardiography device (Advanced Technology Laboratories, Bothell, WA, USA) with a 2-4 MHz phase transducer. Echocardiography was performed in all groups by the same physician who was blinded to the clinical characteristics of the patients. All the measurements were obtained by calculating the mean of three consecutive measurements at 25 cm/sec and under continuous electrocardiographic recording upon expiration. The mitral Doppler signals were recorded in the apical four-chamber view, with the sample volume placed at the tip of the mitral valve leaflets. The peak early diastolic velocity (E) and peak atrial filling velocity (A) were measured. E-wave deceleration time (DT) and E/A ratios were calculated. Tissue Doppler images were obtained by placing the sample volume on the septal and lateral walls of the mitral annulus. The early (Em) and late (Am) diastolic myocardial velocities of each segment were measured. The average of the values from the two walls was presented as the mean Em and Am. The LV mean Em/Am and E/Em values were calculated. Isovolumetric contraction time, ejection time, and the isovolumetric relaxation time for each wall were calculated. The LV MPI was calculated as the sum of the isovolumetric contraction and relaxation times divided by ventricular ejection time.[10] The average of the values from the two walls was presented as the mean MPI.

Statistical analysis. Statistical analysis was performed using the SPSS 13 software. Parametric variables were expressed as mean ± standard deviation (SD). Differences between parametric variables among the three groups were analyzed using one-way analysis of variance (ANOVA) with Bonferroni post-hoc test. Categorical variables were presented as absolute values and comparisons were tested using the chi-square test. Pearson's correlation test was used to demonstrate the correlations between the data exhibiting a parametric distribution. A P value of less than 0.05 was considered statistically significant.

Table 1. Baseline characteristics of the two study groups and the control group

	Obese with MetS (n=44; 16 M/28 F) (Mean±SD)	Obese without MetS (n=32; 16 M/16 F) (Mean±SD)	Control group (n=21; 10 M/11 F) (Mean±SD)
Age (year)	46±7	43±9	42±4
Waist circumference (cm)	106±11*	107±11*	85±7
Body mass index (kg/m^2)	34±4*	35±4*	25±3
Systolic blood pressure (mmHg)	144±11**	129±15	119±11
Diastolic blood pressure (mmHg)	96±9**	84±12	74±13
Fasting blood glucose (mg/dl)	101±13**	94±7	94±10
Total cholesterol (mg/dl)	196±38	198±34	183±28
HDL cholesterol (mg/dl)	42±8**	52±13	47±9
LDL cholesterol (mg/dl)	120±31	119±45	119±30
Triglyceride	181±102**	118±66	89±38

MetS: Metabolic syndrome; *p<0.05, compared to the control group; **p<0.05, compared to the obese group (without MetS) and controls.

RESULTS

The basic characteristics of the three groups are presented in Table 1. There were no differences between the study groups and controls with respect to age and gender. Waist circumference, weight, and BMI were similar between the two obese groups, but were significantly higher compared to the control group (p<0.05). Obese patients without MetS had similar systolic and diastolic blood pressures, fasting blood glucose, triglyceride, and HDL cholesterol levels compared to the control group, but these parameters were significantly different in obese patients with MetS (Table 1).

Comparisons of the echocardiographic parameters among the three groups are shown in Table 2.

Myocardial performance index. Left ventricular MPI was similar in the two obese groups, but was higher in both groups compared to the control group (group 1: 0.59±0.10; group 2: 0.59±0.11; controls: 0.48±0.06, p<0.05). Left ventricular MPI was correlated with BMI, LV mass, and mass index (r=0.24, p=0.02; r=0.31, p=0.002; r=0.21, p=0.04, respectively). There was also a significant correlation between MPI and waist circumference (r=0.30, p=0.005).

Left ventricular mass. Left ventricular mass and mass index were significantly higher in both obese groups with and without MetS compared to healthy controls (Table 2). Body mass index was in close association with the LV mass (r=0.42, p=0.001) and mass index (r=0.33, p=0.001).

Table 2. Echocardiographic characteristics of the two study groups and the control group

	Obese with MetS (n=44; 16 M/28 F) (Mean±SD)	Obese without MetS (n=32; 16 M/16 F) (Mean±SD)	Control group (n=21; 10 M/11 F) (Mean±SD)
Left ventricular M-mode variables			
End-diastolic diameter (cm)	4.46±0.32	4.56±0.29	4.36±0.33
End-systolic diameter (cm)	2.66±0.28	2.80±0.30	2.68±0.32
Interventricular septum thickness (cm)	0.96±0.15*	0.95±0.14*	0.75±0.10
Posterior wall thickness (cm)	0.91±0.13*	0.91±0.11*	0.80±0.14
Ventricular mass (g)	196±38*	198±34*	183±28
Ventricular mass index (g/m^2)	74±17*	74±15*	61±12
Pulse-wave Doppler			
E velocity (cm/sec)	64.4±17.8*	68.3±20.6*	78±16.6
A velocity (cm/sec)	74.0±14.6*	72.0±17.3*	60.3±14.3
E/A	0.88±0.22*	0.98±0.31*	1.36±0.42
Deceleration time (msec)	176.3±47.6*	188.2±44.2*	156.8±34.8
Tissue Doppler data			
Em (cm/sec)	13.6±3.3*	15.2±4.7*	18.6±4.6
E/Em	4.84±1.26	4.70±1.54	4.32±1.06
Myocardial performance index	0.59±0.10*	0.59±0.11*	0.48±0.06

MetS: Metabolic syndrome; *p<0.05, compared to the control group.

Diastolic parameters. Diastolic parameters differed significantly between the control group and the two obese groups, but obese patients with and without MetS were similar in this respect. The E/Em ratio was similar in the three groups (Table 2).

DISCUSSION

In this study, we found that there were significant differences between obese patients and healthy controls in terms of LV diastolic parameters and MPI. However, these parameters did not differ significantly between obese patients with and without MetS. We also showed that LV MPI correlated with BMI, waist circumference, LV mass, and mass index.

Myocardial performance index is a new echocardiographic parameter which correlates with invasive measurements and is used to evaluate both systolic and diastolic functions. It can be measured from the mitral annulus with pulsed-wave TDI and is not affected by cardiac rate, blood pressure, or ventricular geometry.[10] Levent et al.[8] showed significantly higher MPI values in hypertensive obese adolescents compared to normotensive counterparts and concluded that, in spite of normal systolic function, MPI could be important in showing LV dysfunction early in patients with essential hypertension. Andersen et al.[7] found increased MPI in diabetic hypertensives and nondiabetic patients with essential hypertension compared to healthy controls. However, neither of these two studies could clearly determine whether increased MPI values resulted from the effect of hypertension or BMI. Dursunoğlu et al.[6] compared female patients with MetS and healthy control individuals of the same age group and found significantly higher MPI values in patients with MetS. In our study, there was no significant difference between the two obese groups with and without MetS with respect to BMI. Fasting blood glucose, systolic and diastolic blood pressures were significantly higher in obese patients with MetS. Despite this, there was no significant difference between the two obese groups with respect to MPI, which exhibited significantly higher values in both groups compared to the control group. To determine the association of BMI, waist circumference, blood pressure, fasting blood glucose, and lipid profile with MPI, correlation analysis was made which showed that only BMI and waist circumference were correlated with MPI. Review of the literature revealed no data on the association between waist circumference and MPI. This finding may be of value and may be a matter of future research considering the evidence showing that abdominal obesity is more associated with increased cardiovascular risk compared to truncal obesity.

Iacobellis et al.[11] demonstrated that even uncomplicated obesity without glucose intolerance, hypertension, and hyperlipidemia was associated with increased LV mass and impaired LV diastolic parameters compared to lean subjects. In our study, LV mass and LV diastolic parameters were similar in the two obese groups, but were significantly different from the values of the control group. Avignon et al.[12] found that LV mass was increased in normotensive and normoglycemic obese subjects compared with lean subjects and LV mass was positively correlated with BMI. We found that LV mass and mass index were not only correlated with BMI but also were correlated with MPI.

Chronic obesity causes a gradual increase in the LV mass, a progressive impairment in systolic functions, and a more marked diastolic dysfunction.[13] Compared to healthy controls, obese individuals usually have an abnormal diastolic filling pattern.[14] Although parameters showing diastolic function (E/A, Em and E-wave deceleration time) were similar in the two obese groups, they were significantly different from those of the control group; yet, the values obtained in the three groups were within normal limits. The E/Em ratio is a useful parameter to evaluate increased LV filling and also correlates with LV end-diastolic pressures. An E/Em ratio above 10 is associated with increased left atrial filling pressure.[15,16] None of the subjects in our study had a high E/Em ratio.

One possible reason for low and similar E/Em ratios in the three groups may be relatively young ages of the subjects. In normal individuals, the E/Em ratio was reported to be 7.7±1.1 in the thirties and forties; with an increase in the fifties, it was found as 10.2±2.2 in the sixties. [17] On average, all the subjects in our study were in their forties. Additionally, shorter duration of obesity in younger patients may account for the lack of differences between obese patients and non-obese controls.

Study limitations. Firstly, the small sample size of each group poses a limitation; thus, our results should be verified by more comprehensive studies. Secondly, although blood pressures were significantly different between the two obese groups with and without MetS, diastolic parameters were similar. This is in contrast to the literature reports and needs to be clarified, but may result from the relatively young patient population.

In conclusion, obesity alone can impair LV diastolic functions, resulting in increased LV mass and

MPI. We believe that obesity has an important influence on cardiac functions and that losing weight is as important as other methods of protecting cardiac functions. Tissue Doppler-derived MPI is an easily available, noninvasive, and useful parameter in determining potential future risks that these individuals may encounter. It is affected less by physiological conditions and may prove helpful in making an earlier diagnosis.

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