

Tissue doppler echocardiography for evaluating left ventricular functions in obese children

Obez çocuklarda sol ventrikül fonksiyonlarının değerlendirilmesinde doku doppler ekokardiyografi

Mecnun Çetin¹, Mustafa Çağlayan², Münevver Yıldırım¹, Baran Serdar Kızılyıldız³,
Murat Deveci⁴, Şenol Coşkun¹

ABSTRACT

Objective: The aim of this study was to investigate the impact of childhood obesity on ventricular functions using tissue Doppler echocardiography.

Materials and methods: The mitral tissue Doppler signals were recorded in the apical four-chamber view, with the sample volume placed at the lateral walls of mitral annulus. The mitral flow was examined with the sample Pulse Doppler positioned parallelly to flow just at the orifice of the mitral leaflets. Twenty obese (mean age, 161.5±25.8 months) and 20 healthy children (mean age, 151.2±33.5 months) were included to this study.

Results: Body mass index (BMI) was significantly higher in obese group (30.92±6.87). Isovolumic relaxation time (IVRT) which is one of the left ventricular (LV) diastolic function parameters was 66.10±7.30 ms in obese group, and 58.70±9.06 ms in the control group. IVRT was significantly higher in the obese group (p=0.007). In obese group, the mitral annulus tissue Doppler E velocity was decreased, flow velocity was increased and decrement in Em/Am ratio was significant. We found significant negative correlation between BMI and LV Em/Am ratio. Myocardial performance index (MPI) in obese group and control group was 0.50±0.07 and 0.41±0.04, respectively (p<0.001). Between MPI and LV Em/Am ratio there was a significant negative correlation while MPI showed positive correlation with BMI. In obese group septal and LV posterior wall thickness was shown to be significantly increased compared to the control group (p<0.001).

Conclusion: Our findings, may be important for determination of the relationship between obesity and cardiovascular risk factors in children. Tissue Doppler echocardiographic imaging may be useful in revealing this relationship.

Key words: obesity, doppler echocardiography, ventricular dysfunction

ÖZET

Amaç: Bu çalışmada obez çocuklarda transtorasik doku Doppler ekokardiyografik yöntemle sol ventrikül sistolik ve diyastolik fonksiyonlarının değerlendirilmesi amaçlandı.

Gereç ve yöntem: Mitral doku Doppler sinyalleri, mitral annulus lateral duvarlarına yerleştirilen örnek hacmi ile apikal dört boşluktan kaydedildi. Pulse Doppler örneği apikal dört boşluk görüntüde mitral kapak uçlarına, akıma paralel olacak şekilde yerleştirilerek mitral akım trasesi elde edildi. Çalışmaya 20 obez (161,5±25,8 ay) ve 20 (151,2±33,5 ay) sağlıklı çocuk alınarak gerçekleştirildi.

Bulgular: Vücut kitle indeksi (VKİ) obez grupta belirgin yüksekti (30,92±6,87). Sol ventrikül (LV) diyastolik fonksiyon parametrelerinden izovolemik relaksasyon zamanı (IVRT) obez grupta 66,10±7,30 msn, kontrol grubunda ise 58,70±9,06 msn ile obez grupta anlamlı artış saptandı (p=0,007). Obez grubunda mitral anulus doku Doppler E akım hızı azalmış, A akım hızı artmış ve Em/Am oranının anlamlı derecede azalmış olduğu görüldü. VKİ ile LV Em/Am oranı arasında anlamlı negatif ilişki saptandı. Miyokardiyal performans indeksi (MPI) obez grupta 0,50±0,07, kontrol grubunda ise 0,41±0,04 (p<0.001) bulundu. MPI ile LV Em/Am oranı arasında anlamlı negatif ilişki saptandı. MPI ile VKİ arasında anlamlı pozitif ilişki saptandı. Obez grupta kontrol grubuna göre interventriküler septum ve LV arka duvar kalınlığının önemli derecede artmış olduğu gösterildi (p<0.001).

Sonuç: Bu bulgular, pediatrik yaş grubunda obezite ve kardiyovasküler risk faktörleri arasındaki ilişkiyi belirlemek için önemli bulgular olabilir. Doku Doppler ekokardiyografik görüntüleme yöntemi ise aralarındaki bu ilişkinin belirlenmesinde yararlı olabilir.

Anahtar kelimeler: Obezite, doppler ekokardiyografi, ventriküler disfonksiyon

¹ Division of Pediatric Cardiology, Department of Pediatrics, Faculty of Medicine, Celal Bayar University, Manisa, Turkey

² Department of Pediatrics, Faculty of Medicine, Celal Bayar University, Manisa, Turkey

³ Department of Pediatrics, Istanbul Hospital, Van, Turkey

⁴ Division of Pediatric Cardiology, Department of Pediatrics, Faculty of Medicine, Ege University, İzmir, Turkey

Yazışma Adresi /Correspondence: Mecnun Çetin, Pediatric Cardiology,

Department of Pediatrics, Faculty of Medicine, Celal Bayar University, Manisa, Turkey Email: drmecnun@hotmail.com

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INTRODUCTION

Childhood obesity is one of major public health problem affecting children in developed countries. Obese children have increased risk for cardiovascular complications and if childhood obesity would not be treated in early ages; cardiovascular risk for acute myocardial infarction, congestive heart failure and arrhythmias increases in adult ages.^{1,2,3} Obesity is a chronic disease and early diagnosis and appropriate treatment is essential to prevent from complications in both childhood and adult ages.⁴ Tissue Doppler echocardiography is a recent echocardiographic imaging technique that allows evaluation of regional myocardial systolic and diastolic function.⁵ In literature, there are few studies which evaluate effects of obesity in cardiovascular system in childhood.^{6,7} In many of these studies, only left ventricular diastolic functions were evaluated. In this study, our aim is to determine whether there is an effect of childhood obesity in left ventricular functions by using tissue Doppler echocardiography.

MATERIALS AND METHODS

The study was performed in patients admitted to Celal Bayar University Pediatric Endocrinology and Metabolism department for overweight complaint and diagnosed as exogenous obesity by clinical and laboratory findings. A total of 20 patients (8-18 years) that have not hypertension and with normal basal insulin levels enrolled as study group. The control group consisted of 20 patients that referred to pediatric cardiology department for cardiac murmur or chest pain. The patients in control group were considered as healthy after electrocardiographic, telecardiographic and echocardiographic examinations. Informed consent was obtained from all parents. The patients who have a comorbid cardiac or extracardiac disease and under 8 ages or over 18 ages were excluded.

Patients were separated into two groups depends on their body mass index (BMI). BMI was calculated as weight in kilograms divided by the square of height in meters (weight/height² expressed in kg/m²). Patients's BMI scores were determined by the curves of Turkish children reported by Olcay Neyzi.³ For these standards between 10 and 85 percentiles was normal and over 95th percentiles defined as obese. The overweighted children (percentiles between 85-95th) were excluded. Antropo-

metric examination was performed by a pediatric endocrinologist. Echocardiography was performed in all patients by the same physician.

Echocardiography

Echocardiographic examination was performed using a GE Vivid 3 Pro device with 1.5-3.6 MHz phase transducer. Examinations have been made in left lateral position on standard parasternal long axis and apical four chamber views.

Tissue doppler echocardiography

The mitral Doppler signals were recorded in the apical four-chamber view, with the sample volume placed at the lateral walls of mitral annulus. The early (Em) diastolic, late (Am) diastolic myocardial velocities and systolic (Sm) movement velocities, isovolumetric relaxation time (IVRT) and isovolumetric contraction time (IVCT) were measured. The highest values of Em and Am were founded and then Em/Am was calculated. IVCT was defined as the duration of the bidirectional spike between the ending of Am and the beginning of Sm. IVRT was defined as the duration of the bidirectional spike between Sm and Em. Tei (MPI: Myocardial performance index) index was calculated from the sum of isovolumetric contraction time (IVCT) and isovolumetric relaxation time (IVRT), divided by ejection time (ET). (Figure 1) Left ventricle systolic and diastolic functions were determined by using this index.

Standard doppler echocardiography

The mitral flow was examined with the sample pulse Doppler positioned parallelly (<200) to flow just at the orifice of the mitral leaflets. Measurements obtained by maximum velocities. 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. E velocity was defined as peak velocity of fast filling phase of left ventricle; A velocity defined as peak velocity of slow filling flow of ventricle; DT defined as the interval between peak E velocity and the ending of fast filling phase. (Figure 2) Posterior wall of left ventricle and septum thickness were measured from the two dimensional targeted M-mode echocardiographic tracings in the parasternal long axis.

Statistical analysis

Statistical analysis was performed using dedicated software (SPSS 15.0). All data are presented as mean \pm standard deviation. The case and control groups were including 20 children and so Kolmogorov-Smirnov test was used to analyze the numerical results. The statistical significance for all analyses was set at $p < 0.05$. Student's T test was used to compare numerical data in independent groups.

RESULTS

There was no statistically significant difference between two groups regarding age, gender and body height. In obese group the mean body weight was 72.67 ± 19.34 kg, mean height 152.66 ± 12.45 cm, mean body mass index 30.92 ± 6.87 kg/m². These values were 42.75 ± 13.30 kg, 149.60 ± 16.60 cm and 18.55 ± 2.20 kg/m² in control group, respectively. Mean BMI was significantly higher in obese group ($p < 0.001$) (Table 1).

In echocardiographic examination, there was no statistically significant difference between two groups regarding early diastolic wave velocity (Em) ($p = 0.514$). The mean late diastolic wave velocity (Am) was significant higher in obese group (8.67 ± 3.10 / 6.80 ± 2.30 cm/sn, $p = 0.022$). Em/Am value (2.40 ± 0.90 / 3.10 ± 0.80 , $p = 0.016$) among obes was less than control group (Figure 3).

Tissue Doppler IVRT was detected 66.1 ± 7.3 msn in obese group and 58.70 ± 9.06 msn in control group. The difference of IVRT between obes and controls was statistically significant ($p = 0.007$). There was no significant difference between groups respect to total systolic time (TsT) 372.70 ± 30.90 msn in obes and 373.50 ± 38.90 msn in control group, $p = 0.940$. The ET value was 248.50 ± 18.30 msn and 268.50 ± 36.18 msn in obes and controls, respectively. ET value was significantly lower in obes compared to controls ($p = 0.034$) (Table 2).

Left ventricular MPI was higher in obese group compared to the control group (obese: 0.50 ± 0.07 ; control: 0.41 ± 0.04 $p < 0.001$) (Figure 4).

There was no significantly difference between obes and controls regarding early diastolic wave velocity (E), late diastolic wave velocity (A) and deceleration time (DT). The E/A ratio was similar in both groups ($p = 0.066$). Mean left ventricular posterior wall (LVPW) thickness was 7.40 ± 1.30 mm in obes and 5.57 ± 0.97 mm in controls ($p < 0.001$).

The mean value of interventricular septum thickness was 7.30 ± 1.40 mm and 5.40 ± 0.90 mm respectively ($p < 0.001$) (Table 3).

Table 1. General characteristics of the groups

	Obese (n=20)	Control (n=20)	P
Age (months)	161.50 \pm 25.78	151.15 \pm 33.48	0.280
Height (cm)	152.67 \pm 12.45	149.60 \pm 16.60	0.514
Height-Z score (sds)	-0.57 \pm 1.53	-0.25 \pm 1.32	0.490
Weight (kg)	72.67 \pm 19.34	42.75 \pm 13.30	<0.001
Weight-Z score (sds)	1.80 \pm 0.60	-0.20 \pm 0.70	<0.001
BMI (kg/m ²)	30.92 \pm 6.87	18.55 \pm 2.20	<0.001
BMI -Z score (sds)	2.45 \pm 0.54	2.00 \pm 0.30	<0.001
BMI percentile	97.50 \pm 1.30	51.30 \pm 19.50	<0.001

BMI: Body mass index

Table 2. Pulse-wave tissue Doppler echocardiographic characteristics

	Obese (n=20)	Control (n=20)	P
Sm cm/sec	9.90 \pm 2.58	8.35 \pm 1.47	0.024
Em cm/sec	19.20 \pm 5.10	20.24 \pm 4.72	0.514
Am cm/sec	8.67 \pm 3.10	6.80 \pm 2.30	0.022
Em/Am	2.40 \pm .90	3.10 \pm 0.80	0.016
IVRT msec	66.10 \pm 7.30	58.70 \pm 9.06	0.007
IVCT msec	54.20 \pm 10.60	59.25 \pm 13.11	0.188
ET msec	248.50 \pm 18.30	268.50 \pm 36.18	0.034
TsT msec	372.70 \pm 30.90	373.50 \pm 38.90	0.940
MPI	0.50 \pm 0.07	0.41 \pm 0.04	<0.001

Sm: mitral systolic movement velocity, Em: early mitral diastolic velocity, Am: late mitral diastolic velocity. IVRT: isovolumetric relaxation time, IVCT: isovolumetric contraction time, ET: ejection time, TsT: total systolic time, MPI: Myocardial performance index.

Table 3. Transmittal flow pulse wave Doppler echocardiographic characteristics and Two-dimensional-guided M-mode tracing echocardiography.

	Obese (n=20)	Control (n=20)	P
E m/sec	1.00 \pm 0.15	1.08 \pm 1.14	0.122
A m/sec	0.66 \pm 0.15	0.63 \pm 0.18	0.750
DT msec	138.15 \pm 18.37	142.45 \pm 37.06	0.184
E/A	1.60 \pm 0.40	1.80 \pm 0.40	0.066
LVPW (mm)	7.40 \pm 1.30	5.57 \pm 0.97	<0.001
LV İVS (mm)	7.30 \pm 1.40	5.40 \pm 0.90	<0.001

E: early mitral diastolic velocity, A: late mitral diastolic velocity, DT: Deceleration time, LVPW: left ventricular posterior wall, LV İVS: left ventricular interventricular septum.

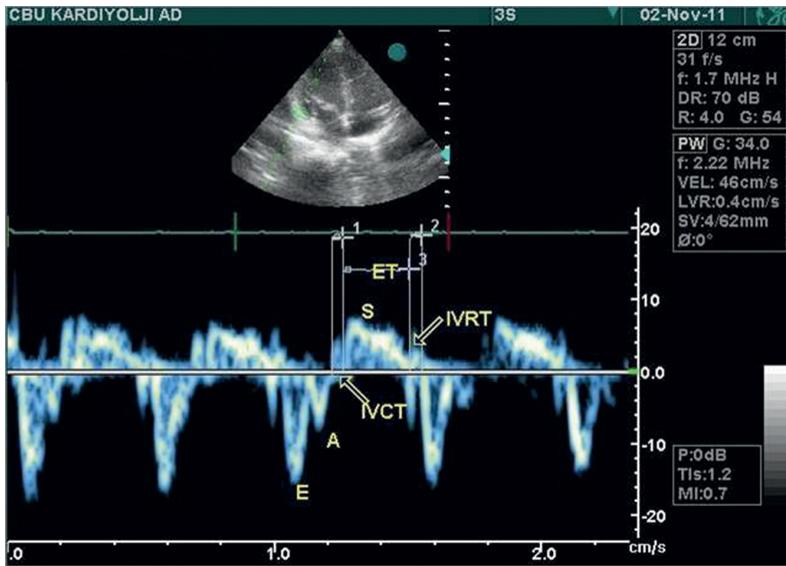


Fig. 1. Tissue Doppler time intervals, S, E, A waves and Tei index. [MPI (Tei index): IVRT+IVCT/ET]. (IVCT: isovolumetric contraction time, IVRT: isovolumetric relaxation time, ET: ejection time, MPI: Myocardial performance index)

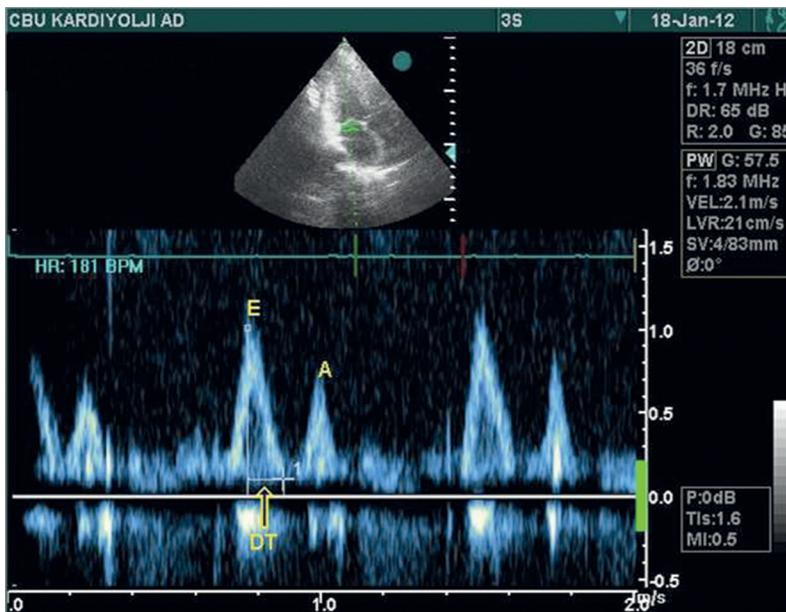


Fig. 2. Mitral Doppler flow (E: early mitral diastolic velocity, A: late mitral diastolic velocity, DT: Deceleration time)

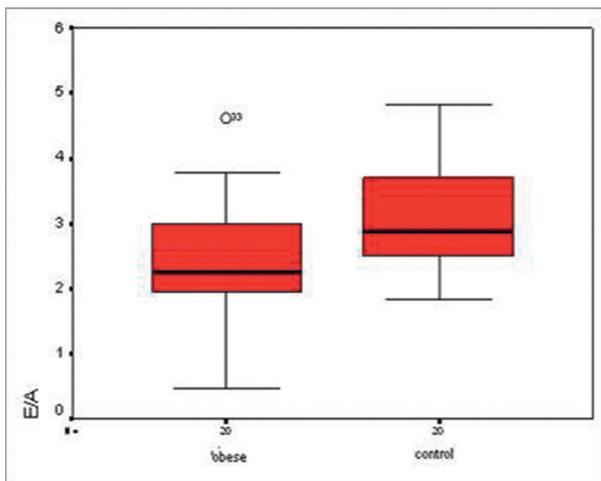


Fig. 3. E/A ratios in obese and control group

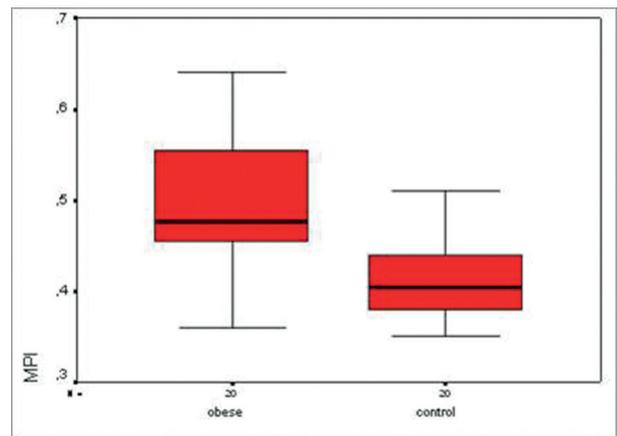


Fig. 4. MPI values of obese and control group (MPI: Myocardial performance index)

DISCUSSION

Obesity is a chronic and insidious disease that specially effects cardiovascular system.^{1,3} Major complications of cardiovascular system are dyslipidemia and hypertension. Childhood obesity is a predictor of adult obesity and of increased coronary heart disease and stroke risk later in life.⁸ Bogalusa Heart Study have been shown that coronary atherosclerosis was usually begun in childhood.⁹ Also obese adolescents are more likely to have hypertension in adulthood (8.5 fold compared to normal weighted).¹⁰ Tissue Doppler Echocardiography (TDE) is a modified form of conventional pulse Doppler echocardiography that is used for researching negative effects of obesity on the heart and it provides to analysis cardiac functions.¹¹ Before using of tissue Doppler imaging digital ventriculography and regional M-mode echocardiography were been used for quantitative assessment of regional functions. But it was so difficult to determine wall motion by these techniques.¹² TDE allows regional assessment of myocardial systolic and diastolic functions.¹³ This technique can detect subclinical left ventricle dysfunctions more sensitively than conventional echocardiography in many diseases which standard LV parameters were normal.¹ In addition, when compared to conventional Doppler parameters, TDE data are relatively independent from preload and afterload so it is useful in assessment of diastolic functions. TDE is a recently used new technique; for that reason there are a few studies for usage of TDE in childhood in literature.^{14,15} Also we used this technique at obese and normal children in our study. Diastolic dysfunction characterized by prolonged IVRT is the earliest abnormality in heart in obese patients. It can be defined as an abnormality of ventricular filling with normal cardiac function and compensatory increased atrial pressure.¹⁶ In this condition, E wave depressed due to decreased fast filling and A wave upraises. In our study IVRT was significantly higher in obesese compared to healthy controls ($p=0.007$). Prolonged IVRT shows diastolic dysfunction as relaxation impairment in ventricle. Em/Am ratio and A values were significantly different from those of the control group similar to other studies in literature.^{13,17} And so it can postulated that impairment of left ventricle relaxation has begun in obese children. Mehta et al. reported no difference in LV diastolic functions between obese and healthy controls by conventional Doppler echocardiogra-

phy but similar to our study they found significant increase of E and decrease of A wave in obese children.⁶ On the other hand contrary to our study Harada et al. have been found significant difference in obese children by using conventional Doppler echocardiography as well as TDE.¹⁸ Diagnosis of diastolic dysfunction can be made by invasive and noninvasive methods such as echocardiography (M-mode, Doppler, TDE), magnetic resonance imaging, radionuclide ventriculography. Doppler echocardiography is the common and acceptable method recently. But TDE can detect regional diastolic dysfunction in patients that pulse wave Doppler trace was normal.¹⁶

One of the important results of our study was the significantly decrease of Em/Am ratio measured by TDE in obese children compared to controls ($p=0.016$). But there was no differences between two groups by conventional Doppler echocardiography. This result suggested that TDE was superior to conventional Doppler echocardiography in detecting subclinical abnormalities.

Myocardial performance index is a new echocardiographic parameter which had a prognostic value in many cardiac disease and used to evaluate both systolic and diastolic functions.¹⁹ In our study we detected significantly higher MPI in obese group compared to controls by using pulse wave TDE ($p=0.000$). This result suggested that there was impairment in both systolic and diastolic functions in obesese. So improving our understanding of cardiac dysfunction related to obesity becomes very important to lead the way for new preventive and therapeutic strategies. However Van Putte-Katier et al. have been reported decreased MPI in obesese,⁷ review of the literature revealed many studies which have concordant results to ours.^{20,21} Other important parameters of LV functions are interventricular septum thickness and left ventricle end-diastolic dimension (LVDD). Obesity together with increased blood volume and hypertension may lead over time to increase in LV mass.²² In our study we found that LVDD and IVS were significantly higher in obesese compared to controls similarly the other studies in literature.²³⁻²⁵ Hypertrophy of LV can decrease LV compliance and so diastolic dysfunction can be occurred in obese children and this hypertrophy causes a decrease in left ventricle compliance and results an impairment of diastolic relaxation pattern. We also found a negative discordance between BMI

and Em/Am ratio. This finding suggested that BMI was closely associated with diastolic dysfunction. Contrastly, Sharpe et al. have been reported no difference between these parameters.²⁶ One possible reason for this may be older ages of our obese patients and so long duration of obesity and also may be higher BMI's in our study.

We showed subclinical changes in LV diastolic functions by using TDE in our study. MPI is an useful parameter in determining both systolic and diastolic functions of LV and could be effected negatively in obese children. For that reason to determine early effects of obesity on cardiovascular system it would be better to use TDE plus normal echocardiographic imagine and that provides early prevention and treatment for patients. Our data support the use of TDE in obese children, because it can detect early effects of obesity in LV functions.

In conclusion, TDE is a useful method in determining the effects of obesity in cardiac functions and the subclinical changes of diastolic functions of left ventricle, right ventricle and interventricular septum. We believe that TDE will place to conventional methods, as a useful and noninvasive method in obese children by the contribution of future studies in larger obese groups.

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