Usefulness of the myocardial performance index (MPI) for assessing ventricular function in obese pediatric patients

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SUMMARY. Levent E, Gökşen D, Özyürek AR, Darcan Ş, Çoker M. Usefulness of the myocardial performance index (MPI) for assessing ventricular function in obese pediatric patients. Turk J Pediatr 2005; 47: 34-38.

Obesity is a prevalent pathological and nutritional disease relating to clinical and sub-clinical disorders. Furthermore, its complications exert a major impact on cardiovascular risk. Myocardial performance index (MPI) has been described as noninvasive Doppler measures of left ventricular (LV) function. The purpose of this study was to assess MPI using transthoracic Doppler echocardiography in normotensive obese and hypertensive obese pediatric patients and in a control group, and to investigate the relationship between MPI and LV mass, and LV systolic and diastolic functions. The study group consisted of 25 healthy cases (M/F: 13/12) as a control group (Group I), 25 normotensive-obese patients (M/F: 13/12) (Group II) and 25 hypertensive-obese patients (M/F. 14/11) (Group III). The mean ages were 12.1±1.8, 11.9±1.5 and 12.4±1.4 years, respectively. Cholesterol levels and body mass index (BMI) were higher in the hypertensive-obese group. The MPI values were 0.37±0.04, 0.43±0.08 and 0.51±0.11 in the three groups, respectively. MPI measurements, LV mass fractional shortening (FS), ejection fraction (EF) and mitral E/A ratio were found significantly different, especially in the hypertensive-obese group. These findings may be important to determine the relationship between obesity and cardiovascular risk factors in pediatric ages. MPI may be useful in determining the relationship between them.

Key words: obesity, cardiovascular risk, myocardial performance index, children.

Obesity is a serious nutritional disorder in most developed countries. The prevalence and severity of obesity are increasing in children and adolescents[1,2]. Hypertension, dyslipidemia, insulin resistance and glucose intolerance may cause an acceleration of cardiovascular complications in obesity[2-6]. Although complications of obesity have traditionally been viewed as problems of adulthood, these abnormalities may begin in childhood and adolescence[6-8]. Initiation of the disease process earlier in life suggests that morbidity and mortality may occur at a younger age. Earlier diagnosis of this process is important for prognosis and therapy[9].

Recently, an easily measured Doppler index (myocardial performance index, MPI) combining systolic and diastolic time intervals has been proposed[10-12]. A combined MPI has been described that may be more effective for analyses of global cardiac dysfunction than systolic and diastolic measures alone[10]. The MPI measures the ratio of isovolumetric time intervals (isovolumetric contraction time, isovolumetric relaxation time) to ventricular ejection time[10]. The index is applicable to both of the ventricles. Recent studies have shown that MPI correlated with other invasive and noninvasive measures of left ventricle function[12]. The MPI has also been shown to have significant clinical utility. Studies have demonstrated that MPI is an indicator of dilated cardiomyopathy[11], primary pulmonary hypertension[13], and congenital heart disease[14] and is efficient in early detection of anthracycline-induced cardiotoxicity in children[15].

The aim of this study was to measure MPI in normotensive obese and hypertensive obese pediatric patients by Doppler echocardiography and to investigate the relationship between obesity and cardiovascular disorders.

Material and Methods

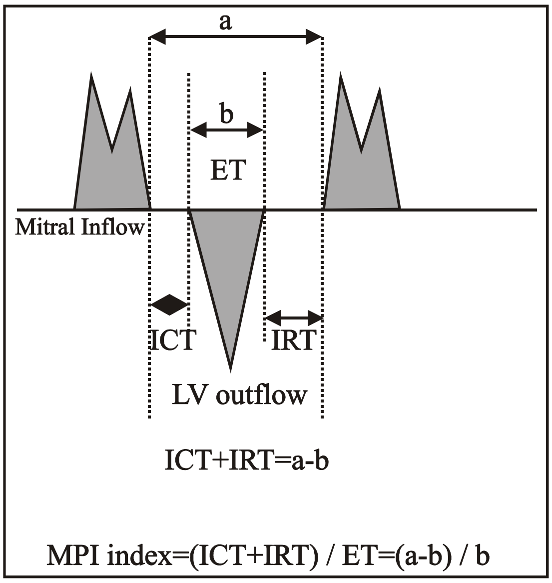
This study was performed in Ege University, Faculty of Medicine, Departments of Pediatric Cardiology and of Pediatric Endocrinology and Metabolism between January 2000 and January 2001. The study group consisted of 25 healthy cases (M/F: 13/12) as a control group (Group I), 25 normotensive-obese patients (M/F: 13/12) (Group II) and 25 hypertensive-obese patients (M/F: 14/11) (Group III). The mean ages were 12.1±1.8, 11.9±1.5 and 12.4±1.4 years, respectively. All the patients were diagnosed as exogenous obesity. Patient and control groups were the same as in our previous study[6].

Height was measured to the nearest 1 cm with a Harpenden stadiometer, and weight was measured to the nearest 0.1 kg using an electronic digital scale. Body mass indrex (BMI) was calculated as weight (kg)/height $(m)^2$. Obesity was defined as BMI above 95th percentile for age and sex. An expert committee has recommended accepting the subject above 95th percentile as obese[9].

After subjects rested in the supine position for 15 minutes, their blood pressure was measured at the brachial artery by (automatic) sphygmomanometer using the ordinary cuff adapted to the arm circumference. Both systolic (P_s) and diastolic (P_d) blood pressures were measured, and the mean of the pressures was obtained after three measurements. If three measurements of blood pressure were above the 95th percentile, subjects were accepted as hypertensive. The patients were divided into two groups according to their blood pressures as normotensive and hypertensive obese patients (Group II and Group III). Plasma glucose and cholesterol measurements were performed after 12 hours of fasting with an Alcyon 300, Abbott Laboratories machine by enzymatic method.

Echocardiographic Measurements and Calculations

Echocardiography was performed on all cases with Hewlett-Packard Sonos 1000 System with a 2.7-3.5 MHz transducer. Echocardiograms were recorded on VHS videotape and all analyses were performed by two pediatric cardiologists (EL and ARO). Doppler signals were displayed at a paper speed of 100 mm/S. MPI was calculated from the Doppler flow interval as measured by echocardiograms using the formula[10], MPI=[(isovolumetric contraction time (ICT) + isovolumetric relaxation time (IRT)] / left ventricular ejection time (LVET) (Fig. 1). These intervals and mitral inflow velocities (E wave and A wave velocities) from cessation to onset of mitral valve inflow were obtained in the four-chamber plane with a PW Doppler signal placed at the mitral valve leaflet tips. The patients with mitral valve regurgitation were omitted. LVET was measured from the five-chamber scan in the LV outflow tract. To account for slight variations in RR cycle length, each time interval was measured on 4-5 consecutive beats and then averaged. The fractional shortening (FS) of the left ventricle is $[(LV_{EDD}-LV_{ESD})/LV_{EDD}] \times 100$, ejection fraction of the left ventricle is $[(LV_{EDD}{}^3-LV_{ESD}{}^3)/LV_{EDD}{}^3] \times 100$, and standard formulas[16,17] were used to calculate left ventricular mass (LVM):



MPI : myocardial performance index.
ICT : isovolumetric contraction time.
IRT : isovolumetric relaxation time.
ET : ejection time.
LV : left ventricle.

Fig. 1. Doppler time intervals and MPI.

$$LVM=(0.8x[1.04(LV_{EDD}+IV_{SDD}+LV_{PWDD})^3-LV_{EDD}{}^3])+0.6$$

were LV_{ESD} is LV end-systolic diameter, LV_{EDD} is LV end-diastolic diameter, IVS_{DD} is interventricular septum diastolic diameter and LV_{PWDD} is left ventricular posterior wall diastolic diameter. They were measured according to the American Society of Echocardiography convention[18]. The total LV mass as well as LV mass corrected (LVMC) for the allometric signal of height (LV mass/height$^{2.7}$) were used in statistical analyses[19]. No evidence of structural cardiovascular disease or mitral regurgitation was detected by two-dimensional echocardiogram or color-flow.

Statistical Analyses

Data are expressed as means±SD. Patients were classified into three groups. Analysis of variance (ANOVA) was used for comparisons of the different groups. Tukey test as a posthoc test was used for comparisons of the groups. Statistical analyses were performed using SPSS 10.0 for Windows. P value <0.05 was considered significant.

Results

In our study, the sample population consisted of 25 normal healthy cases (Group I), 25 normotensive-obese (Group II) and 25 hypertensive-obese (Group III) patients. The characteristics of the groups are given in Table I. There was no statistically significant difference among the three groups according to age, gender, and plasma glucose. BMI, systolic and diastolic blood pressure (BP) and cholesterol measurements were statistically significant in Group III compared with the control group (Group I) and Group II. Table II summarizes the Doppler time intervals for controls and the study groups. The LV MPIs in normal children (control group), normotensive-obese group and hypertensive-obese group were 0.37±0.04, 0.43±0.08 and 0.51±0.11, respectively. LV MPI measurements were statistically significant between Groups I-II ($p<0.001$), Groups I-III ($p<0.001$) and Groups II-III ($p<0.001$). LVM and LVMC measurements were statistically significant between Groups I-II and III. Ejection fraction (EF), FS and mitral E/A ratio were significantly higher in Group III than Groups I and II ($p<0.01$), but those were no statistical differences between Groups I and II ($p>0.05$). None of the subjects had diabetes.

Table I. The Clinical, Laboratory and Statistical Characteristics of All Groups

	Group I (Normal control)	Group II (Normotensive-obese)	Group III (Hypertensive-obese)	ANOVA
Age (years)	12.1±1.8	11.9±1.5	12.4±1.4	NS
M/F ratio	1.08	1.08	1.27	NS
BMI kg/m^2	17.4±3.2	26.9±2.7	31.9±4.4	0.001
Systolic BP mm Hg	104.7±11.6	105.8±9.4	137.6±13.1	0.000
Diastolic BP mm Hg	69.8±6.8	70.2±5.4	89.6±9.1	0.000
Cholesterol g/dl	144±24.5	156.8±13.4	179.6±12.3	0.000
Plasma glucose g/dl	98.9±13.2	99.1±12.4	99.1±12.4	NS

Values presented as means±SD.
BMI: body mass index; BP: blood pressure.

Table II. The Doppler Time Intervals in All Groups

	Group I (Normal control)	Group II (Normotensive-obese)	Group III (Hypertensive-obese)	ANOVA
Heart rate (beats/min)	86±19	90±15	101±28	0.01
LV MPI	0.37±0.04	0.43±0.08	0.51±0.11	0.001
LV ICT (ms)	37±12	42±16	54±22	0.001
LV IRT (ms)	63±9	62±14	61±18	NS
LV ejection time (ms)	300±23	272±32	234±15	0.001
Mitral E/A ratio	2.2±0.5	2.1±0.4	1.7±0.5	0.01
FS	38.1±4.9	39±6.7	43.1±2.3	0.01
EF	69.2±7.3	70.1±11	76.4±6.4	0.01
LVM (g)	91±17	105±16	119±14	0.01
LVMC (g/m$^{2.7}$)	29±4	33±4	37±7	0.01

Values presented as means ± SD.
MPI: myocardial performance index, ICT: isovolumetric contraction time; IRT: isovolumetric relaxation time; LV: left ventricle; LVM: LV mass, LVMC: LVM corrected, FS: Fractional shortening, EF: ejection fraction.

The mean intraobserver variability was 3.1% in the measurement of the LV MPI, whereas the mean interobserver difference was 5.1% in 30 random Doppler recordings.

Discussion

Several epidemiological studies have shown the importance of obesity in adulthood and its relation to systemic hypertension, metabolic abnormalities and cardiovascular disease[1-3]. There is evidence that the prevalence of obesity is increasing among children and adolescents. This means that the risk of cardiovascular complications among this group may also be increasing[1,3].

The Doppler-derived MPI, defined as the sum of isovolumetric contraction and relaxation durations divided by ejection time and reflecting both systolic and diastolic myocardial function, has been found to be related to morbidity and mortality in cardiac problems[10,20-22]. We calculated the MPI using the formula proposed by Tei[10] with transthoracic Doppler echocardiography in obese pediatric patients. In recent studies, MPI has not been affected by age and heart rate[10-14,21,23]. The mitral peak E/A ratio is the parameter used for the assessment of diastolic function, but it is affected by respiration and heart rate, especially in pediatric ages[24].

Eidem et al.[15] showed the clinical efficiency of MPI for early detection of anthracycline-induced cardiotoxicity in children. In their study, they observed that with increasing cumulative dosages of anthracycline, a significant increase was seen in LV MPI, especially before changes in other conventional measurements of LV. In our study, the LV MPI was significantly higher in obese patients, especially in the hypertensive-obese group. A significant increase in LV MPI can be predicted as LV dysfunction.

In Group III, MPI may be affected by three significant factors: BMI, hypertension and hypercholesterolemia. In recent studies, data have suggested that MPI may be a useful parameter and an early indicator of left ventricular dysfunction in essential hypertensive patients with normal systolic function[25,26]. Although Group II did not have hypertension, MPI values were significantly higher in this group. Therefore, our study shows that MPI values may be affected not only by hypertension, but also by other factors like hypercholesterolemia and obesity, etc. In adult studies it has been shown that these factors are important in the prognosis of obesity[4,10]. With this study we showed that these factors are also important in pediatric ages.

Messerli et al.[27] reported that cardiac adaptation to obesity in adults consisted of LV dilatation and hypertrophy regardless of the level of blood pressure. Gottdiener et al.[28] reported that obesity was the strongest clinical predictor of LV mass. In our study, the increase in LVM and LVMC was seen in the obese patients with no hypertension. When this increases evaluated with MPI, it gives important evidence about cardiovascular status in obesity. These findings may be important to determine the relationships among cardiovascular risk factors in pediatric ages, but it would be better to draw definite conclusions after follow-up echocardiograms.

In our study, total LVM was adjusted to the body size (LVMC). The various methods that have been proposed include indexation by lean body mass, body surface area, height, height^2, height$^{2.7}$ and height^3. For comparison with adult results, other authors recommended use of height$^{2.7}$ in the adolescent age group, as in study[4,19,29].

The evaluation of an obese child should include careful consideration of possible complications. Prevention strategies to avoid excess weight gain during childhood and adolescence are essential to promote maintenance of healthy weights throughout adulthood. The evaluation of the child with echocardiograhic examinations is important as well as hypertension and hyperlipidemia monitorization[4,30]. This simple and reproducible index can be useful to determine the high-risk patients needing an aggressive obesity treatment.

In our study, especially hypertensive-obese patients had high LV MPI. This parameter suggests that this group has cardiovascular risk and shows that MPI may be and indicator for cardiovascular complications in high-risk obese pediatric patients.

With reports of increase in the prevalence of childhood and adolescent obesity, it seems reasonable to suggest weight control early in life as an initial step in reducing pediatric and adult cardiovascular risk. The goal of treatment of obesity should be to decrease future morbidity. Prevention strategies to avoid excess weight gain during childhood and adolescence are essential to promote maintenance of healthy weights throughout adulthood.

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