The myocardial performance index in children with isolated left-to-right shunt lesions

İzole soldan-sağa şantlı lezyonu olan çocuklarda miyokard performans indeksi

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ABSTRACT

Objective: The myocardial performance index (MPI) measures the ratio of isovolumic time intervals to ventricular ejection time. The effects of altered ventricular preload or afterload on MPI have yet to be determined. This study was designed to determine the impact of altered preload on left and right ventricular myocardial performance index in the clinical setting of left-to-right lesions.

Methods: The left and right ventricular myocardial performance indexes were measured in 17 patients with atrial septal defect (ages 6 to 148 months), 23 patients with ventricular septal defect (ages 2 to 160 months), and 24 healthy children (ages 3 to 160 months). A complete 2- dimensional and Doppler echocardiographic examination was performed in all study groups.

Results: In patients with atrial septal defect, ventricular septal defect, and control group subjects, the left ventricular MPI was 0.38, 0.37 and 0.32, respectively, and the right ventricular MPI was 0.24, 0.21, and 0.20, respectively. No significant differences in the left and right ventricular myocardial performance indexes were seen between patients with left-to-right shunt lesions and control subjects.

Conclusion: This study documents that the myocardial performance index is a quantitative measure of ventricular function that appears to be relatively independent of changes in preload. *(Anadolu Kardiyol Derg 2005; 5: 108-11)*

Key words: Myocardial performance index, children, left-to-right shunt lesions.

ÖZET

Amaç: Miyokard performans indeksi (MPİ) izovolümik zaman aralıklarının ejeksiyon zamanına bölünmesi ile elde edilir. Ventriküllerin ön ve art yük değişikliklerinde bu indeksin nasıl etkilendiği araştırılmalıdır. Bu çalışma izole soldan sağa şantların neden olduğu ön yük değişikliklerinde sağ ve sol ventriküler miyokard performans indeksinin nasıl etkilendiğini araştırmak amacı ile planlandı.

Yöntem: Yaşları 6 ay ile 148 ay arasında 17 atriyal septal defekt'li olguda, yaşları 2 ay ile 160 ay arasında 23 ventriküler septal defekt'li hastada ve yaşları 3 ay ile 160 ay arasında 24 sağlıklı çocukta sol ve sağ ventrikül için miyokard performans indeksi ölçüldü. Tüm çalışma grubuna MPI hesaplaması için gerekli iki-boyutlu ve Doppler ekokardiyografi ölçümleri hem sağ ventrikül, hem de sol ventrikülden yapıldı.

Bulgular: Sol ventrikül için miyokard performans indeksi atriyal septal defekti ve ventriküler septal defekti olan hastalarda ve kontrol grubundaki sağlıklı çocuklarda sırası ile 0.38, 0.37 ve 0.32 iken sağ ventrikül için MPİ sırası ile 0.24, 0.21 ve 0.20 olarak bulundu. Gruplar arasında sol ve sağ ventrikül MPİ yönünden istatistiksel açıdan anlamlı bir fark yoktu.

Sonuç: Bu çalışma ile ventrikül fonksiyonlarını ölçmeye yarayan miyokard performans indeksinin ön yük değişikliklerinden bağımsız olduğu gösterildi. *(Anadolu Kardiyol Derg 2005; 5: 108-11)*

Anahtar kelimeler: Miyokard performans indeksi, çocuklar, soldan-sağa şantlı lezyonlar

Introduction

The development and progression of heart failure results from a complex interplay of hemodynamic and neurohormonal factors, rather than simply changes in cardiac function. Decompensated state in heart failure can be the product of acute myocardial injury or, as it is the most common case in children, a change in loading conditions. At end-diastole intraventricular pressure and volume are determined by preload (venous return) and the lusitropic state of the ventricular myocardium (1, 2). Systolic and diastolic dysfunctions frequently coexist in heart failure (3, 4). Myocardial performance index (MPI) has been described as a non-invasive Doppler measurement of ventricular function. This index is defined as the sum of the isovolumetric contraction time and the isovolumetric relaxation time divided by the ejection time (3-7). In previous studies, the index has been found to be reproducible, easily obtainable and to correlate closely with invasive measures of both systolic and diastolic function, being independent of heart rate and left ventricular geometry. In cardiac amyloidosis, idiopathic dilated cardiomyopathy, primary pulmonary hypertension, the index was shown to reflect disease severity and to have incremental prognostic value (4-10). The effects of altered ventricular preload on the MPI have yet to be determined. The aim of this study was to determi-

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ne the effects of left-to-right shunt lesions on left and right ventricular myocardial performance indexes.

Material and Methods

The study populations consisted of 3 groups. 1) The study group for isolated right ventricular volume overload consisted of children with isolated secundum atrial septal defect (ASD) with evident left-to-right shunts by colour flow Doppler echocardiography. All ASD patients had normal right ventricular systolic pressure as assessed by tricuspid regurgitation velocity, calculated from the modified Bernoulli equation (11). 2) Second group consisted of children with left-to-right shunt lesions at the level of ventricles and / or arteries (ventricular septal defects (VSD) and / or patent ductus arteriosus). 3) Control group consisted of children referred to our clinic for innocent heart murmur and found to be totally free of significant cardiovascular disease by clinical examination, electrocardiogram, chest X-ray, and 2- dimensional / Doppler echocardiography. Patients with additional cardiac problems (arrhythmias, stenosis and/or overt regurgitations, complex cardiac defects, etc.) and systemic diseases were excluded from the study.

A complete 2- dimensional and Doppler echocardiographic examination was performed with commercially available ultrasound instrumentation Hewlett-Packard Sonos 1000 (Hewlett-Packard Inc.) with 2.5 or 3.5 MHz transducer. The echocardiographic examination was performed using standard views and techniques according to the guidelines of the American Society of Echocardiography (12). The left ventricular ejection fraction was measured by the method previously described by Quinones et al. (13). The mitral and tricuspid inflow velocities were recorded from the apical-4-chamber view with the pulsed-wave Doppler sample volume positioned at the tips of the mitral or tricuspid leaflets during diastole, respectively. The left ventricular outflow velocity pattern was recorded from the apical long-axis view with Doppler sample volume positioned just below the aortic valve, and the right ventricular outflow velocity pattern was recorded from the parasternal short axis view with Doppler sample volume positioned just below the pulmonary valve. The size of the Doppler sample volume was set at an axial length of 1 to 2 mm with a 100 Hz wall filter setting. An electrocardiogram was simultaneously recorded with a Doppler echocardiogram in all subjects. Two-dimensional and Doppler tracings were recorded at a paper speed of 100 mm/s on videotape for later playback and analysis.

Doppler time intervals were measured from the atrioventricular valve inflow and ventricular outflow Doppler tracings, as described by Tei and co-workers (6). The interval 'a' from cessation to onset atrioventricular valve inflow is equal to the sum of isovolumetric contraction time (ICT), ejection time, and isovolumetric relaxation time (IRT). Ejection time ' b ' is derived from the duration of ventricular outflow Doppler velocity profile. The sum of ICT and IRT was obtained by substracting ' b ' from ' a '. The MPI was calculated as: : (a – b) / b. Isovolumetric relaxation time was measured by subtracting the interval ' d ' between the R wave and cessation of ventricular outflow from the interval 'c' between the R wave and the onset of atrioventricular valve inflow. Isovolumetric contraction time was calculated by subtracting isovolumetric relaxation time from (a-b). Peak velocities of early (E) and late (A) filling were derived from atrioventricular valve inflow velocity profiles. Deceleration time (DT) was measured as the time from peak E velocity to the intercept of the deceleration of flow with the baseline. The ratio of early to late peak velocities (E/A) was subsequently calculated. Five consecutive beats were measured and averaged for each measurement.

Statistical analysis: Continuous data are presented as mean ± standard deviation. Age variable was mentioned as the median because of abnormally distributed variable. All study groups were compared by one-way variance analysis if appropriate. If there was a statistical difference, we used Tukey-HSD test as a secondary test. If the data were not appropriate for parametric test, we used Kruskal – Wallis test to compare the data.

Results

Clinical characteristics and general echocardiographic / Doppler findings are shown in the Table 1. There were 17, 23, and 24 patients in the ASD, VSD and control groups, respectively. Age, gender, body surface area, heart rate, systolic and diastolic blood pressure, aorta / left atrial dimension ratio, ejection fraction, and shortening fraction were not significantly different among the groups. But left ventricular systolic diameter index (left ventricular systolic diameter / body surface area), left ventricular diastolic diameter index (left ventricular diastolic diameter / body surface area), and cardio-thoracic index were significantly elevated in the VSD group ($p< 0.05$), and cardio-thoracic index was significantly elevated in the ASD group ($p < 0.05$).

Table 2 shows the Doppler-derived time intervals and velocities. The left and right ventricular MPI's were higher in the atrial septal defect and ventricular septal defect groups, but these increments were not significant (Fig. 1). Patients of ASD, VSD and control groups did not differ with respect to left and right ventricular IRT, left and right ventricular ICT, E / A ratio for left and right ventricles, and tricuspid DT, but mitral DT was significantly reduced in both atrial septal defect and ventricular septal defect groups ($p < 0.05$) as compared with control group.

Discussion

In the presence of congestive heart failure, systolic and diastolic dysfunctions frequently coexist (3). Numerous studies have shown that systolic and diastolic time intervals are closely linked to systolic and diastolic left ventricular performance. Although individual time intervals of the cardiac cycle can be easily obtained from Doppler velocity profiles as measurements of cardiac function, heart rate and load dependency have limited their clinical use (14-16). Tei et al. (6) proposed a Doppler-derived index for assessment of overall left ventricular function that combines systolic and diastolic time intervals. The myocardial performance index is potentially applicable not only to the evaluation of global left ventricular function but also to the evaluation of right ventricular function in children with congenital heart disease (10). The objective of this study was to assess the effect of increased preload on myocardial performance index.

Previous studies have shown that an elevation in preload increases ICT and ejection time but reduces IRT (8, 17). In our study the changes in isovolumetric relaxation time and isovolumetric contraction time among the study groups were not significant, so we found no significant changes in MPI although left and right ventricular myocardial performance indexes were slightly elevated in the ASD and VSD groups. Eidem et al. (5) have found out that right ventricular MPI was relatively independent of preload in children, which is in agreement with our findings.

In our study, mitral DT shortened significantly in the ASD and VSD groups compared to the control group. Dujardin et al. (4) also have found similar results. They explained this finding with mitral restrictive filling pattern that was seen in the setting of increased left atrial pressures. In their study, the patients with a deceleration time of < 150 ms had a similar mean value of index with a shorter IRT but longer ICT and shorter ejection time compared to the patients with a DT of > 150 ms. Thus, in the patients with restrictive filling patterns, the shortening of the isovolumetric relaxation time was counterbalanced by a shortening of the ejection time and prolongation of the isovolumetric contraction time, so the index remained prognostically useful whereas the mitral DT could be potentially misleading. However, in our study, there were no significant changes in left and right ventricular isovolumetric relaxation time, left and right ventricular isovolumetric contraction time. Shortening of mitral deceleration time may be the preceding change in congestive heart failure in patients with left-to-right shunt lesions.

Conclusions: The myocardial performance index offers an easily obtained, quantitative, reproducible assessment of left and right ventricular function. This study demonstrates that myocardial performance index is not influenced by increments of preload and is consistent with previous data showing that mitral filling is significantly altered during preload alternations.

Table 1. Clinical characteristics and general echocardiographic findings

	ASD	VSD	Controls
Number of patients	17	23	24
Age (min /max /median) (month)	6 / 148 / 24	2 / 160 / 12	3 / 160 / 17
Gender (male/female)	8 / 9	13 / 10	14 / 10
Body surface area (m^2)	0.548±0.225	0.479±0.234	0.576±0.259
Heart rate (beat/minute)	117.82±19.81	122.83±20.74	111.33±17.92
Systolic blood pressure (mm Hg)	83.53±8.62	85.87±16.00	84.58±10.10
Diastolic blood pressure (mm Hg)	52.14±4.26	55.88±10.04	56.47±7.02
Cardio-thoracic index	0.54±0.06	0.55±0.05	0.50±0.03†
Aorta/left atrium dimensions ratio	0.851±0.149	0.846±0.145	0.833±0.070
LVSDI (mm/m^2)	29.00±5.83	40.39±12.88†	30.71±6.3
LVDDI (mm/m^2)	51.36±7.93	68.65±20.97†	52.33±11.57
Ejection fraction	0.73±0.08	0.71±0.04	0.71±0.05
Shortening fraction	0.41±0.06	0.39±0.03	0.39±0.04

†- differences are significant, $p < 0.05$
ASD: atrial septal defect; LVDDI: Left ventricular diastolic diameter index (left ventricular diastolic diameter / body surface area); LVSDI: Left ventricular systolic diameter index (left ventricular systolic diameter / body surface area); VSD: ventricular septal defect

Table 2. Doppler derived time intervals and velocities

	ASD	VSD	Controls
Left ventricular MPI	0.38±0.16	0.37±0.08	0.32±0.09
Right ventricular MPI	0.24±0.15	0.21±0.10	0.20±0.08
Left ventricular IRT (ms)	43.53±15.39	49.57±12.96	46.67±19.26
Right ventricular IRT (ms)	34.71±26.95	44.78±13.77	39.58±16.28
Left ventricular ICT (ms)	39.75±22.53	28.70±22.42	28.33±25.48
Right ventricular ICT (ms)	20.59±25.85	13.91±21.90	10.83±15.86
Left ventricular E/A	1.46±0.27	1.44±0.46	1.58±0.29
Right ventricular E/A	1.37±0.36	1.53±0.45	1.35±0.34
Left ventricular DT (ms)	104.56±28.31	109.56±37.59	142.86±24.49†
Right ventricular DT (ms)	103.23±32.76	101.41±39.94	115.62±25.45

† - differences are significant, $p < 0.05$
ASD: Atrial septal defect; DT: deceleration time; EA/: E/A ratio; ICT: Isovolumetric contraction time; IRT: Isovolumetric relaxation time; MPI: Myocardial performance index; VSD: Ventricular septal defect

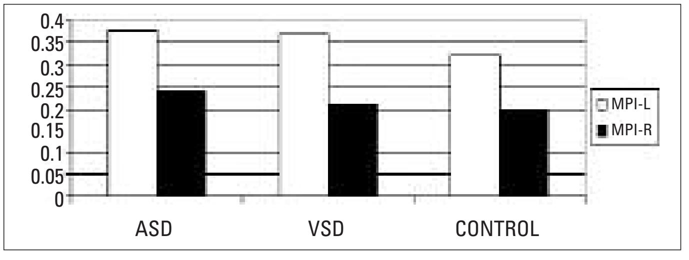

Figure 1. Myocardial performance index for left and right ventricles.
ASD: Atrial septal defect, MPI-L: Myocardial performance index for left ventricle, MPI-R: Myocardial performance index for right ventricle, VSD: Ventricular septal defect.

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