Is the myocardial performance index a reliable parameter in patients with restrictive filling pattern?

Miyokard performans indeksi restriktif doluş paterni olan hastalarda güvenilir bir parametre midir?

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ABSTRACT

Objective: The myocardial performance index (MPI) enables noninvasive estimation of combined systolic and diastolic function. The only diastolic function parameter used in the index is the isovolumic relaxation time (IRT). We assessed the impact of shortened IRT in restrictive filling pattern on MPI.

Methods: The MPI was defined as the sum of the isovolumic contraction time (ICT) and the IRT divided by the ejection time (ET), and was calculated in 13 controls (group 1), and 39 patients with ischemic heart disease with left ventricular systolic dysfunction (ejection fraction<50%). The patients were classified into two groups according to mitral early filling deceleration time (DT): group 2 with DT>140 ms (n = 20), and group 3 with DT ≤140 ms (n = 19).

Results: The ICT was longer and the ET was shorter in group 2 and group 3 than in group 1. The ICT and ET were not different in group 2 and group 3. The IRT was longer in group 2 (130±23 ms) compared to group 1 (82±10 ms, p<0.001) and group 3 (85±19 ms, p<0.001), but did not differ between group 1 and group 3. The MPI was higher in group 2 and group 3 compared to group 1 (0.79±0.25 and 0.65±0.19 vs 0.42±0.08, p<0.001 and p<0.001; respectively). However, it was lower in group 3 than in group 2 (p=0.03) due to significantly shortened IRT.

Conclusion: Shortened IRT in patients with restrictive filling pattern results in reduction of the MPI. Therefore, the MPI may not reflect true level of ventricular dysfunction in these patients. *(Anadolu Kardiyol Derg 2006; 6: 221-8)*

Key words: Myocardial performance index, myocardial performance, diastolic function, restrictive filling pattern

ÖZET

Amaç: Miyokard performans indeksi (MPİ) sistolik ve diyastolik fonksiyonu birlikte yansıtan bir parametredir. İndeks, diyastolik fonksiyon parametresi olarak sadece izovolümik gevşeme zamanını (İVGZ) kullanır. Restriktif doluş paterninde kısalan İVGZ'nin MPİ üzerine etkisini değerlendirdik.

Yöntemler: Miyokard performans indeksi, İVGZ ile izovolümik kasılma zamanı (İVKZ) toplamının ejeksiyon zamanına (EZ) bölünmesi şeklinde tanımlanarak 13 kontrol (grup 1) ve 39 sol ventrikül sistolik disfonksiyonu (ejeksiyon fraksiyonu<50%) olan iskemik kalp hastasında hesaplandı. Hastalar mitral erken akım deselerasyon zamanına (DT) göre 2 gruba ayrıldı: DT>140 ms olanlar grup 2 (n=20), DT≤140 ms olanlar grup 3 (n=19).

Bulgular: Grup 1 ile karşılaştırıldığında grup 2 ve grup 3'te İVKZ daha uzun ve EZ daha kısa bulundu. İzovolümik kasılma zamanı ve EZ grup 2 ile grup 3 arasında farklılık göstermedi. İzovolümik gevşeme zamanı grup 2'de (130±23 msn) grup 1 (82±10 msn, p<0.001) ve grup 3'e (85±19 msn, p<0.001) oranla anlamlı olarak uzun bulundu, grup 1 ile grup 3 arasında ise farklı değildi. Miyokard performans indeksi, grup 2 ve grup 3'te grup 1'den daha yüksek bulundu (sırasıyla 0.79±0.25, 0.65±0.19 ve 0.42±0.08; p<0.001 ve p<0.001). Ancak, önemli ölçüde kısalmış İVGZ nedeniyle grup 3'te grup 2'den daha düşük bulundu (p=0.03).

Sonuç: Restriktif doluş paterni olan hastalarda kısalan İVGZ MPİ'nin azalmasına neden olur. Bu nedenle, bu grup hastada MPİ ventrikül disfonksiyonu derecesini doğru olarak yansıtamayabilir. *(Anadolu Kardiyol Derg 2006; 6: 221-8)*

Anahtar kelimeler: Miyokard performans indeksi, miyokard performansı, diyastolik fonksiyon, restriktif doluş paterni

Introduction

Left ventricular (LV) systolic and diastolic dysfunctions frequently coexist in a variety of heart disease. Noninvasive echocardiographic indexes of systolic and diastolic ventricular function are of great clinical importance in the diagnosis and management of patients with heart disease. However, there is no universally accepted gold standard to assess overall left ventricular contractility and relaxation. Recently, the Doppler myocardial performance index (MPI) has been propo-

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sed as a reflection of overall cardiac function (1-6). The MPI, which combines parameters of both systolic and diastolic ventricular function, is easily obtainable and has been clinically useful in noninvasive assessment of global ventricular function. This index is defined as the sum of isovolumic contraction time (ICT) and isovolumic relaxation time (IRT) divided by ejection time (ET), and reflects both systolic and diastolic cardiac function (1-6).

To calculate the index, only IRT is used as diastolic function parameter. However, the relation between IRT and diastolic dysfunction is not linear. Diastolic dysfunction results in a biphasic change of the IRT. In early stage of diastolic dysfunction (nonrestrictive filling = NRF) it is characterized by a prolonged IRT, while restrictive filling (RF) is associated with shortening of the IRT (7). The impact of a shortened IRT on the MPI in patients with RF has not been investigated previously. Therefore, the goal of this study was to investigate whether shortening of IRT causes any significant impacts on MPI in patients with RF or not.

Methods

Subjects

The study group consisted of 13 controls (group 1) and 39 patients with ischemic heart disease who were referred to our laboratory for echocardiographic evaluation; among them 20 consecutive patients with nonrestrictive filling, and 19 consecutive patients with restrictive filling patterns. Patient population was comprised of 19 patients with previous myocardial infarction (at least 6 months earlier before the study); 8 patients with stable effort angina, positive noninvasive coronary stress tests and without previous myocardial infarction; and 12 patients with significant coronary artery disease confirmed by coronary angiography, without previous myocardial infarction. The patients were selected from those with depressed LV systolic function (ejection fraction (EF) <50%), because RF is usually associated with LV systolic dysfunction (8). Criteria for exclusion included the presence of rhythm or conduction abnormalities, valvular heart disease, moderate to severe mitral regurgitation according to the method of Helmcke et al. (9), prosthetic valve, pericardial or myocardial disease, and inadequate echocardiographic imaging.

Control group included age and gender matched 13 normal subjects (11 men, 2 women; mean age 57±10 years) with no cardiovascular or any other system diseases, no cardiovascular symptoms, and normal findings on physical examination, electrocardiography (ECG), chest radiography and echocardiography.

Echocardiography

Echocardiograms were obtained using commercially available ultrasound equipment (Sonos 5500, Hewlett-Packard, Andover, Massachusetts) with a 2.5-3.5 MHz transducer. Simultaneous ECG recordings were also obtained. All patients were examined at rest in the left lateral decubitus position.

M-mode and 2-dimensional echocardiography

M-mode echocardiograms were recorded from the parasternal window at rest to determine left atrial and LV dimensions. Left ventricular end-systolic volume, LV end-diastolic volume, and EF were determined from apical two- and four-chamber view using the Simpson's biplane formula, according to the suggestions of the American Society of Echocardiography (10). Tracing of endocardial borders in end-diastole and end-systole was made in the technically best cardiac cycle, and the mean of 3 measurements were used. Ventricular volumes were corrected for body surface area; LV end-systolic volume index and LV end-diastolic volume index were quantified. The wall motion score index (WMSI) was calculated (10).

Doppler Echocardiography

Mitral pulsed wave Doppler measurements were obtained with the transducer in the apical 4-chamber view. The Doppler beam was aligned as perpendicular as possible to the plane of the mitral annulus. Sample volume was placed between the tips of the mitral leaflets during diastole (11). Doppler measurements were calculated from an average of 5 consecutive cardiac cycles. The following transmitral Doppler parameters were analyzed: peak early (E) and late (A) transmitral filling velocities, the ratio of early to late peak velocities (E/A), deceleration time of E wave (DT). The IRT, defined as the time from aortic valve closure to mitral valve opening, was assessed by simultaneously measurement of the flow into the LV outflow tract and mitral inflow by Doppler echocardiography (12). The LV outflow velocity curve was recorded from the apical long-axis view with the Doppler sample volume positioned just below the aortic valve.

Time intervals were also measured from mitral inflow and LV outflow recordings. The time interval “a” from the cessation to the onset of mitral inflow was equal to the sum of ICT, ET, and IRT. Left ventricular ET “b” was the duration of the LV outflow velocity profile. The MPI of combined LV systolic and diastolic function (the sum of ICT and IRT divided by ET) was calculated as (a - b)/b (1,2).

The sum of ICT and IRT was obtained by subtracting “b” from “a”. The ICT was obtained as (a - b) - IRT. All time intervals (ICT, IRT and ET) were corrected for heart rate by using Bazzet formula (13): Corrected ICT = ICT/square root of R-R interval, where ICT is expressed in milliseconds and RR in seconds.

According to the Doppler mitral flow velocity profile, as expressed by the mitral DT, the patients were assigned to the following groups: group 2 (DT > 140 ms) representing NRF (n=20) and group 3 (DT ≤ 140 ms) representing RF (n=19). The subdivision and cut-off values were predefined and based on previous combined echocardiographic Doppler and invasive hemodynamic studies (14-16)

Reproducibility

Two independent observers repeated 10 MPI measurements. The differences in the measurements by the 2 observers were obtained to express interobserver variability. The same observer repeated the 10 measurements, and intraobserver variability was also evaluated. Statistical analysis

Values were expressed as a mean ± standard deviation or percentage. One-way analysis of variance (ANOVA) with post-hoc test by Bonferroni was used for comparison of continuous variables among groups. Differences between categorical variables were assessed using the Chi-square test. Pearson's correlation test was performed to correlate continuous variables with each other. Statistical analyses were performed using SPSS software (Version 9.05, SPSS, Inc, Chicago, Ill). A p value of <0.05 was considered statistically significant.

Results

Clinical characteristics

Table 1 summarizes the clinical characteristics of the groups. There were no statistically significant differences in age, gender, and diastolic blood pressure among the groups, but significant differences were observed in terms of diabetes, hypertension, smoking, prior myocardial infarction, heart rate and systolic blood pressure. Heart rate was higher in group 3 than in groups 1 and 2. Systolic blood pressure was higher in group 2 and group 3 compared to group 1. In spite of higher rates of prior myocardial infarction and LV systolic dysfunction in the patient groups the rates of the appropriate drugs use were lower because of poor adaptation of the patients.

Conventional echocardiographic variables

The results of echocardiographic variables analysis by one-way ANOVA with post-hoc Bonferroni test for the three groups are shown in tables 2 and 3. Comparison of conventional echocardiographic variables between group 1 and 2 showed that LV end-systolic dimension was larger (p=0.002), the EF was lower (p<0.001), the wall motion score index was higher (p<0.001), the E/A ratio was lower (p=0.001), the A wave was higher (p<0.001), and the IRT was longer (p<0.001) in group 2 than in group 1.

When comparing group 3 with group 1, left atrial diameter, the LV end-systolic and end-diastolic dimensions were larger (p=0.013, p=0.001 and p=0.003 , respectively), the EF was lower

Table 1. Clinical characteristics in each group

Variables	Group 1 (n=13)	Group 2 (n=20)	Group 3 (n=19)
Age, years	57±10	61±10	57±8
Men, n (%)	11 (85)	16 (80)	14 (74)
Diabetes mellitus, n (%) *	0 (0)	4 (20)	6 (32)
Arterial hypertension, n (%) #	0 (0)	8 (40)	11 (58)
Smoker, n (%) #	0 (0)	12 (60)	9 (47)
Prior MI, n (%) †	0 (0)	6 (30)	13 (68)
Anterior wall MI, n (%) †	0 (0)	2 (10)	9 (47)
Inferior wall MI, n (%)	0 (0)	4 (20)	4 (21)
Heart rate, beats/min	71±3	78±12	87±14 ‡
Systolic blood pressure, mmHg	105±12	130±29	122±21 §
Diastolic blood pressure, mmHg	72±8	76±20	80±17
Therapy, n (%)			
ACE-inhibitors/AT II blockers †	0	8 (40)	8 (42)
Beta blockers **	0	6 (30)	5 (26)
Diuretics ##	0	4 (20)	7 (37)
Calcium channel blockers	0	4 (20)	0
Digitalis	0	2 (10)	4 (21)

* Chi-square p=0.048; # Chi-square p=0.001;
† Chi-square p< 0.001; ‡ p< 0.001 vs group 1 and p= 0.032 group 2;
¶ p=0.010 vs group 1; § p= 0.029 vs group 1;
** Chi-square p=0.054; ## Chi-square p=0.027.
ACE- angiotensin converting enzyme, AT- angiotensin, MI- myocardial infarction; group 1- controls, group 2- patients with nonrestrictive filling pattern, group 3- patients with restrictive filling pattern

Table 2. Echocardiographic variables in each group

Variables	Group 1 (n=13)	Group 2 (n=20)	Group 3 (n=19)
Left atrial diameter, mm	34±5	36±5	43±6 *
LV end-systolic dimension, mm	30±3 #	41±9	47±12
LV end-diastolic dimension, mm	47±5	53±9	57±10 †
LVESVI, ml/m^2	13±4	42±17	56±27 ‡
LVEDVI, ml/m^2	38±8	67±22	81±29
EF, %	66±6 ¶	38±6 §	33±7
Wall motion score index	1.0±0 ¶	2.0±0.4	2.3±0.4
Peak velocity of E wave, cm/s	70±13	53±16	83±25 **
Peak velocity of A wave, cm/s	45±7	76±19 ##	45±24
E/A ratio	1.7±0.4 ††	0.8±0.4 ‡‡	2.2±1.0
Deceleration time, ms	211±26	256±51	133±11 ¶¶

* p= 0.013 vs group 1 and p= 0.039 vs group 2;
\# p= 0.002 vs group 2 and p< 0.001 vs group 3;
† p= 0.003 vs group 1;
‡ p= 0.027 vs group 1;
¶ p< 0.001 vs group 2 and group 3;
§ p= 0.052 vs group 3;
** p= 0.054 vs group 1 and p< 0.001 vs group 2;
\## p< 0.001 vs group 1 and group 3;
†† p= 0.001 vs group 2 and p= 0.042 vs group 3;
‡‡ p< 0.001 vs group 3;
¶¶ p< 0.001 vs group 1 and group 2.
EF- ejection fraction, LV- left ventricle, LVEDVI- left ventricular end-diastolic volume index, LVESVI- left ventricular end-systolic volume index, group 1- controls, group 2- patients with nonrestrictive filling pattern, group 3- patients with restrictive filling pattern.

Table 3. Myocardial performance index and Doppler time intervals in each group

Variables	Group 1 (n=13)	Group 2 (n=20)	Group 3 (n=19)
MPI	0.42±0.08 *	0.79±0.25 #	0.65±0.19
IRT, ms	82±10	130±23 †	85±19
ICT, ms	51±21 ‡	100±54	91±32
ET, ms	316±19 ¶	293±38	277±49
IRT/ET	0.26±0.05 §	0.45±0.10 †	0.32±0.09
ICT/ET	0.16±0.06 **	0.34±0.19	0.34±0.13

* p< 0.001 vs group 2 and group 3;
\# p= 0.03 vs group 3;
† p< 0.001 vs group 1 and group 3;
‡ p= 0.002 vs group 2 and p= 0.017 vs group 3;
¶ p= 0.012 vs group 3;
§ p= 0.040 vs group 3;
** p= 0.002 vs group 2 and p= 0.003 vs group 3.
ET- ejection time, ICT- isovolumic contraction time, IRT- isovolumic relaxation time, MPI- myocardial performance index, group 1- controls, group 2- patients with nonrestrictive filling pattern, group 3- patients with restrictive filling pattern

(p<0.001), the LV end-systolic volume index, the wall motion score index, and the E/A ratio were higher (p=0.027, p<0.001 and p=0.04, respectively), and DT was shorter (p<0.001) in group 3 than in group 1.

Comparison of data between groups 2 and 3 demonstrated that left atrial diameter was larger (p=0.039), the E wave and the E/A ratio were higher (p<0.001 and p<0.001, respectively), the A wave was lower (p<0.001), and the DT and IRT were shorter (p<0.001 and p<0.001, respectively) in group 3 than in 2. Systolic function parameters (EF and WMSI) were not significantly different in groups 2 and 3 (p > 0.05 for both).

Doppler time intervals and MPI

Doppler time intervals and MPI values of the groups are listed in Table 3. When comparing group 2 with group 1, IRT and ICT were significantly shorter (p<0.001 and p=0.002, respectively) in group 1 than in group 2. But, there was an insignificant difference in ET between the two groups. As a result of these differences, both IRT/ET and ICT/ET were significantly lower (p=0.002 and p=0.002, respectively) in group 1 compared to group 2. The MPI, which is sum of IRT/ET and ICT/ET, was also lower in group 1 than in group 2 (0.42±0.08 vs 0.79±0.25, p < 0.001).

Comparison of variables between groups 1 and 3 showed that the IRT was similar between the groups. The ET was shorter (p=0.01) and the ICT was longer (p=0.017) in group 3 than in group 1. In spite of a similar IRT values, IRT/ET ratio was higher (p=0.04) in group 3 than in group 1 due to a shorter ET. Also, ICT/ET was higher (p=0.003) in group 3 compared to group 1. Consequently, the patients in group 3 had significantly higher MPI than patients in group 1 (0.65±0.19 vs 0.42±0.08, p < 0.001).

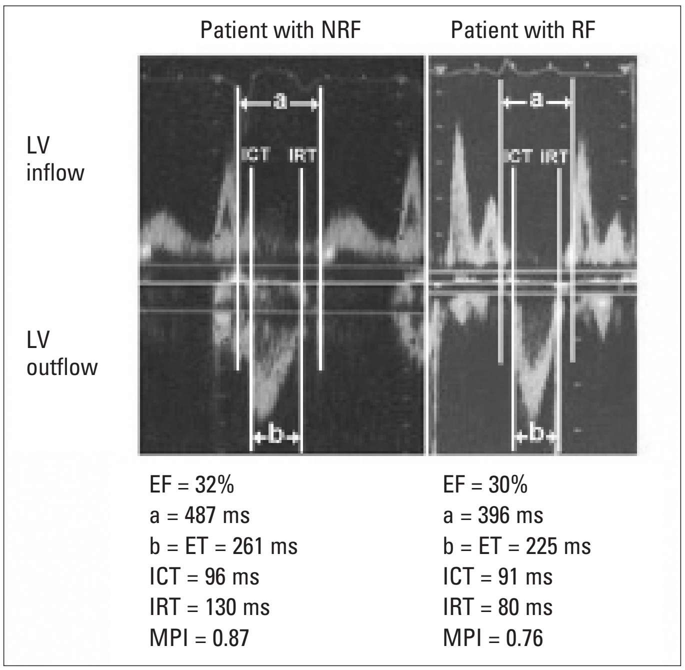


Figure 1. Representative patients. Left panel, this patient had NRF with prolonged IRT. Right panel, this patient had RF with shortening of IRT, resulting in a decreased MPI.

a- time from the end to onset of mitral inflow, b - time from onset to the end of left ventricular outflow - ejection time, EF- ejection fraction, ET- ejection time, ICT- isovolumic contraction time, IRT- isovolumic relaxation time, LV- left ventricle, MPI- myocardial performance index, NRF- nonrestrictive filling; RF- restrictive filling

Comparative analysis of group 3 and group 2 demonstrated that the ICT and ET were not statistically different (p>0.05 for both), and therefore the ICT/ET ratio was also similar within the groups (0.34±0.19 in group 2, and 0.34±0.13 in group 3, p>0.05). But, IRT was significantly shorter in group 3 than in group 2 (85±19 ms vs 130±23 ms, p < 0.001). A significantly shortened IRT in group 3 resulted in a lower IRT/ET in this group than in group 2 (0.32±0.09 vs 0.45±0.10, p<0.001). Because of this, the MPI was significantly lower in group 3 compared to group 2 (0.65±0.19 vs 0.79±0.25, p=0.03). Figure 1 shows recordings of Doppler velocity curves and calculation of the MPI in two patients with NRF and RF. Also, comparison of the MPI, IRT, IRT/ET and ICT/ET values among controls, patients with NRF, and those with RF is illustrated in Figure 2.

The MPI values according to DT values were presented in a scatter graph (Figure 3). The patients with short DT (≤ 140 ms) had lower MPI values compared to patients with DT > 140 ms.

Correlation analysis

Correlation analysis between the MPI and other echocardiographic parameters is summarized in Table 4. The DT was positively correlated with the MPI in all subjects (n=52, r = 0.284, p = 0.026). This correlation became more significant when it was performed only in the patient group (n=39, r = 0.486, p = 0.002).

Reproducibility

The inter- and intra-observer variability for the measurement of the MPI was 0.021 ± 0.003 (3.0 ± 0.5%) and 0.019 ± 0.004 (2.7 ± 0.5%) of the mean value, respectively.

Discussion

In the present study, a decrease of the MPI in patients with RF was accompanied by significant shortening of the IRT. We, therefore, suggest that RF results in reduction of the MPI due to shortened IRT. Hence, the MPI is generally good in expressing global cardiac function, but may not be ideal in patients with RF.

MPI and IRT

The MPI may not be useful to express global cardiac function when ICT, ET or IRT are not determined by cardiac function. As an example, Yoshifuku S et al. (17) reported that severe right ventricular infarction can be manifested with limited or no increase in the right ventricular MPI due to significantly shortened right ventricular ICT. The shortening of right ventricular ICT was related to approximate equalization of end-diastolic right ventricular and pulmonary artery pressures. Highly elevated right ventricular end-diastolic pressure due to decreased right ventricular compliance by severe infarction resulted in shortening of ICT and the pseudonormalized right ventricular MPI. Another such situation is the case of RF. Despite severe diastolic dysfunction, IRT can be normal or even extremely short due to increased left atrial pressure (7). Therefore, we hypothesized that elevated filling pressures shorten the IRT and thereby lower the value of the MPI. In a study of patients with dilated cardiomyopathy by Dujardin K. et al. (18), it has been shown that the patients with RF had a similar mean value of the MPI despite a longer ICT and shorter ET compared to those with NRF, due to shortened IRT related to RF. In that study, more advanced systolic dysfunction in the patients with RF compared to those with NRF (longer ICT and shorter ET) was counterbalanced by the shortening of the IRT. Although both systolic and diastolic functions were worse in patients with RF, there was no significant difference in the MPI between these subgroups. This finding is in consistence with our results. But, in our study, systolic functions were similar between the patients with RF and NRF (ICT, ET and ICT/ET). Therefore, the shortening of the IRT resulted in reduction of the MPI in patients with RF compared to those with NRF. Essentially, decrease of the MPI in patients with RF is not surprising. Because, IRT is a solely diastolic function parameter that used in calculation of the MPI, and it is shortened in RF.

There are many studies demonstrating the usefulness of the MPI in various heart diseases (1-6,18-24). Previous studies have shown that an increased MPI indicates deteriorated ventricular function and poor prognosis (4,5,18-24). In contrast, the present study demonstrated a decrease in the MPI in patients with RF. These results, for the first time, show the decreased MPI with progression of cardiac disease. Load dependence of the MPI in the left ventricle has been reported as modest (19,25); however, the present study showed significant load dependence of the MPI in RF. Essentially, being in agreement with our study, a recent study shows that MPI is preload sensitive parameter (26). The increased left atrial pressure results in an earlier mitral valve opening and shortened IRT in patients with RF. In our study, the IRT was shorter in group 3 than in group 2. The MPI value was negatively affected from this situation. Thus, the MPI did not reflect true level of global ventricular function in patients with RF.

Two previous studies (27,28) showed that MPI was higher in patients with pseudonormal restrictive filling than in those with normal filling pattern. Similarly, in spite of shortened IRT in group 3, the value of the MPI remained significantly elevated compared to group 1 (Table 3) in our study. Comparable systolic function is uncommon between control subjects and patients with RF (8). Hence, even when IRT is comparable, differences in systolic functions (ICT and ET) may cause a signifi-

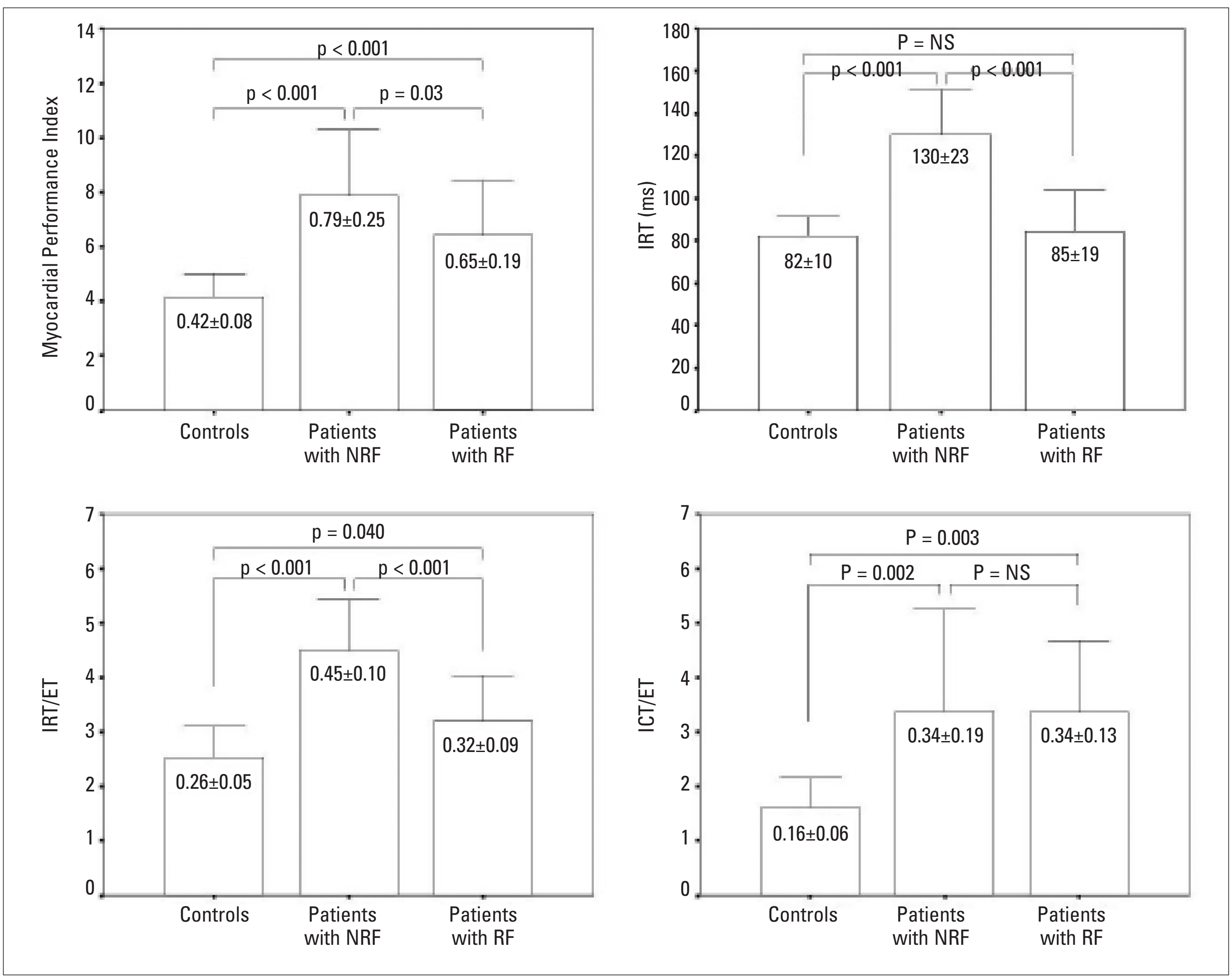


Figure 2. Comparison of the Doppler-derived myocardial performance index, IRT, IRT/ET and ICT/ET among the groups

ET - ejection time, ICT - isovolumic contraction time, IRT - isovolumic relaxation time

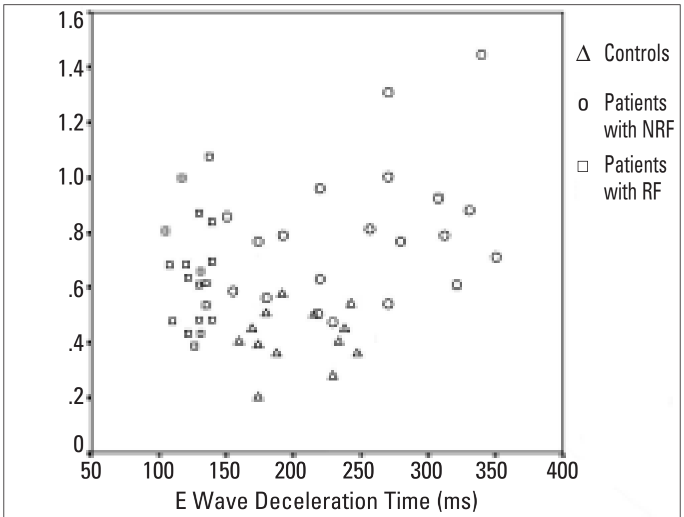
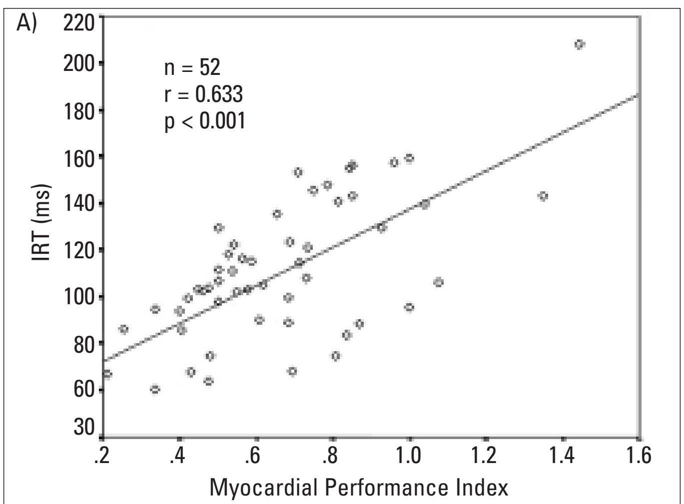


Figure 3. Graph of the MPI according to DT values. The MPI shows an increase in patients with DT > 140 ms (with NRF). But, it is lower in patients with DT ≤ 140 ms (with RF) compared to patients with NRF

DT- deceleration time, MPI- myocardial performance index, NRF- nonrestrictive filling, RF- restrictive filling



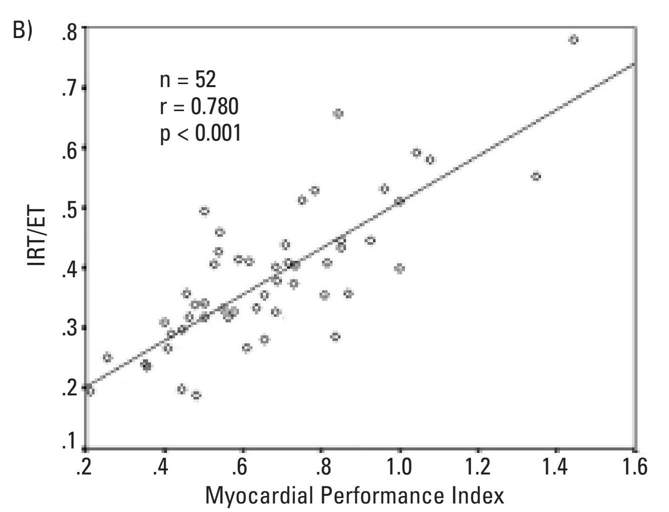


Figure 4. Corelation graphs of the MPI index with IRT and IRT/ET

ET- ejection time, IRT- isovolumic relaxation time, MPI- myocardial performance index

cant increase in MPI in patients with RF compared with controls. This increase was due to prolongation of ICT and shortening of ET, and thereby raise of ICT/ET. On the other hand, when systolic function is comparable (ICT and ET), shortened IRT may cause significant decrease in the MPI in patients with RF compared to those with NRF, which have prolonged IRT. We found no significant differences in ICT, ET and ICT/ET between group 2 and group 3, so that shortening of IRT resulted in significant reduction of the MPI in group 3 compared to group 2 (Table 3). Whereas systolic functions were similar, diastolic functions were worse in group 3 than in group 2. Such comparison was not performed in the above mentioned studies. In those studies, only differentiation of pseudonormal/restrictive filling from normal mitral flow could be performed by using MPI. But, essential drawback of MPI is its failure to differentiate the level of LV dysfunction of patients with NRF, which have lengthened IRT, from that of those with RF, which have shortened IRT, especially when their systolic functions are similar.

Another finding of our study was positive correlation of DT with the MPI in all subjects. When correlation test was performed only in the patient groups (n=39), association of the MPI with DT was found to be positive and more significant. This finding also indicated that the MPI is decreased in patients with RF, which have shorter DT than in those with NRF.

Clinical Implications

It should be taken into consideration that shortened IRT causes reduction of MPI in patients with restrictive filling. Although left ventricular dysfunction level can be distinguished by MPI between controls and patients with restrictive filling, difference between patients with impaired relaxation and those with restrictive filling may not be demonstrated. Therefore, MPI may not be ideal for assessing left ventricular dysfunction in patients with restrictive filling.

Limitations and strengths of the study

One potential limitation of the study is the lack of simultaneous hemodynamic measurement. However, this kind of correlation has been performed by other investigators (11,12,14-16,29,30) who showed a close correlation between DT and diastolic function and pulmonary capillary wedge pressure, irrespective of the filling pattern expressed by the E/A ratio. Moreover, it is known that mitral E/A>1 indicates pseudonormal/restrictive flow in patients with an impaired systolic func-

Table 4. Correlation analysis between the MPI and other echocardiographic parameters in all subjects (n=52)

Variables	MPI	
	r	p
EF, %	- 0.512	< 0.001
Wall motion score index	0.438	< 0.001
Peak velocity of E wave, cm/s	-0.291	0.021
Peak velocity of A wave, cm/s	0.353	0.026
E/A ratio	-0.256	0.041
Deceleration time, ms	0.288	0.024

EF- ejection fraction, MPI- myocardial performance index tion (8). In our study, the EF and wall motion score index were impaired and none of patients had E/A<1 in group 3. Therefore, we believe that the present classification of LV filling pattern is reasonable without being optimal. In the current study, heart rate and systolic blood pressure were different among groups. But, the MPI is not greatly influenced by changes in heart rate and blood pressure (19,31). Doppler-derived IRT, ICT and ET have been shown to be heart rate dependent (2,4,5,32). Therefore, we corrected Doppler time intervals for heart rate. In addition, we excluded moderate to severe MR according to the method of Helmcke et al. (9) because of early opening of mitral valve. However, severity of MR can be over or underestimated by this method. Also, the rates of the use of some drugs were different among the groups. Although no data is present in the literature regarding the effect of these drugs on MPI, our result may be affected by this factor. Finally, because the intervals between onset and end of mitral inflow and ejection time are not measured simultaneously, the index would be less reliable in the presence of arrhythmias. However, in the present study, only patients with sinus rhythm were included.

Conclusions

This study demonstrates that the MPI is affected by shortened IRT in patients with RF. Shortened IRT results in reduction of the MPI in patients with RF. Thus, the MPI may be less reliable in these patients.

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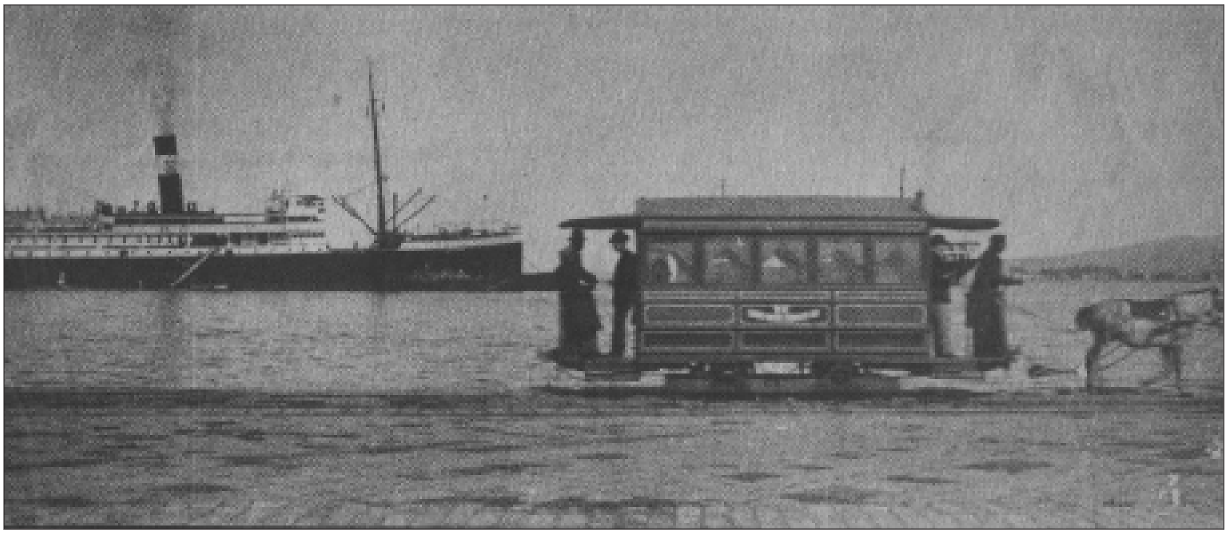

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