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ORIGINAL ARTICLE

DOPPLER DERIVED MYOCARDIAL PERFORMANCE INDEX (TEI INDEX) IN THE EVALUATION OF PATIENTS WITH HEART FAILURE

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ABSTRACT: Echocardiography is one of the most important noninvasive tests in the evaluation, management and follows up of patient with congestive heart failure. It allows the accurate assessment of structural and functional abnormalities associated with congestive heart failure. Left ventricular ejection fraction (LV EF) is still the most common measurement in the evaluation of heart failure which differentiates heart failure into 2 groups: Heart failure with reduced ejection fraction (systolic heart failure: LV EF is less than 50%) and Heart failure with preserved or normal ejection fraction (Diastolic heart failure: LV EF is equal to or above 50%). LV EF measurement depends upon Left ventricular geometry[1] and diastolic indices are effected by heart rate, loading conditions.[2] Hence there is a need for an index which is affected to a limited extent by these factors and is easy to measure and accurate and easily reproducible. **AIM:** To evaluate the measurement of myocardial performance index (MPI) as method of evaluation of ventricular function in patients with heart failure secondary to systolic or diastolic dysfunction) in comparison with normal persons. **METHODS:** A Total of 170 individuals, 60 controls and 120 patients with heart failure who come for echocardiography examination are studied. Patients with organic valvular heart disease and other than sinus rhythm were excluded. Transthoracic echocardiography was done in all cases In addition to the standard echocardiographic measurements, MPI is measured as followed: The time interval from the cessation of onset of next mitral flow (period a: consists of ICT+ET+IVRT) and ventricular ejection time from Doppler outflow spectrum (period b: ET) were measured and MPI was calculated. Myocardial performance index (Tei index) is the ratio between the sum of isovolumic time intervals namely, isovolumic contraction time (ICT) plus isovolumic relaxation time (IVRT)) and ejection time (ET). MPI = (ICT+IVRT) / ET = (a-b)/b = (a/b) -1. Measurements were taken from three consecutive beats and averaged. **RESULTS:** LV-MPI in normal subjects was 0.32±0.07 and it is significantly increased in patients with both systolic and diastolic dysfunction, 0.95±0.26 and 0.59±0.13, respectively. RV MPI in normal individuals is 0.23±0.06 and significantly increased in patients with LVsystolic function 0.72 ± 0.28, but not in patients with diastolic heart failure0.34±0.15. LV MPI is significantly correlated with Left ventricular ejection fraction and left ventricular dilatation.

KEYWORDS: Heart failure, systole, diastole, myocardial performance index (MPI), ejection fraction (F).

INTRODUCTION: Congestive heart failure is one of the commonest diseases of the heart in adults and accounts for an increasing number of hospital admissions world-wide. Investigators have previously focused on the abnormalities of systolic function to explain the clinical signs and symptoms of heart failure. More recently, it has been demonstrated that systolic and diastolic dysfunction coexists in the majority of patients with congestive heart failure. One-third of all cases, systolic function is normal, and heart failure occurs solely on the basis of diastolic dysfunction.

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Echocardiography is one of the most important noninvasive tests in the evaluation, management and follows up of patient with congestive heart failure. It allows the accurate assessment of structural and functional abnormalities associated with congestive heart failure.

Left ventricular ejection fraction (LV EF) is still the most common measurement in the evaluation of heart failure which differentiates heart failure into 2 groups:

1. Heart failure with reduced ejection fraction (systolic heart failure: LV EF is less than 50%) – HfdEF.
2. Heart failure with preserved or normal ejection fraction (Diastolic heart failure: LV EF is equal to or above 50% and diastolic flow abnormalities – HfnEF.

LV ejection fraction (EF) measurement depends upon Left ventricular geometry [1] and may not be accurate in patients with regional wall motion abnormalities like in myocardial infarction and diastolic indices are affected by heart rate, loading conditions [2]. Hence there is a need for an index which is affected to a limited extent by these factors and is easy to measure and accurate and easily reproducible.

Myocardial performance index (MPI, Tei index) is a Doppler-derived index combining systolic and diastolic time intervals, was proposed by Tei and co-workers, which is defined as the sum of isovolumic contraction and relaxation time divided by the ejection time, was reported to be simple, reproducible and independent of heart rate and blood pressure, which overcomes many of the limitations of traditional indices. It is easy to calculate, assess combined systolic as well as diastolic function and more over can be used for the assessment of right ventricular function.

AIM: To evaluate the measurement of myocardial performance index (MPI – Tei index as a method of assessment of ventricular function in normal persons and in patients with heart failure.

METHODS: 170 persons attending the Cardiology department, King George Hospital, Visakhapatnam, both as in-patients and out-patients were studied. They were divided in to 3 groups:

1. Control group: - 50 asymptomatic individuals with normal trans thoracic echocardiogram and ejection fraction above 50% and normal mitral inflow pattern.
2. LV systolic dysfunction group: 60 patients with features of congestive heart failure and ejection fraction less than 50%.
3. LV diastolic dysfunction group: 60 patients with features of congestive heart failure and ejection fraction above 50% with diastolic mitral inflow abnormalities.

   They were further divided into 2 groups:

   Group A: those with relaxation abnormality pattern as evidenced by mitral E/A less than or equal to 1 and IVRT above 90msec (Grade 1 diastolic dysfunction)

   Group B: those with restrictive pattern of filling as evidenced by E/A ratio 2 or above and IVRT less than or equal to 60msec (Grade 3 diastolic dysfunction)

EXCLUSION CRITERIA:

1. Patients with organic valvular diseases.
2. Patients with other than sinus rhythm.

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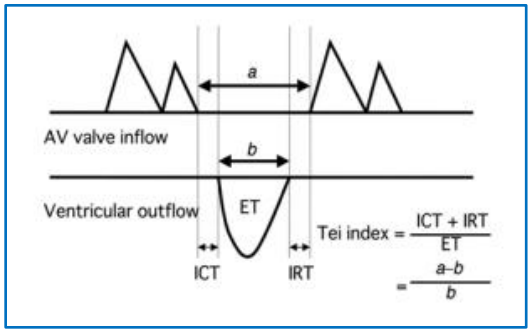
Transthoracic echocardiography using standard echo windows was done in all case and standard measurements were obtained. In addition LV myocardial performance index was calculated as follows: Mitral inflows were obtained by keeping sample volume at the tips of the fully opened mitral leaflets. From mitral inflow signal, E velocity, A velocity, E acceleration time, E deceleration time the duration from the cessation to the onset of next mitral inflow (Lva-ICT+ET+IRT) were obtained. Pulse Doppler of measurement of left ventricular outflow were obtained by keeping sample volume just below the aortic valve in apical 5 chamber view and ejection time (LVb) was calculated from the onset to the cessation of outflow signal.



Calculation of Myocardial performance index (Tei index).
LV MPI was calculated by the formula.

$$MP1 = \frac{a-b}{b} \text{ or } \frac{a}{b} - 1$$

LV isometric relaxation time (IVRT) was obtained by pulse doppler by keeping sample volume near the tip of the anterior mitral leaflet and both mitral inflow and LV outflow signals were obtained. IVRT is measured from the cessation of outflow signal to the onset of mitral E wave. LV isometric contraction time (ICT) was obtained by subtracting ejection time, IVRT from the period between cessation to the onset next mitral inflow (Lva).

STATISTICAL ANALYSIS: Data is expressed in mean + SD. Comparison between groups was done using students t test. P valve < 0.05 was considered significant. Correlation between MPI and other echo parameters was performed using linear regression model.

RESULTS:

- Study subject distribution is as follows: Normal controls: 50.
- Systolic dysfunction group (EF<50%): 60. of which 11patients with EF ≤ 25%, 22patients had EF in the range of 26-30%, 18 had EF 31-40% and 9 patients had EF in the range of 41-49%.
- Diastolic dysfunction group (EF>50%): 60. This group is further divided into:
  Subgroup 1: Delayed relaxation group: 52.
  Sub group 3: restrictive filling group: 8.

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Baseline parameters of the study group is as follows:

	Normal (n=60)	Pts with Predominantly LV systolic dysfunction (n=60)	Pts with Predominantly LV diastolic dysfunction (n=60)
Age (yrs)	38.4± 14.02	50.45± 13.34	52.78± 10.49
Males	28 (56%)	47 (78.3%)	45 (75%)
Female	22 (44%)	13 (21,7%)	15 (25%)
Hypertension	12 (24%)	42 (70%)	43 (78.2%)
Smoking	9 (18%)	35 (58.3%)	26 (47.3%)
H/o CAD	----	40 (66.6%)	8 (14.5%)

Table 1: Baseline characters

Of the 60 patients with predominantly LV systolic dysfunction, etiology of LV dysfunction was as follows:

Ischemic cardiomyopathy --- 40 (66.6%).
Dilated cardiomyopathy --- 15 (25%)
Ch.HTN leading to LV
systolic dysfunction --- 2 (3.3%)
Peripartum cardiomypathy --- 2 (3.3%)
Toxic myocarditis --- 1 (1.7%)

Most of the patients with systolic dysfunction & diastolic dysfunction had symptoms of NYHA class 3 or 4.

Base line echo measurements were as follows:

Parameter	Normal	Predominantly LV Systolic dysfunction		Predominantly LV Diastolic dysfunction	
	(n=50)	(n=60)	P val	(n=60)	P val
Ao (EDD) cms	2.72± 0.405	2.78± 0.38	NS	2.97± 0.41	0.01
LA (ESD)cms	3.29± 0.47	3.98± 0.56	<0.001	3.45± 0.47	0.01
IVS (d)cms	0.87± 0.19	0.92± 0.28	NS	1.14± 0.57	<0.001
LVPW (d)cms	0.85± 0.17	0.89± 0.23	NS	1.1± 0.23	<0.001
LVID (d) cm	4.62± 0.46	5.78± 0.66	<0.001	4.7± 0.66	NS
LVID (S)	2.89± 0.42	4.9± 0.69	<0.001	3.1± 0.57	NS
EF	0.68± 0.05	0.31± 0.68	<0.001	0.64± 0.08	NS
FS (%)	37.6± 4.1	15.63± 4.21	<0.001	34.68± 6.49	NS
PJV (cms/sec)	96.02± 15.71	65.18± 17.07	<0.001	85.32± 19.9	<0.05
PAT (msec)	106.52± 21.62	76.12± 22.83	<0.001	99.34± 24.2	0.01
Ao.flow (cms/sec)	118.68± 21.5	96.2± 22.67	<0.001	110.36± 21.14	0.05-0.02

Table 2: Baseline echo features in various sub groups

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Patients with systolic dysfunction had significant dilatation of left ventricle with reduction in ejection fraction, reduction in pulmonary and aortic flow velocities and decrease in pulmonary acceleration Time, whereas patients with predominant diastolic dysfunction have significant increase in LV wall thickness, ejection fraction and arterial flow velocities being normal.

Doppler echo parameters of left ventricular function in various groups were as follows:

Parameter	Normal	Systolic dysfunction		Diastolic dysfunction			
	(n=50)	(n=60)	P value	Type l (n=52)	P value	`Type3 (n=8)	P value
Mitral E Velocity (cm/sec)	95.08± 19.61	81.59± 21.42	<0.001	70.13+/- 22.65	<0.001	90.18± 15.59	0.5-0.2
Mitral A Velocity (cm/sec)	63.04± 15.42	51.82± 22.91	<0.01	86.68+/- 6,59	<0.001	35.01± 5.12	0.001
E/A ratio	1.58± 0.45	1.93± 1.03	0.001	0.8+/-0.18	<0.001	259± 0.38	<0.001
EDT (msec)	178± 25.05	122.25± 42.06	<0.001	211.12+/- 47.03	0.001	118.75± 12.17	0.01
ICT	23.75± 6.26	98± 41.54	<0.001	46.+/-21.86	<0.001	90. ± 14	0.001
IVRT	72.83± 6.67	84.23± 37.88	0.02	111.23+/- 19.99	0.001	57.85± 7.56	0.001

Table 3: Doppler echo parameters of left ventricular function in various groups

Patients with LV systolic dysfunction had increased E/A ratio, prolonged isometric contraction time and decreased E deceleration time. Patients with diastolic dysfunction were grouped into 2 types: those with Type1 pattern (relaxation abnormalities), had decreased E velocity, increased A velocity, with E/A ratio less than or equal to one, with prolongation of E deceleration time and both ICT and IVRT, where as in patients with Type 3 pattern (restrictive pattern) had E/A ratio above 2, with significantly shortened E deceleration time and IVRT and prolongation of ICT.

LV—MPI in various groups was as follows:

Parameter	Normal	Systolic dysfunction		Diastolic dysfunction	
LV a	(n =50)	(n =50)	P	(n =50)	p
	376.2± 36.75	381.53± 58.07	NS	410.08± 52.01	0.001
LV B	286.4± 29.26	198.17± 39.58	<0.001	259.25± 39.21	NS

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LV MPI	0.3176± 0.069	0.9458± 0.2642	<0.001	0.588± 0.1309	<0.001

Table 4: LV MPI in various subgroups

LV-MPI in normal subjects was 0.32 ± 0.07 and it is significantly increased in patients with both systolic and diastolic dysfunction, 0.95 ± 0.26 and 0.59 ± 0.13, respectively.

LV MPI in various subgroups of LV dysfunction is as follows. In patients with mild, moderate LV dysfunction (EF in the range of 31 to 49%) MPI is 0.77-0.89 where as in cases of severe LV dysfunction (EF less than 25-30%) it is significantly high and above 1.

Sl. No	EF	Number	MPI
	≤ 25%	11	1.07
	26 – 30%	22	1.04
	31- 40%	18	0.89
	40-49%	9	0.77

Table 5: LV MPI according to the severity of LV dysfunction

Correlation of LVMPI with other echo parameters in various subgroups was as follows:

Parameter	Normal (n=50)		Systolic dysfunction (n=60)		Diastolic dysfunction			
					Type1 (n=52)		Type 2 (n=2)	
	r	p	r	p	R	p	p	p
LV ID (d)	-0.007	NS	0.4289	0.001	0.002	NS	-0.005	NS
LVID (s)	0.05	NS	0.5371	0.001	0.11	NS	0.04	NS
EF	-0.14	NS	-0.5132	0.001	-0.2	NS	0.35	>0.1 (NS)
E/A ratio	-0.091	NS	-0.0857	NS	-0.26	NS	0.56	0.05
EDT	-0.3	0.0I (NS)	-0.103	NS	0.1735	NS	0.57	0.02
MR Sensitivity	-		-0.15	NS	-		-	
RVSP (mm of Hg)	-		0.061	NS				

Table 6: Correlation of LV MPI with other echo parameters

When MPI was correlated with other echo parameters, in patients with LV systolic dysfunction there was significant positive correlation between MPI and LV dimensions, i.e., MPI tend to increase as LV dimensions increase and there was significant negative correlation with ejection fraction, i.e., MPI tend to increase as ejection fraction decreases. No correlation was noticed between

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MPI and E/A ratio and E deceleration time. No correlation was noticed with severity of MR or RV systolic pressure.

In patients with type1 pattern of LV diastolic dysfunction, no correlation was noticed between MPI & other parameters like E/A ratio, EDT.

In patients with type 3 pattern of LV diastolic dysfunction, weak positive correlation was noticed with E/A ratio and negative correlation with E deceleration time.

DISCUSSION: In the present study, LV-MPI in normal individuals was found to be 0.32± 0.07. In the study by Tei C[3]et al. in 45 normal persons, LV-MPI was found to be 0.39 ± 0.04. In Dujardin[4] et al series of 75 individuals it was 0.37± 0.05. In a series published by Poulsen[5] et al normal LV-MPI was found to be 0.4 ± 0.08.

LV-MPI in patients with systolic dysfunction in the present study was found to be 0.95 ± 0.26. In the study by Peltier[6] et al, in 100 patients with LV systolic Dysfunction mean LV-MPI was found to be 0.69 ± 0.3. In Dujardin[4] et al series of 75 patients with dilated cardiomyopathy, MPI was found to be 0.87 ± 0.38. The difference may be due to the heterogeneity of the population considered, as majority of the patients in the present study comprised of NYHA functional class 3 & class 4. In a study by Tei C[3] et al of patients with amyloidosis, with LV ejection fraction <50%, MPI was found to be 0.91 ± 0.22.

In the present series LV-MPI in patients with diastolic dysfunction was 0.59 ± 0.13. In a study by Anderson [7] et al, LV-MPI was 0.51± 0.12, in patients with essential hypertension and diabetes mellitus with normal ejection fraction, similar to the present series. In patients with diastolic dysfunction no significant difference in MPI was noted among subgroups with relaxation abnormalities and restrictive filling 0.58 ± 0.14 and 0.62 ± 0.06 respectively. In contrast, in the study by Nearchos S. nearchou et al[8] in patients with myocardial infarction and diastolic dysfunction 0.77 ± 0.05 in delayed relaxation group and 0.59 ± 0.05 in restrictive filling group.

In the present study LV-MPI in normal individuals was found to vary with in a narrow range not related to other echo parameters. In paients with LV systolic dysfunction, significant correlation was noted between MPI and LV end-diastolic dimension (r:0.42, p<0.001); LV end-systolic dimension (r:0.54,p<0.001); ejection fraction (r:-0.5132, p<0.001);fractional shortening (r:-0.5132,p<0.001)and no correlation was noticed with E/A ratio, E deceleration time, severity of MR, pulmonary artery systolic pressures. Similar findings were observed in the study by Peltier [6]et al who found correlation of LV MPI with LV end diastolic dimension (r:0.4,p 0.0008) end systolic dimension (r:0.42,p 0.0005) ejection fraction (r:-0.4, p 0.0043) and fractional shortening (r:-0.34,P 0.0006) and no correlation was noted with E/A ratio, E deceleration time PA systolic pressures. In Dujardin[4] et al series correlation of LV-MPI with end diastolic dimension was r:0.23 (p 0.05): end-systolic dimension r:0.37 (p 0.003) and with EF r:-0.41 (0.001). In the study by Bruch C et al [9] similar correlation was seen.

When individual time intervals which constitute MPI were analyzed, in normal persons LV isometric contraction time (ICT) was found to be 23.75 ± 6.26 msec; isovolumic relaxation time (IVRT) 72.83 ± 6.67 msec and LV ejection time 286.4 ± 29.26msec.respectively.

In patients with LV systolic dysfunction isometric conraction time was significantly prolonged, 98 ± 41.54 msec. and ejection time was significantly shortened,198.17 ± 39.58 msec with no significant change in isovolumic relaxation time,84.23 ± 37.88 msec. These findings indicate that

prolongation of MPI in LV systolic dysfunction is secondary to prolongation of isometric contraction time and shortening of ejection time.

In patients with type 1 diastolic dysfunction (relaxation abnormalities) significant prolongation of isovolumic relaxation time (IVRT),111.23 ± 19.99 msec and isometric contraction time,46.1 ± 21.86 msec was found with no significant change in ejection time,259.25 ± 39.27msec. These findings indicate that the prolongation of MPI was secondary to prolonged isovolumic relaxation time.

In patients with type 3 pattern of diastolic dysfunction (restrictive pattern) significant shortening of IVRT was noticed, 0.57 ± 7.56 m sec with prolongation of isometric contraction time, 90 ± 14 msec and no significant change in ejection time, 238.13 ± 33.8 msec. These changes indicate that in patients with restrictive pattern of filling abnormality, there may be some underlying contraction abnormalities, though LV ejection is preserved. Conclusions:

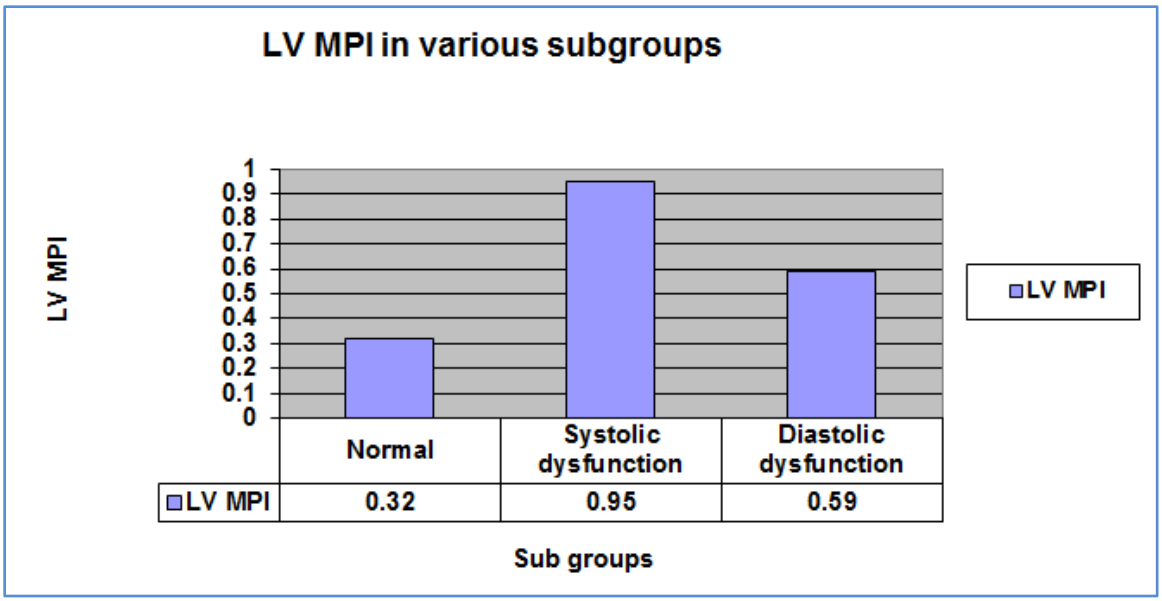
Left ventricular myocardial performance index (Tei index) is significantly increased in patients with heart failure because of both systolic as well as diastolic dysfunction. In patients with systolic heart failure, MPI correlated inversely with left ventricular ejection fraction. In patients with diastolic heart failure, no correlation was noted between MPI other Doppler parameters. MPI is a simple, easily obtainable index that can be done during routine echocardiography.

REFERENCES:

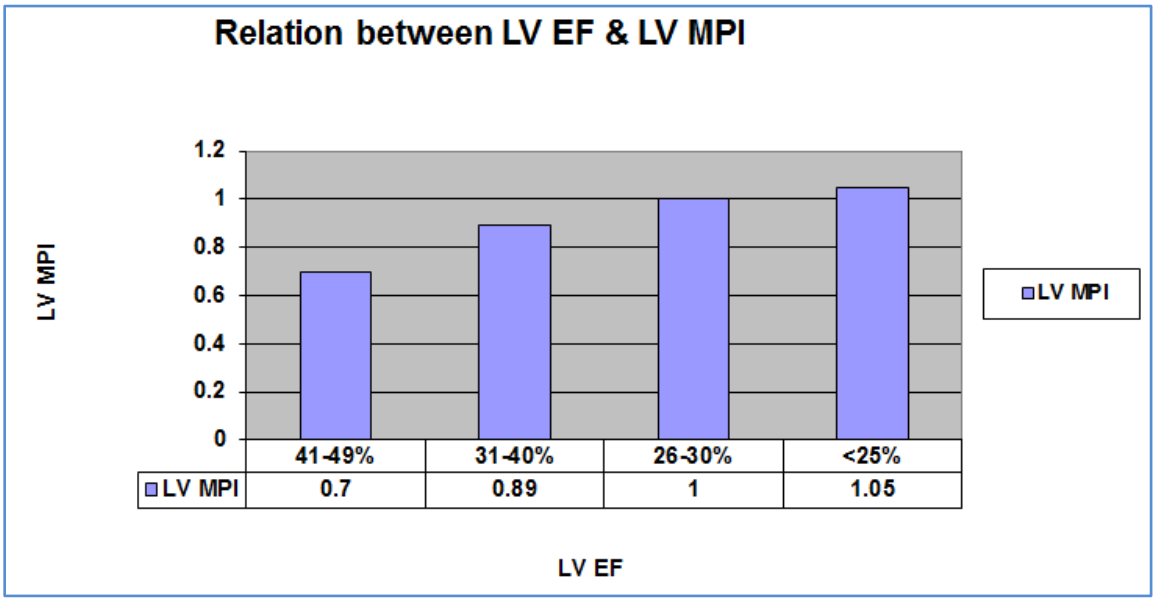
1. Perrone F, Bacharach S, Dilsizian V, Bonow R. Effects of regional systolic asynchrony on left ventricular global diastolic function in patients with coronary artery disease. J Am Coll Cardiol. 1992; 19: 739-744.
2. Harrison M, Clifton G, Pennell A,et al. Effect of heart rate on left ventricular diastolic transmitral flow velocity patterns assessed by Doppler echocardiography in normal subjects. Am J Cardiol. 1991; 167: 622-627.
3. Tei C, Ling LH, Hodge DO, Bailey KR, Oh JK, Rodeheffer RJ, Tajik AJ, Seward B. New Index of combined systolic and diastolic myocardial performance: a simple and reproducible measure of cardiac function, a study in normal and dilated cardiomyopathy. J. Cardiol 1995; 26: 357-366.
4. Dujardin KS, Tei C, Yeo TC, Hodge DO, Rossi A, Seward JB. Prognostic value of a Doppler index combining systolic and diastolic performance in idiopathic – dilated cardiomyopathy. Am J Cardiol. 1998; 82: 1071-1076.
5. Poulsen S, Nielsen J, et al. The influence of heart rate on the Doppler derived myocardial performance index. J Am Soc Echocardiogr. 2000; 13: 379-384.
6. Peltier M, Slama M, Garbi S, et al. Prognostic value of Doppler-derived myocardial performance index in patients with left ventricular systolic dysfunction. Am J Cardiol. 2002 Dec 1; 90 (11): 1261-3.
7. N. H. Andersen H. Poulsen K, et al: Impact of Essential Hypertension and Diabetes Mellitus on Left Ventricular Systolic and Diastolic Performance. European Heart Journal - Cardiovascu Imaging Volume 4, Issue 4 Pp. 306 – 312.
8. Nearchos S. nearchou, Alexandros K. tsakiris, marios D. tsitsirikos et al Tei Index as a Method of Evaluating Left Ventricular Diastolic Dysfunction in Acute Myocardial Infarction Hellenic J Cardiol 46: 35-42, 2005.

DOI: 10.14260/jemds/2015/308

9. Bruch C, Schmermund A, Marin D, Katz M, Bartel T, Schaar J, Erbel R Tei-index in patients with mild-to-moderate congestive heart failure. Eur Heart J. 2000 Nov; 21 (22): 1888-95.
10. Lakoumentas JA, Panou FK, Kotseroglou VK, Aggeli KI, Harbis PK: The Tei index of myocardial performance: application in cardiology. Hellenic J Cardiol 2005, 46: 52–58.



Graph 1: LV MPI in Normal & pts with systolic & diastolic Heart Failure



Graph 2: Relation between LV EF & LV MPI

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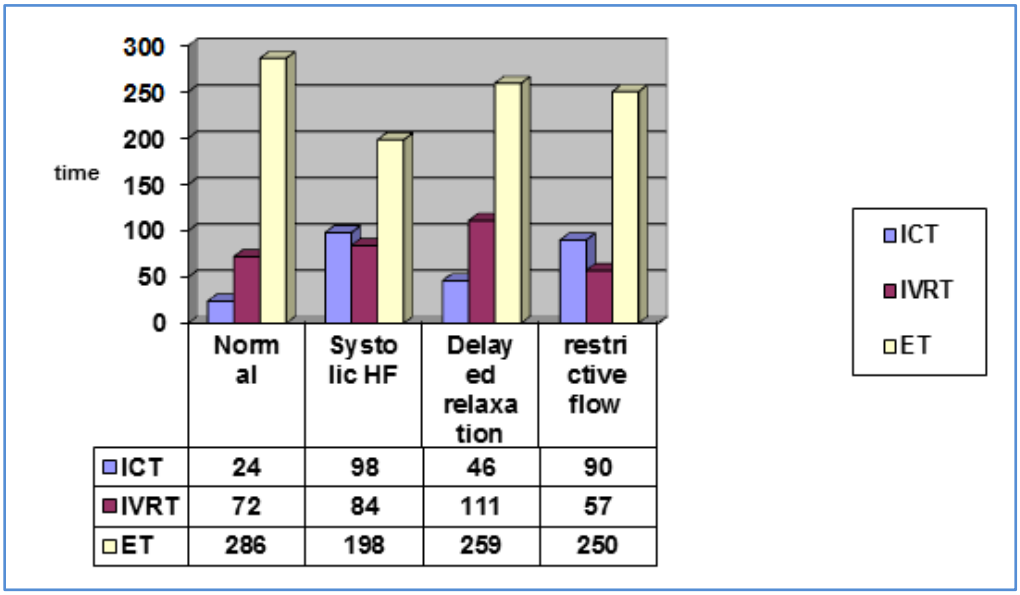

	Normal	Systolic HF	Delayed relaxation	restrictive flow
ICT	24	98	46	90
IVRT	72	84	111	57
ET	286	198	259	250

Graph 2: Time intervals in various sub groups of the study

ABBREVIATIONS USED IN THE ARTICLE: LV: left ventricle, MPI: myocardial performance index, ICT: Isovolumic contraction time, IVRT: Isovolumic relaxation time, ET: Ejection time, EDD: End diastolic dimension, ESD: End systolic dimension, LVIDD: Left ventricular internal diameter in diastole, LVIDS: left ventricular internal diameter in systole, FS: fractional shortening, EDT: E deceleration time, PJV: pulmonary jet velocity, PAT: pulmonary acceleration time, MR: mitral regurgitation, RVSP: right ventricular systolic pressure, CAD: coronary areety disease, HTN: hypertension.

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