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Original Article

Myocardial performance index as an echocardiographic predictor of early in-hospital heart failure during first acute anterior ST-elevation myocardial infarction

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ABSTRACT

Objectives: To determine the value of Myocardial Performance Index (MPI) as an echocardiographic predictor of early in-hospital heart failure (HF) during first acute anterior ST-Elevation Myocardial Infarction (STEMI).

Background: Myocardial infarction induces variable degrees of impairment in left ventricular (LV) systolic and diastolic functions. The ejection fraction (EF) and transmitral flow, the most frequently used methods for evaluation of systolic and diastolic functions respectively, both have considerable limitations. The MPI is a single parameter, capable of estimating combined systolic and diastolic performance and lacks such limitations.

Methods: We enrolled 60 patients presented with a first acute anterior STEMI who have undergone primary PCI. Echocardiography was done within 24 h of chest pain with measurement of MPI. The LV MPI was calculated as (isovolumic contraction time "ICT" + relaxation time "IRT")/Ejection time "ET". Besides, clinical and echocardiographic variables were analyzed and CHF was defined as Killip class $\geq$ II.

Results: Early in-hospital HF occurred in 23 of patients (38%). Ejection fraction was found to have a highly significant negative correlation with the development of in-hospital HF ($p = .0001$), while MPI was found to have a highly significant positive correlation ($p = .0001$). A cut-off point of MPI > 0.73 showed a very high specificity (94.6%) and sensitivity (78.3%) for identifying patients with HF. On the other hand, a cut-off point of EF $\leq$ 33% has shown 94.6% specificity and 56.5% sensitivity for HF prediction.

Conclusions: The MPI might be a strong predictor of in-hospital HF after first acute anterior STEMI.

1. Introduction

Acute myocardial infarction (MI) remains a leading cause of morbidity and mortality worldwide. It induces variable degrees of impairment in left ventricular (LV) systolic and diastolic functions.[1] ST segment elevation myocardial infarction is the most serious presentation of atherosclerotic coronary artery disease carrying the most hazardous consequences.[2] Heart failure (HF) is one of the most dreadful complications following myocardial infarction (MI) affecting morbidity and mortality. Early detection of patients with acute MI at risk of development of in-hospital HF is necessary to limit myocardial injury and LV dysfunction.[3]

Echocardiography allows assessment of systolic and diastolic LV functions which are predictors of HF. The ejection fraction (EF) and the trans-mitral flow, the most frequently used methods for evaluation of systolic and diastolic functions respectively; both have considerable limitations especially in the setting of an acute MI.[4] A single index that allows assessment of the global myocardial performance has been suggested as an alternative to the individual assessment of systolic and diastolic functions.[5]

In 1995, Tei and colleagues proposed an index; Tei index or myocardial performance index (MPI) which is a Doppler derived time interval index defined as the sum of iso-volumic contraction time (IVCT) and iso-volumic relaxation time (IVRT) divided by ET. This index is easily obtained from trans-mitral flow and LV outflow velocity time intervals with good reproducibility, and is independent from LV geometry and heart rate.[5] It has a good correlation with invasive measures of LV function (systolic and diastolic),[6] and was also found to be superior to conventional echocardiographic parameters in correlation with patient outcome in various

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myocardial diseases.[7,8] However, there is limited data on the clinical value of the MPI in patients with acute MI.[9,10]

2. Methods

Briefly, the study was a single center, prospective, observational study designed to measure the MPI within 24 h in patients with anterior ST elevation myocardial infarction (STEMI) treated by Primary Percutaneous Coronary Intervention (PPCI). It included 60 patients who presented with documented first acute anterior STEMI and underwent PPCI in Ain Shams University hospitals in the time period from November 2014 till June 2015.

This study was approved by the ethical committee of Ain Shams University Hospitals. Informed consent was obtained from each participant.

All patients were subjected to thorough history taking, physical examination, Killip classification,[11] 12 lead ECG, and then they have undergone PPCI with documentation of pain-to-door (PTD) time. All angiographic and procedural details were noted, including TIMI flow and myocardial blush grade following PPCI.

A trans-thoracic echocardiography was done during first 24 h of admission. Standard echocardiographic measurements were done as well as measurement of MPI. From trans-mitral flow and LV outflow velocity time intervals, Doppler time intervals were measured as shown in Fig. 1. The interval "a" from the cessation to the onset of trans-mitral flow was equal to the sum of isovolumic contraction time (ICT), ejection time (ET), and isovolumic relaxation time (IRT). The interval "b" was the LV outflow ET. The LV Tei index was calculated as (a − b)/b, which means (ICT + IRT)/ET (Fig. 1).[12]

Patients with known history of dilated cardiomyopathy were excluded. Patients were also excluded when they had had previous PCI or Coronary Artery Bypass Grafting (CABG). Other exclusion criteria were patient's refusal and non-sinus rhythm.

2.1. Statistical analysis

Continuous variables are reported as the mean ± SD and were compared using one-way analysis of variance. Categorical variables are reported as frequencies (percentages) and were compared with the Pearson's chi-square test. A p-value < .05 was considered statistically significant in all analyses. Data were analyzed with SPSS 21 (IBM, Armonk, New York).

3. Results

A total number of 60 patients were recruited. Baseline demographic and clinical characteristics of the study population are listed in Table 1. The study population was divided into 2 groups according to Killip classification during hospital stay.[11] Group 1 (no HF group) included 37 of patients (61.7%) with Killip class I. Group 2 (HF group) included 23 patients (38.3%) with Killip class > I. Of patients in group 2, 17 patients (28.3%) were in Killip class II, 6 patients (10%) were in Killip class III, and none were in Killip class IV (Fig. 2).

The MPI for the overall population ranged from 0.4 to 1.35, with a mean ± SD of 0.69 ± 0.2. Ejection fraction ranged from 25 to 51%, with a mean ± SD of 38.06 ± 6.01%. In the group of patients with HF, the MPI ranged from 0.57 to 1.35, with a mean ± SD of 0.88 ± 0.18 while it ranged from 0.4-0.79, with a mean ± SD of 0.58 ± 0. 11 in those with no HF (p = .0001). For EF, it ranged from 25 to 43%, with a mean ± SD of 33.91 ± 5.37% for HF group as opposed to a range of 32–51%, with a mean ± SD of 40.64 ± 4.86 in those with no HF (p = .0001). Clinical, electrocardiographic, echocardiographic

Table 1
Socio-demographic data and risk factors in both groups.

		Group 1 (HF)[a] (n = 23)	Group 2 (no HF)[a] (n = 37)	P-value
Age	Mean ± SD	56.6 ± 8.98	51.67 ± 12.26	.1
Gender	Females	4	7	.075
	Males	19	7	
Hypertension	Negative	12	26	.2
	Positive	11	11	
Diabetes mellitus	Negative	14	22	.9
	Positive	9	15	
Smoking	Negative	5	8	.9
	Positive	18	29	

[a] Heart failure.

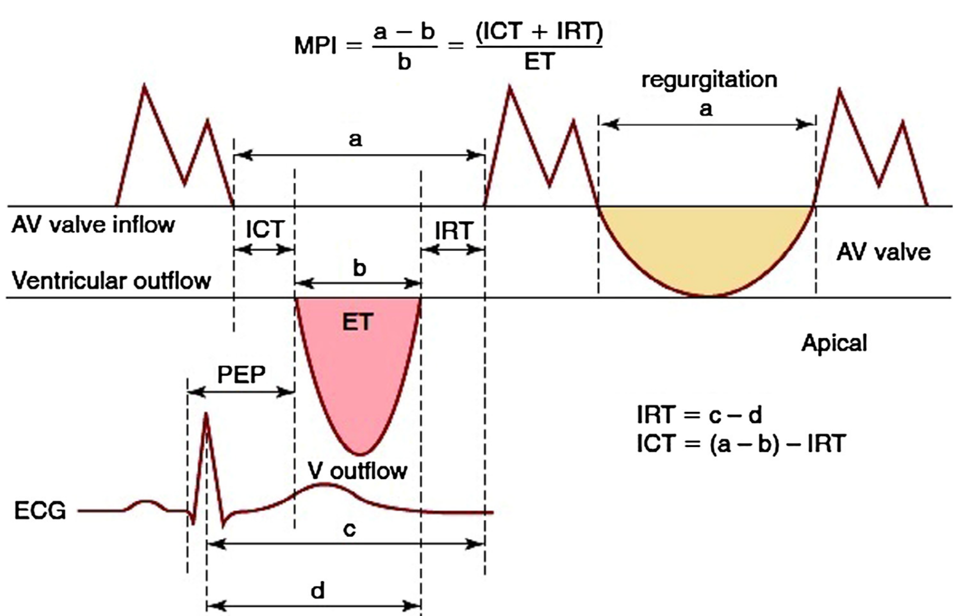

Fig. 1. Doppler flow diagram explaining Tei index calculation.

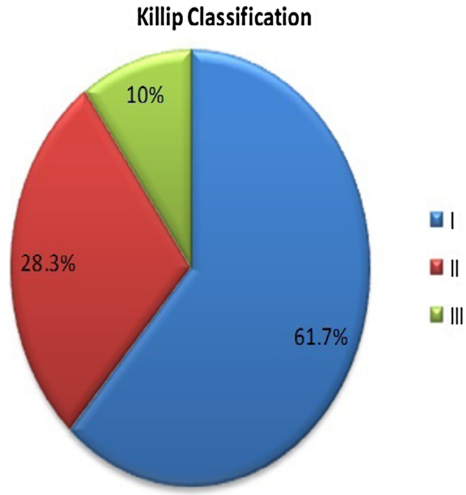

Fig. 2. Distribution of Killip class among study population.

as well as angiographic characteristics of both groups are listed in Tables 1–4.

It has been found that MPI greater than 0.73 has a sensitivity of 78.3% and specificity of 94.6% in prediction of in-hospital heart failure. On the other hand, EF less than or equal to 33% has a sensitivity of 56.5% and 94.6% (Figs. 3 and 4).

4. Discussion

In this study, MPI was significantly higher in patients who experienced in-hospital HF (Killip class ≥ II) compared to patients with no HF (Killip class I); 0.88 ± 0.18 and 0.58 ± 0.11 respectively (p = .0001). This study adds to the body of findings supporting MPI as a predictor for HF in patients with STEMI.

A clear correlation between MPI and in-hospital HF after acute MI was confirmed by many reports. In 2011, Souza et al.[10] reported that MPI was prolonged in patients with HF after studying the echocardiographic predictors of early in-hospital HF in patients presented with first acute STEMI (0.65 ± 0.16 vs 0.57 ± 0.14, p = .01). Yuasa et al.[12] have studied MPI in 80 patients presented with first acute anterior STEMI. They have found that MPI was also significantly higher in patients with in-hospital adverse outcomes when compared to other patients (0.69 ± 0.16 vs 0.5 ± 0.11, p = <.0001). This correlation was also concluded by Ascione et al.[13] who studied the predictive value of MPI in 94 patients presented with first acute MI and stated that MPI was significantly higher in patients with cardiac events and HF (0.65 ± 0.20 vs 0.43 ± 0.16, P = .0001). Though they differ in study group demographics and clinical characteristics, there are many other studies emphasizing the significant correlation between MPI and in-hospital HF following acute MI.[9,14]

The mean MPI in current study (0.88) was higher than previous studies (0.50–0.85). This may be due to the fact that we have studied only patients with acute anterior STEMI, while other studies either included all types of acute MI (NSTEMI and different types of STEMI)[9,13,14] or only STEMI (including anterior, inferior and lateral STEMIs).[10] Interestingly, the other study[11] which only included only anterior STEMI showed similar mean MPI (0.85).

Both MPI and EF were found to be strong predictors of development of in-hospital HF (p = .0001 for both). A cut-off point of MPI > 0.73 and EF ≤ 33% showed a very high specificity (94.6%) for identifying patients with HF. However, MPI showed a higher sensitivity (78.3%) than EF (56.5%). Results of Ascione et al.[13] showed that a cut-off point of MPI > 0.47 had a sensitivity of 90% and a specificity

Table 2
Electrocardiographic findings and pain-to-door time in both groups.

		Group 1 (HF)[a] (n = 23)	Group 2 (no HF)[a] (n = 37)	P-value
Number of leads with ST elevation	4 leads	5	9	.2
	5 leads	0	2	
	6 leads	7	18	
	7 leads	1	1	
	8 leads	10	7	
Maximum ST elevation (mm)	3 mm	4	1	.02
	4 mm	11	10	
	5 mm	8	22	
	6 mm	0	4	
ST elevation resolution after 60 minutes of reperfusion	25%	1	0	.007
	50%	12	7	
	75%	10	22	
	100%	0	8	
Pain-to-door time (hours)	Mean ± SD	9.95 ± 3.25	5.21 ± 3.37	.0001

[a] Heart failure.

Table 3
Laboratory findings in both groups.

		Group 1 (HF)[a] (n = 23)	Group 2 (no HF)[a] (n = 37)	P-value
CK-MB[b] initial	Mean ± SD	242.73 ± 227.49	159.89 ± 122.79	.07
CK-MB[b] peak	Mean ± SD	734.91 ± 416.15	635.45 ± 265.38	.2
CK-MB[b] time to decline	Mean ± SD	39.13 ± 9.56	25.62 ± 11.09	.0001
Creatinine	Mean ± SD	1.17 ± 0.45	1.05 ± 0.4	.2
Hemoglobin	Mean ± SD	14.28 ± 1.8	14.04 ± 1.74	.6
Total leucocytic count	Mean ± SD	13.18 ± 5.79	10.51 ± 5.02	.06
HBA1c	Mean ± SD	7.38 ± 2.61	6.87 ± 2.21	.4

[a] Heart failure.
[b] Creatine kinase – myocardial band.

Table 4
Echocardiographic and angiographic findings in both groups.

		Group 1 (HF)[a] (n = 23)	Group 2 (no HF)[a] (n = 37)	P-value
LVESD[b]	Mean ± SD	38.91 ± 4.58	38.1 ± 5.2	.5
LVEDD[c]	Mean ± SD	52.34 ± 5.28	50.32 ± 5.95	.075
EF[d]	Mean ± SD	33.91 ± 5.37	40.64 ± 4.86	.0001
MPI[e]	Mean ± SD	0.88 ± 0.18	0.58 ± 0.11	.0001
DT[f]	Mean ± SD	160.21 ± 58.9	159.98 ± 47.42	.9
TIMI[g] flow (number of patients)	II	5	2	.055
	III	18	35	
MBG[h] (number of patients)	I	1	0	.002
	II	11	4	
	III	11	33	
LAD[i] artery site (number of patients)	Proximal	19	26	.2
	Non-proximal	4	11	

[a] Heart failure.
[b] Left ventricular end systolic diameter.
[c] Left ventricular end diastolic diameter.
[d] Ejection fraction.
[e] Myocardial performance index.
[f] Deceleration time.
[g] Thrombolysis-in-myocardial-infarction.
[h] Myocardial blush grade.
[i] Left anterior descending.

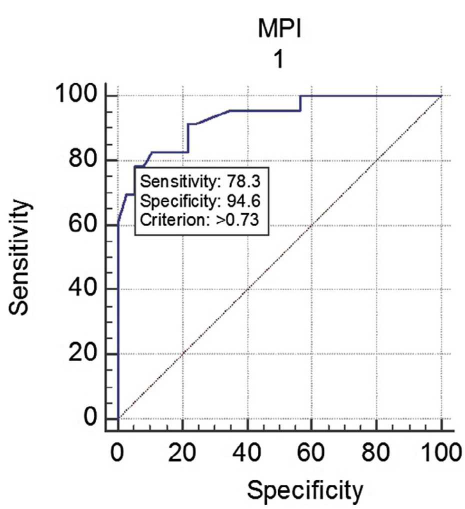

Fig. 3. The RoC curve for myocardial performance index (MPI).

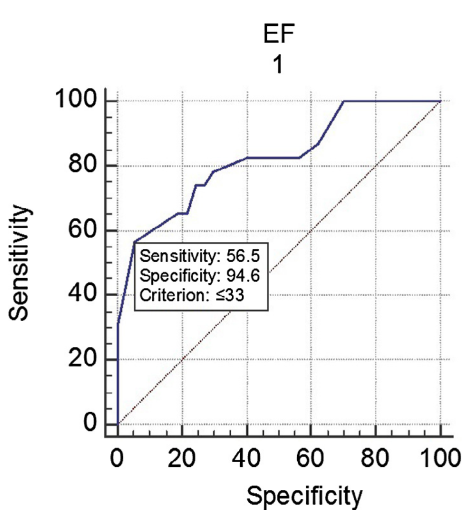

Fig. 4. The RoC curve for ejection fraction (EF).

of 68% for identifying patients with events, whereas a LV EF < 50% had a sensitivity of 85% and a specificity of 65%. Yuasa et al.[12] found that a cut-off point of MPI > 0.59 showed 76% sensitivity and 79% specificity, while a cut-off point of EF < 45% showed 69% sensitivity and 79% specificity indicating higher sensitivity of MPI, which is also concordant to our results. Poulsen et al.[9] found a cut-off point of MPI > 0.45 with 100% sensitivity and 41% specificity, while a cut-off point of EF < 50% had 50% sensitivity and 33% specificity.

The current study showed a higher cut-off for MPI, a lower cut-off for EF, and higher values of sensitivity and specificity as compared to previous studies. This can be attributed to differences in the study population, as we included only patients with acute anterior STEMI unlike the previous studies that included all types of acute MI.

It is noteworthy in current study that there was no significant correlation between socio-demographic parameters as sex, smoking, diabetes mellitus, or hypertension and the development of in-hospital HF after acute MI. This goes hand-by-hand with earlier studies.[10,13]

Our small study did have some limitations. First of all, it was a single center study. Moreover, the number of patients enrolled was small and so clinical significance of results should be validated by a larger multi-center studies. The design was observational, and though there were no significant demographic or clinical differences between both groups (HF and no HF groups), residual confounding may remain. Also, the study only included patients with an acute anterior STEMI (other types of STEMI and NSTEMI were excluded). Besides, MPI was measured only once within the first 24 h of presentation and not serially (though some studies showed temporal changes in MPI value).

5. Conclusions

The simple and easily obtained non-geometric MPI might be a strong predictor of in-hospital HF after first acute anterior STEMI. Whereas both MPI and EF were able to highly predict in-hospital HF in the setting of first acute anterior STEMI, MPI was more sensitive than EF. However, the clinical application of these results requires further validation.

Conflict of interests

The authors declare no conflicts of interest.

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None.

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