International Journal of Research in Medical Sciences
Benjamin B. Int J Res Med Sci. 2018 Dec;6(12):3908-3915
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20184881

Original Research Article

Evaluation of correlation between myocardial performance index and left ventricular ejection fraction in patients with acute ST-elevation myocardial infarction

Bino Benjamin*

Department of Cardiology, Kottayam Medical College, Kerala, India

Received: 11 October 2018
Accepted: 03 November 2018

***Correspondence:**
Dr. Bino Benjamin,
E-mail: binobenjaminc@gmail.com

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ABSTRACT

Background: In the diagnosis of patients with ST-elevation myocardial infarction (STEMI), prediction of left ventricular systolic function is one of the vital elements. Traditionally, assessment of left ventricular function is focused on measurement of left ventricular ejection fraction (LVEF). But it is load dependent and sensitive to the alterations in preload and after-load. However, myocardial performance index (MPI) demonstrates supremacy over older established indexes. Hence, the purpose of the study is to estimate the correlation between MPI and LVEF in patients with acute STEMI.
Methods: A total of 105 consecutive patients underwent conventional estimation of ejection fraction and LV end-systolic volume by a Teichholz method. All patients received 325mg dispersible aspirin, 300mg clopidogrel at the time of admission and streptokinase. Doppler echocardiographic evaluations were performed at presentation, immediately after thrombolysis (90 minutes) and before discharge on 3rd to 5th days.
Results: The mean patient age was 56.36years and 89 (84.76%) patients were male. A low LVEF of <40%, significantly correlated with higher (worse) MPI at the time of presentation (P= 0.04). LVEF showed improvement after thrombolysis, moreover it was significantly higher at 0' (P= <0.03) and 3rd day (P= 0.05) in patients with MPI <0.5.
Conclusions: A significant correlation was found between left ventricular ejection fraction and myocardial performance index; lesser the left ventricular ejection fraction, higher the myocardial performance index. However, myocardial performance index could not predict adverse cardiac events during the hospital stay.

Keywords: Doppler echocardiography, Left ventricular ejection fraction, Myocardial performance index, ST elevation myocardial infarction, Thrombolysis, Teicholtz method

INTRODUCTION

ST-elevation myocardial infarction (STEMI) is a leading source of cardiovascular death and thus accounts for a high burden on health care services worldwide. According to the heart disease and stroke statistics update 2016 of the American Heart Association (AHA), the estimated annual incidence of coronary attack in America is approximately 660000 new attacks and 305000 recurrent attacks.[1] Left ventricular (LV) systolic function is an important prognostic factor, associated with increased mortality in patients with STEMI.[2,3] LV function is measured by Two-dimensional (2D) echocardiography, M-mode echocardiography, Doppler

echocardiography, and 3D echocardiography, both during systole as well as diastole.[4] A LV function is assessed by LV systolic function and diastolic function. Traditionally, assessment of LV function is focused on measurement of left ventricular ejection fraction (LVEF) and measurement of peak blood flow velocities during rapid filling (E wave) and atrial systolic contraction (A wave) represented the initial foray into the non-invasive assessment of diastolic ventricular function, which varies with age in normal subjects and is exquisitely sensitive to alterations in loading conditions. Both of them have not correlated with severity of symptoms, exercise capacity, myocardial oxygen consumption also unable to distinguish patients with clinical heart failure from those without heart failure, with equivalent ventricular dysfunction. Main limitations of LVEF is the load dependency, sensitivity to the alterations in preload and after-load and the geometrical assumptions involved in estimation of LVEF may not be appropriate in conditions like myocardial infarction where considerable alteration in the shape of LV occurs.[5-7] In 1995, Tei et al, proposed an index of myocardial performance (Tei index) that evaluates the LV systolic and diastolic function in combination. It demonstrates clear advantages over older established indexes and prognostic value in idiopathic dilated cardiomyopathy, cardiac amyloidosis and primary pulmonary hypertension.[8,9] Therefore, the present study was to evaluate the relationship of TEI index and LVEF in patients with acute ST-elevation myocardial infarction.

METHODS

The study was undertaken on 105 consecutive patients at Kottayam medical college, in the department of cardiology from 1st September 2005 to 31st August 2006. The study was approved by Kottayam medical college ethical committee. Patients with first acute ST-elevation myocardial infarction admitted in the cardiac ICU within 12hours of the onset of chest-pain (ST elevation was defined as ≥l mm ST-elevation in at least 2 contiguous leads with a history of prolonged chest pain.) were included in the study. However, patients with pre-existing coronary artery disease, prior structural heart disease, cardiogenic shock, acute pulmonary edema, mechanical complications of myocardial infarction, sustained arrhythmia, on temporary pacemaker support, insufficient echo window which interferes with proper assessment of myocardial performance index (MPI), contraindication for thrombolysis at the time of admission were excluded from the study.

Study procedures

All patients received 325 mg dispersible aspirin and 300 mg of clopidogrel at the time of admission. All patients were given streptokinase. Patients underwent Doppler echocardiographic evaluations at the time of presentation, immediately after thrombolysis (90 minutes) and before discharge on 3rd to 5th days. All patients underwent conventional estimation of ejection fraction and LV end-systolic volume by a Teicholtz method.[10] They were followed-up during the period of hospitalization and monitored for the occurrence of recurrent ischemia, need for urgent target vessel revascularization and death.

Estimation of myocardial performance index

MPI is defined as the sum of isovolumic contraction time (ICT) and isovolumic relaxation time (IRT) divided by ejection time (ET). The sum of ICT and IRT is equal to the difference between the interval from Cessation to Onset of the Mitral inflow (MCO) and ET (Figure 1).[11]

$$MPI = (IVRT + IVCT)/ET$$

Where, IVRT= measured from a closure of aortic valve and opening of mitral valve, IVCT= measured from a closure of mitral valve and opening of aortic valve, ET= measured from opening and the closure of the aortic valve on the left ventricular outflow velocity profile. Reported normal range for LV myocardial performance index is 0.39±0.05. MPI values greater than 0.45, were considered abnormal.

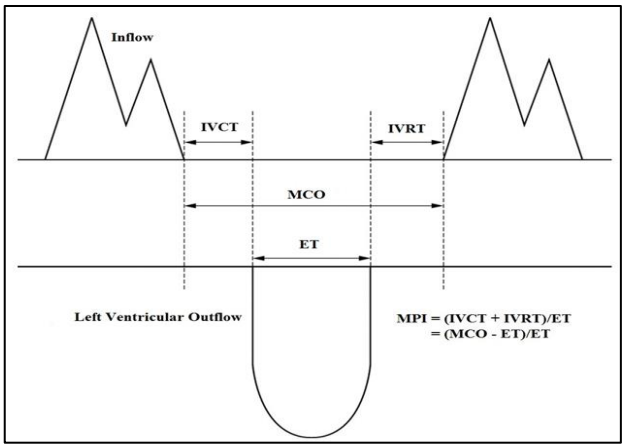

Figure 1: Diagrammatic representation of measurement of doppler intervals.[11]

Statistical analysis

Statistical analysis was carried out using Microsoft Excel spreadsheet (version 2007, Microsoft Corp, Seattle, Washington). Values were expressed as a Mean±standard deviation or as percentages.

RESULTS

A total of 105 patients were included in the study. Baseline clinical characteristics and echocardiographic parameters are mentioned in Table 1 and Table 2.

In group with LVEF <40%, majority of patients (91.5%) had an LVEF >40% at the time of presentation. MPI was lower in the group with better LVEF at 0', 90' and on 3rd

day. Moreover, it is statistically significant on 3rd day (P=0.04).

Table 1: Baseline clinical characteristics.

Characteristics	N=105
Age	55.98
Gender	
Male	89 (84.76)
Female	16 (15.23)
Clinical examination	
Hypertension	73 (69.5%)
Diabetes mellitus	31 (29.5%)
Smoking	38 (36.2%)
COPD	6 (5.7%)
Dyslipidemia	12 (11.4%)
Lesions	
LAD	51 (48.6%)
RCA	44 (41.9%)
LCx	10 (9.05%)

Incidences of in-hospital complications and LV systolic dysfunction are significantly higher in patients with LVEF <40%. (P=0.03 and P=0.0002 respectively) (Table 3). In the group with LVEF <50%, majority of patients 79 (74.2%) had an LVEF >50% at the time of presentation. In this group, the difference in the incidence of LV dysfunction between the two groups is significant (P=0.007). Also, the incidence of mitral regurgitation (MR) was significantly low at 0' (P=0.04), 90' (P=0.04) and on 3rd day (P=0.00) in patients with LVEF >50% (Table 4). None of the variables showed any significant difference in the group with ST-segment resolution (STR) >50% at 90min (Table 5).

LVEF showed improvement after thrombolysis from 54.8%, 58.6% and 60.9% in the group with MPI >0.5 to 60%, 61.6% and 64.5% in the group with MPI <0.5 at 0', 90' and 3rd day respectively. Moreover, it is statistically significant at the time of presentation (P= <0.03) and on the 3rd day (P=0.05) (Table 6). None of the variables were showing any significant difference in the group of patients with MPI <0.6 at 90 min. (Table 7).

Table 2: Echocardiographic parameters of patients stratified by whole group, LAD, RCA and LCx territory involvement groups.

Echocardiographic parameters	Total (n=105)	LAD (n=51)	RCA (n=44)	LCx (n=10)
ST Elevation	12.09	16.48	7.66	10.1
LV ejection fraction				
0'	55.5	56.8	54.5	53.7
90'	59	59.7	57.6	62.8
3 days	61.5	62.6	59.8	63.7
Wall motion score index				
0'	1.55	1.55	1.49	1.56
90'	1.44	1.47	1.42	1.39
3 d	1.32	1.35	1.29	1.31
MPI				
0'	0.56	0.57	0.53	0.53
90'	0.52	0.54	0.5	0.44
3 d	0.42	0.44	0.42	0.38
Mitral regurgitation				
0'	19 (18.1%)	8 (15.7%)	7 (15.9%)	3 (30%)
90'	16 (15.3%)	4 (7.8%)	10 (22.7%)	2 (20%)
3 ds	6 (5.7%)	1 (1.96%)	4 (9.1%)	1 (10%)
In-hospital complications	36 (34.3%)	19 (37.25%)	15 (34.1%)	2 (20%)
In -hospital arrhythmias				
0'	20 (19.05%)	0	18 (40.1%)	2 (20%)
In- hospital	16 (15. 24%)	4 (7.8%)	11 (25%)	1 (10%)
Major in-hospital arrhythmias				
Tachyarrhythmia	9 (0.6%)	4 (7.8%)	5 (11.4%)	0
Bradyarrhythmia	5 (4.8%)	0	4 (9.1%)	1 (10%)
Other in-hospital complications				
Left ventricular failure	7 (6.7%)	6 (11.7%)	1 (2.3%)	0
Post infarction angina	9 (8.6%)	5 (10%)	3 (6.8%)	1 (10%)

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; LAD- left anterior descending artery, RCA- right coronary artery, LCx- left ramus circumflex coronary artery and MPI- myocardial performance index

Table 3: Group with LVEF <40% and >40%.

	LVEF <40%	LVEF >40%	Z value	P value
Total number	9/105 (8.5%)	96/105 (91.5%)		
In-hospital complication	6/9 (66.67%)	30/96 (31.25%)	2.1	0.03
LV systolic dysfunction	3/9 (33.3%)	3/96 (3.12%)	3.7	0.0002
In-hospital arrhythmia	3/9 (33.3%)	14/96 (14.6%)	1.5	NS
Post-infarction angina	0/9 (0%)	9/96 (9.4%)	1	NS
MPI				
0'	0.58	0.55	-0.65	NS
90'	0.54	0.51	-0.68	NS
3 d	0.49	0.41	-2.07	0.04
Mitral regurgitation				
0'	3/9 (33.3%)	15/96 (15.6%)	1.3	NS
90'	2/9 (22%)	13/96 (13.5%)	0.7	NS
3 d	1/9 (11%)	4/96 (4.1%)	0.9	NS

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; LVEF- left ventricular ejection fraction and MPI- myocardial performance index

Table 4: Group with LVEF <50% and >50%.

	LVEF <50%	LVEF >50%	Z value	P value
Total number	26/105 (24.76%)	79/105 (74.24%)	-7.31	0.00
In-hospital complication	13/26 (50%)	23/79 (29.1%)	1.95	NS
LV systolic dysfunction	5/26 (19.2%)	1/79 (1.3%)	3.42	0.007
In-hospital arrhythmia	3/26 (11.5%)	14/79 (17.7%)	-0.74	NS
Post-infarction angina	4/26 (15.4%)	5/79 (6.3%)	1.43	NS
MPI				
0'	0.59	0.54	-1.83	NS
90'	0.53	0.51	-1.09	NS
3 days	0.47	0.40	-0.049	NS
Mitral regurgitation				
0'	8/26 (30.8%)	10/79 (12.7%)	2.12	0.04
90'	7/26 (26.9%)	8/79 (10.1%)	2.12	0.04
3 days	5/26 (19.23%)	0/79 (0%)	3.99	0.00

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; LVEF- left ventricular ejection fraction and MPI- myocardial performance index.

As shown in the Table 8, the whole group of patients was divided into three subgroups based on the myocardial performance index (MPI), - MPI <0.5, MPI 0.5 -0.59, and MPI >0.6. All parameters analyzed, there was no statistical significance among any of the three subgroups.

DISCUSSION

LV MPI (Tei index), is formulated as a parameter which can assess both systolic and diastolic function to express them as a single value. It is widely perceived as one parameter which is less often affected by the loading conditions.[8,10] LVEF measurement has provided valuable prognostic information regarding clinical outcome in patients with heart failure.[5]

Steen et al, evaluated the value of LV MPI in acute myocardial infarction and found that an LV MPI value of ≥0.45 was a powerful predictor of the in-hospital development of heart failure.[11] Jacob et al, reported a total of 799 patients with acute myocardial infarction were found that an LV MPI value of >0.5 predicted low ejection fraction.[12] Present study also comes out with similar observations. Out of 9 patients who had LVEF <40%, mean LV MPI value was 0.58 as compared with a mean LV MPI of 0.55 in patients with LVEF >40% at the time of presentation.

Even though this difference was not significant at the time of presentation, a significant difference was found on the 3rd day (MPI 0.49 in LVEF <40% group,

compared to 0.41 among those with LVEF >40% (P=0.04)). The mean LVEF in patients with MPI>0.5 was significantly lower when compared with those with MPI <0.5 at the time of presentation (54.8% v 60%, P <0.03). Moreover, in the same group, the LVEF was lower even on the 3rd day and this difference was also statistically significant (60.9% Vs 64.5% P=0.05). However, the difference was insignificant when the parameters like arrhythmic and mechanical complications, post infarction angina etc. were compared between the groups with MPI >0.5 and <0.5. This was probably due to selection criteria because of which a smaller number of complications occurred in the study patients. Yuasa et al, study reported 80 patients with anterior wall myocardial infarction (MI).

Table 5: Group with ST-segment resolution <50% and >50% at 90'.

	STR <50%	STR >50%	Z value	P value
Total number	41/105 (39%)	64/105 (61%)	3.17	0.007
In-hospital complication	16/41 (39%)	20/64 (31.2%)	0.82	NS
LV systolic dysfunction	4/41 (10%)	2/64 (3.1%)	1.42	NS
In-hospital arrhythmia	6/41(14.6%)	11/64 (17.2%)	-0.35	NS
Post-infarction angina	5/41 (12.2%)	4/64 (6.2%)	1.06	NS
MPI				
0'	0.55	0.55	-0.04	NS
90'	0.52	0.50	0.92	NS
3 d	0.42	0.42	0.19	NS
LVEF				
0'	57.2%	55.4%	-0.82	NS
90'	60.3%	58.4%	-0.90	NS
3 d	63.1%	60.4%	-1.52	NS
Mitral regurgitation				
0'	9/41 (22%)	9/64 (14%)	1.05	NS
90'	8/41 (19.5%)	7/64 (10.9%)	1.22	NS
3 d	3/41 (7.3%)	2/64 (3.1%)	0.98	NS

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; STR- ST-segment resolution, LVEF- left ventricular ejection fraction and MPI- myocardial performance index

Table 6: Group with MPI >0.5 and <0.5.

	MPI >0.5	MPI < 0.5	Z value	P value
Total number	70/105 (66.67%)	35/105 (33.3%)	4.8	0.00
In-hospital Complications	28/70 (40%)	8/35 (22.9%)	1.74	NS
LV systolic dysfunction	6/70 (8.5%)	0/35 (0%)	1.78	NS
In-hospital arrhythmia	11/70 (15.7%)	6/35 (17.1%)	-0.18	NS
Post infarction angina	7/70 (10%)	2/35 (5.7%)	0.74	NS
Mitral regurgitation				
0'	10/70 (14.3%)	8/35 (22.9%)	1.09	NS
90'	7/70 (10%)	8/35 (22.9%)	-1.77	NS
3 d	2/70 (2.8%)	3/35 (8.5%)	-1.29	NS
LVEF				
0'	54.8%	60%	-2.28	<0.03
90'	58.6%	61.6%	-1.36	NS
3 d	60.9%	64.5%	-1.97	0.05

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; MPI- Myocardial Performance Index and LVEF- left ventricular ejection fraction

It showed that a mean LV MPI value of 0.59 can predict mortality with a sensitivity and specificity of 77% and 86% respectively.[13] Because of fewer mortality (n=2) in this study, the variable was not analyzed between the

groups with variable MPI and LVEF. The low mortality of STEMI in this study could be related to the selection bias. Patients with MR were only of mild degree, with a maximum of patients having RCA involvement. This finding is similar to most of the series of STEMI where the occurrence of MR is mainly among inferior wall MI with RCA territory involvement.[14] Authors found a significant correlation between MR and LVEF in this study. In patients with LVEF >50%, the incidence of MR was significantly low at presentation, 90 min and on the 3rd day. However, there was no correlation between the incidence of MR and MPI when compared among groups based on MPI (neither when the cut off MPI value was 0.5, nor when it is 0.6). In the small group of patients, the development of MR was predicted better with LVEF than MPI. Generally, arrhythmias are more common in inferior wall MI. All of the 5 patients, who developed brady arrhythmias were having inferior wall MI. Even life-threatening tachyarrhythmias were more in inferior wall MI (5 vs 4; not significant).

Table 7: Group with group with MPI >0.6 and <0.6.

	MPI >0.6	MPI < 0.6	Z value	P value
Total number	36/105 (34.3%)	69/105 (65.7%)	-4.55	0.00
In hospital complication	15/36 (41.7%)	21/69 (30.4%)	1.15	NS
LV systolic dysfunction	3/36 (8.3%)	3/69 (4.3%)	0.84	NS
In-hospital arrhythmia	7/36 (19.4%)	10/69 (14.5%)	0.65	NS
Post infarction angina	4/36 (11.1%)	5/69 (7.2%)	0.67	NS
Mitral regurgitation				
MR 0'	6/36 (16.6%)	12/69 (17.4%)	-0.09	NS
90'	5/36 (13.9%)	10/69 (14.5%)	-0.08	NS
3 d	2/36 (5.5%)	3/69 (4.3%)	0.28	NS
LVEF				
0'	54%	57.9%	-1.72	NS
90'	58.2%	60.4%	-1.00	NS
3 d	60%	63.2%	-1.66	NS

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day; MPI- myocardial performance index, LV-left ventricular, MR- Mitral Regurgitation and LVEF- left ventricular ejection fraction

Table 8: The whole group with MPI <0.5, 0.5 -0.59 and >0.6.

	A	B	C
	MPI <0.5	**MPI 0.5 -0.59**	**MPI >0.6**
Total number	35/105 (33.3%)	34/105 (32.4%)	36/105 (34.3%)
In-hospital complication	8/35 (22.86%)	12/34 (35.3%)	15/36 (41.7%)
LV systolic dysfunction	0/35 (0%)	3/34 (8.8%)	3/36 (8.3%)
In-hospital arrhythmia	4/35 (11.4%)	5/34 (14.7%)	7/36 (19.4%)
Post infarction angina	2/35 (5.7%)	3/34 (8.8%)	4/36 (11.1%)
LVEF			
0'	60%	55.7%	54
90'	63.04%	59.1%	58.2
3 d	65.1%	61.9%	60
Mitral regurgitation			
0'	7/35 (20%)	5/34 (14.7%)	6/36 (16.7%)
90'	7/35 (20%)	3/34(8.8%)	5/36 (13.9%)
3 d	3/35 (8.6%)	0/34 (0%)	2/36 (5.55%)

Data are expressed as mean number of patients and percent; 0' Parameter measured at the time of presentation; 90' Parameter measured immediately after (90 minutes) thrombolysis; 3 d Parameter measured before discharge on 3rd or 5th day

Brady arrhythmias were not observed in anterior wall MI at all. This finding is also consistent with the previously reported incidences of arrhythmias in MI. Left ventricular failure was more common among anterior wall MI. Post-infarction angina occurred both in anterior and inferior wall MI, without any significant differences. These findings are understandable as anterior wall MI with

more myocardial function loss and low LVEF is known to be associated more with LV failure.[11]

Only 61% of the patients had good reperfusion with streptokinase, as evident from STR >50% at 90min. The patients who had STR <50% LV systolic dysfunction, in-hospital complications and arrhythmias were higher, without a significant difference. None of the other variables like MPI and MR were showing any significant difference. Patients with ST resolution <50%, showed better LVEF and in-hospital complications which is contradictory to the finding from previous study.[15] This change may be due to the small sample size and the relatively small number of in-hospital complications in this study group.

Limitation of the present study are patients who were restless and dyspnoeic at the time of admission were not included in the study due to the inability to obtain a good echocardiogram, thus excluding many patients with high risk for further complications. Patients who had significant arrhythmia at the time of admission were excluded due to inability to calculate myocardial performance index accurately. A Teichholz method was used for LVEF estimation to save time since it was to measure before thrombolysis. Patients were monitored only during their hospital stay. They were not followed-up to study early and late out of hospital outcomes. The numbers of patients studied were relatively less, considering the large incidence of ST -elevation myocardial infarction.

CONCLUSION

In ST-elevation myocardial infarction patients, a significant correlation was found between low left ventricular ejection fraction and higher myocardial performance index at presentation and on 3rd day. Myocardial performance index could not predict adverse cardiac events during the hospital stay. Mitral regurgitation was maximal in myocardial infarction due to RCA involvement but unable to correlate with left ventricular ejection fraction. No correlation was found between myocardial performance index, left ventricular ejection fraction, in-hospital complications and ST-segment resolution. Myocardial performance index could not distinguish anterior wall myocardial infarction from inferior wall myocardial infarction.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Benjamin B. Evaluation of correlation between myocardial performance index and left ventricular ejection fraction in patients with acute ST-elevation myocardial infarction. Int J Res Med Sci 2018;6:3908-15.