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Correlation of in-hospital outcome with myocardial performance index and left ventricular systolic function in patients with first attack of ST elevated myocardial infarction

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Abstract:
Objective: *The purpose of the study is to correlate in-hospital outcome with myocardial performance index (MPI) and left ventricular systolic function in first attack of ST elevated myocardial infarction.*
Background: *In the diagnosis of patients with left ventricular dysfunction in acute ST elevated myocardial infarction, prediction of left ventricular systolic function plays the pivotal role. Because systolic and diastolic functions frequently coexist. Thus, it is hypothesized that a combination of left ventricular performance may be more reflective of overall cardiac function than individual assessment of systolic and diastolic function. Traditionally, assessment of left ventricular systolic function is concentrated on measurement of left ventricular ejection fraction (LVEF) which is load dependent and sensitive to the preload and after-load. However, myocardial performance index (MPI) demonstrates supremacy over older established indexes.*
Methods: *This cross-sectional analytical study was conducted in the Department of Cardiology of United Hospital limited since September, 2019 to August, 2020. Total 148 patients inflicted with first attack of ST elevated myocardial infarction were included considering inclusion and exclusion criteria. The sample population was divided into three groups: Group–I: Patients with mild LV systolic dysfunction (LVEF: 45-54%), Group–II: Patients with moderate LV systolic dysfunction (LVEF: 35-44%) & Group–III: Patients with severe LV systolic dysfunction (LVEF: <35%). Then In-hospital outcome, LVEF and MPI values were correlated.*
Results: *In this study 148 patients were enrolled. The mean age of the study group was 54.47±11.65, among them male were 129 (87.2%) & female were 19 (12.8%). 81 (54.7%) were hypertensive, 70 (47.3%) were diabetic, 27 (18.2%) having positive family history of CAD, 81 (54.7%) are current smoker, 99 (66.9%) dyslipidaemic & 15 (10.1%) were asthmatic. The mean Troponin-I & NT- Pro BNP levels were 20.57±10.73 & 183.02±29 respectively. The mean LVEF of the groups were: 47.30±3.08, 36.17±1.51 & 25.00±6.05 respectively. The mean MPI of the groups were: 0.32±0.15, 0.45±0.05 & 0.75±0.18 which were statistically significant. Analysis showed that patients with highest level of MPI had severe left ventricular systolic*

dysfunction (LVEF <35%) with worse in-hospital outcome and vice versa-the patients with the lowest levels of MPI had better systolic function (LVEF ≥ 45%) & in-hospital outcome.

Conclusion: *The research team was able to conclude that left ventricular ejection fraction and myocardial performance index were significantly correlated with each other & in-hospital outcome; more severe the systolic function, more the myocardial performance index with worse in-hospital outcome.*

Keywords: *• Doppler echocardiography • Left ventricular ejection fraction • Myocardial performance index • ST elevated myocardial infarction • Thrombolysis • Bi-plane modified Simpson's method • In-hospital outcome.*

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I. Introduction

Recent studies have documented the frequent coexistence of systolic and diastolic dysfunction in people[1-2]. The systolic dysfunction is reflected in a decrease in left ventricular ejection fraction and a prolongation of the pre-ejection and shortening of the ejection phases of the cardiac cycle[3-6]. The diastolic dysfunction is reflected in alterations in pattern of the inflow velocity of the left ventricle in early and late diastole[7,8] as well as the prolongation of the relaxation phase of the cardiac cycle[9]. ST-elevation myocardial infarction (STEMI) is a leading cause 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[10]. Left ventricular (LV) systolic function is an important prognostic factor, associated with increased mortality in patients with STEMI[11,12]. LV function is measured by Two-dimensional (2D) echocardiography, M-mode echocardiography, Doppler echocardiography, and 3D echocardiography, both during systole as well as diastole[13]. 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). Main limitations of LVEF are 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[14-16]. In 1995, Tei et al, proposed myocardial performance index or Tei index that evaluates the LV systolic and diastolic function in combination has clear advantages over older established indexes and prognostic value[17,18]. The present study was designed to find out correlation between myocardial performance index with left ventricular ejection fraction (LVEF) in patients with first attack of ST elevated myocardial infarction. This index of left ventricular dysfunction takes advantage of the ease of measurement of the isovolumetric and ejection phases of the cardiac cycle that becomes available in the echocardiographic Doppler recording of the mitral and aortic flow velocity profile[19].

II. Methods

Study population

This cross-sectional analytical study was conducted in the Department of Cardiology of United Hospital limited since July, 2021 to December, 2021. Total 148 patients who sustained first attack of ST elevated myocardial infarction were included in the study considering inclusion and exclusion criteria. Purposive sampling was done using a structured case record form.

Study population was divided into three groups to study and compare myocardial performance index (MPI) with left ventricular systolic function depicted as left ventricular ejection fraction (LVEF).

Group-I comprised of 45 patients with mild LV systolic dysfunction (LVEF: 45-54%). Among them 35 were males, 10 were females having mean age of 52.44±13.55 years.

Group-II consisted of 70 patients with moderate LV systolic dysfunction (LVEF: 35-44%). Among them 64 were male & 06 were females having mean age of 54.48±10.45 years.

Group-III consisted of 33 patients with severe LV systolic dysfunction (LVEF: <35%). Among them 30 were males & 03 females having mean age of 56.50±10.40 years.

All the study subjects were selected on the basis of following inclusion and exclusion criteria.

a) Inclusion Criteria:

1) Patients with first attack of ST segment elevation myocardial infarction.

b) Exclusion Criteria:

1) Patients with unstable angina and non- ST elevated myocardial infarction.
2) Patients with valvular heart disease and congenital heart disease.
3) Patients had major non- cardiovascular disorder causing elevation of Troponin-I such as severe renal impairment, prolonged immobilization, major surgery, chest trauma, myocarditis (pericarditis), acute pulmonary embolism, prolonged tachyarrhythmia.

4) Any systemic infection.
5) Patients were under chemotherapy on discovery of malignancy.
6) Patient not willing to get themselves enrolled in study.

Before examination a detailed briefing about the purpose of the study was given to the subjects and written consents were taken for all of the study population.
Total 148 cases were enrolled in the study after qualifying the inclusion & exclusion criteria.

Study procedures

All patients received guideline directed medical therapy at the time of admission. All patients were undergone for either primary PCI or thrombolytic (Tenecteplase or Streptokinase). All patients underwent conventional estimation of ejection fraction and LV end- systolic volume by a Bi-plane modified Simpson's method at the time of presentation, immediately after thrombolysis (120 minutes) and before discharge on 3^{rd} to 6^{th} days. They were followed-up during the period of hospitalization and monitored for the occurrence of recurrent ischemia, acute left ventricular failure, different types of arrhythmias (like sinus tachycardia, sinus bradycardia, ventricular tachycardia, ventricular fibrillation etc.), acute mechanical complication (like mitral regurgitation), hospital stay and death.

Echocardiographic examination

A complete two-dimensional pulsed wave, continuous wave and colour flow Doppler echocardiographic examination using ***Vivid E9 Pro of General Electronics Inc. Limited, USA*** was performed[20,21]. Left ventricular dimensions were measured at mid-ventricular level from the two- dimensional guided M-mode echocardiogram obtained by directing the cursor perpendicularly to the para sternal short axis view. Left ventricular ejection fraction (LVEF) was measured by using Bi-plane modified Simpson's volumetric method because of pronounced segmental asynergy in some patients.

Doppler examination

The mitral velocity inflow pattern was recorded from the apical four chamber view with the Pulsed wave Doppler sample volume positioned at the tip of mitral leaflets during diastole. Following this the left ventricular outflow velocity was recorded from the apical long axis view with the pulsed wave Doppler sample volume positioned just below the aortic annulus. Doppler colour flow imaging was used to semi- quantitate mitral regurgitation.

Echo/ Doppler measurements

For echo/ Doppler parameters three consecutive beats were measured and averaged for each parameter. **Figure 1** shows a schema for analysis of Doppler time intervals. Mitral closure-to-opening interval (a) is the time from the cessation to the onset of mitral in-flow. Ejection time (ET) was measured as the duration of left ventricular outflow (b). Isovolumetric Contraction Time (ICT) + Isovolumetric Relaxation Time (IRT) was obtained by subtracting 'b' from 'a' and an index: (ICT+IRT)/ET was derived as (a-b)/b. To compare this index to traditional parameters IRT, ICT and Pre-ejection period (PEP) were also measured. IRT was measured as (c-d) by subtracting the interval between the Electrocardiography (ECG) R wave and the cessation of left ventricular outflow from the interval (c) between the R wave and the onset of mitral flow. ICT was obtained by subtracting IRT from (a-b). PEP was measured from the onset of the QRS waveform to the onset of left ventricular outflow. Reported normal range for LV myocardial performance index is 0.39±0.05. MPI values greater than 0.45, were considered abnormal.

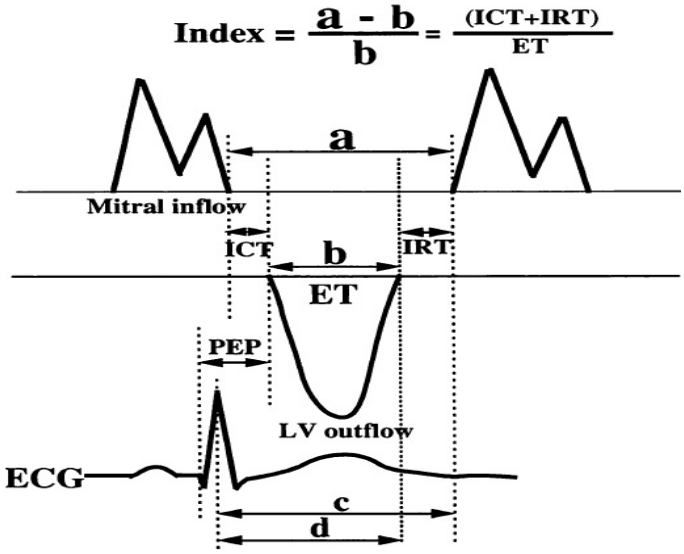

Figure 1: Schema of Doppler time intervals. The index (ICT+IRT)/ET is derived as (a-b)/b, where 'a' is the interval between cessation and onset of the mitral inflow and 'b' is the ejection time (duration of left ventricular outflow). IRT (isovolumetric relaxation time) is measured as (c-d), where 'c' is the interval between the ECG 'R' wave and the onset of mitral flow, and the 'd' is the interval between the R wave and the cessation of the left ventricular outflow. ICT (isovolumetric contraction time) is obtained by subtracting IRT from (a-b). PEP (pre-ejection period) is the interval from the onset of the QRS waveform to the onset of left ventricular outflow[22].

Mitral regurgitation was diagnosed by colour Doppler echocardiography and the severity of mitral regurgitation semi- quantitated from the area of the maximum regurgitant jet[23].

Variables studied:

Age, Sex, BMI, Smoking, Hypertension, Diabetes Mellitus, Dyslipidemia, F/H of CAD, Heart rate, Blood pressure (systolic & diastolic), Troponin-I, NT-pro BNP, Left Ventricular Ejection Fraction (LVEF), Myocardial performance index (MPI) and in-hospital outcome.

The data were processed and analyzed by computer software SPSS (Statistical package for social science) Version 23. Level of significance was considered as p value less than 0.05 ($p < 0.05$).

Statistical Method and analysis:

Continuous data were expressed as mean ± SD. Categorical data were analyzed with x^2 test. Student's t" test was used for analysis of continuous variables. Comparison between groups was done by unpaired t-test.

III. Results

This cross-sectional analytical study was conducted in the Department of Cardiology of United Hospital limited since July, 2021 to December, 2021. Total 148 patients were included considering inclusion and exclusion criteria. Purposive sampling was done using a structured case record form. Study population was divided into three groups to study and compare myocardial performance index with left ventricular ejection fraction.

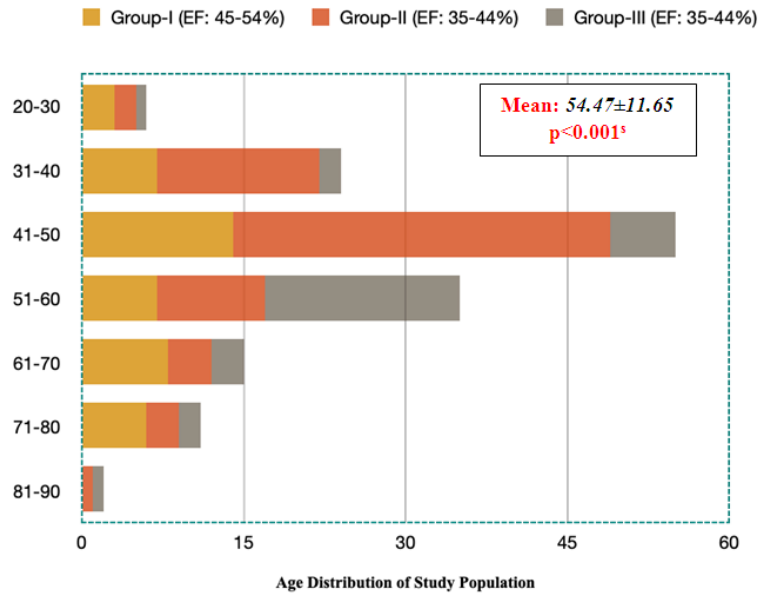

Figure 2: Age distribution of the study population (n=148)

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Figure 2 showed the age distribution of the study population. Majority of the study population were in the 41-50 years age group. Then 51-60 years group & 31-40 years group subsequently. Statistical analysis showed significant age difference between the groups (p<0.05).

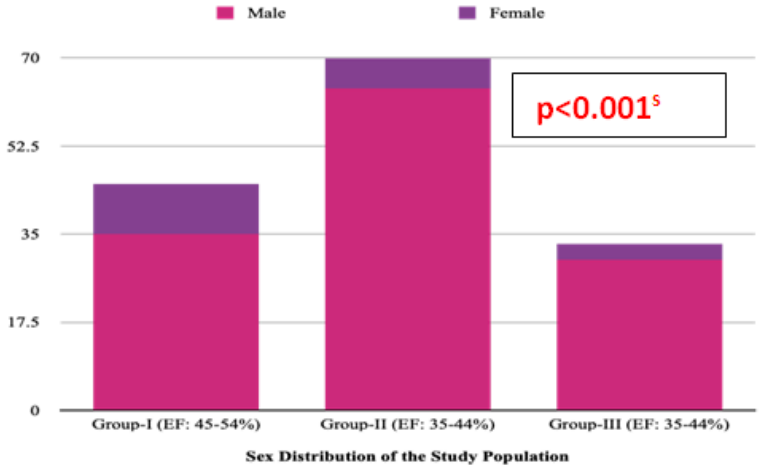

Figure 3: Sex distribution of the study population (n=148)

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Figure 3 showed the sex distribution of the study population. Majority of the study population were male (129, 87.2%). Statistical analysis showed significant sex difference between the groups (p<0.001).

Table I: Anthropometric distribution of the study population (n=500)

Anthropometric Parameter	Group-I	Group-II	Group-III	p-Value
BMI	24.84±3.37	25.77±3.75	26.06±4.99	**0.015^{s}**

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table I showed the anthropometric parameter distribution of the study population. It showed group-III people were more obese than rest of the groups. Statistical analysis showed significant difference between the groups (p<0.05).

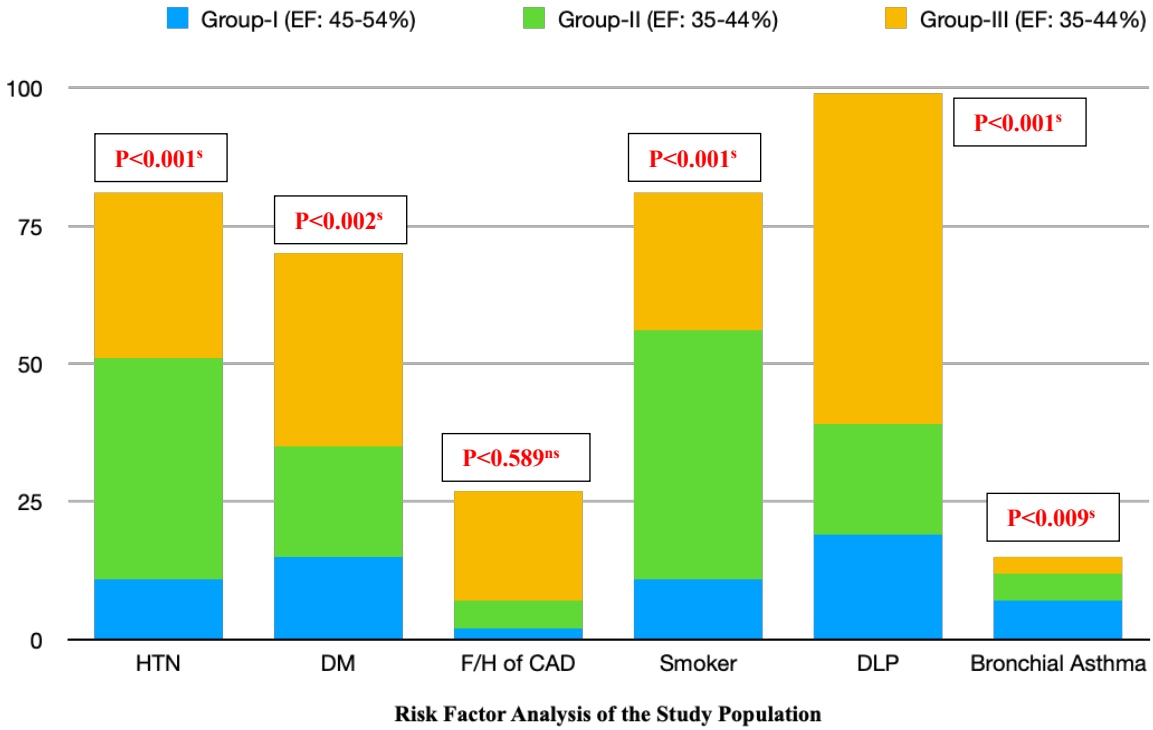

Figure 4: Risk factor analysis of the study population (n=148)

s means significant
ns means not-significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Figure 4 showed the risk factor analysis of the study population. It showed majority of the study population were dyslipidaemic & hypertensive. Then diabetic, current smoker & asthmatic. Statistical analysis showed diabetic, dyslipidaemia, smoking & bronchial asthma were significantly different between the groups (p<0.05).

Table II: Sub-group analysis of dyslipidaemia among the study population (n=148)

Lipid Profile	*Group-I*	*Group-II*	*Group-III*	*p-Value*
Total Cholesterol	175.64±35.70	195.02±38.63	207.39±37.18	**<0.001^{s}**
LDL	132.11±22.72	142.91±18.33	160.91±47.60	**<0.001^{s}**
HDL	45.27±7.28	54.64±6.86	55.55±5.47	**<0.001^{s}**

Triglyceride	170.25±53.73	185.08±91.95	198.15±72.70	**<0.018[s]**

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table II showed the sub-group analysis of dyslipidaemia among the study population. It showed group-III were high in total cholesterol, LDL, HDL & triglyceride. Statistical analysis showed significant difference between the groups (p<0.05).

Table III: Cardiac profile of the study population (n=148)

Cardiac Profile	*Group-I*	*Group-II*	*Group-III*	*p value*
Heart Rate	88.76±10.83	98.60±13.36	102.28±17.30	**<0.001[s]**
Systolic BP	137.34±18.14	147.90±21.13	156.01±20.99	**<0.048[s]**
Diastolic BP	85.82±10.16	89.57±12.45	99.90±12.63	**<0.040[s]**

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table III showed the cardiac profile among the study population. It showed all parameters are important factors to influence global cardiac function. Statistical analysis showed significant difference between the groups (p<0.05).

Table IV: Cardiac biomarker level of the study population (n=148)

Parameter	*Group-I*	*Group-II*	*Group-III*	*p-Value*
Troponin-I	8.94±4.97	16.41±9.58	36.37±17.64	**<0.001[s]**
NT- pro BNP	121.36±5.78	141.60±253.08	300.15±249.41	**<0.001[s]**

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table IV showed the Troponin-I & BNP level of the study population. It showed people of the group-III had the highest level of Troponin-I & NT- pro BNP level. Statistical analysis showed significant difference between the groups (p<0.05).

Table V: Echo profile of the study population (n=148)

Echo Parameters	*Group-I*	*Group-II*	*Group-III*	*p-Value*
LVEF	47.30±3.08	36.17±1.51	25.00±6.05	**<0.001[s]**
Ejection Time	423.84±46.19	393.76±40.27	297.17±48.28	**<0.001[s]**
ICT	94.89±17.32	98.69±16.70	88.24±15.55	**<0.001[s]**
IRT	96.09±19.45	108.38±19.54	99.26±17.88	**<0.001[s]**
MPI	0.32±0.15	0.45±0.05	0.75±0.18	**<0.001[s]**

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table V showed the echo parameters among the study population. It showed group-III of the study population had the majority of the lowest indices of cardiac function & highest MPI level. On the other hand, group-I study population had the highest indices of cardiac function but lowest MPI level. Statistically significant difference was found between the groups (p<0.05).

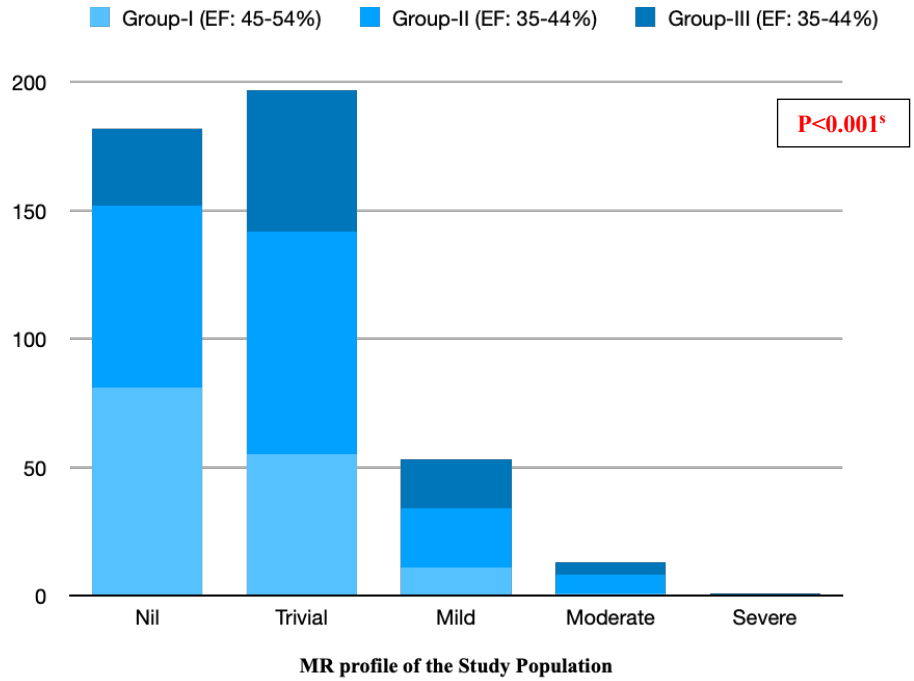

Figure 5: Mitral Regurgitation profile of the study population (n=148)

s means significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Figure 5 showed the mitral regurgitation profile among the study population. It showed majority had trivial to mild regurgitation. Statistically significant difference was found between the groups (p<0.05).

Table VI: Group with <45% & >45% (n=148)

	LVEF: <45%	***LVEF: >45%***	***p-Value***
Total number	103 (69.6%)	45 (30.4%)	
In-hospital complication	68/103 (70%)	16/45 (35%)	**0.003ˢ**
Acute left ventricular failure	10/103 (9.71%)	5/45 (11.1%)	**0.02ˢ**
In-hospital arrhythmias	36/103 (35%)	10/45 (22.2%)	**<0.002ˢ**
Post MI angina	3/103 (2.9%)	23/45 (51.1%)	**<0.001ˢ**
Hospital stay (days)	6.0±1.5	3.5±1.3	**0.02ˢ**
MPI			
0'	0.51	0.46	**0.134ⁿˢ**
120'	0.48	0.41	**0.254ⁿˢ**
5th day	0.47	0.39	**0.031ˢ**
Mitral Regurgitation			
0'	20/103 (19.4%)	15 (33.3%)	**0.541ⁿˢ**
120'	14/103 (13.6%)	10 (22.2%)	**0.81ⁿˢ**

5th day	10/103 (9.7%)	06 (13.3%)	**0.74ns**
Death	3/103 (2.9%)	00 (0.0%)	**0.65ns**

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table VI shows that more depressed LV function patients more the complications. Statistical analysis showed significant differences between groups (<0.05).

Table VII: Group with <35% & >35% (n=148)

	LVEF: <35%	***LVEF: >35%***	***p-Value***
Total number	33 (22.3%)	115 (77.7%)	
In-hospital complication	23/33 (69.7%)	36/115 (31.3%)	**0.004s**
Acute left ventricular failure	15/33 (45.5%)	8/115 (6.9%)	**0.001s**
In-hospital arrhythmias	26/33 (78.8%)	10/45 (22.2%)	**<0.001s**
Post MI angina	2/33 (6.1%)	23/45 (51.1%)	**<0.003s**
Hospital stay (days)	7.0±3.1	5.5±2.3	**0.01s**
MPI			
0'	0.59	0.55	**0.364ns**
120'	0.54	0.51	**0.813ns**
5th day	0.51	0.46	**0.031s**
Mitral Regurgitation			
0'	12/33 (36.4%)	25/115 (21.7%)	**0.74ns**
120'	09/33 (27.3%)	16/115 (13.9%)	**0.854ns**
5th day	06/33 (18.2%)	12/115 (10.4%)	**0.004s**
Death	07/33 (21.2%)	04/115 (3.5%)	**<0.001s**

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table VII shows that more depressed LV function patients more the complications. Statistical analysis showed significant differences between groups (<0.05).

Table VIII: Group with ST segment resolution <50% and >50% at 120 minutes (n=148)

	STR <50%	***STR >50%***	***p-Value***
Total number	40/148 (27.0%)	108/148 (72.9%)	**0.005**
In-hospital complication	25/40 (62.5%)	30/108 (27.8%)	**0.345ns**
Acute left ventricular failure	05/40 (12.5%)	02/108 (1.8%)	**0.001s**
In-hospital arrhythmias	26/40 (65.0%)	20/108 (18.5%)	**0.451ns**
Post MI angina	10/40 (25.0%)	25/108 (23.1%)	**0.653ns**
Hospital stay (days)	8.0±2.1	4.5±1.3	**0.81ns**
MPI			
0'	0.56	0.55	**0.364ns**
120'	0.53	0.49	**0.813ns**

5th day	0.41	0.41	**0.631ns**
LVEF			
0'	48.1%	50.1%	**0.453ns**
120'	42.3%	52.1%	**0.561ns**
5th day	45.5%	54.3%	**0.367ns**
Mitral Regurgitation			
0'	25/40 (62.5%)	35/108 (32.4%)	**0.94ns**
120'	30/40 (75.0%)	25/108 (23.1%)	**0.754ns**
5th day	16/40 (40.0%)	15/108 (13.9%)	**0.348ns**
Death	02/40 (5.0%)	00/108 (0.0%)	**0.453ns**

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table VIII shows that ST segment resolution <50% causes more complications than ST segment resolution >50%.

Table IX: Group with MPI >0.5 and <0.5 (n=148)

	MPI >0.5	***MPI <0.5***	***p-Value***
Total number	80/148 (54.0%)	40/148 (27.0%)	**0.001**
In-hospital complication	45/80 (56.2%)	20/40 (50%)	**0.445ns**
Acute left ventricular failure	08/80 (10%)	03/40 (7.5%)	**0.03s**
In-hospital arrhythmias	30/80 (37.5%)	15/40 (37.5%)	**0.651ns**
Post MI angina	20/80 (25.0%)	12/40 (30.0%)	**0.753ns**
Hospital stay (days)	6.0±4.1	5.1±1.3	**0.86ns**
LVEF			
0'	45.2%	51.3%	**0.253ns**
120'	41.5%	50.2%	**0.51ns**
5th day	40.5%	47.5%	**0.467ns**
Mitral Regurgitation			
0'	45/80 (56.3%)	15/40 (37.5%)	**0.04s**
120'	45/80 (60.0%)	17/40 (42.5%)	**0.754ns**
5th day	28/40 (70.0%)	12/40 (30.0%)	**0.003s**
Death	03/40 (7.5%)	01/40 (2.5%)	**0.002s**

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table IX shows that increased level of MPI causes more complications but they are not statistically significant (>0.05).

Table X: Group with MPI >0.6 and <0.6 (n=148)

	MPI >0.6	***MPI <0.6***	***p-Value***
Total number	68/148 (45.9%)	80/148 (54.1%)	**<0.001**
In-hospital complication	45/68 (66.2%)	20/80 (25.0%)	**0.44^{ns}**
Acute left ventricular failure	14/68 (20.6%)	10/80 (12.5%)	**0.02^{s}**
In-hospital arrhythmias	51/68 (75.0%)	30/80 (37.5%)	**0.65^{ns}**
Post MI angina	23/68 (33.8%)	10/80 (12.5%)	**0.75^{ns}**
Hospital stay (days)	9.0±3.2	6.2±3.5	**0.83^{ns}**
LVEF			
0'	42.5%	52.1%	**0.23^{ns}**
120'	45.1%	49.2%	**0.45^{ns}**
5th day	41.2%	48.6%	**0.47^{ns}**
Mitral Regurgitation			
0'	25/68 (36.7%)	15/80 (18.8%)	**0.741^{ns}**
120'	15/68 (22.1%)	10/80 (12.5%)	**0.54^{ns}**
5th day	08/68 (11.8%)	05/80 (6.3%)	**0.873^{ns}**
Death	03/68 (4.4%)	01/80 (1.3%)	**0.632^{ns}**

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table X shows that increased level of MPI causes more complications but they are not statistically significant (>0.05).

Table XI: Total study population with MPI <0.5, 0.5-0.59 and >0.6 (n=148)

	MPI <0.5	***MPI 0.5-0.59***	***MPI >0.6***
Total number	40/148 (27.0%)	40/148 (27.0%)	68/148 (45.9%)
In-hospital complication	20/40 (50.0%)	30/40 (75.0%)	45/68 (66.2%)
Acute left ventricular failure	03/40 (7.5%)	18/40 (45.0%)	14/68 (20.6%)
In-hospital arrhythmias	15/40 (75.0%)	30/40 (37.5%)	51/68 (75.0%)
Post MI angina	12/40 (30.0%)	10/40 (25.0%)	23/68 (33.8%)
Hospital stay (days)	5.1±1.3	6.2±3.5	9.0±3.2
LVEF			
0'	51.3%	43.1%	42.5%
120'	50.2%	46.2%	45.1%
5th day	47.5%	47.6%	41.2%
Mitral Regurgitation			
0'	15/40 (37.5%)	16/40 (40.0%)	25/68 (36.7%)
120'	17/40 (42.5%)	12/40 (30.0%)	15/68 (22.1%)
5th day	12/40 (30.0%)	08/40 (20.0%)	08/68 (11.8%)
Death	01/40 (2.5%)	04/40 (10.0%)	03/68 (4.4%)

s means significant
ns means not significant

Group-I: Patients having mild LV systolic dysfunction with LVEF: 45-54%
Group-II: Patients having moderate LV systolic dysfunction with LVEF: 35-44%
Group-III: Patients having severe LV systolic dysfunction with LVEF<35%

Table XI shows that increased level of MPI causes more complications.

Table XII: Multi-variate regression analysis of the study population (n=148)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.998	.775		5.156	.000
	Age of Patient	-.005	.002	-.079	-2.467	**.014[s]**
	Sex of Patient	-.129	.056	-.075	-2.305	**.022[s]**
	BMI of Patient	.002	.006	.009	.293	.770
	Hypertension	.020	.048	.013	.419	.676
	Diabetes	-.139	.072	-.089	-1.947	.052
	Smoking	.056	.044	.041	1.278	.202
	Dyslipidaemia	.127	.060	.081	2.120	**.035[s]**
	Bronchial Asthma	.084	.075	.031	1.123	.262
	Total Cholesterol	.000	.001	-.013	-.198	.843
	LDL	.001	.001	.033	.588	.557
	HDL	.005	.004	.043	1.400	.162
	Triglyceride	.000	.000	.005	.142	.887
	Troponin-I	.009	.001	.203	6.800	**.000[s]**
	BNP	.000	.000	-.039	-1.216	.225
	LVEF	-.028	.005	-.429	-6.314	**.000[s]**
	MR	-.011	.029	-.011	-.378	.705
	Ejection Time	-.001	.002	-.075	-.716	.474
	ICT	.081	.038	1.799	2.139	**.033[s]**
	IRT	.081	.038	2.105	2.142	**.033[s]**
	MPI	.385	.163	.079	2.359	**.019[s]**
	In-hospital outcome	.341	.152	.075	2.135	**.015[s]**

s means significant

Table XII showed the multi-variate regression analysis of the significant variables of the study population. It showed age, sex dyslipidaemia, troponin-I, LVEF, ICT, IRT, MPI & In-hospital outcome were statistically significant confounding variables.

Table XIII: Uni-variate regression analysis of the study population (n=148)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.291	.187		12.274	.000
	Age of Patient	.003	.002	.072	1.783	.075
	Sex of Patient	-.029	.045	-.027	-.654	.513
	Dyslipidaemia	-.014	.048	-.014	-.293	.770
	Troponin-I	-.018	.051	-.017	-.478	.645
	LVEF	-.034	.003	-.517	-11.715	**.000[s]**
	ICT	-.032	.031	-1.096	-1.038	.300
	IRT	-.022	.030	-.900	-.729	.466
	MPI	.748	.131	.238	5.696	**.000[s]**
	In-hospital outcome	.751	.129	.231	5.134	**.000[s]**

s means significant

Table XIII showed the uni-variate regression analysis of the significant confounding variables of the study population. It showed LVEF, MPI & In-hospital outcome were statistically significant confounding variables.

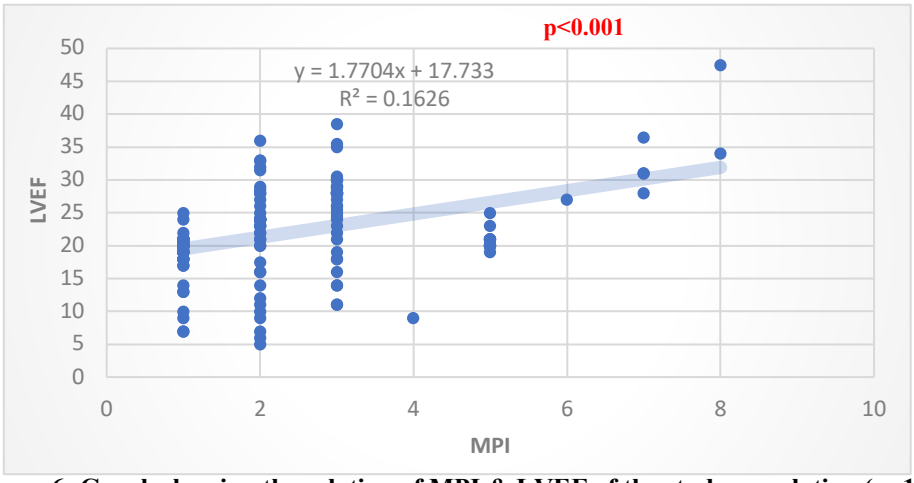

Figure 6: Graph showing the relation of MPI & LVEF of the study population (n=148)

Figure 6 showing the correlation between MPI & left ventricular systolic function assessed by LVEF. Statistical analysis proved significant correlation between MPI & LVEF ($p<0.05$).

IV. Discussion

Left Ventricular 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[22,24]. LVEF measurement has provided valuable prognostic information regarding clinical outcome[25].

Global left ventricular performance is a function of both ventricular function & ejection. Numerous parameters are used to assess systolic or diastolic function till now. Since diastolic dysfunction is an integral part of systolic dysfunction [26, 27]a measure of both combinedly may better reflect 'global' function rather assessing them isolately. In this study, we tried to assess global cardiac function which incorporates factors related to both systolic & diastolic function.

Earlier studies showed isovolumic contraction time (ICT) & isovolumic relaxation time (IRT) reflect systolic & diastolic function of heart respectively [28-30]. They correspond with the active ventricular contraction & early relaxation [31]. Although individual measurement of ICT & IRT were required but MPI can be calculated from two easily measured Doppler time intervals (mitral closure-to-opening interval and ejection time).

In case of, patients with mitral regurgitation ICT & IRT do not exist. In these cases, 'duration of mitral closure-to-aortic-opening' and 'duration of aortic-closure-to mitral opening' are more appropriate variables to be considered. However, for easy understanding in this study we used considered ICT & IRT.

The rationale of the utility of MPI in the left ventricular dysfunction lies in the fact that (ICT+IRT)/ET corresponds with the important periods of contraction & relaxation of cardiac cycle. Calcium transportation at the myocellular level regulates the different cellular mechanisms of ICT & IRT [31]. Active myocardial processes are used to be suppressed in congestive heart failure and result in prolongation of active contraction & relaxation. Active contraction is reflected by an increase in ICT [33]. On the other hand, prolonged relaxation is initially associated with an increase in IRT but progressively worsening degree of ventricular dysfunction will influence this factor due to the involvement of other factors like left atrial pressure and the degree of mitral regurgitation [34]. Although due to the different factors, the present study proved that the sum of ICT & IRT proportionately increased as the left ventricular function depressed [35-37]. Ejection time (ET) was shorter in patients with severe left ventricular dysfunction compared to mild dysfunction. Thus, with worsening left ventricular dysfunction (ICT+IRT)/ET increases disproportionately to any change of individual components.

Ejection fraction (EF) is the most commonly used index for the assessment of systolic function. It has served consistently as a good indicator of cardiovascular outcome and thus has great clinical relevance [38]. However, EF may not hold the true reflection of function in absence of normal shaped ventricles [39]. The adjunctive use of MPI may potentially provide useful support in these circumstances.

Use of EF alone may erroneously assess the contractility and thus function in patients with mitral regurgitation [40]. This limitation can be overcome by using MPI in adjunction with EF for the assessment of global function.

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.[41] 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.[42] Present study also comes out with similar observations. Out of 104 patients who had LVEF <40%, mean LV MPI value was 0.53 as compared with a mean LV MPI of 0.50 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 5th day (MPI 0.43 in LVEF <40% group, compared to 0.49 among those with LVEF >40% (p=0.031)). 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). It showed that a mean LV MPI value of 0.59 can predict mortality with a sensitivity and specificity of 77% and 86% respectively.[43] 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 available newer treatment modalities.

Patients with MR were only of trivial degree. This finding is similar to most of the series of STEMI.[44] Authors found a significant correlation between MR and LVEF in this study. In patients with LVEF <35%, the incidence of MR was significantly higher on the 5th 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).

Generally, arrhythmias are more common in STEMI. Majority of life-threatening arrhythmias were tachyarrhythmias with few bradyarrhythmia which were not statistically significant. This finding is also consistent with the previously reported incidences of arrhythmias in MI.

Left ventricular failure was more common among lower LVEF & higher MPI which was statistically significant. Post- infarction angina occurred in patients, without any significant differences. These findings are understandable as wide area of infarction with more myocardial function loss and low LVEF is known to be associated more with LV failure.[41]

About 73% of the patients had good reperfusion with thrombolytics (Tenecteplase or Streptokinase), as evident from STR >50% at 120 minutes. The patients who had STR <50% LV systolic dysfunction, in-hospital complications and arrhythmias were higher, without a significant difference except acute left ventricular failure. None of the other variables like MPI and MR were showing any significant difference. Patients with ST resolution <50%, showed better LVEF but more in-hospital complications which is contradictory to the finding from previous study.[45] This change may be due to the small sample size and the relatively small number of in-hospital complications in this study group.

V. Conclusion

The study team concluded that in ST-elevation myocardial infarction patients, poor left ventricular ejection fraction and higher myocardial performance index at presentation and on 5th day significantly correlated with in-hospital outcome. Myocardial performance index was also able to give a hint for adverse cardiac events during the hospital stay. The research team also appreciate its use to assess both systolic and diastolic myocardial function in patients with unstable angina as well as non- ST elevated myocardial infarction. We also welcome further study to clarify the utility of MPI in other patient populations and in the determination of cardiovascular outcome and prognosis.

Limitations of the study

The study team acknowledged several limitations during this study. These are:

- The study population was small.
- The study duration was also small.
- The patients from single center were enrolled during the study. Incorporation of more centers can reflect more to the adult population of Bangladesh & thus the novelty of the study.
- As LVEF is load dependent variable, there was no correlation found between EF with other load dependent parameters like heart rate, blood pressure etc. However, further study is necessary to clarify the effect of loading conditions on MPI.
- MPI was measured only primarily in patients with systolic dysfunction.
- In the presence of significant valvular heart disease & secondary myocardial dysfunction, Doppler time intervals may be influenced by abnormal haemodynamics related to abnormal valvular function.
- The result of this study may not be used in reference in the patients with congestive heart failure from primary diastolic dysfunction such as hypertrophic & restrictive cardiomyopathies.

- Last but not the least patients of other wings of acute coronary syndrome (i.e., unstable angina & non- ST elevated myocardial infarction) were not included in this study. So, this study is not referential for the patients inflicted with acute coronary syndrome as a whole.

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