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Original Article

Prognostic significance of NT-proBNP, 3D LA volume and LV dyssynchrony in patients with acute STEMI undergoing primary percutaneous intervention

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ABSTRACT

Objectives: The aim of the present study was to assess the short term prognostic significance of N-terminal pro BNP (NT-proBNP), 3D left atrial volume (LAV) and left ventricular (LV) dyssynchrony in patients of acute ST-elevation myocardial infarction (STEMI) who underwent primary Percutaneous intervention (PCI).

Background: NT-proBNP, LV dyssynchrony and LAV in patients with acute coronary syndrome have been associated with PCI outcomes and predict the short and long-term prognosis.

Methods: This study consisted of 142 patients with a first STEMI who underwent primary PCI. Baseline echocardiographic data was collected at admission and at 6 months follow up. Left ventricular dyssynchrony was measured by tissue Doppler imaging and LAV by real time 3D-echocardiography, plasma NT-proBNP levels were estimated between 72 and 96 h of admission.

Results: During study period 3 patients expired and 4 developed congestive heart failure (CHF). Baseline NT-proBNP and LV dyssynchrony correlated with LV size and LV ejection fraction (LVEF) at baseline and during follow up. Patients with higher NT-proBNP levels and higher LV dyssynchrony showed significant increase in LV size with decrease in LVEF during follow-up. Baseline Left atrial volume index (LAVI) showed significant correlation with LV size but no association with LVEF at baseline and during follow-up.

Conclusions: Higher levels of NT-proBNP and higher LV dyssynchrony can predict patients with increase in LV size, worsening of LV systolic and diastolic function during follow-up. Patients with higher NT-proBNP levels at baseline developed CHF during follow-up.

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1. Introduction

There is a world wide epidemic of coronary heart disease (CHD) and ST-elevation acute myocardial infarction (STEMI) is one of the most lethal form of acute coronary syndrome (ACS). Primary Percutaneous Coronary Intervention (PCI) has been shown to reduce death, reinfarction, stroke and hemorrhagic stroke in patients with STEMI.[1]

After acute myocardial infarction (AMI) left ventricular (LV) remodeling occurs in up to 25% of patients[2,3] and is a detrimental complication characterized by dilatation of heart chambers, change in chamber geometry and progressive deterioration of LV function. Remodeling is directly related with development of heart failure and poor prognosis.[4,5]

N-terminal pro brain natriuretic peptide (NT-proBNP) is secreted predominantly from the ventricles, and its levels in plasma have been shown to be increased after AMI and associated with LV systolic dysfunction.[6] In previous studies it was suggested that elevated NT-proBNP is associated with development of heart failure (HF) and mortality after AMI.[7–9] In patients with AMI, plasma NT-proBNP levels estimated 2–4 days after its development independently predicted LV ejection fraction (LVEF) and 2 years survival.[9]

Regardless of QRS width ACS has significant impact on LV dyssynchrony and this has been shown to have detrimental effects on the systolic function of LV.[10] In patients with impaired LV function, dyssynchrony predicts LV remodeling[11] and long-term outcome.[12] For the first time Zhang et al[13] demonstrated that infract size was the main determinant of LV dyssynchrony after AMI. Later Mollema et al[14] in their study showed that LV dyssynchrony in patients with STEMI independently predicted LV remodeling at 6 months. Left atrial volume (LAV) is an independent predictor of adverse late outcome in patients with AMI and prior MI. Left atrial volume is superior to conventional Doppler indices of diastolic function in predicting long-term outcomes after AMI.[15]

The present study was done to assess the short-term prognostic significance of NT-proBNP, LV dyssynchrony and left atrial volume index (LAVI) in patients with AMI undergoing primary PCI.

2. Methods

2.1. Study population

A total of 142 patients who were diagnosed with a first STEMI, defined as characteristic chest pain lasting for more than 20 min, typical ST segment elevation >1 mm in at least two contiguous leads associated with transient rise of creatine kinase MB or troponin and who underwent primary PCI, from May 2012 to February 2013 were enrolled after taking informed written consent. Institutional ethics committee approval was obtained prior to initiation of the study. These patients were followed for a period of 6 months and at the time of follow up, data was collected pertaining to current clinical status, prior hospitalization and occurrence of any of the adverse events.

Patients above 80 years of age, with previous history of MI, coronary bypass surgery, angioplasty, presence of valvular heart disease, with non-sinus rhythm, with pre-existing bundle branch block, with renal failure and echocardiographic images of poor quality were excluded from the study.

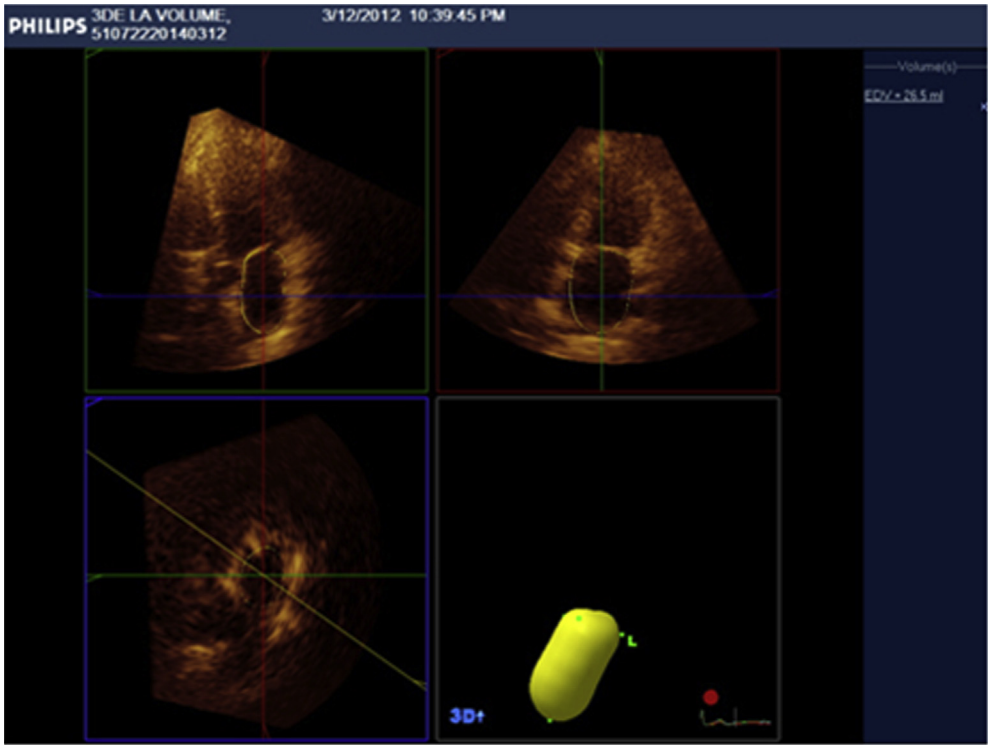

Fig. 1 – Image showing LA volume by RT3DE in a study patient.

2.2. Measurement of NT-proBNP levels

N-terminal-proBNP levels were measured by using Roche CARDIAC proBNP test kit (code 04659449190, Roche Diagnostics Ltd. Germany) and cobas h 232 POC (Point Of Care) system. About 2 mL of blood sample for NT-proBNP levels was collected by venipuncture into heparinized tubes between 72 and 96 h after primary PCI. The reaction times for the assay were between approximately 10 and 15 min, the sample volumes needed were 150 μL of heparinized venous whole blood. Detection range of the assay is 60–9000 pg/mL of NT-proBNP.

2.3. Echocardiographic data

Transthoracic M mode, 2-dimensional, and Doppler echocardiography data were recorded for all the patients within 48 h of primary PCI and after 6 months of procedure using a Philips IE-33 machine, Holland. Parameters included were LVEF (%), LV end-systolic diameter (LVESD) (mm), LV end-diastolic diameter (LVEDD) (mm), MV peak E-wave velocity (cm/s), MV peak A-wave velocity (cm/s), MV peak E/A ratio and E/E′ ratio.

Mitral inflow was assessed from the apical four-chamber view with pulsed-wave Doppler and the beam was aligned parallel to the direction of flow and a 1–2 mm sample volume was placed between the tips of mitral leaflets during diastole.[16] From the mitral inflow profile, the E- and A-wave velocity, and E/A velocity ratio was measured. Diastolic function was categorized as normal function (E′ ≥10 or E/E′ ≤8), mild dysfunction (E′ <8 and E/E′ <8), moderate dysfunction (E′< 8 and E/E′ 9–14) and severe dysfunction (E′ <5 or E/E′≥ 15).[17–19] Patients were classified as having normal LV systolic function when LVEF is >50%, mild LV systolic disfunction when LVEF was 41–49%, moderate LV systolic dysfunction when LVEF was 35–40% and severe LV systolic dysfunction when LVEF was below 35%.

2.4. Left atrial volume assessment by real-time 3-dimensional echocardiography

Using a Real-time 3D (RT3D) matrix array transducer LAV was collected in four-cycles full volume made during a breath hold within 48 h of AMI and zoom function gain adjustments was used to clearly define the endocardial border. This 3D dataset was transferred to a Q-LAB system for offline analysis. Left atrial volume was calculated by a semiautomated tracing of the LA endocardial border by marking five atrial points: the anterior, inferior, lateral, septal mitral annuli and the LA apex. When necessary modifications were made to correct automatic tracings (Fig. 1).[20] The obtained 3D LAV was indexed to body surface area.

2.5. Left ventricular dyssynchrony assessment by tissue Doppler imaging

In the left lateral decubitus position, the 2D colour-Tissue Doppler imaging (TDI) cine loops of multiple beats were stored digitally for off line analysis.[21,22]

1. The ''Depth'' option was adjusted so that the acquired loop includes only the LV from the apex down to level of the mitral valve annulus.
2. The ''Angle'' option was adjusted to clearly visualize the opposing LV walls with the narrowest possible sector.
3. Maximum available frame rate was set for the corresponding sector width.

From each of the apical 4-chamber, apical 2-chamber and apical long-axis views color coded TDI loops were obtained. Time velocity plots were determined by placing region of interests (ROI) in the basal and mid segments of opposing LV walls. For each view 4 regions were selected excluding the apical segments (4 regions/view). From the beginning of the QRS complex to the peak myocardial systolic velocity during the ejection phase was taken as Time to peak systolic velocity (Ts) and thus we calculated the Ts for 12 segments and the LV dyssynchrony was measured as the difference between the maximum and minimal Ts among these 12 segments (Fig. 2).[11,23]

2.6. Statistical analysis

Data was tabulated on MS-Excel 2007 spreadsheets (Microsoft Corporation, Redmond, WA, USA). Descriptive statistics for the categorical variables were performed by computing the frequencies (percentage) in each category. For the quantitative variables, mean and standard deviation were calculated.

Independent Student's 't'-test and ANOVA tests were performed to test the significant differences of means wherever appropriate. Pearson's correlation test was performed to find out the relationship between various parameters. Multivariate analysis was performed to test the association of different independent variables with dependent variable. A p-value ≤0.05 was considered as significant p-value. Statistical software package SPSS 20 (IBM corporation, Chicago, IL, USA) was used for statistical analysis.

3. Results

The study group consisted of 142 patients (123 men and mean age was 53.30 ± 11.88 years). The mean time from onset of symptoms to presentation was 6.33 h (±3.60 h). Majority of the study patients presented with Killips class-I (78.2%). Anterior wall MI was present in 57.7% of patients (Table 1).

At baseline, mean NT-proBNP levels in these patients were 1616.82 pg/mL. Because of wide variation in the levels of NT-proBNP in the study group (range 60–9000), log transformation was done for NT-proBNP levels. After log transformation mean log NT-proBNP levels was 6.97 (±0.91) (Table 1).

Left Anterior Descending (LAD) artery was the culprit vessel in 54.9%, Left Circumflex (LCx) artery in 11.3%, Right Coronary artery (RCA) in 33.8% of the patients. Multi-vessel disease was present in 34.5% of patients. Total occlusion of culprit vessel was present in 68.3% whereas 31.7% of patients showed subtotal occlusion. Thrombus aspiration was done in 27.5% of patients. Drug eluting stents (DES) were deployed in 83.1% and bare metal stents (BMS) in 13.4% of patients.Only

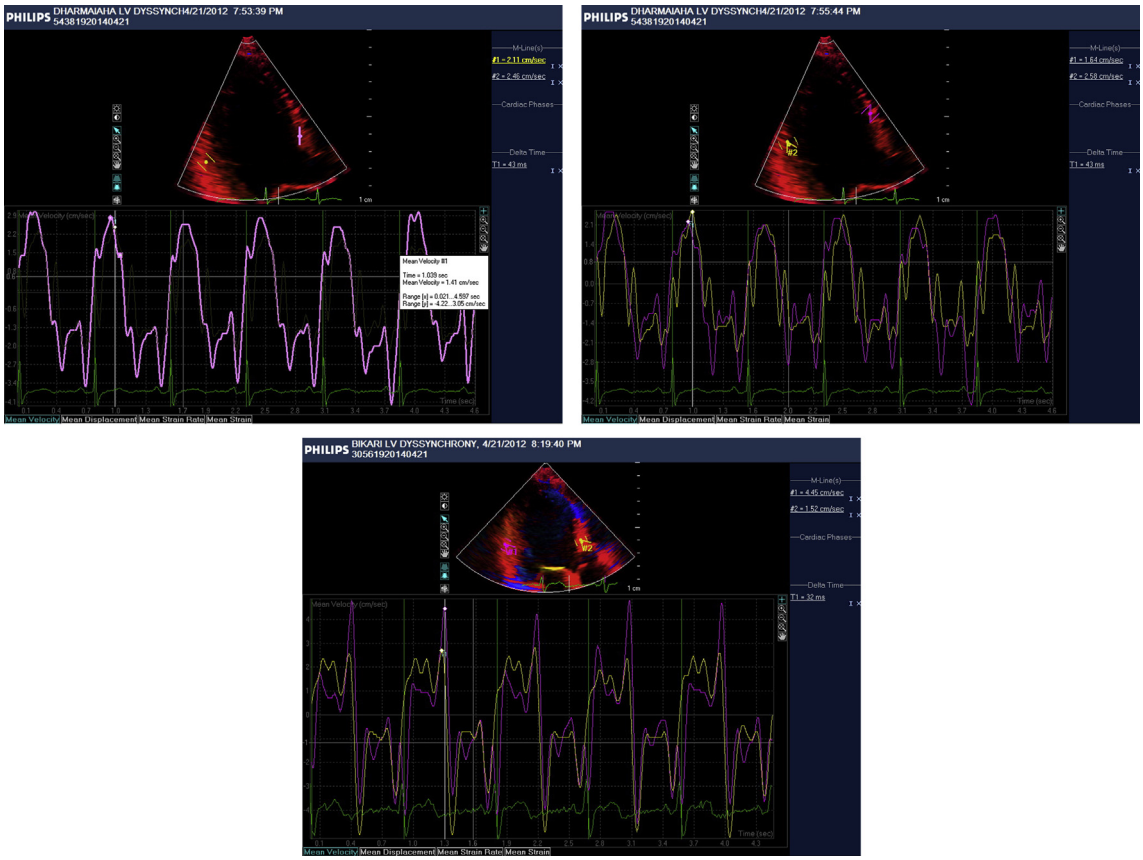

Fig. 2 – Image showing assessment of LV dyssynchrony by TDI.

3.5% of patients underwent plain old balloon angioplasty (POBA). Glycoprotein (GP) 2b/3a inhibitors were used in 87.3% of patients (Table 1).

Mean LVEDD and LVESD of the study population were 46.81 (±4.59) mm and 34.15 (±4.74) mm respectively. Mean LVEF was 50.84 (±8.30)%. Mean E′ and E/E′ were 6.40 (±1.56) cm/sec and 11.72 (±3.40) respectively. Mean left ventricular end diastolic diameter index (LVEDDI) and left ventricular end systolic diameter index (LVESDI) were 28.97 mm/m^2 (±8.50) and 21.2 mm/m^2 (±7.01) respectively. Mean LV dyssynchrony of the study population was 55.79 (±14.93 ms). Mean LAVI in these patients was 17.71 mL/m^2 (±4.41) (Table 2).

After six months mean LVEDD has increased from 46.81 mm to 49.62 mm which was statistically significant ($p < 0.001$) whereas there was no significant change in LVESD (34.15 mm–34.78 mm, $p = 0.129$) compared to baseline. There was significant improvement in LVEF after six months of follow up period (50.84%–54.73%, $p < 0.001$). During follow-up if change in LVEDD and LVESD was more than 10% of the baseline, it was considered significant and accordingly patients were categorized into two groups. Similarly more than 10% change in baseline LVEF either way was considered significant.

Three patients were lost to follow up after discharge. During follow up, 3 deaths were observed in the study population. Two patients developed sudden cardiac death within the first month of the index procedure. Only 4 patients developed congestive heart failure (CHF) during the study period. Among them one patient developed CHF with NYHA class-IV dyspnea within the first month of the index procedure and expired during the hospital stay with severe LV systolic dysfunction. Another patient developed CHF during index hospitalization, recovered and was lost to follow up after discharge. Two more patients developed CHF within the six months of index procedure improved with hospitalization and increase in dosage of diuretics.

3.1. *Log NT-proBNP levels*

Age, window period, Killips class at presentation showed significant positive correlation with log NT-proBNP levels. Female patients had significantly higher levels compared to males ($p = 0.022$). Smokers had significantly lower levels compared to non-smokers ($p = 0.034$). Type of MI, hypertension and diabetes did not significantly influence log NT-proBNP levels. The levels were significantly higher in patients with multi-vessel disease ($p = 0.004$) and with total occlusion of culprit vessel ($p = 0.019$) (Table 2).

Log NT-proBNP levels had significant positive correlation with baseline LVESD, LVEDDI, LVESDI, E/E′, LAVI, LV dyssynchrony and negative correlation with E′ (Table 3). The levels had significant positive correlation with follow-up LVEDD, LVESD and negative correlation with LVEF both at baseline and follow-up (Table 4). Patients with higher NT-proBNP levels had significant increased in LVESD with decrease in LVEF during follow-up (Table 4).

Table 1 – Demographics and PCI data.

Characteristic ($n = 142$)	Mean ± SD/n (%)
Age (years)	53.30 ± 11.88
Gender:	
Male	123 (86.6%)
Female	19 (13.4%)
Type of MI:	
AWMI	82 (57.7%)
Non-AWMI	60 (42.3%)
KILLIPS Class:	
Class-I	111 (78.2%)
Class-II	19 (13.4%)
Class-III	4 (2.8%)
Class-IV	8 (5.6%)
Hypertension:	
Hypertensives	56 (39.4%)
Non-hypertensives	86 (60.6%)
Diabetes mellitus:	
Diabetics	51 (35.9%)
Non-diabetics	91 (64.1%)
Tobacco consumption:	
Yes	93 (65.5%)
No	49 (34.5%)
Window period (hours)	6.33 ± 3.60
NT-proBNP (pg/mL)	1616.82 ± 1737.24
log NT-proBNP	6.97 ± 0.91
IRCA:	
LAD	78 (54.9%)
LCX	16 (11.3%)
RCA	48 (33.8%)
No. of vessels involved:	
SVD	93 (65.5%)
2VD & TVD	49 (34.5%)
Type of Obstruction:	
Total occlusion	97 (68.3%)
Subtotal occlusion	45 (31.7%)
Thrombus aspiration:	
Done	39 (27.5%)
Not done	103 (72.5%)
Type of Stent:	
DES	118 (83.1%)
BMS	19 (13.4%)
POBA	5 (3.5%)
No. of Stents:	
No Stent	5 (3.5%)
1 Stent	107 (75.4%)
2 Stents	29 (20.4%)
3 Stents	1 (0.7%)
GP 2b/3a inhibitors:	
Given	124 (87.3%)
Not given	18 (12.7%)

AWMI: anterior wall myocardial infarction; NT-proBNP: N-terminal pro B-type natriuretic peptide; LAD: left anterior descending artery; LCX: left circumflex artery; RCA: right coronary artery; SVD: single vessel disease; 2VD: two vessel disease; TVD: triple vessel disease; DES: drug eluting stent; BMS: bare-metal stent; POBA: plain old balloon angioplasty.

3.2. *LV dyssynchrony*

Patients with anterior wall MI had significantly higher LV dyssynchrony. Higher LV dyssynchrony was found in patients with higher Killips class at presentation. There was significant positive correlation with log NT-proBNP levels. (Table 2) Patients with culprit lesion in RCA had lesser LV dyssynchrony compared to LAD and LCX ($p = 0.002$), but there was no significant difference between patients with culprit lesions in LAD and LCX (Table 2).

LV dyssynchrony had significant positive correlation with LVESD, LAVI, LVEDDI, LVESDI and negative correlation with LVEF at baseline.(Table 3) It also had positive correlation with LVEDD, LVESD and negative correlation with LVEF at follow-up (Table 4). Higher baseline LV dyssynchrony was found in patients who had significant increase in LVEDD, LVSED compared to those who had no significant increase in LV diameters and also in patients with significant decrease in LVEF at follow-up (Table 4).

3.3. *Left atrial volume index*

LAVI was significantly lower in diabetic patients ($p = 0.031$) and there was significant positive correlation with basal log NT-proBNP levels ($p = 0.041$).Significantly higher LAVI was seen in patients with total occlusion of the culprit vessel (Table 2). LAVI had significant positive correlation with baseline LVEDD, LVESD, E velocity, E/E′, E/A ratio, LVEDDI, LVESDI and LV dyssynchrony (Table 3). In the study group LAVI had significant positive correlation with follow up LVEDD, LVESD. There was no significant difference in LAVI between the patients who had significant change in LVEDD, LVSED, LVEF compared to those who had no significant change (Table 4).

Fig. 3 showing comparison of NT-proBNP, LA volume and LV dyssynchrony in patients with increase in LVEDD and no change in LVEDD.

Binary logistic regression analysis was done for predictors of significant increase in LVESD after six months of primary PCI. It showed that LV dyssynchrony (ODDS ratio: 0.942, $p = 0.004$), LVEDDI (ODDS ratio: 0.498, $p = 0.007$), LVESDI (ODDS ratio: 2.439, $p = 0.011$), log NT-pro BNP (ODDS ratio: 0.457, $p = 0.013$) were the independent predictors of significant increase in LVESD during follow up. Binary logistic regression analysis was done for predictors of significant decrease in LVEF after six months of primary PCI. It showed that only log NT-proBNP (ODDS ratio: 0.320, $p = 0.013$) as an independent predictor for decrease in LVEF during follow up (Table 5).

4. Discussion

Primary PCI has been implemented in routine daily practice as the preferred reperfusion therapy in patients with STEMI and early detection of LV remodeling is an important task, as it is a detrimental complication in these patients.[4,5,24,25]

4.1. *NT-proBNP in Primary PCI*

The diagnostic and prognostic role of plasma NT-proBNP levels in patients with LV systolic and diastolic dysfunction has been extensively studied. In this prospective study we assessed the prognostic significance of plasma NT-proBNP levels in patients with AMI.

Talwar et al[26] in their study observed that plasma NT-proBNP levels assessed between 72 and 120 h following AMI better predicted LV systolic dysfunction and poor out comes

Table 2 – Relationship of demographics and PCI data with study parameters on Univariate analysis.

	Log BNP levels		LV dyssynchrony		LAVI	
	Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value
Age (years)	0.348	<0.0001**	0.131	0.121	0.152	0.071
Gender:						
Male	6.90 ± 0.91	0.022*	55.31 ± 14.69	0.332	17.84 ± 4.44	0.349
Female	7.41 ± 0.79		58.89 ± 16.50		16.82 ± 4.22	
Type of MI:						
AWMI	7.06 ± 1.01	0.164	59.59 ± 16.19	<0.001**	17.16 ± 4.26	0.088
Non-AWMI	6.85 ± 0.74		50.58 ± 11.21		18.45 ± 4.55	
KILLIPS Class:						
Class-I	6.81 ± 0.79	<0.0001**	54.11 ± 12.59	0.035*	17.50 ± 4.24	0.395
Class-II	7.46 ± 1.13		60.84 ± 21.58		17.89 ± 4.65	
Class-III&IV	7.69 ± 0.99		63.33 ± 19.44		19.32 ± 5.58	
Hypertension:						
Hypertensives	6.96 ± 0.96	0.924	55.61 ± 17.21	0.907	18.51 ± 5.13	0.079
Non-hypertensives	6.97 ± 0.88		55.91 ± 13.35		17.18 ± 3.82	
Diabetes mellitus:						
Diabetics	6.79 ± 1.03	0.072	53.61 ± 13.18	0.194	16.65 ± 3.82	0.031*
Non-diabetics	7.07 ± 0.82		57.01 ± 15.78		18.30 ± 4.63	
Tobacco consumption:						
Yes	6.85 ± 0.90	0.034*	54.56 ± 12.07	0.178	17.35 ± 4.13	0.186
No	7.19 ± 0.88		58.12 ± 19.18		18.38 ± 4.88	
Window period (hours)	0.262	0.002**	0.151	0.072	0.005	0.956
IRCA:						
LAD	7.07 ± 1.01	0.346	59.24 ± 16.04	0.002*	17.16 ± 4.29	0.258
LCX	6.93 ± 0.67		56.81 ± 15.87		18.25 ± 5.59	
RCA	6.83 ± 0.79		49.83 ± 10.54		18.42 ± 4.14	
No. of vessels involved:						
SVD	6.81 ± 0.79	0.004**	54.47 ± 14.77	0.149	17.25 ± 4.06	0.086
2VD & TVD	7.27 ± 1.04		58.28 ± 15.09		18.59 ± 4.95	
Type of Obstruction:						
Total occlusion	7.09 ± 0.83	0.019**	57.00 ± 15.84	0.157	18.32 ± 4.54	0.014**
Subtotal occlusion	6.71 ± 1.01		53.18 ± 12.55		16.38 ± 3.85	
Thrombus aspiration:						
Done	6.81 ± 0.67	0.193	54.67 ± 12.05	0.584	17.63 ± 4.37	0.898
Not done	7.03 ± 0.98		56.21 ± 15.93		17.74 ± 4.45	
log NTproBNP	–	–	0.473	<0.0001**	0.72	0.041*

AWMI: anterior wall myocardial infarction; IRCA: infarct related coronary artery; LAD: left anterior descending artery; LCX: left circumflex artery; RCA: right coronary artery; SVD: single vessel disease; 2VD: two vessel disease; TVD: triple vessel disease; BNP: B-type natriuretic peptide.

during follow up, hence we measured plasma NT-proBNP levels between 72 and 96 h following AMI.

We observed higher NT-proBNP levels in elderly patients, those patients with longer window period and higher Killips class at presentation. Contrary to that observed by Talwar et al[26] there was no significant difference in plasma NT-proBNP levels between anterior wall MI and non anterior wall MI patients in our study. Patients with multi vessel disease and total occlusion of infarct related coronary artery had higher NT-proBNP levels compared to those with single vessel disease and subtotal occlusion respectively. This may probably be due to larger ischemic burden in these patients.

Plasma NT-proBNP levels were not influenced by thrombus aspiration, administration of GP 2b/3a inhibitors and type of stent deployed during primary PCI. In this study patients with high NT-proBNP levels had larger basal LV dimensions, low LVEF, high LAVI and severe diastolic dysfunction, they also showed progressive increase in their LV size with significant reduction in LVEF during follow up. The 4 patients who developed symptomatic heart failure had higher basal NT-proBNP levels (mean = 6698.75) compared to rest of the study group. The REVE-2 study,[27] in contrast to the present study, showed that baseline LVEF was the sole independent predictor of LV remodeling but not basal NT-proBNP levels in patients with AMI.

Results of previous studies on the association between NT-proBNP levels and LV remodeling were conflicting, with some studies showing a positive association like our study[28–31] and some showing no association.[27,32] These conflicting observations may be related to heterogenous study populations, retrospective study designs, or timing of blood sampling in addition to problems related to sample size.

4.2. *Left ventricular dyssynchrony in primary PCI*

Left ventricular dyssynchrony is seen early in AMI even in the absence of wide QRS complex or bundle branch block. The degree of LV dyssynchrony is mainly determined by infarct size.[13] We observed higher LV dyssynchrony in patients with anterior wall MI and those with higher Killips class at presentation. Severity of LV dyssynchrony in our study was not significantly influenced by patient's age, window period,

Table 3 – Relationship of baseline echocardiographic data with study parameters on Univariate analysis.

	Mean ± SD	log NTproBNP levels		LV dyssynchrony		LAVI	
		Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value
LVEDD (mm)	46.81 ± 4.59	0.065	0.44	0.021	0.802	0.317	<0.0001**
LVESD (mm)	34.15 ± 4.74	0.323	<0.0001**	0.253	0.002**	0.248	0.003**
LVEF%	50.84 ± 8.30	−0.537	<0.0001**	−0.467	<0.0001**	−0.084	0.323
E velocity (cm/s)	72.65 ± 19.58	−0.027	0.752	−0.061	0.471	0.185	0.027*
A velocity (cm/s)	80.53 ± 19.05	0.057	0.498	−0.040	0.637	−0.053	0.531
E/A	0.96 ± 0.40	0.029	0.729	0.054	0.524	0.192	0.022*
E′ (cm/s)	6.40 ± 1.56	−0.296	<0.0001**	−0.087	0.303	−0.019	0.822
E/E′	11.72 ± 3.40	0.271	0.001**	0.098	0.246	0.197	0.019*
LA volume (mL)	29.46 ± 7.99	−0.023	0.790	0.020	0.816	–	–
LAVI (mL/m^2)	17.71 ± 4.41	0.172	0.041*	0.220	0.009**	–	–
LV dyssynchrony (ms)	55.79 ± 14.93	0.473	<0.0001**	–	–	0.220	0.009**
LVEDDI (mm/m^2)	28.97 ± 8.50	0.261	0.002**	0.238	0.004*	0.418	<0.0001**
LVESDI (mm/m^2)	21.2 ± 7.01	0.359	<0.0001**	0.340	<0.0001**	0.399	<0.0001**
Diastolic function:							
Normal function to mild dysfunction	51 (35.9%)	6.79 ± 0.73	<0.0001**	55.61 ± 11.90	0.431	17.28 ± 4.91	0.613
Moderate dysfunction	62 (43.7%)	6.83 ± 0.96		54.50 ± 15.58		17.79 ± 3.65	
Severe dysfunction	29 (20.4%)	7.56 ± 0.86		58.86 ± 18.11		18.29 ± 5.05	
Systolic function:							
Normal	85 (59.9%)	6.65 ± 0.82	<0.0001**	51.75 ± 12.29	<0.0001**	17.32 ± 4.19	0.425
Mild dysfunction	41 (28.9%)	7.32 ± 0.79		58.76 ± 15.02		18.20 ± 4.36	
Moderate & severe dysfunction	16 (11.2%)	7.75 ± 0.87		69.62 ± 18.13		18.53 ± 5.67	

LVEDD: left ventricular end diastolic diameter; LVESD: left ventricular end systolic diameter; LVEF: left ventricular ejection fraction; LVEDDI: left ventricular end diastolic diameter index; LVESDI: left ventricular end systolic diameter index; LAVI: left atrial volume index.

Table 4 – Relationship of follow-up data with study parameters on Univariate analysis.

	Mean ± SD/n (%)	log NTproBNP levels		LV dyssynchrony		LAVI	
		Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value	Mean ± SD or *r*-value	*p*-value
LVEDD (mm)	49.62 ± 4.63	0.321	<0.0001**	0.253	0.003**	0.296	<0.0001**
LVESD (mm)	34.78 ± 5.34	0.473	<0.0001**	0.350	<0.0001**	0.207	0.016**
LVEF%	54.73 ± 9.23	−0.521	<0.0001**	−0.398	<0.0001**	−0.044	0.613
Change in LVEDD (mm):							
Significant increase	43 (31.9%)	7.15 ± 0.81	0.061	59.02 ± 18.51	0.035*	17.39 ± 4.29	0.629
No significant change	92 (69.1%)	6.84 ± 0.92		53.52 ± 11.29		17.78 ± 4.31	
Change in LVESD (mm):							
Significant increase	37 (27.4%)	7.26 ± 0.96	0.008**	60.94 ± 18.53	0.004**	18.35 ± 4.49	0.246
No significant change	98 (72.6%)	6.81 ± 0.84		53.13 ± 11.52		17.39 ± 4.21	
Change in LVEF%:							
Significant decrease	10 (7.4%)	7.78 ± 0.96	0.004**	64.10 ± 14.37	0.004**	19.03 ± 4.74	0.386
No significant change	69 (51.1%)	6.80 ± 0.92		51.65 ± 11.39		17.23 ± 4.22	
Significant increase	56 (41.5%)	6.95 ± 0.77		58.16 ± 15.98		17.93 ± 4.32	
Diastolic function:							
Normal to mild dysfunction	47 (34.8%)	6.53 ± 0.70	<0.0001**	53.59 ± 11.49	0.009**	17.39 ± 4.39	0.048*
Moderate dysfunction	70 (51.9%)	6.96 ± 0.85		53.97 ± 12.57		17.24 ± 4.08	
Severe dysfunction	18 (13.3%)	7.89 ± 0.80		64.722 ± 21.75		19.96 ± 4.38	
Systolic function:							
Normal	104 (77.1%)	6.73 ± 0.83	<0.0001**	52.99 ± 13.34	0.002**	17.75 ± 4.33	0.502
Mild dysfunction	21 (15.6%)	7.44 ± 0.68		62.19 ± 14.66		16.75 ± 3.41	
Moderate to severe dysfunction	10 (7.3%)	8.01 ± 0.75		64.50 ± 14.35		18.53 ± 5.57	

LVEDD: left ventricular end diastolic diameter; LVESD: left ventricular end systolic diameter; LVEF: left ventricular ejection fraction.
*indicates $p < 0.05$; **indicates $p < 0.01$.

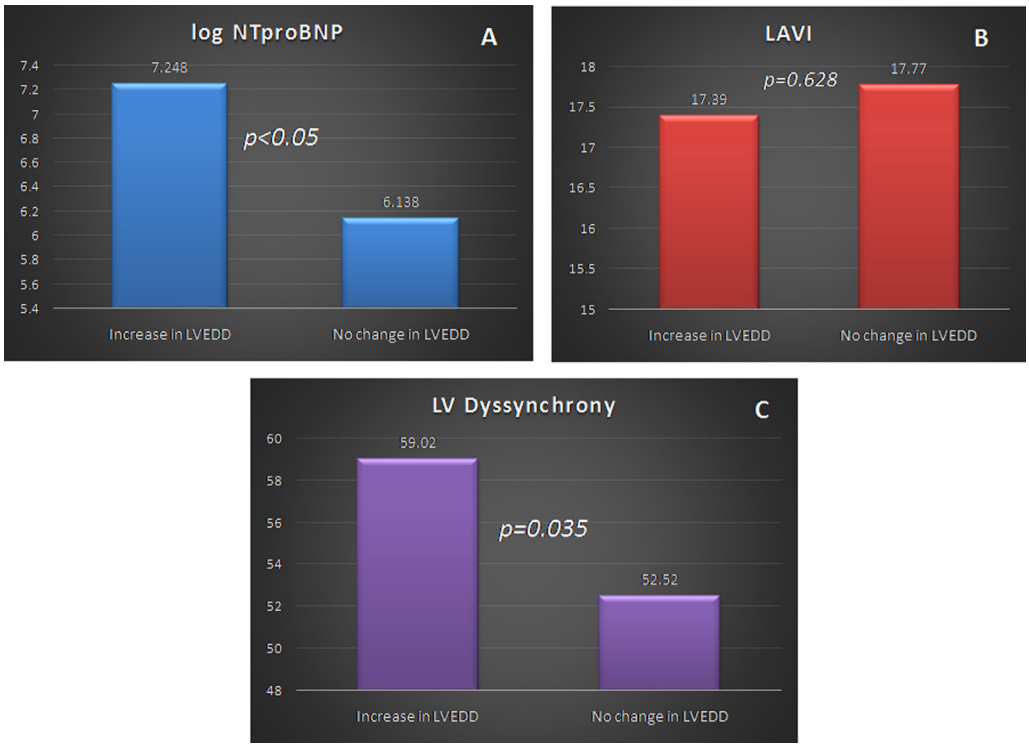

Fig. 3 – Comparison of NT-proBNP, LA volume and LV dyssynchrony in patients with increase in LVEDD and no change in LVEDD.

number of vessels involved, whether infarct related coronary artery totally occluded or not, thrombus aspiration and administration of GP 2b/3a inhibitors during primary PCI.

Patients with culprit lesion in RCA showed lesser LV dyssynchrony compared to patients with lesions in LAD and LCX ($p = 0.023$). But in a study by Ng et al[11] patients with proximal LCX stenosis had higher LV dyssynchrony and no significant difference between patients with lesions in LAD and RCA.

In our study, LV dyssynchrony was higher in patients with low baseline LVEF which was also seen in a previous study by Nucifora et al[10] and we also observed that these patients had significant increase in their LV dimensions with decrease in LVEF and severe diastolic dysfunction at 6 months follow up.

Numerous reports have been published on LV dyssynchrony mainly in relation to prediction of response to cardiac resynchronization therapy. In the present study a significant degree of LV dyssynchrony is predictive of LV remodeling. This may offer a possibility to identify patients at risk for LV remodeling early after infarction and to subsequently intensify treatment of these patients.

Table 5 – Multivariate analysis.

	B	S.E	*p*-val	Exp(B)
LAVI	−0.048	0.078	0.540	0.953
LV dyssynchrony	−0.006	0.023	0.781	0.994
log NTproBNP	−1.139	0.461	0.013	0.320
Baseline LVEF	0.008	0.016	0.623	0.104
LVEDD	−0.110	0.035	0.241	0.829
LVESD	0.134	0.045	0.411	0.532

Dependent variable: change in LVEF.

4.3. *Left atrial volume index in primary PCI*

The Doppler variables of LV diastolic function are affected by acute hemodynamic changes, but LAVI is a more stable parameter, integrating the effects of elevated LV filling pressures from pre-existing cardiovascular conditions as well as acute disease.[33] In the present study, LAVI showed significant correlation with baseline LV dimensions and diastolic function, but not with baseline LV systolic function. Patient's with higher baseline LAVI had severe diastolic dysfunction at 6 months follow up but could not predict increase in LV dimensions and decrease in LVEF at 6 months follow up.

Contrary to our findings, previous studies[15,34,35] reported prognostic role of LAVI in predicting survival and heart failure in patients with MI during follow up. In these studies patients were older, did not undergo revascularization, had higher baseline LAVI, followed up for longer time period (20 months–5 years) and only clinical events were noted without assessment of LV remodeling.

In a recent study by Lonborg et al[36] in patients with STEMI observed that maximal LA volume had no significant role in predicting MACE, but LA fractional change and LA minimal volume could better predict cardiovascular events in these patients.

In our study 3 patients died during follow up, of whom one patient died due to CHF and the other 2 patients who experienced sudden cardiac death may be due to probable stent thrombosis. Because of low mortality in our study it was not

possible to define the prognostic information of NT-proBNP levels, LV dyssynchrony and LAVI on survival rate.

Binary logistic regression analysis showed that LV dyssynchrony and log NT-proBNP as independent predictors for increase in LVSED after 6 months and only NT-proBNP for decrease in LVEF.

4.4. *Limitations*

The main limitation of our study was relatively small sample size with 142 patients and short duration of follow up. As TDI is angle dependent, it cannot exclude the influence of motion of entire heart and "tethering" movement of adjacent segments. In this study patients with prior coronary artery bypass grafting, history of previous MI, very old age, presence of atrial fibrillation, pre existing bundle branch block and patients with renal failure were excluded. This may introduce the risk of selection bias on prognostic value of NT-proBNP, LAVI and LV dyssynchrony. Left ventricular mass was not assessed in this study, which could influence the NT-proBNP levels and LAVI. Left ventricular volumes were not assessed at base line and during follow up. Only LV size was assessed. In the present study echocardiographic parameters were assessed within 48 h after primary PCI not at a fixed time point in all patients. This may have impact in the assessment of LV diastolic, systolic function and LV dyssynchrony as these parameters are likely to be greatly altered by changes in LV contractile function resulting from early reperfusion.

5. Conclusions

In patients with AMI, higher basal NT-proBNP levels can predict progressive increase in LV size, worsening of LV systolic, diastolic function and occurrence of CHF during follow-up.

Higher LV dyssynchrony at baseline can predict patients with increase in LV size and deterioration of LV systolic and diastolic functions during follow up. It has incremental prognostic value to NT-proBNP levels in predicting increase in LV size during follow up.

Conflicts of interest

The authors have none to declare.

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