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Impact of Left Atrium Function on In-hospital Course in Patient with ST-segment Elevation Myocardial Infarction undergoing Primary Percutaneous Coronary Intervention

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ABSTRACT

Background: Left atrial (LA) volumetric assessment by echocardiography remains a simple, non-invasive technique for left atrial functional assessment.

Objective: The aim of the current work was to assess the left atrial function and its relation to the severity of the lesion in-hospital course in patients with ST-segment Elevation Myocardial Infarction (STEMI) undergoing Primary Percutaneous coronary intervention (PCI).

Patients and Methods: This cross-sectional study included a total of 135 patients with acute STEMI, attending at Department of Cardiology, Zagazig University Hospitals. The included subjects were categorized into two groups; **Group 1** included those, who developed adverse events. (31 patients "23%"), and **Group 2:** included patients with benign course. (104 patients "77%"). Coronary angioplasty as well as Echocardiography were done to all patients.

Results: Regarding the echocardiographic parameters, there were significant differences between both study groups as regards Wall motion score index, left atrium volume index, Left atrium expansion index, LA total ejection fraction and E/e′ ratio. There was no significant difference between the two groups regarding LVEF. There was a high significant correlation between left atrial volume index and Wall Motion Score Index, Syntax score, Left atrium expansion index, LA total ejection fraction and E/e′ ratio. On a multivariate model for independent predictors for hospital adverse events were High syntax score, Left atrium volume index and Left atrium expansion index.

Conclusion: It could be concluded that LA functions has high significant correlated with the severity of the lesion and a good prognostic factor in hospital course of STEMI patients undergoing primary PCI.

Keywords: Left Atrium, ST-segment Elevation Myocardial Infarction, Percutaneous Coronary Intervention

INTRODUCTION

Despite breakthroughs in the identification and treatment of acute coronary syndromes, they are still the greatest cause of death and disability in the world[1].

Primary percutaneous coronary intervention, current antithrombotic treatment and secondary preventative measures have all contributed to the reduction in immediate and long-term mortality following a STEMI [2].

Even still, mortality is significant, with 13% of patients dying within six months, with higher death rates among patients with higher risks, which warrants ongoing efforts to enhance care quality, adherence to recommendations, and research [3].

Prior to a fibrinolytic treatment procedure known as primary PCI, individuals with a STEMI should be treated with an immediate percutaneous catheter intervention (PCI). By preventing some of the bleeding risks of fibrinolysis and preserving coronary artery patency, it lowers the mortality rate [4].

In coronary angiography, the SYNTAX score is one of several measures of CAD severity**.** When performing three-vessel PCI, it's important to know your patient's SYNTAX score because it can help you decide whether or not they'll have a successful outcome[5].

Highest risk and poorest prognosis for revascularization with PCI than with coronary bypass surgery is found in patients with the highest grades [6]. CAD has been demonstrated to produce both systolic and diastolic dysfunction of the left ventricle. More than a third (38 percent) of patients with MI had symptoms of diastolic dysfunction, and a quarter (24 percent) had restrictive left ventricular filling due to this dysfunction [7].

As part of the LA phasic function, the Left Atrium functions as a continuation of the Left Ventricular system, especially during diastole, hence its function and size are greatly influenced by the left ventricular compliance [8].

During ventricular systole, the pulmonary venous return is stored in the LA. Early in ventricular diastole, it becomes a route for pulmonary venous return. The late diastole LV filling is aided by this pump, which acts as a backup pump [8].

The early emergence of ischemic mitral regurgitation, which is frequent in heart failure patients, can be prevented by better understanding the adverse effects of left atrial ischemia, such as LA dysfunction and dilatation. Managing ischemia in the LA would eventually benefit patients with CAD, with higher rates of morbidity as well as mortality [9]. Though CT or MRI are more advanced methods of assessing left atrial function, the ability to use echocardiography to measure the volume of the left atrium (LA) during the acute phase of a myocardial infarction has rarely been studied [10].

Semiquantitative less angle dependent non-invasive Tissue Doppler Imaging can identify the inherent low velocities of atrial myocardial wall in a non-invasive manner [10].

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Percutaneous coronary intervention (PCI) was employed in this study to explore how left atrial function and coronary disease severity affect hospitalization outcomes for patients with STEMI receiving percutaneous coronary intervention (PCI).

Primary percutaneous coronary intervention (PPCI) was tested in individuals with ST-segment elevation myocardial infarction to see if it improves left atrial function.

SUBJECTS AND METHODS

This cross-sectional study included a total of 135 patients with acute STEMI, attending at Department of Cardiology, Zagazig University Hospitals. The included subjects were categorized into two groups; **Group 1** included those, who developed adverse events. (31 patients "23%"), and **Group 2:** included patients with benign course. (104 patients "77%").

***Ethical Consideration*:**

The Zagazig University research ethics committee approved the study (ZU-IRB#7656) as long as all participants signed informed consent forms and submitted them to the committee. For human experimentation, we adhered to the Helsinki Declaration, issued by the World Medical Association.

Inclusion criteria: All patients presenting with STEMI in the ECG.

Exclusion criteria: Individuals who have previously undergone a CABG, those who have had a previous MI, patients with previous PCI, non-ST Segment elevation MI, thrombolytic therapy, significant valvular disease, permanent atrial fibrillation, cardiogenic shock, permanent pacemaker, and mechanical complication of myocardial infarction (MI).

All Patients were subjected to:

1. **A thorough review of the patient's medical history,** CAD, DM, dyslipidemia and family history.
2. **Thorough general and cardiac physical examination.**
3. **Twelve (12) leads ECG.**
4. **Preoperative lab investigations before surgery including** serum creatinine, CK-MB, troponin at the time of presentation, 3 hours, 6 hours, and 12 hours following reperfusion therapy, and 2 hours after the procedure. When the patient was admitted to the hospital, CK-MB and troponin levels were measured. Troponin T levels over the 99th percentile of the normal reference range (i.e., 0.01ng/mL) were deemed positive.
5. **Coronary angiography and PCI:** STEMI patients were treated with primary PCI within 12 hours of the beginning of symptoms, if possible (i.e., 120min from STEMI diagnosis).
6. **Analysis of coronary angiograms according to syntax score for:** Lesion number, culprit lesion and severity of its stenosis.

An initial diagnostic angiogram for an AMI was used to calculate the SYNTAX score by three interventional cardiologists utilizing the SxS algorithm, which found on the internet (www.syntaxscore. Com).

Primary outcomes included TIMI flow grade, systolic function, re-infarction, and inpatient mortality. Angina pectoris was described as no antegrade flow, and TIMI flow grade 1 was defined by the feeble antegrade coronary flow with partial filling of the distal coronary bed, A slow or sluggish antegrade flow with complete filling of the distal area is TIMI flow grade 2, and the distal coronary bed has been completely filled by normal TIMI 3 flows. Final TIMI flow grade 3 was used to define the no-reflow phenomenon.

Echocardiography:

Resting echocardiograms were conducted 24 to 48 hours following initial PCI.

- The following formulas were used to determine the LA's mechanical function [11]:
  - Total ejection fraction, LAEF = (LAmax - LAmin/LAmax) × 100;
  - L'expansion index, expressing LA reservoir function [(LAmax - LAmin/LAmin) × 100].

The echocardiograms were analyzed by an investigator who was unaware of the patient's clinical and angiographic data.

- The anterior–posterior left atrial (LA) diameter was measured in the parasternal long-axis view. Apical 4- and 2-chamber views were used to assess superior–inferior and medial–lateral LA diameters. End-ventricular systole measures were taken.
- Atrial wall thickness was determined by from 4- and 2-chamber apical views, drawing the inner linings of the atrial walls.

Follow up occurrence any of the following complications for the patients during in hospital stay course**: (**heart failure, arrhythmia, reinfarction, cardiogenic shock, Acute pulmonary edema, Cardiorespiratory arrest and death).

Statistical analysis

The Statistical Package of Social Services, version 20, was used to execute analyses on the data collected (SPSS). In order to convey the findings, tables and graphs were employed. The mean, median, standard deviation, and 95% confidence range were used to summarize the quantitative data. Qualitative data, such as the frequency and proportions, were used to illustrate the points made. Quantitative data were examined using the student t test (T) and the Kolmogorov-Smirnov statistic. Researchers used the Pearson Chi-Square Test and the Chi-Square for Linear Trend (2) to assess qualitatively independent data. Significant results were defined as those with a p value of 0.05 or lower.

RESULTS

When it came to factors such as age and gender as well as BMI and hypertension and dyslipidemia as well as diabetes and a family history of early CAD, there was no statistically significant differences. In addition, the principal drugs used by both groups were comparable **(Table 1).**

Table (1): Clinical characteristics

	Group (I) (N = 31 %)	Group (II) (N =104 %)	P value
Age (year)	40.0 – 85.0 62.5 ±13.4	35.0 – 83.0 59 ±14.3	0.10
Male, n (%)	28 (90.3%) males 3 (9.7%) females	95 (91.3%) males 9 (8.65%) females	0.236
BMI (kg/m^2)	34.2 ± 8.3	34.2 ± 8.3	1.0
Hypertension, n (%)	13 (41.9%)	40 (38.4%)	0.880
Dyslipidemia, n (%)	10 (32.5%)	30 (28.8%)	0.624
Diabetes mellitus, n (%)	22 (70.9)	70 (67.3%)	0.988
Smoker, n (%)	25 (80.6%)	80 (76.92%)	0.213
Family history of premature CAD	3 (9.6%)	10 (96.15%)	0.343
Systolic BP [mmHg]	118.7 ± 25.1	119.6 ± 17.88	0.770
Diastolic BP [mmHg]	78.43 ± 15.6	78.33 ± 13.43	0.854
Heart rate [bpm]	80.90 ± 11.20	76 ± 10.1	0.683
Creatinine [μmol/L]	0.85 ± 0.17	0.85 ± 0.17	0.970
American Society of Anesthesiologists (ASA)	31 (100%)	104(100%)	1.0
Clopidogrel/Ticagrelor	31 (100%)	104 (100%)	1.0
Beta-blockers	65%	55%	0.998
Angiotensin-converting enzyme inhibitors (ACEI)/ angiotensin receptor blockers (ARB)	79%	83%	0.241
Statins	90%	87%	0.278
Anterior wall MI	65%	60.5%	0.624

In-hospital adverse outcomes are illustrated in (**Table 2).**

Table (2): In-hospital adverse outcome

Event	N (%)
Acute pulmonary edema	3 (2.22%)
Atrial fibrillation	3 (2.22%)
Shock	1 (0.74%)
Reinfarction	1 (0.74%)
Cardiorespiratory arrest and death	2 (1.48%)
HFrEF	9 (6.675)
HFpEF	13 (9.62%)

In group I, mean of EF% was 54.5 ± 6.3, mean of Wall motion score index was 1.59 ± 0.21, mean of Left atrium volume index (ml/m2) was 41.5 ± 3.3, mean of LA total ejection fraction [%] was 54.9 ± 6.0, Left atrium expansion index (ml/m^2) was 112.8 ± 25.7and mean of E/e′ ratio was 14.5 ± 3.1. In group II, mean of EF% was 56.3 ± 5.9, mean of Wall motion score index was 1.42 ± 0.23, mean of Left atrium volume index (ml/m2) was 31.5 ± 2.8, mean of LA total ejection fraction [%] was 52.4 ± 5.4, mean of Left atrium expansion index (ml/m^2) was 125.7 ± 31.2 and mean of E/e′ ratio was 8.9 ± 1.5. Wall motion score index, left atrium volume index (ml/m2), Left atrium expansion index (ml/m2), LA total ejection fraction [percent] and E/e′ ratio were significantly different between the two groups tested **(Table 3).**

Table (3): Baseline echocardiographic characteristics

	Group (I)	Group (II)	P value
EF%	54.5 ± 6.3	56.3 ± 5.9	0.25
Wall motion score index	1.59 ± 0.21	1.42 ± 0.23	0.01
Left atrium volume index (ml/m2)	41.5 ± 3.3	31.5 ± 2.8	0.001
Left atrium expansion index (ml/m^2)	112.8 ± 25.7	125.7 ± 31.2	0.01
LA total ejection fraction [%]	54.9 ± 6.0	52.4 ± 5.4	0.01
Peak E (m/s)	0.79 ± 0.3	0.77 ± 0.1	0.63
Peak A (m/s)	0.78 ± 0.1	0.76 ± 0.1	0.53
e'	5.5± 0.3	8.7± 0.3	<0.01
S'	10.9 ±1.3	11.5±1.3.	0.38
E/e′ ratio	14.5 ± 3.1	8.9 ± 1.5	<0.003

Both group I and group II had a significant variation in Syntax score. (30.1 ± 5.1 vs 19.8 ± 7.9, p <0.001) **(Table 4).**

Table (4): Angiographic characteristics

	Group (I)	Group (II)	P value
S-TO-B [min]	398 ± 173	393 ± 189	0.39
D-TO-B [min]	51 ± 18	53 ± 19	0.35
Syntax score	30.1 ± 5.1	19.8 ± 7.9	<0.001
Multivessel coronary disease	31%	39%	0.19
Number of stents 1 2	25 (80%) 6 (20%)	90 (86.5%) 14 (13.5%)	0.417
TIMI flow before pPCI	0= 25 (80%) 1=5 (16%) 2=1 (4%) 3=0	0= 86 (82.8%) 1=10 (9.6%) 2=5 (4.8%) 3= 3 (2.8%)	0.583
Thrombus aspiration	0	0	

Wall motion index, Syntax score, left atrium expansion index [ml/m2], LA total ejection fraction [percent], and E/e′ ratio) had a high significant connection with the left atrial volume index **(Table 5).**

Table (5): Correlation analysis of left atrial volume index and other studied parameters

Variable	r	P value
Wall motion score index	0.21	0.02
Syntax score	0.29	0.01
Left atrium expansion index (ml/m^2)	0.41	<0.001
Left atrium ejection fraction	0.33	0.003
E/e′ ratio	0.35	0.003

In order to identify the variables that affect adverse occurrences in the hospital and the risk factors, researchers used the univariate and multivariate Cox proportional hazards models. High syntax score left atrium volume index, and left atrium expansion index (ml/m^2) were found to be independent predictors of hospital adverse events on a multivariate model **(Tables 6, 7).**

Table (6): Univariate regression analysis of variable to predict in-hospital adverse events

	Odds ratio	95% (CI)	p value
Time of perfusion	1.006	0.99–1.01	0.31
High syntax score	1.16	1.05-1.17	<0.03
Wall motion score index	7.13	1.99–3821	<0.01
Ejection fraction	0.65	0.63–0.81	0.51
Left atrium volume index	1.43	1.13–1.83	<0.001
Left atrium expansion index (ml/m^2)	0.95	0.88–1.01	<0.003
Left atrium ejection fraction%	0.99	0.85–1.09	<0.01

Table (7): Multivariate regression analysis of variable to predict in-hospital adverse events.

	Odds ratio	95% (CI)	p value
High syntax score	1.13	1.01-1.19	<0.05
Left atrium volume index	1.39	1.13–1.69	0.001
Left atrium expansion index (ml/m^2)	0.87	0.71–0.95	<0.003

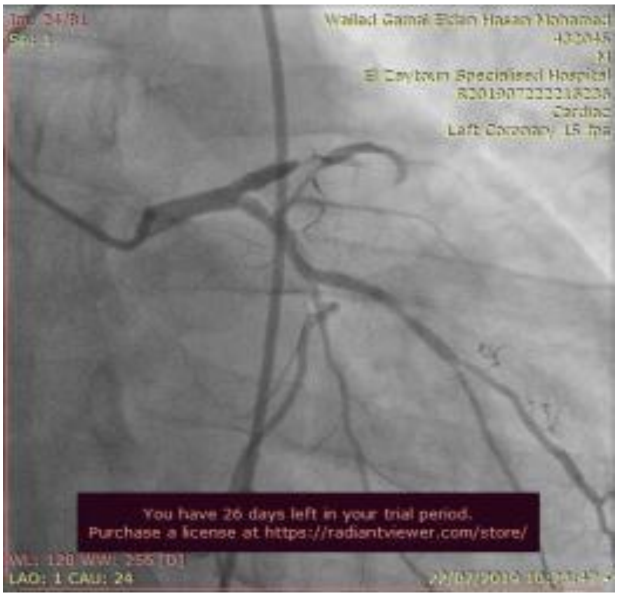

Figure (1): Left system showing proximal total occlusion of LAD.

Figure (2): Left system after primary pci to LAD with 1DES.

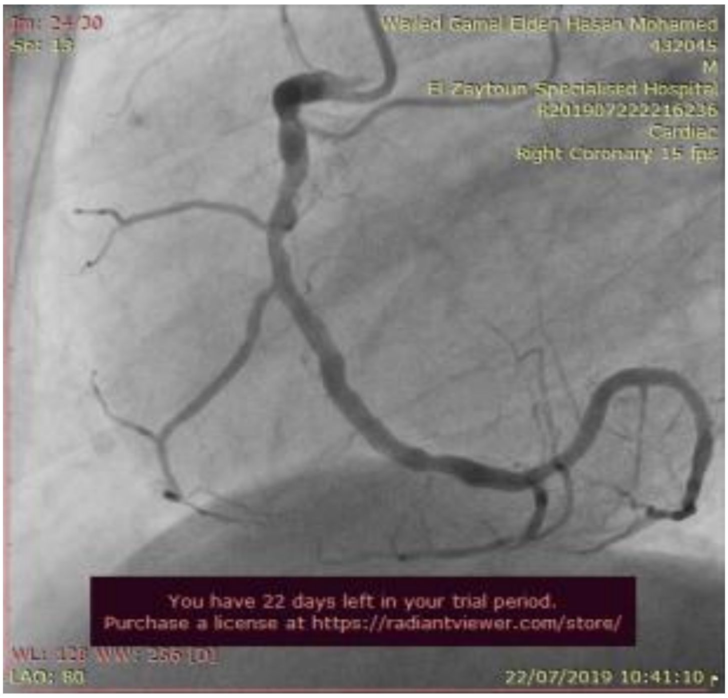

Figure (3): Right system showing normal RCA.

Figure (4): Minimum left atrial volume in apical 4 view.

Figure (5): Maximum left atrial volume in apical 4 view.

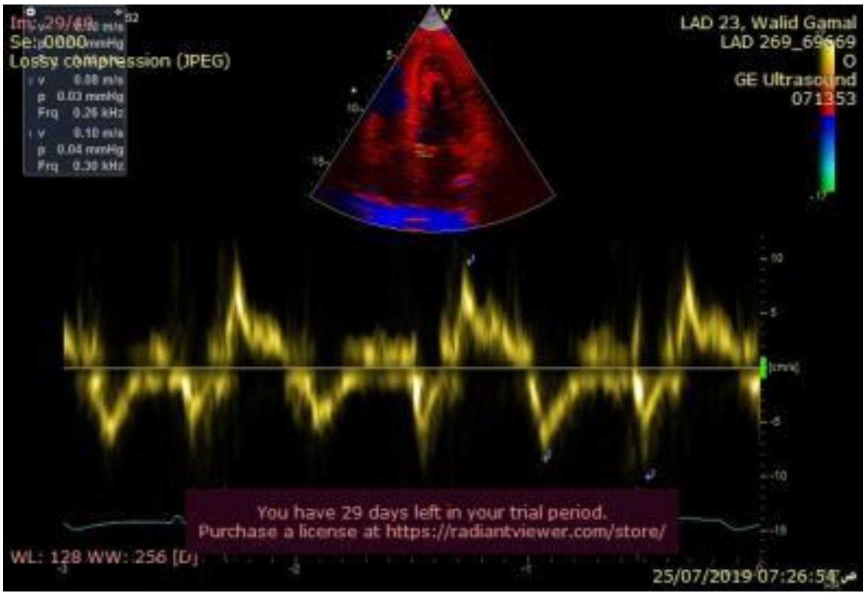

Figure (6): TDI of the left atrium septal wall (Peak (S′), peak (E′), and peak (A′)).

Figure (7): pulsed-wave Doppler of Mitral inflow velocity (Peak early (E) and late (A) diastolic velocities).
Figure 1-7: 43 years old male patient presented with benign course (no adverse events). Smoker, dyslipidemia, Troponin I: 1.74 ng/ml, CKMB: 41 ng/ml, Creatinine: 0.8 mg/d, T cholesterol: 224 mg/dl, TG: 134 mg/dl, LDL: 159 mg/dl, and RBS: 85mg/dl.

DISCUSSION

Despite advances in the diagnosis, prognosis, and treatment of STEMI, it remains the major cause of cardiovascular mortality and morbidity in developing nations [(12)]. Primary therapeutic options for MI currently include percutaneous coronary intervention (PCI) and pharmacological thrombolysis [(13)]**.** At least one serious lesion in an artery other than the culprit was found in 50–60% of individuals undergoing initial PCI [(14)]**.**

According to several studies, increasing left ventricular end-diastolic pressure results in significant remodeling of the LA after an AMI (LVEDP) [(15)], AMI-related morbidity and death can be predicted by the volume of the lungs, according to research [(9)]**.** Consequently, appropriate atrial assessment during cardiac evaluation is essential [(15)]**.**

The present study included 135 patients. During hospital stay, major cardiac events (MACE) occurred to 31 patients (23%). 3 patients complicated with Acute pulmonary edema, 3 patients with Atrial fibrillation, 1 patient with cardiogenic shock, 1 patient re-infarcted, heart failure 9 patients with reduced ejection fraction and 13 patients with preserved ejection fraction and 2 patients died.

In another study done by **Sakaguchi *et al.*** [(16)] included 205 consecutive patients, MACE occurred in 29 patients (14%). Also, **Cho *et al.*** [(17)] enrolled 253 patients with AMI, MACE occurred in 59 patients (23%).

Results of this study showed no significant differences in the two groups in terms of age, gender, BMI, or any other concomitant conditions (hypertension, dyslipidemia, diabetes mellitus or family history of premature CAD). In addition, both groups took the same primary medicines.

Also, **Cho *et al.*** [(17)]**,** stated that both groups' baseline clinical features, medications, and laboratory data showed no significant differences.

Regarding demographics, the current study showed that the group of MACE (G I) displayed significantly higher Wall motion score index(1.59 ± 0.21 vs 1.42 ± 0.23; P= 0.01), higher left atrium volume index (41.5 ± 3.3 vs 31.5 ± 2.8 ; P=0.001), lower Left atrium expansion index (112.8 ± 25.7 vs 125.7 ± 31.2 ; P=0.01), A greater percentage of the overall LA ejection fraction (54.9 ± 6.0 vs 52.4 ± 5.4; P=0.01),higher E/e′ ratio (14.5 ± 3.1 vs 8.9 ± 1.5; P <0.003). There was no statistically significant difference in LVEF between the two groups.

In agreement with this study **Sakaguchi *et al.*** [(16)] found that admission LAVI with P value =0.0007, discharge LAVI with P-value < 0.0001 and discharge E/e′ with P value=0.0003were all significantly higher in the MACE group.

In disagreement with this study, **Cho *et al.*** [(17)] showed no significant difference regarding E/e ′ and no significant difference regarding WMSI between the two groups.

Regarding LVEF, our study was discordant with **Cho *et al.*** [(17)]**, Sakaguchi *et al.*** [(16)]**, Modin *et al.*** [(18)] studies which stated that baseline LVEF was significantly lower in the MACE group.

Our research found a substantial difference in Syntax score between the two groups (30.1 ± 5.1 vs 19.8 ± 7.9, p <0.001) as it was higher in the MACE group.

Syntax score and echocardiographic LA function have not been evaluated in predicting MACE after AMI and correlated with the degree of coronary artery disease (CAD). However, in studies of LA function measured by 2D speckle-tracking

Bayramoğlu *et al.* [19] study showed that high syntax score was associated with high LAVI and high E/e.

Include established risk factors for in-hospital adverse outcomes in a logistic regression model (MACE) (Only High syntax score, Left atrial volume index, Left atrium expansion index, and Left atrium ejection fraction persisted as independent predictors of in-hospital MACE in patients with coronary artery disease [21].

The present study's novel and significant findings are that LA size and function were both good predictors of AMI after first PCI. Combining measurements of atrial size and function may boost the diagnostic utility of echocardiography, according to a recent study. When a patient has had an AMI, In other words, the size of the LA is a reliable indicator of mortality or hospitalization in patients with heart failure. As soon as the AMI is over in Los Angeles, remodeling may begin this is regulated by the EF, the left ventricular size, and the wall motion score[20].

In our study WMSI was significantly higher in the MACE group. Predictors of mortality and cardiovascular morbidity can be found in the remodeling of the aorta. The LA volume is a measure of diastolic burden, and a larger LA volume often indicates that the ventricular filling pressure is excessive. The open mitral valve exposes the left atrium to LV pressure during ventricular diastole. AMI causes the LA to rise as a result of the decreased contractility of the heart muscle. Excessive LA pressure lengthens and enlarges the atrial myocardium, which causes it to bulge outward and dilate [21]. The best way to gauge the size of the atrium is through the use of volumetric measurements [22].

After initial PCI, LAVI was found to be a good predictor of AMI, and it was also an independent predictor of MACE during the hospital stay.

Moller and colleagues. [23]**, as well as Beinart and colleagues** [9] they concurred that when patients were admitted to the hospital, LAVI was a major predictor of death, and it remained so even after an AMI.

Individuals with more severe LA enlargement exhibited higher degrees of LV diastolic dysfunction and a larger E/e′ ratio, a sign of elevated LV filling pressures, according to these findings. However, the multivariate logistic regression analysis indicated that E/e′ ratio was not a significant prognostic factor in the MACE group.

According to **Hillis *et al.*** [24]**,** E/e′ on admission was a powerful predictor of death, but in this study it was not.

We showed in our study that pump function (LA total emptying fraction) of the LA increase in MACE group of patients but the reservoir function (LA expansion index) lower in MACE group than the non-MACE group both of them were high significant in MACE group and high significant correlation between each of them and left atrial volume index but The multivariate logistic regression analysis found that the total LA emptying fraction was not a significant prognostic factor.

Analyses have previously found logarithmic relationships between changes in LA volume and the ratio of LV filling pressure (the LA expansion index) [25]. Diastolic characteristics can be accurately predicted using the LA expansion index. LV diastolic dysfunction and arterial stiffness are more directly linked to LA function than to LA volume on their own [26].

Angina, acute myocardial infarction, and severe mitral regurgitation can be effectively predicted using the LA expansion index when the LV filling pressure is adequately evaluated (logarithmic correlation). Another application for this metric is in predicting death in the short and long term after bypass surgery and heart failure hospitalization [25].

In our study LA expansion index was independent predictor for MACE after AMI during in hospital stay period with the LA volume index.

This work supports the idea that risk categorization models can be improved by assessing the size and function of the LA in the immediate aftermath of an AMI.

In our study, in STEMI patients the relationship was examined between the severity of CAD and the LA size and function. High syntax score associated with increase in LAVI and decrease in LAEI in the MACE group of patients. The relationship between LAVI, LAEI, and SYNTAX score could be useful in clinical practice.

CONCLUSION

It could be concluded that LA functions has high significant correlated with the severity of the lesion and a good prognostic factor in hospital course of STEMI patients undergoing primary PCI.

Our study suggests that LA volume index, LA expansion index and syntax score are useful tools for prognostication and are independent predictors for MACE during in hospital stay course in STEMI patients undergoing primary PCI.

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