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Original Research Article

2D Echocardiographic Assessment of Left Ventricular Function in Case of Myocardial Infraction

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Abstract:

Background: The quantitation of left ventricle (LV) volumes and ejection fraction is an important aspect of cardiac evaluation in all cardiac disorders. So, two-dimensional (2D) ejection fraction is meaningful when applied across populations or to stratify risk in individuals.

Aims and objectives: To assess the prevalence of left ventricular systolic and diastolic dysfunction in patients with acute myocardial infraction and to evaluate their association with variables such as smoking, diabetes, hypertension, Kilip class, type of myocardial infraction etc. Relationship between the echocardiographic indices of systolic and diastolic dysfunction with development of early in hospital congestive heart failure was also assessed.

Material and Method: Individuals who were admitted for acute Myocardial Infarction in the Intensive Coronary Care Unit from FEBUARY 2019 to DECEMBER 2020 were evaluated for Left Ventricular Systolic and Diastolic function by 2D Doppler Echocardiography within 48 hours of admission. On the basis of this wall motion analysis scheme, a wall motion score index (WMSI) is calculated for each patient. Diastolic function is assessed by measuring the Trans-valvular pressure gradients using Doppler Echocardiography. The systolic and diastolic dysfunction assessed by the above methods was correlated with other variables such as Age, Sex, Smoking, Type of Myocardial Infarction, Killip class.

Results: There were 100 patients (male 72, females 28) included in the study with acute ST elevation Myocardial Infarction (MI). Anterior wall MI was found in 64 patients while inferior wall MI was seen in 36 patients. Males had higher incidence of Anterior MI compared to females. All the patients had regional wall motion abnormalities in their Echocardiogram and underwent thrombolysis. The mean Left Ventricular Ejection Fraction (LVEF) is lower in the Anterior MI group ($p<0.05$). Both left ventricular end systolic diameter and end diastolic diameters were higher in Anterior MI patents, but the difference was not statistically significant ($p>0.05$). The regional wall motion scoring index (RWMI) was higher in Anterior MI patients (1.57 ± 0.33 vs 1.30 ± 0.07). This was statistically significant ($p<0.05$) and can be explained by the difference in infarct dimensions among the groups. Older patients (age 56-60 years), presence of diabetes and smoking are significantly associated risk factors with heart failure in our study. LV Ejection Fraction had an AUC (area under the curve) of 0.862 which denotes that the LVEF has very high diagnostic accuracy in predicting heart failure (p value of <0.0001).

Conclusion: In-hospital congestive heart failure is more common in anterior wall myocardial infarction patients. Left ventricular ejection fraction predicted early heart failure best. Smoking and diabetes were linked to early in-hospital cardiac failure after myocardial infarction.
Key words: myocardial infraction, left ventricular ejection fraction, heart failure.

Introduction

In both sexes, Acute Myocardial Infarction ranks high on the list of main causes of death. Ventricular arrhythmias are the leading cause of premature death. Myocardial infarction can cause these arrhythmias, which lead to unexpected death. Left ventricular dysfunction and its consequences are typically responsible for the late mortality seen in patients with Myocardial Infarction. Myocardial infarction prognosis relies heavily on the amount of left ventricular function that survives the injury.

For patients with Acute Myocardial Infarction, echocardiography is the go-to non-invasive method for assessing left ventricular function. Systolic function can be evaluated with two-dimensional echocardiography, while diastolic function can be studied with Doppler echocardiography.

In addition, there are other risk factors that can lead to AMI. Inactivity, smoking, alcohol consumption, dyslipidemia, diabetes mellitus, hypertension, and obesity are all major contributors. Therefore, it is essential to address these risk factors to reduce the likelihood of developing AMI and to account for them in AMI treatment.

In light of the importance of left ventricular systolic and diastolic dysfunction in determining early in-hospital morbidity, particularly early Congestive Heart Failure, and risk factors associated with such patients, this study aimed to estimate prevalence using various echocardiographic indices in patients with Acute ST elevation Myocardial Infarction.

Material and Methods

The methodology used here was observational. Patients admitted to the Intensive Coronary Care Unit, Department of Medicine, with acute Myocardial Infarction from February 2019 to December 2020 were assessed. Within the first two days of admission, 2D Doppler Echocardiography was used to evaluate the systolic and diastolic function of the patient's left ventricle. Two-dimensional echocardiography is used to determine the ejection fraction of the left ventricle, the most widely used expression of left ventricular systolic performance.

Abnormalities in regional wall motion are also evaluated and classified as normal, hypokinesia, severe hypokinesia -akinesia, dyskinesia, or aneurysm. Using this method of wall motion analysis, we may approximate the severity of localized wall motion anomalies by computing a wall motion score index (WMSI).[1] A WMSI of 1 indicates a normal left ventricle, whereas higher values indicate more severe wall motion problems. All segments of the left ventricular (LV) wall can be seen in 2D-echocardiography from the parasternal, apical, and sometimes subcostal imaging windows. The American Society of Echocardiography suggests using a 16-segment model for analyzing regional wall motion. [2]

Diastolic function is assessed by measuring the Trans-Mitral pressure gradients using Doppler Echocardiography. Diastolic dysfunction is graded according to the filling pattern into: [3]

Grade I – impaired relaxation with normal filling pressures

Grade II – Pseudonormalised mitral inflow pattern

Grade III – reversible restrictive pattern

Grade IV – irreversible restrictive pattern

Age, sex, smoking status, myocardial infarction subtype, and Killip class all correlate with the systolic and diastolic dysfunction evaluated above. Clinical evaluation of individuals with acute Myocardial Infraction (MI) necessitated the development of the Killip classification. Individuals are categorized based on how severely they are affected by heart failure after a myocardial infarction.

Killip Classification: [4]

- Class I – no signs of heart failure,
- Class II – crackles in lower lung fields and 3rd heart sound,
- Class III – acute pulmonary edema,
- Class IV – cardiogenic shock

During their hospital stays, the individuals were observed clinically to detect the onset of congestive heart failure. Heart failure was diagnosed in patients with a Killip class lower than II. Killip evaluations are performed daily, with the best grade counted. Patients were categorized as having no congestive heart failure (Killip class = I) or having mild to moderate CHF (Killip class II) based on the Killip classification system. Recurrent angina or early malignant arrhythmias due to electrical instability are two examples of adverse events that occurred during the in-hospital development but were not addressed since they could be attributable to variables other than LV dysfunction.

After receiving standard therapeutic treatment (including beta blockers and angiotensin converting enzyme inhibitors), patients were monitored during their daily evolution in the hospital. Streptokinase was used for reperfusion treatment on all patients, as recommended by recommendations.

Statistical analysis

Unless otherwise noted, data were displayed as mean ± SD or as a proportion of the whole. SPSS version 20 was used for the statistical analysis. The Mann-Whitney U test or analysis of variance (ANOVA) was used to compare the continuous variables. The optimal threshold for Echocardiographic variables in predicting heart failure was determined by plotting ROC curves. In order to evaluate the correlation between the clinical and echocardiographic variables and heart failure, univariate logistic regression was performed. The significant univariate variables were incorporated into a full multivariate logistic regression model. A significance level of 0.05 was used.

Results

Acute ST-elevation myocardial infarction was the presenting symptom in each of the 100 study participants. The Echocardiograms of all the patients showed anomalies in regional wall motion, and all of them received thrombolysis. The breakdown (table 1) showed 72 males and 28 females. Only patients aged 30-60 were included in the study, and males are more likely to get an ST-elevation myocardial infarction (STEMI) in this age range.

The rate of STEMI diagnoses rises with age, as depicted by the chart showing the breakdown of diagnoses by age group. The majority of female patients are between the ages of 56 and 60, suggesting that postmenopausal women are at a higher risk for MI (table 1).

Table 1: Age group and sex wise distribution

Age group (years)	Sex		Total
	Female	Male	
<40	2	6	8
41-45	4	8	12
46-50	6	16	22
51-55	4	22	26
56-60	12	20	32
Total	28	72	100

There was no significant difference in age or sex wise distribution between the two groups. Mean age in the Anterior MI group was 51 years compared to a mean age of 52 in the Inferior MI group. Males had higher incidence of Anterior MI compared to females. However, the difference was not statistically significant when compare with a fisher exact test (p=0.325f). The mean systolic blood pressure was higher in the Anterior MI group (133 ± 26 mmHg vs 117 ± 30 mmHg in Inferior MI group) however the difference did not reach statistical significance (p>0.05). The diastolic blood pressure was not statistically significant in both the groups (p>0.05) (table 2).

Table 2: Distribution based on type of MI

MI type	Age (years)	Sex		Systolic BP (mmHg)	Diastolic BP (mmHg)
	Mean ± SD	Female (n)	Male (n)	Mean ± SD	Mean ± SD
Inferior	52 ± 7	14	22	117 ± 30	83 ± 20
Anterior	51 ± 6	14	50	133 ± 26	89 ± 19
P value (ANOVA)	0.426	0.325		0.057	0.303

The mean LVEF (Left Ventricular Ejection Fraction) is lower in the Anterior MI group (p<0.05) implying that Anterior Myocardial Infarction patients are more likely to develop LV systolic dysfunction, which is not surprising given the fact that Anterior MI tends to affect larger area of left ventricle. Both left ventricular end systolic diameter (LVESD) and left ventricular end diastolic diameters (LVEDD) were higher in Anterior MI group, but the difference was not statistically significant (p>0.05). The regional wall motion scoring index (RWMI) was higher in Anterior MI patients (1.57 ± 0.33 vs 1.30 ± 0.07). This was statistically significant (p<0.05) and can be explained by the difference in infarct dimensions among the groups (Table 3).

Table 3: Echocardiographic parameters in MI types

Parameters	Type of Myocardial infarction			
	Inferior	Anterior	Comparison between groups	
	Mean ± SD	Mean ± SD	F	P
LVEF (%)	48 ± 13	42 ± 10	4.281	0.044
LVEDD (cm)	4.5833 ± 0.8847	4.7750 ± 0.8116	0.602	0.441
LVESD (cm)	3.4278 ± 0.9067	3.7781 ± 0.8003	2.006	0.163
RWMI	1.3056 ± .0770	1.5742 ± 0.3309	11.421	0.001

There was no significant difference in the distribution of diastolic dysfunction among the MI types (p>0.05). Diastolic dysfunction tends to be equally distributed between anterior and inferior myocardial infarction groups. 52 patients (52%) had normal LV filling while 48 patients (48%) had diastolic dysfunction. Among those 48 patients, 40 patients had grade I diastolic dysfunction and only 8 patients had grade II diastolic dysfunction. None had grade III or grade IV diastolic dysfunction which is uncommon in the setting of first AMI. The left ventricular Ejection Fraction was significantly less in the anterior MI group compared to the inferior MI group (p<0.05). Similarly, the regional wall motion scoring index also was higher in the anterior MI group (p<0.05). However, diastolic dysfunction was equally distributed between the MI types. There was no difference in number of days of ICCU stay or hospital stay between males and females. Diabetics had higher duration of ICCU and hospital stay compared with non-diabetics. Similarly, smokers also had a higher duration of hospitalization. Patients with symptoms of heart failure had longer duration of ICCU as well as total hospital stay as expected (table 4).

Table 4: Hospital stay for different groups (in days)

Clinical variable		ICCU		Total Hospital	
		Mean	**SD**	**Mean**	**SD**
Sex	Female	2.545	0.688	6.636	0.674
	Male	2.676	0.768	6.912	0.996
MI Type	Inferior	2.750	0.856	7.000	1.155
	Anterior	2.586	0.682	6.759	0.786
Diabetes	No	2.703	0.740	6.625	0.966
	Yes	2.375	0.744	6.892	0.744
Smoking	No	2.500	0.673	6.545	0.671
	Yes	2.783	0.795	7.130	1.058
Heart Failure	No	2.368	0.496	6.684	0.671
	Yes	2.846	0.834	6.962	1.076

All the 100 patients were monitored for development of early in-hospital congestive heart failure (defined as Killip class ≥ II). The highest class during the hospital stay was considered for analysis. There was no significant difference in incidence of heart failure among the different MI types (p>0.05). Older patients (51-60 years) had higher percentage of heart failure symptoms. However, the difference in heart failure rates among the age groups, did not reach statistical significance (p>0.05). Prior history of systemic hypertension was comparable between the groups. The admission mean systolic blood pressure was 15 mmHg lower in the heart failure group. This difference can be attributed to the patients with cardiogenic shock in the heart failure group. But the difference was not statistically significant (p>0.05). Risk factors like diabetes mellitus was significantly associated with heart failure patients (p>0.05). Also the number of days spend in ICCU were more seen in heart failure patients (p>0.05) (table 5).

Table 5: Baseline Clinical variables in Heart failure groups

Clinical variables	Heart Failure (Killip class ≥ II)		P value
	Absent (n=19)	**Present (n=31)**	
Age (years)	50.16 ± 6.98	52.29 ± 5.23	0.336
Systemic Hypertension	12 (50%)	12(50%)	0.496
At Admission Systolic BP	136.32 ± 29.10	121.55 ± 26.38	0.143
At Admission Diastolic BP	90.53 ± 16.82	83.87 ± 20.11	0.347
Diabetes Mellitus	2 (8.3%)	22 (91.7%)	0.018*
Smoking	12 (24%)	38 (74%)	0.079
Hyperlipidemia	8(33.3%)	16 (66.7%)	0.490
No. of days in ICCU	2.37 ± 0.50	2.85 ± 0.83	0.046*
Total no. of days in hospital	6.68 ± 0.67	6.96 ± 1.08	0.514

Echocardiographic parameters like Left ventricular end systolic diameter (LVESD), left ventricular end diastolic diameters (LVEDD), left ventricular ejection fraction (LVEF) and the regional wall motion scoring index (RWMI) were evaluated and all the parameters were found statistically significant compared with the patients without heart failure. Echocardiographic parameters are significantly abnormal in the heart failure group compared with the normal group. Among the echocardiographic parameters the LV ejection fraction had the most significant difference between the groups. Hence it appears that diastolic dysfunction as detected by echocardiography has a significant relationship with heart failure. Diabetes was significantly correlating with heart failure. Diabetic patients were 9 times more likely to develop heart failure symptoms following AMI compared with non-diabetics (p value of <0.05). Similarly, smokers were also 3 times more likely to develop heart failure compared to non-smokers (p value of <0.05). Among the Echocardiographic parameters LV Ejection Fraction <40 had the strongest predicting ability with an odds ratio of 24 which was statistically highly significant (p<0.001). Wall motion scoring index and diastolic dysfunction also had good ability to predict heart failure with an odds ratio of 9 and 7 respectively (p value <0.05). While there was no significant correlation between clinical parameters age, sex, MI location, admission Systolic blood pressure.

Table 6: Univariate Regression analysis for determining variables associated with early Heart Failure

Variable	Odds ratio	Regression coefficient	Standard error	P value
Age	1.063	0.061	0.050	0.222
Sex	3.030	1.109	0.650	0.088
MI Type	2.200	0.788	0.606	0.193
Systolic BP	0.980	-0.020	0.012	0.084
Diabetes mellitus	9.900	2.293	1.094	0.036*
Smoking	3.431	1.233	0.616	0.045*
LVEF ≤ 40	24.437	3.196	0.853	<0.001*
RWMI ≤ 1.7	8.571	2.148	1.097	0.049*
Diastolic dysfunction	6.818	1.920	0.676	0.005*

We did multivariate regression model where all the three significantly correlating echocardiographic parameters (in univariate analysis) are simultaneously analyzed for any confounders and interdependence among the variables. The overall model was statistically significant with a p value of <0.001. LV Ejection Fraction and Diastolic Dysfunction correlated significantly with heart failure. The corrected odds ratio for LVEF ≤ 40 for predicting heart failure was 14.38 i.e. a patient with a LVEF of less than 40% is 14 times more likely to develop heart failure symptoms than a patient with LVEF >40. The corrected odds ratio for Diastolic Dysfunction was 5.74, and it was statistically significant with a p value of 0.035.

However, the Regional Wall Motion Scoring Index though had a higher odd associating it with heart failure, it was not statistically significant within the model. This paradox is likely due to the fact that LV ejection fraction and Wall Motion Scoring are highly inter-dependent variables. When both of them are included in the model it becomes superfluous. Further when we look at the univariate analysis the correlation between LV

Ejection Fraction and heart failure is better than that between Regional Wall Motion Scoring Index and heart failure. This could be because of the complex and operator dependent nature of the index.

All the clinical and echocardiographic variables couldn't be analyzed in the same Multivariate Logistic Regression model, making it less robust as the sample size was small and the number of variables to sample ratio should be maintained more than at least 1:10 or preferably 1:20. So only the three main echocardiographic variables were included in the regression model.

When backward conditional elimination of variables was followed, Wall motion scoring index was removed from the model and only LV Ejection Fraction and Diastolic Dysfunction remained. On the whole the model was able to accurately classify the patients into heart failure or normal in 80% of the cases.

Discussion

In this study one hundred patient's diagnosed first time with Acute Myocardial Infarction were evaluated in the study. The study mainly focuses on the echocardiographic evaluation of patients with Myocardial Infraction (MI) and identification of left ventricular systolic and diastolic dysfunction in them.

In our study 50% (n=25) of the patients had systolic dysfunction (LV ejection fraction <40%). As patients with previous MI, heart failure symptoms or valvular heart disease have been excluded, the systolic dysfunction can be predominantly attributed to the index coronary event. In a similar Portuguese study by PS Mateus et al [5], 56% had LV systolic dysfunction (they had used LEVF cut-off of 45%). The TRACE trial [6] had a more stringent cut off (LVEF<35%) and found that 40% had Systolic dysfunction. In a Kosovo study by Kocinaj D et al [7] 48% of patients with first Anterior wall MI had LV systolic dysfunction. Our study results were comparable with other similar studies with similar cut-off for detecting LV systolic dysfunction.

A total of 24 out of 50 patients (48%) had restrictive filling pattern in echocardiogram (diastolic dysfunction). In a similar study by S H Poulsen et al,[8] 35% of the patients had impaired LV filling pattern while in the study done by Whalley et al[9] 20% of the patients had LV dysfunction. However, the range has varied depending on the criteria used to identify patients with diastolic dysfunction. This wide variation among studies can be explained by the fact that different echocardiographic parameters and different criteria were used.

Our study which graded diastolic dysfunction based on the ASE/EAE guidelines [10] pegged the incidence of diastolic dysfunction at 48% following AMI, which was midway between the extreme ranges reported in other studies. The age, sex wise distribution of systolic and diastolic dysfunction was not statistically significant. Systolic dysfunction was found more frequently in patients with Anterior MI compared with inferior MI. Many studies in the past had similar results comparing the site of infarction with LV ejection fraction. In the study by Mc Clements BM et al,[10] the LV ejection fraction was 8% lower for anterior compared with inferior MI.

The Regional wall motion scoring index was significantly higher in the Anterior MI group. The same has been shown in the study done by McClements BM et al. [10] The incidence of heart failure symptoms (as defined by Killip class ≥ II) was 63% (n=31). This was both at the time of hospital admission as well as during the subsequent stay in the hospital. In the study of Yuasa[11] et al which included CHF among other end points such as paroxysmal atrial fibrillation, ventricular tachycardia, ventricular fibrillation, AV block, pericardial effusion and cardiac rupture, the prevalence of CHF was only 19%. The Valsartan in Acute Myocardial Infarction trial (VALIANT) trial [12] showed an incidence of 23.1 at admission, with a higher number being discharged with a diuretic.

In our study only LVEF and presence of Diastolic Dysfunction were strong independent predictors for the development of early CHF following AMI. Wall motion scoring index, when adjusted for age also was a good predictor. However, in our study wall motion scoring index though correlated well in the univariate analysis did not reach statistical significance in the multivariate regression analysis.

In the above study they also correlated Myocardial Performance Index (MPI) with heart failure. However even though MPI is a global myocardial performance index including both systolic and diastolic echocardiographic indices, it did not significantly correlate with development of heart failure symptoms.

In a retrospective study done by Lavine et al [13] found that LVEF was superior to other indices in predicting development of heart failure in patients without any clinical evidence of CHF at admission during the first 15 days of admission following AMI. In the study by schwammenthal et al. [14] also reported a LVEF ≤0.40 as a powerful and independent predictor of poor outcome.

Regional wall motion scoring index of LV systolic function did not provide any additional prognostic information over LV ejection fraction. This paradox may be explained by the fact the both variables are interdependent and Wall motion analysis is a complex and highly subjective quantification of inter-observer variation. In comparison LVEF is an easily measurable echocardiographic index and is easily reproducible, thereby the errors in LVEF estimation are very less. Similar findings were obtained in studies by Yuvasa et al [11] and DeMichele. [15]

In our study, Diabetes and Smoking were predictors of early in hospital heart failure in the univariate analysis. Further studies are needed with larger study population to assess the interdependence of clinical and echocardiographic parameters.

Limitations of the study

Though extremes of age were excluded in the study to minimize the influence of age on diastolic dysfunction, the study group included a sizeable number of diabetics and hypertensive who might have pre-existing diastolic dysfunction, which might confound the results.

Our results about the prognostic influence of Regional Wall Motion scoring Index for first ST-elevation AMI was inconclusive, due to the limited number of patients in the study group and operator dependent nature of the index.

We couldn’t analyze all the clinical and echocardiographic variables simultaneously in the multivariate logistic regression as the study group was small and the variable to population ratio (1:10) would exceed the guidelines.

The recent global indices of systolic and diastolic function like the Myocardial Performance Index (MPI) were not included for analysis.

Conclusion

Early hospital-onset congestive heart failure is more common in patients diagnosed with anterior wall myocardial infarction who have not previously experienced heart failure symptoms. Not only was that, but the best indicator of impending heart failure the ejection fraction of the left ventricle. Early hospitalization for heart failure after a myocardial infarction was substantially linked to the presence of risk factors like smoking and diabetes.

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