Original Article

TISSUE DOPPLER IMAGING VERSUS CONVENTIONAL ECHOCARDIOGRAPHY IN ASSESSMENT OF LEFT VENTRICULAR SYSTOLIC AND DIASTOLIC FUNCTION FOLLOWING MYOCARDIAL INFARCTION

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ABSTRACT:
Objective:
Following myocardial infarction (MI), left ventricular (LV) systolic and diastolic function can be quantitative assessed by tissue Doppler imaging (TDI). The present study was aimed at comparing TDI and conventional echocardiography in evaluation of left ventricular systolic and diastolic function in patients with first episode of acute MI.
Material & Methods:
This was a single centre, prospective, comparative, observational study, performed over a period of 1 year, involving 100 consecutive patients of acute ST elevation MI (STEMI), admitted in the ICCU, Department of Cardiology of tertiary care teaching institute. Based on the left ventricular ejection fraction (LVEF), patients were divided into two groups: Group I (LVEF > 50%) and Group II (LVEF < 50%).
Results:
Majority of the patients i.e., 52% had LVEF < 50%. The mean IVRT (isovolumic relaxation time) was statistically higher in group II as compared to group I (p-value < 0.0001) and sensitivity and specificity were 80.76 % and 75 %, respectively. Also, compared to group I, the mean E/e' ratio at septal mitral annulus was significantly higher in group II patients (p-value < 0.0001) and sensitivity and specificity were 98.07 % and 89.59 %, respectively.
Conclusion: As the TDI parameter such as E/e' ratio was significantly higher in patients with LV systolic and diastolic dysfunction, TDI can help in forecasting LV dysfunction.

Keywords: Echocardiography; Left ventricular dysfunction; Myocardial infarction; Tissue Doppler imaging.

INTRODUCTION

Globally, cardiovascular diseases (CVD) are the principal cause of death, and ischemic heart disease Diseases (IHD) is the primary reason for the loss of health.[1,2] Similarly, Indian population has higher prevalence and poor control of cardiovascular risk factors, but is significantly younger, has significantly higher incidence of angina and significantly lower incidence of myocardial infarction as compared to the rest of the world.[3]

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Following acute MI, diastolic dysfunction can be identified during both the early and late phases of MI, with or without left ventricular (LV) systolic dysfunction.[4] Echocardiography has progressed as a well-recognized non-invasive technique for the assessment of functioning of localized and entire myocardium.[5] Conventional echocardiographic indicators of poor prognosis, including LVEF and restrictive filling pattern have been lately enriched by the introduction of tissue Doppler imaging (TDI).[6] TDI is an echocardiographic procedure that allows evaluation of atrioventricular annular and regional myocardial velocities, and might be more sensitive compared to conventional echocardiography in identifying aberrations of LV systolic and diastolic functions.[7]

Diastolic dysfunction is a prominent indicator of consequences after MI because it is linked to evolving LV dilatation, progression of heart failure and cardiac death.[8] The TDI parameters such as early and late diastolic velocity are robust markers of cardiac mortality. In patients with LV systolic dysfunction, early diastolic tissue velocity at mitral annulus is an effective prognostic indicator of cardiac mortality.[9,10] Comparison of TDI and conventional echocardiography imaging finds its mention in Western literature. But such studies from the perspective of adult Indian patients are lacking. Thus, this study was commenced with an objective of evaluating the role of different parameters of TDI in assessment of LV systolic and diastolic function and comparing it with conventional echocardiography. The secondary objective was to assess the different predictors of cardiac function early after MI.

MATERIAL AND METHODS

Study design and participants

This was a single centre, prospective, comparative, observational study. It was conducted on 100 consecutive cases of acute ST elevation MI (STEMI), admitted in the ICCU, Department of Cardiology, S.S Institute of Medical Sciences and Research Centre Hospital, Davangere. The study was performed over a period of 1 years (i.e., from August 2017 to July 2018). Based on the left ventricular ejection fraction (LVEF), patients were divided into two groups: Group I (Normal LV function group i.e. LVEF >50%) and Group II (LV dysfunction group i.e. LVEF <50%).

Patients aged 18 to 80 years, presenting with first attack of acute STEMI, and having sinus rhythm were included in the study. While, those with past history of MI; failed primary PCI; suffering from cardiogenic shock, right ventricular infarction, supraventricular or ventricular arrhythmias; presence of LBBB on the ECG or LV aneurysm at echocardiography; any medical condition interfering with standard medical management; and those on thrombolytic agents were excluded from the study.

Written informed consent was obtained from each patient before enrolment in the study by explaining the nature of the study to the patients in their native language. The study was approved by the Institutional Ethics Committee.

Study procedure

All patients were subjected to detailed history taking; full clinical assessment with special attention to hemodynamic parameters; standard medical treatment according to international guidelines; and echocardiographic examination. All patients underwent conventional TTE examination as well as TDI within few hours of admission, using GE VIVID S6 – colored echocardiographic machine with TDI software incorporated in the device using a 3.5 MHz transducer.

Study parameters

Conventional trans-thoracic echocardiography (TTE) was performed to measure LV systolic function by M-mode and by biplane Simpson's; and LV diastolic function by measuring transmitral early and late velocities (E, A velocities), and E/A ratio.

Doppler echocardiography was performed to measure peak early diastolic inflow velocity (E-wave velocity; cm/s), peak late diastolic inflow velocity (A-wave velocity; cm/s), E/A ratio; E-wave deceleration time (EDT; msec); and left ventricular isovolumic relaxation time (IVRT; msec).

Tissue Doppler imaging (TDI) was performed to measure mitral annular or basal segmental systolic velocity (S; cm/s); and mitral annular or basal segmental early diastolic velocity (e'; cm/s) in, and E/e' ratio.

Statistical analysis

Quantitative data was expressed as Mean ± standard deviation (SD) and qualitative data was expressed as frequencies. Unpaired t-test was used for comparing means of two independent groups. Fisher's exact test was used for comparing frequencies of two independent groups. Receiver operating characteristic (ROC) curve was drawn to define the cut-off values and its sensitivity and specificity for prediction of LV dysfunction. A p-value < 0.05 was considered as statistically significant.

RESULTS:

Majority of the patients i.e., 52% had LVEF < 50%. Table 1 demonstrates demographic characteristics and risk factors in both the study groups. Mean ages of male and female patients in group I were 53.26±11.99 years and 55.29±9.09 years, respectively. Similarly, mean ages of male and female patients in group II were 58.00±11.84 years and 60.63±8.61 years, respectively. None of the demographic characteristics or risk factors in the study population revealed significant difference in both groups. This shows homogenous nature of the study population.

Table 2 demonstrates the effect of mean LVEF (%), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean blood pressure (MBP) on the left ventricular function in both the study groups. There was a statistically significant greater LVEF (%) in group I, as compared to group II (p-value < 0.0001). However, compared to group I, group II showed significantly higher mean HR (p-value < 0.0001). Further analysis revealed no statistically significant difference in both the groups with respect to mean SBP (p-value = 0.1231), DBP (p-value = 0.1404), and MBP (p-value = 0.1072).

Table 1. Comparison between demographic characteristics and risk factors in both

Sr. no.	Characteristics	Group I	Group II	p-value
1	**Age (years)**	54.15±10.7	59.21±10.5	0.2032#
2	**Gender – Male**	27 (56.3)	28 (53.9 %)	0.8427$
3	**Diabetes mellitus**	27 (56.3%)	32 (61.6 %)	0.6851$
4	**Hypertension**	21 (43.8%)	25 (48.1%)	0.6924$
5	**Dyslipidaemia**	23 (47.9%)	29 (55.8%)	0.5482$

(# - Unpaired t-test; $ - Fisher's exact test)

Table 2. Effect of mean LVEF (%), HR, SBP, DBP, MBP on LV function

Groups	LVEF (%)	HR (/min)	SBP (mmHg)	DBP (mm Hg)	MBP (mmHg)
I (n = 48)	53.60± 2.01	76.3 ±8.6	136.5± 16.4	83.96 ±7.4	101.5 ±9.7
II (n = 52)	40.04± 5.49	87.8± 11.2	130.9± 18.7	81.35 ±9.9	97.9 ±12.0
#p-value	< 0.001	< 0.001	0.1231	0.1404	0.1072

(*Data expressed as mean±SD; LVEF – Left Ventricular Ejection Fraction (%); HR – Heart rate; SBP – Systolic BP; DBP – Diastolic BP; MBP – Mean BP; # - Unpaired t-test; p-value < 0.05 is considered as statistically significant.*)

Table 3 demonstrates the effect of mean E/A ratio, EDT, and isovolumic relaxation time (IVRT) on the left ventricular function. There was no statistically significant difference between the two study groups in mean E/A ratio (p-value = 0.1074) and mean EDT (p-value = 0.1492). However, there was a statistically significant higher mean IVRT in group II when compared to group I (p-value < 0.0001).

Table 4 demonstrates the effect of mean s-wave velocity, mean e'-wave velocity, and mean E/e' ratio at septal mitral annulus on left ventricular function. On comparing both the groups, the mean S-wave measured at septal mitral annulus failed to show a significant difference (p-value = 0.0755).

However, the mean baseline e'-wave measured at the septal mitral annulus revealed a statistically significant difference between both the study groups (p-value < 0.0001). Furthermore, compared to group I, the mean E/e' ratio calculated at septal mitral annulus was significantly higher in group II patients with LV dysfunction after myocardial infarction (p-value < 0.0001).

Table 3. Effect of mean E/A ratio, EDT (msec), and IVRT (msec) on left ventricular function

Particulars	Group I (n = 48)	Group II (n = 52)
E/A ratio		
Mean±SD	1.05±0.21	0.97±0.24
Range	0.625–1.5	0.55–1.6
#p-value	0.1074	
EDT (msec)		
Mean±SD	189.44±24.68	197.67±31.27
Range	144–235	135–262
#p-value	0.1492	
IVRT (msec)		
Mean±SD	100.54±13.37	129.11±20.44
Range	74–141	78–158
#p-value	< 0.0001	

(*Data expressed as mean±SD; E/A ratio – transmitral early and late diastolic velocities; EDT – E wave deceleration time (msec); IVRT – isovolumic relaxation time (msec); # - Unpaired t-test; p-value < 0.05 is considered as statistically significant.*)

Table 4. Effect of mean S-wave velocity, e'-wave velocity, and E/e' ratio at septal mitral annulus on left ventricular function

	Group I (n = 48)	Group II (n = 52)
S-wave (cm/s)		
Mean±SD	7.19±0.93	6.82±1.11
#p-value	0.0755	
e'-wave (cm/s)		
Mean±SD	9.29±0.56	5.63±0.92
#p-value	< 0.0001	
E/e' ratio		
Mean±SD	8.21±1.38	13.63±2.63
#p-value	< 0.0001	

DISCUSSION

The occurrence of heart failure and/or left ventricular systolic dysfunction following MI significantly increases the morbidity and mortality. However, the incidence of heart failure after MI has decreased over the last few decades.[11,12] After acute MI, the absence of signs and symptoms of HF results in the hindrance in the process of diagnosis and management.

Recently, TDI has been used extensively and a number of its parameters have been suggested to be beneficial in numerous cardiac diseases. The long-axis motion of the ventricle is represented by the mitral annular or basal LV velocities and is a valuable constituent of LV systolic and diastolic function.[13] Finally, the mildly inadequate LV systolic function is indicated by peak systolic velocity and it is sensitive enough even in those with a normal LVEF or seemingly conserved LV systolic function.[14] Following MI, the TDI parameters combined with other echocardiographic indicators can forecast survival and these parameters includes the S-wave velocity, e'-wave velocity, and ratio of the early diastolic mitral filling velocity to the early diastolic tissue velocity of the mitral annulus (E/e').[15,16]

In the present study, mean age of the patients was 55.86±11.11 years. Majority of the patients were male i.e., 55 %. Mean ages of male and female patients were 55.67±12.04 and 58.13±9.14 years, respectively. These findings are in agreement with the previous studies, according to which CAD is more prevalent in middle-aged male patients and in women, incidence of CAD increases with age.[17] In the present study, male patients had higher incidence of LV dysfunction following AMI, but this finding did not reach statistically significant association (p-value = 0.8427). But Kenawy et al.[7] and Mateus et al.[18] reported contradictory findings, in which females had higher incidence of LV dysfunction.

The prevalence of major CVD risk factors in Indian patients has been reported by World Health Statistics.[19] Mateus et al. concluded that the prior presence of CV risk factors has a positive correlation with possibility of developing LV dysfunction after the first episode of MI.[18] In the present study, risk factors were prevalent in patients who developed LV dysfunction, but none showed significant ability to predict the development of LV dysfunction. These results were similar to those reported by Alam et al.20 and Mateus et al.[18]

Heart rate is a key goal for the management of ischemia and LV dysfunction and it is observed that relatively increased HR is involved in pathophysiological processes.[21] In the present study, the heart rate was significantly higher in the patients with LV dysfunction. These results are similar to those reported by Lewis et al.[22] and Choy et al.[23] The present study used the SBP, DBP, and MBP measurements and found no effect on LV function. Similar studies by Lewis et al. in 2003 and 2008 reported that after an acute MI, elevated SBP is associated with an increased risk of subsequent cardiovascular events[22,23]. Kenawy et al.7 reported no effect of MBP on LV function.

Conventional trans-thoracic echocardiography (TTE)

In the present study, 52 % of the patients had LVEF ≤ 50 %. Thus, this observation is in correspondence with the previous epidemiological studies.25 There was a statistically significant greater LVEF in group I as compared to group II (p-value < 0.0001). Lewis et al. concluded that following MI, LVEF was the second most significant indicator of LV dysfunction (p-value < 0.001).[24] Schwammenthal et al. reported similar findings.[26]

Doppler echocardiography

In the present study, on comparison between the groups, none of these parameters were found to be statistically significant i.e., E/A ratio (p-value = 0.1074), and EDT (p-value = 0.1492), except IVRT which was found to be statistically significant (p-value < 0.0001). In contrast to our findings, study by Schwammenthal et al. reported significant difference in E/A ratio (p-value = 0.002) and EDT (p-value = 0.000008) between the study groups.26 This was mainly due to larger study population. Similar to the present study, Kenawy et al. reported significant difference in IVRT (p-value = 0.003) between the study groups.[7] In the present study, based on IVRT, the sensitivity and specificity were 91.7% and 76.9%, respectively. Kenawy et al. reported a lower sensitivity of 85% and a greater specificity of 84%, respectively.[7]

Tissue Doppler imaging (TDI)

In the present study, it was observed that group II patients had lower mean S-wave velocity (Sm), but there was no statistically significant difference between the two groups (p-value = 0.0755). Alam et al. reported that a mean Sm of ≥ 7.5 cm/s predicted a preserved LVEF with relatively high sensitivity and specificity.20 Study by Wang et al. reported similar findings.[15]

In the present study, there was a statistically significant difference between the two groups in mitral diastolic velocity (e') (p-value < 0.0001), indicating that after AMI, diastolic dysfunction is associated with systolic dysfunction. Following MI, the decreased velocity at the site of infarction represents myocardial damage.[17] Similar results were reported in studies by Alam et al.[20] and Wang et al.[15]

In the present study, based on the E/e' ratio at the septal mitral annulus, the sensitivity and specificity were 100% and 96.2%, respectively. However, Kenawy et al. reported a lower sensitivity and specificity of 79% and 88%, respectively.[7] There was a statistically significant difference between the two groups for E/e' ratio (p-value < 0.0001). Studies by Wang et al.15 and Park et al.27 reported similar findings. A study by Moller et al. reported that E/e' ratio is a strong indicator of cardiac death and readmission as a result of HF following first MI.[28]

Limitations of the study

Limitations includes the relatively small number of the patients which restricts generalizability of the study results to general population and no follow-up period in the study protocol.

CONCLUSION

As the TDI parameter such as E/e' ratio was significantly increased in patients with LV systolic and diastolic dysfunction, TDI can help in forecasting LV dysfunction in patients with acute MI. Thus, leading to early initiation of medications for the management of impending heart failure.

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