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Assessment of Left Ventricular Diastolic Dysfunction by Tissue Doppler Imaging in Acute Myocardial Infarction

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Abstract

Introduction: Coronary artery disease is the primary cause of global morbidity and mortality, with myocardial infarction (AMI) as its most prevalent manifestation. Left ventricular (LV) diastolic dysfunction is commonly observed after acute myocardial infarction (AMI) and is a significant predictor of unfavourable remodelling, heart failure, and death. Tissue Doppler Imaging (TDI) offers a quantitative evaluation of myocardial relaxation and may address the shortcomings of traditional Doppler indices. The aim of present study is to evaluate left ventricular systolic and diastolic function by Tissue Doppler imaging after acute myocardial infarction.

Material and methods: This cross-sectional study was performed at the Department of Cardiology for a duration of six months. A total of 128 individuals with acute myocardial infarction (within 6 months) were enrolled following the application of inclusion and exclusion criteria. A thorough echocardiographic assessment was conducted, encompassing conventional Doppler and tissue Doppler imaging (TDI) and all the parameters were measured. Statistical relationships between Em and echocardiographic parameters were examined.

Results: The average age of the study population was 47.2 ± 6.5 years, comprising 68.8% men. Decreased Em velocities were noted at all annular sites, although Am velocities remained reasonably intact. A total of 86 patients (67.2%) demonstrated diastolic dysfunction: Grade I (42.2%), Grade II (20.3%), and Grade III (4.7%), whereas 32.8% indicated normal function. Em exhibited substantial positive relationships with ejection fraction ($r = 0.52$, $p < 0.001$) and early mitral inflow velocity E ($r = 0.61$, $p < 0.001$). The correlations with isovolumic relaxation time ($r = -0.12$, $p = 0.18$) and deceleration time ($r = -0.09$, $p = 0.27$) were minor and statistically insignificant.

Conclusion: TDI is a dependable method for evaluating left ventricular diastolic function following acute myocardial infarction. The reduced Em velocity signifies both localised and global relaxation problems and exhibits a strong correlation with EF and mitral inflow velocity, underscoring its prognostic value. The restricted associations with IVRT and DT highlight the superiority of TDI compared to traditional Doppler markers in this clinical context.

Keywords: Ejection fraction, left ventricular dysfunction, Peak diastolic velocity, Tissue Doppler imaging

Introduction

Coronary artery disease is the primary cause of global mortality and morbidity, with acute myocardial infarction being the most prevalent manifestation [1, 2]. In individuals with acute myocardial infarction, heart failure is defined by either isolated systolic dysfunction or a combination of systolic and diastolic dysfunction. Diastolic dysfunction has been identified both in the early and post-myocardial infarction phases, with or without concomitant left ventricular systolic dysfunction [3, 4]. Diastolic dysfunction is a significant prognostic indicator after myocardial infarction, as it correlates with progressive left ventricular dilatation, the onset of heart failure, and cardiac mortality [5,6]. Two-dimensional (2D) echocardiography is regarded as the superior technique for assessing both the overall and localised function of the ventricles. Nonetheless, the conventional assessment of wall motion, which depends on the visual interpretation of the inner layer of the heart's movement and myocardial thickness, possesses inherent limitations. This is a qualitative method that is subjective and depends on the evaluator's skill [7].

Tissue Doppler Imaging (TDI) is an enhanced version of conventional Doppler echocardiography that allows for direct assessment of tissue velocities by modifying the image acquisition procedure. The original utilization of TDI in assessing cardiac mechanical activities involved estimating the maximum systolic and diastolic tissue velocities of the specific segment. TDI parameters, i.e., systolic velocity (Sm), early diastolic velocity (Em) and late diastolic velocity (Am) are powerful predictors of cardiac mortality [8, 9]. The outcomes have shown considerable promise thus far [10].

The present study was done with an aim to evaluate left ventricular systolic and diastolic function by Tissue Doppler imaging after acute myocardial infarction.

Material and Methods

The present cross-sectional study was conducted at Department of Cardiology for a period of 6 months. Ethical clearance for conducting the research was taken from institutional ethics committee of college and hospital. Written informed consent was taken from patients.

Through consecutive sampling a total of 128 patients of myocardial infarction were recruited for the study after applying the inclusion and exclusion criteria.

Inclusion criteria

1. Patients diagnosed with myocardial infarction recently within 6 months of study.
2. Patients willing to participate in the study.

Exclusion criteria

1. Patients of age above 50 years.
2. Patients with old MI.
3. Patients with congestive cardiac failure, valvular lesions, arrhythmias, cardiomyopathy, left bundle branch block, hypertension and coronary artery by-pass grafting
4. Patients of diabetes mellitus.

Patients underwent comprehensive evaluation. Each patient got a comprehensive echocardiographic evaluation, specifically conventional echocardiography and tissue Doppler imaging (TDI). The pulsed wave TDI was conducted at four distinct locations on the mitral annulus: lateral, septal, anterior, and inferior. The apical 4-chamber view was utilised for lateral and septal sites, while the apical 2-chamber view was employed for anterior and inferior sites. Peak Em and peak Am were assessed at all four locations of the mitral annulus. The ejection fraction was determined using the Modified Simpson’s technique from apical four and two-chamber images. All echocardiographic measurements were evaluated. Data analysis was conducted using SPSS (Statistical Package for Social Sciences) version 25.0 for Windows. The mean and standard deviation serve as descriptive statistics for quantitative data, whereas the median and range are utilised for non-normally distributed data. The Student's t-test and the non-parametric Mann-Whitney test were employed to compare the means of two independent groups. The Chi-square and Fisher exact tests were employed to assess the independence of proportions. A p-value less than 0.05 is deemed significant.

Results

The average age of the study population was 47.2 ± 6.5 years. Among the total, 88 patients (68.8%) were male, while 40 patients (31.2%) were female as shown in table 1.

Table 1: Demographic profile of the study participants

Variable	Value
Age (mean ± SD)	47.2 ± 6.5 years
Male (%)	88 (68.8%)
Female (%)	40 (31.2%)

TDI velocities were measured at four mitral annular locations: septal, lateral, anterior, and inferior. The mean early diastolic velocity (Em) varied from 5.2 ± 1.4 cm/s (septal) to 6.3 ± 1.6 cm/s (lateral), whereas the late diastolic velocity (Am) ranged from 9.1 ± 2.3 cm/s (septal) to 10.2 ± 2.8 cm/s (lateral). In general, Em velocities decreased at all annular sites, although Am velocities remained reasonably intact, suggesting compromised myocardial relaxation in a significant number of patients as shown in table 2.

Table 2: Tissue Doppler Imaging parameters

Parameter	Mean ± SD
Septal Em	5.2 ± 1.4
Septal Am	9.1 ± 2.3
Lateral Em	6.3 ± 1.6
Lateral Am	10.2 ± 2.8
Anterior Em	5.8 ± 1.5
Anterior Am	9.7 ± 2.6
Inferior Em	5.5 ± 1.7
Inferior Am	9.4 ± 2.4

Patients were classified into diastolic function groups according to the TDI indices. Among the 128 patients, 42 (32.8%) demonstrated normal diastolic function, whereas 86 (67.2%) displayed varying degrees of diastolic dysfunction. The predominant abnormality identified was Grade I diastolic dysfunction (impaired relaxation), noted in 54 individuals (42.2%). Grade II dysfunction (pseudonormal pattern) was observed in 26 individuals (20.3%), but a lesser proportion, 6 patients (4.7%), exhibited Grade III dysfunction (restrictive pattern) as shown in table 3.

Table 3: Distribution of diastolic dysfunction among patients

Diastolic Dysfunction Grade	Patients (n)	Percentage (%)
Normal	42	32.8
Grade I (Impaired relaxation)	54	42.2
Grade II (Pseudonormal)	26	20.3
Grade III (Restrictive)	6	4.7

Em exhibits a substantial correlation with EF (r=0.52) and mitral inflow (r=0.61) with significant results (p<0.001). The correlation of Em with IVRT (r=-0.12) and DT (r=-0.09) was minimal and statistically non-significant as shown in table 4.

Table 4: Correlation between mitral annular mean early diastolic velocity (Em) on TDI and echocardiographic parameters

Correlation Analysis	Correlation Coefficient (r)	p-value
Em (TDI) vs. Ejection Fraction (EF)	0.52	<0.001
Em (TDI) vs. Mitral inflow early velocity (E)	0.61	<0.001
Em (TDI) vs. Isovolumic Relaxation Time (IVRT)	-0.12	0.18
Em (TDI) vs. Deceleration Time (DT)	-0.09	0.27

Discussion

Coronary artery disease is the most common heart ailment. Routine assessment of individuals with suspected or confirmed coronary artery disease almost invariably incorporates echocardiography. Acute myocardial infarction is defined by localised myocardial injury that can result in both systolic and diastolic dysfunction, subsequently increasing the risk of left ventricular remodelling, local and systemic neurohormonal activation, and vascular dysfunction [11, 12].

A variety of metrics from TDI have been suggested to be beneficial in various heart disorders. Mitral annular or basal left ventricular velocities indicate the longitudinal motion of the ventricle, which is a crucial component of left ventricular systolic and diastolic function [13]. The amplitude of long-axis motion during systole correlates significantly with left ventricular ejection fraction (LVEF), a relationship that also applies to the right ventricle (RV) [14]. The peak systolic velocity is a sensitive indicator of modestly decreased left ventricular (LV) systolic function, even in individuals with a normal left ventricular ejection fraction (LVEF) or seemingly maintained LV systolic function, such as in cases of "diastolic heart failure" [15].

The prevalence of diastolic dysfunction in our sample (67.2%) aligns with prior studies.The significant prevalence of Grade I dysfunction indicates that most patients were diagnosed in the initial phases of aberrant filling, but a minor fraction evolved to more severe restrictive physiology (Grade III). Restrictive filling is significantly correlated with worse prognosis and increased mortality following acute myocardial infarction. Salehi *et al* found a similar prevalence of 62% [10]. Mollema *et al*. found that 31% of patients exhibited a restrictive pattern of left ventricular diastolic dysfunction, whereas we recorded 28% [16]. Diastolic filling abnormalities in post-myocardial infarction individuals may result in insufficient cardiac output despite a normal or near-normal ejection fraction. Sherif *et al* showed a significant decrease in peak early diastolic velocity at all locations, with the most pronounced reduction observed at the infarction site, and our study's findings corroborate this [17].

Our examination of TDI parameters indicated a uniform decrease in early diastolic velocity (Em) at all four mitral annular locations (septal, lateral, anterior, and inferior), although late diastolic velocity (Am) values were comparatively maintained. This pattern is characteristic of compromised myocardial relaxation, wherein early diastolic suction is reduced, although atrial contribution to ventricular filling remains preserved. The Em velocity is extensively recognised as a load-independent indicator of diastolic function and exhibits a substantial correlation with cardiac relaxation markers. [18]

A moderate positive connection was identified between Em and ejection percent. Em exhibited a robust positive connection with the early velocity of mitral inflow (E). This discovery is biologically credible, as both parameters signify early diastolic filling, albeit from distinct viewpoints: E is affected by left atrial pressure and transmitral gradients, whereas Em indicates myocardial relaxation at the annular level. The alignment of these measures enhances the dependability of TDI as an adjunctive instrument in assessing diastolic function. Identical observations were documented by Palmary *et al*. and Sherif *et al*. [17, 19]. There was no link between mean Em velocity with deceleration time (DT) and IVRT. The transmitral flow velocities and the IVRT are contingent upon left ventricular relaxation and left atrial pressure; thus, an increase in left atrial pressure correlates with greater left ventricular diastolic dysfunction. The early diastolic mitral annular velocity assessed by TDI is hypothesised to be independent of filling pressure. This may explain the strong association between early diastolic velocity measured by TDI and LV ejection fraction [19].

The significant prevalence of early diastolic dysfunction highlights the necessity for regular diastolic evaluation in myocardial infarction patients, including those without apparent heart failure symptoms. The Em velocity generated from TDI and its associations with EF and transmitral E serve as reliable indicators of relaxation and filling efficiency, aiding in risk classification and therapeutic decision-making. The restricted dependability of IVRT and DT in this context underscores the importance of prioritising TDI-based indices above traditional Doppler measures during the acute period.

Conclusion

Tissue Doppler imaging is a dependable modality of echocardiography. The maximum early diastolic velocity is diminished, particularly at the infarction sites, indicating regional diastolic dysfunction. The diminished mean early diastolic velocity from four mitral annulus sites indicates global diastolic dysfunction and correlates well with the ejection fraction.

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