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Assessment of Left Ventricular Systolic Function after Acute Myocardial Infarction by Tissue Doppler Imaging

Mousa Qasim Hussein [a, *], Omar S. Hamad [b], NoorHamzaAbdulkhdhur Al-khuzaie [c]

[a] University of Baghdad, Al-kindy College of Medicine, Baghdad, Iraq
[b] Al-Karkh General Hospital Al-Karkh Health Directorate, Baghdad, Iraq
[c] Baghdad Teaching Hospital-Medical City, Baghdad, Iraq

Abstract

The coronary artery disease is the leading cause of mortality and morbidity globally and acute myocardial infarction is the commonest mode of presentation. The tissue Doppler imaging shows myocardial motion (measured as tissue velocity) at specific locations in the heart.

Tissue velocity indicates the rate at which a particular point in the myocardium moves toward or away from the transducer. Integration of velocity over time yields displacement or the absolute distance moved by that point. The most common method for determining ventricular volumes is the Simpson rule, or the "rule of disks." This technique requires recording an apical, four- and/or two-chamber view from which the endocardial border is outlined in end-diastole and end-systole. A cross-sectional study carried out in The AL-Kindey Teaching Hospital (November 2017 – July 2018), 60 patients, 39 (65 %) males and 21(35 %) females with acute myocardial infarction of first time admitted to CCU. All patient were admitted to Coronary Care Unit and Left Ventricular systolic function had been evaluated by measuring Systolic myocardial velocity (sm) by Pulse Wave tissue Doppler imaging and Ejection Fraction by Simpson's method.

Results revealed that 25 patients (41.7 %) of them presented with anterior Myocardial infarction, inferior Myocardial infarction in 17 patients (28.3 %), lateral Myocardial infarction in 11 patients (18.3 %), and septal Myocardial infarction in 7 patients (11.7 %). (60.6 %) of anterior Myocardial infarction, (24.2 %) of inferior Myocardial infarction, (9.1 %) of lateral Myocardial infarction, and (6.1) of septal Myocardial infarction were associated with Ejection Fraction <55.

There were significant differences between means of 4 mitral annular sites Sm by ejection fraction for patients with anterior, lateral Myocardial infarction, and septal Myocardial infarction.

Keywords: myocardial infarction, tissue doppler imaging, left ventricular ejection fraction.

1. Introduction

Coronary artery disease is the leading cause of mortality and morbidity globally and acute myocardial infarction is the commonest mode of presentation. In patients with acute myocardial infarction heart failure is characterized either by systolic dysfunction alone or by both systolic and diastolic dysfunction (Goldberg et al., 2006).

Myocardial infarction (MI) can be recognized by clinical features, including electrocardiographic (ECG) findings, elevated values of biochemical markers (biomarkers) of myocardial necrosis, and by imaging, or may be defined by pathology. It is a major cause of death

* Corresponding author
E-mail addresses: drmusaqassim2016@gmail.com (M.Q. Hussein)

and disability worldwide. MI may be the first manifestation of coronary artery disease (CAD) or it may occur, repeatedly, in patients with established disease (Thygesen et al., 2012).

The tissue Doppler imaging shows myocardial motion (measured as tissue velocity) at specific locations in the heart. Tissue velocity indicates the rate at which a particular point in the myocardium moves toward or away from the transducer. Integration of velocity over time yields displacement or the absolute distance moved by that point (Zaca et al., 2010).

2. Materials and methods

Tissue Doppler Imaging

Tissue Doppler imaging (TDI) is a novel use of ultrasound to image the motion of tissue with Doppler echocardiography. Doppler echocardiography records and displays the velocities of the moving targets. The Principles of TDI; Doppler echocardiography relies on detection of the shift in frequency of ultrasound signals reflected from moving objects. With this principle, conventional Doppler techniques assess the velocity of blood flow by measuring high-frequency, low-amplitude signals from small, fast-moving blood cells. In TDI, the same Doppler principles are used to quantify the higher amplitude, lower-velocity signals of myocardial tissue motion. There are important limitations to TD interrogation. TDI can be performed in pulsed wave and color modes. Pulsed-wave TDI is used to measure peak myocardial velocities and is particularly well suited to the measurement of long-axis ventricular motion because the longitudinally oriented endocardial fibers are most parallel to the ultrasound beam in the apical views. Because the apex remains relatively stationary throughout the cardiac cycle, mitral annular motion is a good surrogate measure of overall longitudinal LV contraction and relaxation (Galiuto et al., 2002).

To measure longitudinal myocardial velocities, the sample volume is placed in the ventricular myocardium immediately adjacent to the mitral annulus. The cardiac cycle is represented by 3 wave forms:

(1) Sm, systolic myocardial velocity above the base- line as the annulus descends toward the apex.

(2) Ea, early diastolic myocardial relaxation velocity below the baseline as the annulus ascends away from the apex.

(3) Aa, myocardial contraction velocity associated with atrial. The lower-case “a” for annulus or “m” for myocardial (Ea or Em) and the superscripted prime symbol (E') are used to differentiate tissue Doppler velocities from conventional mitral inflow. Pulsed-wave TDI has high temporal resolution but does not permit Simultaneous analysis of multiple myocardial segments. With color TDI, a color-coded representation of myocardial velocities is superimposed on gray-scale 2-dimensional or M-mode images to indicate the direction and velocity of myocardial motion. Color TDI mode has the advantage of increased spatial resolution and the ability to evaluate multiple structures and segments in a single view (Edvardsen et al., 2001). From TDI uses are:

Assessment of Myocardial Relaxation:-

Early diastolic velocity (Em and Am) of the mitral annulus measured with TDI is a good indicator of LV myocardial relaxation. This is one of the most important components of myocardial diastolic function the mitral annulus can be appreciated visually from the parasternal long-axis and apical four-chamber views, but TDI records and demonstrates the velocity of the longitudinal motion in numerical value (Otto et al., 2013).

Estimation of Left Ventricular Filling Pressure:

LV diastolic filling pressures can be estimated reliably with 2D and Doppler echocardiography. The deceleration time (DT) of mitral inflow early diastolic velocity (Em) has a good inverse correlation with the pulmonary capillary wedge pressure (PCWP) of less than 130 milliseconds usually indicate a PCWP greater than 20 mm Hg. However, mitral inflow DT alone is not highly accurate in patients who have a relatively normal LVEF or atrial fibrillation. Because Em is reduced in patients with impaired relaxation and is affected less by preload than mitral inflow E, the ratio (E/Em) between mitral inflow early diastolic velocity and mitral annulus early diastolic velocity increases as PCWP increases (Takashioki, 2003).

Evaluation of Regional and Global Systolic Function:

Assessment of LV Systolic Function: Systolic myocardial velocity (Sm) at the lateral mitral annulus is a measure of longitudinal systolic function and is correlated with measurements of LV ejection fraction and peak dP/dt. A reduction in Sm velocity can be detected within 15 seconds of the onset of ischemia and regional reductions in Sm are correlated with regional wall motion abnormalities (Alam et al., 2007). Incorporation of TDI measures of systolic function in exercise testing to assess for ischemia, viability, and contractile reserve has been suggested because peak Sm velocity normally increases with dobutamine infusion and exercise and decreases with ischemia (Marwick et al., 2004). The present study aimed to evaluate the Systolic myocardial velocity (Sm) and its relation to ejection fraction (EF) by Simpson's method in first acute myocardial infarction.

Patients and Method

A cross-sectional study carried out in The AL-Kindy Teaching Hospital (November 2017 – July 2018). The study duration was 8 months and was approved by hospital ethical committee, Number of people were included 60 patients, 39 (65 %) males and 21(35 %) females, aged from 45 to 60 years with acute myocardial infarction of first time admitted to CCU. All patient were admitted to CCU and LV systolic function had been evaluated by measuring Sm by PW tissue Doppler imaging and EF by Simpson's method. All patients were in sinus rhythm.

The diagnosis of MI was based on the following criteria:

Characteristic chest pain, ECG changes and positive test (Galiuto et al., 2002).

Evaluation of LV EF <55 % suggested LV systolic dysfunction [10,11]. Then pulsed wave TDI was performed on four different sites on the mitral annulus i.e. lateral, septal, anterior and inferior. For lateral and septal sites apical 4-chamber view and for anterior and inferior sites apical 2-chamber view was used.

3. Results

Sixty patients with acute first myocardial infarction were included. The mean age was (53.03 ± 4.64) years as shown in Table 1, there were 39 males (65 %) and 21 females (35 %) as shown in Figure 1.

Note: A p-value of ≤ 0.05 was considered as significant.

Table 1. Mean ± SD of age of all study patients

Variable	Mean ±SD	Range
Age (years)	53.03 ± 4.64	**45-60**

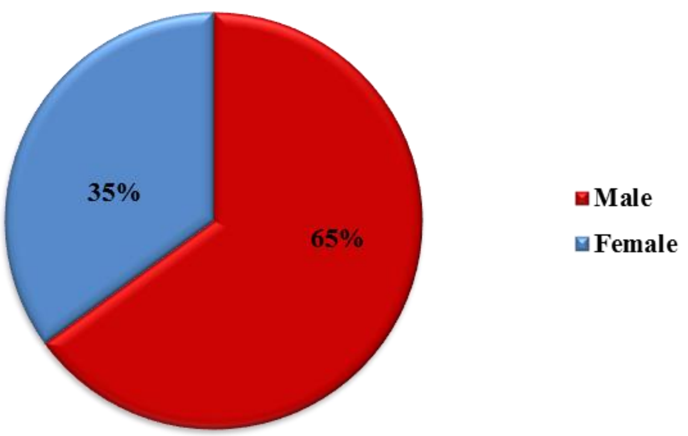

Fig. 1. Distribution of patients according to gender

Figure 2 shows the distribution of patients according to type of myocardial infarction. Majority 25 patients (41.7 %) of them presented with anterior MI, inferior MI in 17 patients (28.3 %), lateral MI in 11 patients (18.3 %), and septal MI in 7 patients (11.7 %).

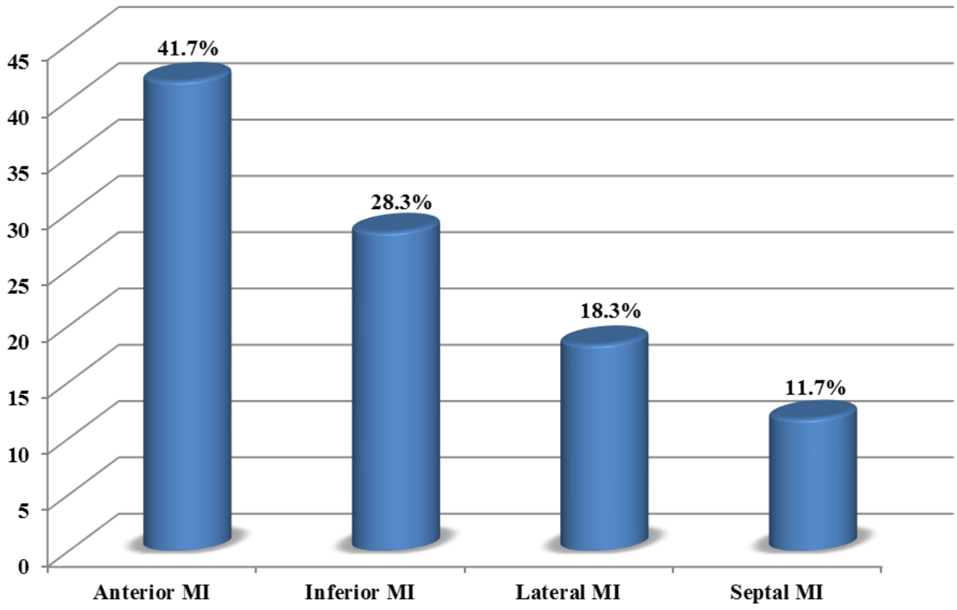

Fig. 2. Distribution of patients according to type of MI

Table 2 shows the association between type of myocardial infarction and ejection fraction [<55 % (impaired LV systolic function) or ≥55 % (normal LV systolic function)], (60.6 %) of anterior MI, (24.2 %) of inferior MI, (9.1 %) of lateral MI, and (6.1) of septal MI were associated with EF <55 and there was a significant association between type of MI and EF, p = 0.006.

Table 2. The association between type of MI and ejection fraction

Variable	**Ejection fraction**		**P-value**
	LV dysfunction (<55 %)	**Normal function (≥55 %)**	
			Type of MI
Anterior	20 (60.6 %)	5 (18.5 %)	
Inferior	8 (24.2 %)	9 (33.3 %)	
Lateral	3 (9.1 %)	8 (29.6 %)	**0.006**
Septal	2 (6.1 %)	5 (18.5 %)	
Total	33 (100 %)	27 (100 %)	

Figure 3 shows the correlation between mean Sm velocity and ejection fraction among patients with MI. There was a significant positive linear correlation between these two variables (r = 0.787, P-value = <0.001).

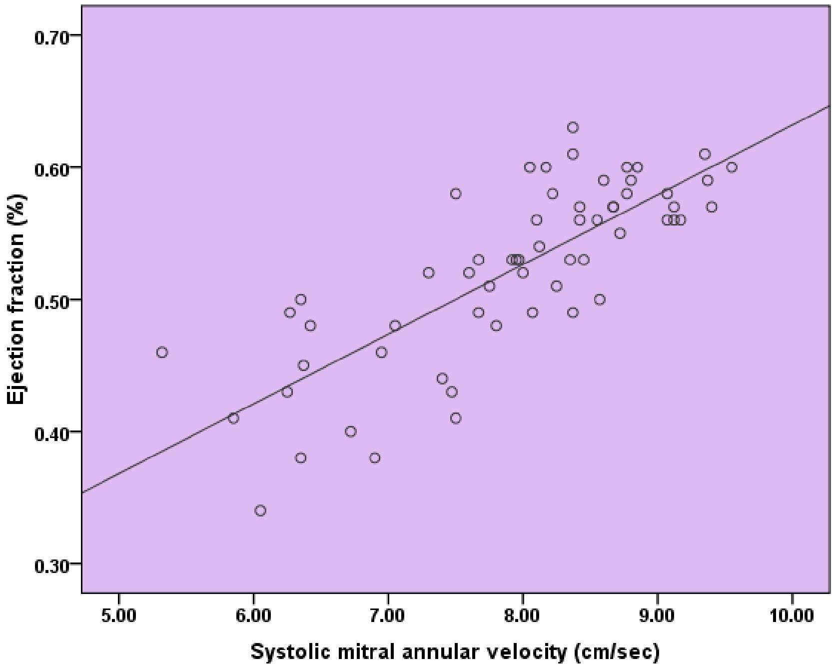

Fig. 3. The correlation between mean systolic mitral annular velocity and ejection fraction

Figure 4 illustrated the differences of the mean mitral Sm velocity assessed by Doppler tissue imaging at different sites of the mitral annular among patients with anterior MI. There was difference between means of Sm at 4 mitral annular sites with significant reduction in ant and septal mitral annular Sm (6.136, 6.86 respectively) than other mitral annular sites [inferior and lateral (8.172, 7.524 respectively)] among patients with anterior MI (Friedman test P-value < 0.001).

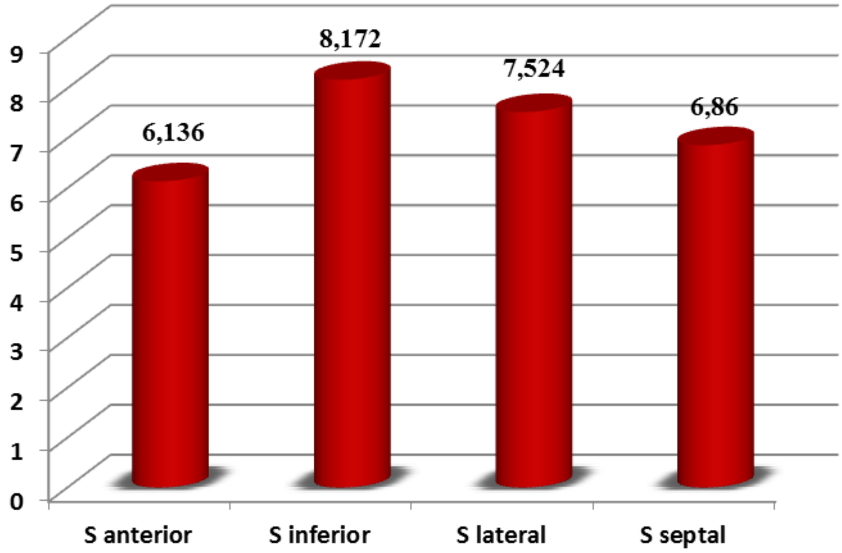

Fig. 4. The means of the Sm at 4 mitral annular sites among patients with anterior MI

Figure 5 shows the differences of Mean mitral Sm velocity assessed by Doppler tissue imaging at different sites of the mitral annular among patients with inferior MI. There was significant reduction of mean Sm of inferior and septal mitral annular sites (6.041, 8.429 respectively) than other [lat and ant mitral annular sites (9.429, 9.211 respectively)] among patients with inferior MI (P-value < 0.001).

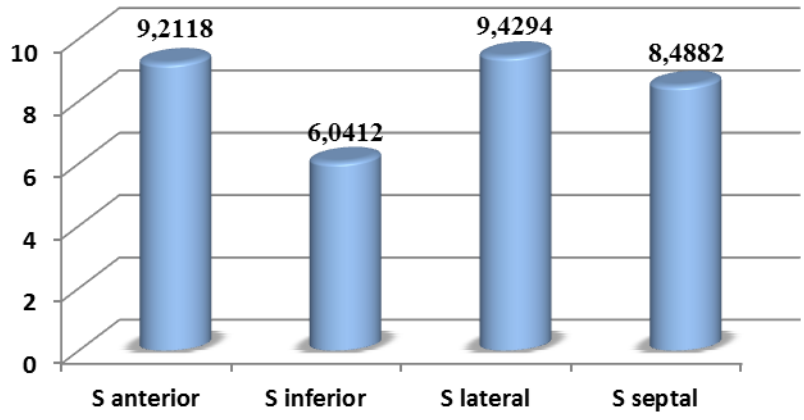

Fig. 5. The means of the Sm at 4 mitral annular sites among patients with inferior MI

Figure 6 shows the differences of Mean mitral Sm velocity assessed by Doppler tissue imaging at different sites of the mitral annular among patients with lateral MI. There was significant reduction of mean Sm of lateral mitral annular site (5.845) than other mitral annular sites among patients with lateral MI (P-value < 0.001).

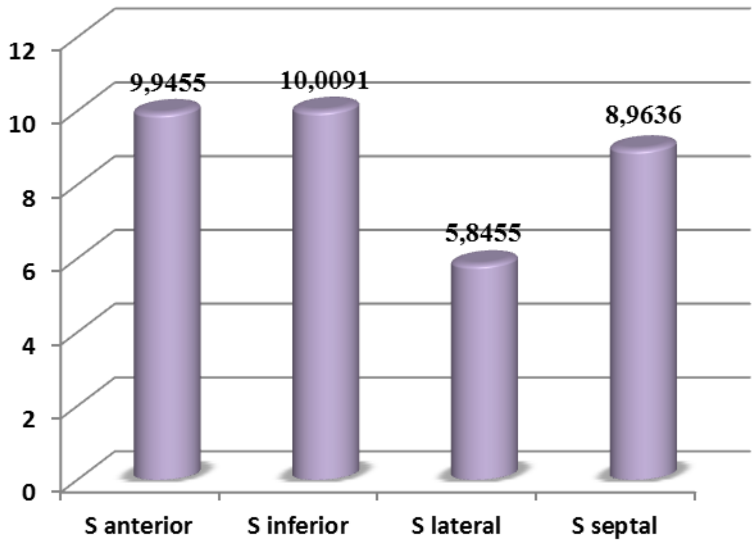

Fig. 6. The means of the Sm at 4 mitral annular sites among patients with lateral MI

Figure 7 shows the differences of Mean mitral Sm velocity assessed by Doppler tissue imaging at different sites of the mitral annular among patients with septal MI. There was a significant reduction of mean Sm of septal mitral annular site (5.257) than other mitral annular sites among patients with septal MI (P-value < 0.001).

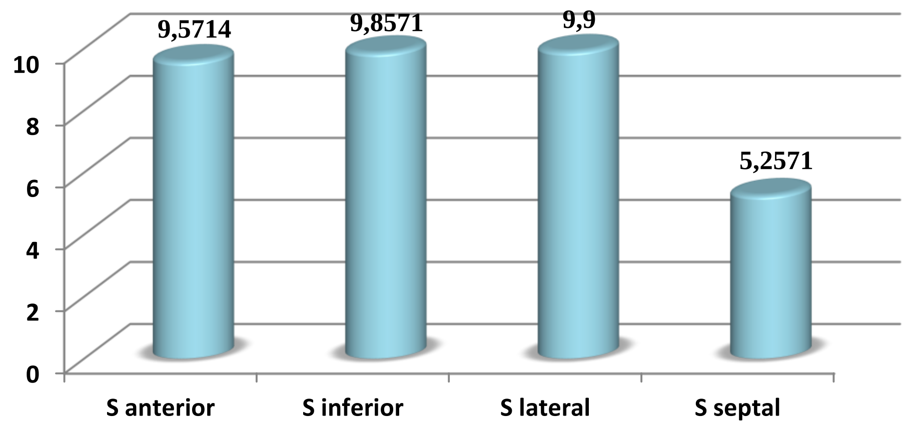

Fig. 7. The means of the Sm at 4 mitral annular sites among patients with septal M

Table 3 shows the mean differences of mean mitral annular peak systolic velocities (Sm) of all 4 mitral annular sites by ejection fraction among patients with MI. There were significant differences between means of 4 mitral annular sites Sm by ejection fraction for patients with anterior, lateral MI, and septal MI (p value < 0.001, 0.006, 0.016 respectively).

Table 3. The means of the mitral annular peak systolic velocities (Sm) of all 4 mitral annular sites by ejection fraction among patients with anterior, lateral and septal MI

Type of MI	Categories %	N	Mean ± S.D	t-test	P value
Anterior MI	LV dysfunction (<55)	20	6.93 ± 0.68	-5.233	<0.001
	Normal function (≥ 55)	5	8.10 ± 0.36		
Lateral MI	LV dysfunction (<55)	3	8.05 ± 0.27	-3.57	0.006
	Normal function (≥ 55)	8	8.92 ± 0.38		
Septal MI	LV dysfunction (<55)	2	7.51 ± 0.08	-3.569	0.016
	Normal function (≥ 55)	5	8.69 ± 0.44		

Table 4 shows the mean differences of mean mitral annular peak systolic velocities (Sm) of all 4 mitral annular sites by ejection fraction among patients with inferior MI, and there was significant association between mean Sm and EF (p value 0.001).

Table 4. The means of mitral annular peak systolic velocities (Sm) of all4 mitral annular sites by ejection fraction among patients with inferior MI

Type of MI	Categories	N	Mean Rank	Z	P value
Inferior MI	LV dysfunction (< 55 %)	8	4.75	-3.274	0.001
	Normal function(≥ 55 %)	9	12.78		

Mann-Whitney test

4. Discussion

In the present study, acute first myocardial infarction was shown to occur 1.6 time more in male in comparison with female but it was statistically insignificant (P-value 0.285).

When we divided the MI patients into those with anterior or inferior, lateral and septal MIs, we found lower mitral annular velocity at sites of infarction (P-value < 0.001).

There was significant association between type of MI and EF, p value 0.006.

A significant regional difference was found in the peak systolic velocity at the mitral annulus related to the infarction site (P-value < 0.001). The similar pattern has been reported by Salehi et al. (2010).

In current study, the acute anterior MI was the more frequent among MI cases, accounted (41.7%) of all patients. The patients with acute anterior MI had Sm reduction of all four mitral annular sites with significant reduction in anterior and septal mitral annular Sm than other mitral annular sites (inferior and lateral) (P-value < 0.001). These findings agreed that of previous study done by Rahman et al. (2011) who showed significant reduction in anterior and septal mitral annular Sm than other mitral annular sites (inferior and lateral) in patients with acute anterior MI.

In our study, patients with acute anterior MI were divided into two groups according to an ejection fraction, those with EF (<55 %) and (≥55) as LV systolic dysfunction and normal LV systolic function respectively (Ommen et al., 2000; Otto et al., 2013a) and it was seen that majority (80 %) of anterior MI patients, which constituted (60.6 %) of all patients had LV systolic dysfunction, Although the myocardial velocity and ejection fraction are two different measurements, there was significant correlation between mean Sm reduction of all four mitral annular sites and EF (p value < 0.001), These findings agreed that reported by Rahman et al., (2011) who reported LV systolic dysfunction in 82 % of ant MI patients and 79 % among all patients with LV systolic dysfunction. This correlation between the mean mitral annular systolic velocity and LV ejection fraction indicates that systolic velocity plays an important role in the pumping function of the left ventricle.

In the present study, the patients with acute inferior MI represented 28.3 % of all patients. The patients with inferior MI had lower Sm of all four mitral annular sites with significant reduction in inferior mitral Sm and septal mitral Sm (P < 0.001), and this reduction of septal Sm may be due to partial damage to the septum in inferior MIs, as the posterior part of the septum is usually supplied by the right coronary artery (Salehi et al., 2010).

When the inferior MI patients were divided in to those with EF (≥0.55) and those with EF (<55 %), we found 47 % among patients with inferior MI which constituted 24.2 % of all patients had been impaired LV systolic function and there was significant correlation between mean Sm and EF (p value = 0.001), this has been reported by Rahman et al. (2011) but with LV systolic dysfunction was found in 22 % of patients with acute inferior MI and 20 % of all MI patients with LV systolic dysfunction, and the cause of this variation was thought to be due to higher no. of patients in study(200 patients).

In current study, patients with lateral MI represented 18.3 % of all patients. Those had Sm reduction at the non-infarction sites, in addition to Sm reduction at the infarction sites, and there was significant reduction of peak lateral mitral annular Sm velocity (p value < 0.001). The similar pattern has been reported by Alam et al. (2000).

From other point of view, the mean Sm of all mitral annular sites patients with lateral MI was significantly low (p value < 0.001). Similar observation had reported by Alam et al. (2000).

In our study 9.1 % of patients with lat. MI had LV systolic dysfunction, and there was significant correlation between mean Sm and EF in patients with lat. MI (p value = 0.006). These findings agreed that of study done by Esmailzadeh et al. (2009) (p value < 0.001).

While patients with septal MI represented 11.7 % of all patients in the study. In addition to the Sm reduction at the infarction sites, Sm at the non-infarction sites was also reduced as compared with healthy subjects, and there was significant lower peak septal Sm velocity (p value < 0.001). This finding was similarly reported by Alam et al. (2000).

From other point of view, the mean Sm of all mitral annular sites was significantly reduced in septal MI (p value < 0.001). Similar observation has been reported by Alam et al. (2000).

LV systolic dysfunction was found in 28 % of patients with septal MI which constituted 6.1 % of all MI patients with impaired LV systolic function, and there was significant correlation between mean Sm and EF in patients with septal MI (p value = 0.03). This finding was similarly reported by Esmailzadeh et al. (2009).

In current study, 55 % of all patients had been found with LV systolic impairment and associated with a significant reduction of mean Sm of four mitral annular sites (p value < 0.001). These findings agreed that of previous study done by Zaca et al. (2010).

In the present study, there has been relatively significant positive linear correlation between mean Sm and EF (r = 0.787, P < 0.001), as in Figure 6, this is similarly reported by Rahman et al., (2011) with (r = 0.74, P < 0.001).

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