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Original Article

Assessment of Longitudinal Strain in Acute ST – Elevation Myocardial Infarction

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Abstract

Introduction: Strain imaging measures tissue deformation rather than tissue velocity. It localizes regional wall motion abnormalities as does the conventional methods such as WMSI and Simpson method. Conventional methods are based on the principle of measuring tissue velocity.

Results: Peak systolic longitudinal strain was reduced in the individual ischemic myocardial segments and uniformly normal in the non-ischemic segments. In anterior wall MI patients the WMSI was increased and strain reduced in mid, apical septum: LV apex: basal mid and apical lateral: basal mid and apical anterior segments statistical analysis of the data revealed positive correlation (>0.50) between the value obtained by WMSI and strain in the basal, mid and apical lateral segments basal mid and apical anterior. Even though the –mid septal apical septal and apical segments showed reduced strain statistical positive correlation was lacking in these areas. Similarly the basal septal, mid apical lateral segments: basal mid, apical inferior segments showed reduced strain and increased WMSI. However only the basal septum, basal, mid, and apical inferior segments showed positive correlation (>0.5). Correlation between 2D Simpson derived EF and strain derived EF was also calculated. The correlation was strongly positive in the AWMI group with a value of 0.87. The correlation in the IWMI group was also positive at 0.59.

Conclusion: Objective measurement of deformation (strain), in patients with acute myocardial infarction detected myocardial regions involved as well as the overall left ventricular (LV) function. These measurements, the WMSI and strain correlated with each other with regards to the regional as well as global LV function. Analysis based on coefficient of correlation showed peak systolic longitudinal strain as good as WMSI in this prediction

Key words: Ejection fraction, Longitudinal strain, ST elevation myocardial infarction

INTRODUCTION

Coronary artery disease is the leading cause of death worldwide. Every year about 29.8 million people in India suffer from acute myocardial infarction (AMI).[1] The AMI incidence though shows declining trend in the west it is on the rise in the developing work. Effective management of this increasing epidemic imposes a technical challenge as well as a socioeconomic burden to the third world countries.

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In addition to the routine clinical and electrocardiographic (ECG) evaluation, echocardiography is an integral part of AMI management. Assessment of overall left ventricular (LV) function and the regional wall motion of individual myocardial segments is the essence of echocardiography in the patients with AMI. Traditionally, the regional wall motion is assessed subjectively by two-dimensional (2D) imaging and objectively by calculation of wall motion score index (WMSI). Global LV function is usually assessed by Teichholz and Simpson's methodologies. These modalities have their own limitations in patients with AMI. Tissue Doppler imaging offsets some of the disadvantages of 2D echocardiography but by itself has several disadvantages in the assessment of regional and overall LV function. The introduction of strain imaging has stood the test of time since its introduction a decade ago. The modality of strain imaging is fast advancing with the initial

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reports of Doppler based strain imaging now giving way to strain by 2D speckle tracking.

This study utilizes longitudinal strain derived by 2D speckle tracking for assessment of regional and global LV function in patients with AML and compares the same with traditional parameters such as WMSI and 2D derived ejection fraction (EF).

MATERIALS AND METHODS

Study Population

The study was conducted in patients admitted to the intensive care unit of Government Rajaji Hospital. Madurai. 52 patients with a diagnosis of acute ST elevation anterior wall myocardial infarction (AWMI) were studied. 32 patients have an acute AWMI, and 20 had inferior wall MI (IWMI). Age group of study in the AWMI group was 52.7 ± 9.4, in the IWMI group it was 50.7 ± 9.1. 22% of AWMI patients and 20% in the IWMI group were females. 32% patients in the AWMI and 30% in IWMI were diabetic. The prevalence of systemic hypertension in the AWMI was higher 43% and in the IWMI group was 20% smoking prevalence was substantial in both MI groups, 75% and 87% in AWMI and IWMI, respectively. 75% in the AWMI and 85% in the IWMI group were eligible candidates, and they were thrombolysed.

Inclusion Criteria

Patients with acute ST elevation MI (STEMI) - AW and IW.

Exclusion Criteria

1. Previous MI
2. Patients with unstable rhythm (atrial fibrillation, heart blocks, and ventricular tachycardia)
3. Patients with associated valvular heart disease
4. Patients with permanent pacemakers
5. Patients with congenital heart diseases.

In our study, the automated tracking by the machine may either be accepted as such or altered according to the wish of the operator if the automated tracking is not satisfactory. This is accomplished using the reference points function and adjusting the same to match the segment correctly. The strain was obtained at the peak systole by ECG gating placing the cursor at the individual curve at the peak systolic line gives the value of longitudinal strain of individual segment. Thus, the values are calculated for all the segments and displayed separately is a table. The global strain derived is automatically displayed by the software, and if the tracking is acceptable, this valve may be taken as such. In other cases where the tracking is not satisfactory, the image settings are adjusted until a proper tracking is obtained. The image taken at the apical long axis view was consistently measured as that of the septum and lateral wall by the software though it did not mean it. Hence for the sake of questionable acceptability in recognized forms, the values in the particular view were ignored. This might be considered as one of the major limitation of the study.

The longitudinal strain obtained is depicted along the Y-axis of the image as % shortening/lengthening. The value can be manually calculated by noting the excursion of the plot of the individual myocardial segment. A good excursion of the plot along the X-Y axis is indicative of good myocardial strain, and hence a good LV function of the segment concerned.[2] When there is a uniformly good excursion of all segments, it indicated normal global LV function.

Statistical Analysis

Data analysis was performed with the help of computer using epidemiological information package (EPI 2008) developed by Center for Disease Control, Atlanta. Using this software, range frequencies, percentages, means, standard deviations, and coefficient of correlation and P values were calculated. A $P < 0.05$ is taken to denote significant relationship. If the coefficient of correlation is more than or equal to ±0.5 is taken to denote significant relationship. If the coefficient of correlation is more than or equal to ±0.5, then there exists a significant relationship between the two variables. A coefficient of correlation of 0.8 or more signifies that a very strong relationship exists between the two variables.

RESULTS

Peak systolic longitudinal strain (PSLS) was reduced in the individual ischemic myocardial segments and uniformly normal in the non-ischemic segments. In AWMI patients the WMSI[3,4] was increased and strain reduced in mid, apical septum: LV apex: Basal mid and apical lateral: Basal mid and apical anterior segments. Statistical analysis of the data revealed positive correlation (>0.50) between the value obtained by WMSI and strain in the basal, mid and apical lateral segments basal mid and apical anterior. Even though the – mid-septal apical septal and apical segments showed reduced strain statistical positive correlation was lacking in these areas. Similarly, the basal septal, mid apical lateral segments: Basal mid, apical inferior segments showed reduced strain and increased WMSI. However, only the basal septum, basal, mid, and apical inferior segments showed a positive correlation (>0.5) (Table 1).

Correlation between 2D Simpson derived EF and strain derived EF was also calculated. There was a positive correlation in the EF between the different modalities.[5] The correlation was strongly positive in the AWMI group with a value of 0.87. The correlation in the IWMI group was

Table 1: Comparison of WMSI and PSLS values with coefficient of correlation

Myocardial segment	AWMI group			IWMI group		
	WMSI	PSLS	Correlation coefficient	WMSI	PSLS	Correlation coefficient
Basal septum	1.28±0.46	−16.7±4.6	0.32	1.8±0.5	−10.3±9	**0.58**
Mid septum	2.06±0.67	−7.5±4.5	0.42	1.35±0.49	−17.3±4.4	0.49
Apical septum	2.44±0.5	−3.0±4.2	−0.02	1.0±0	−15.1±4.2	-
Basal lateral	0.34±0.55	−15.9±4.7	**0.53**	1.25±0.44	−17.2±4.1	0.44
Mid lateral	1.44±0.56	−11.6±5.5	**0.68**	1.45±0.51	−12.4±4.8	**0.54**
Apical lateral	1.81±0.59	−7.3±5.8	**0.62**	1.45±0.51	−11.6±4.3	0.23
Apex	2.44±0.5	0.7±5.8	0.28	1.0±0	−15.2±3.3	-
Basal anterior	1.5±0.57	−11.3±4.9	**0.64**	1.0±0	−20±2.6	-
Mid anterior	2.38±0.49	−5±4	**0.56**	1.0±0	−18.2±1.4	-
Apical Anterior	2.28±0.58	−3.1±4.5	**0.52**	1.0±0	−17.6±1.93	-
Apical inferior	1.0±0	−17±1.8	-	2.3±0.47	−3.25±4.81	**0.56**
Mid inferior	1.0±0	−17.8±2.8	-	2.35±0.49	−1.85±5.7	**0.63**
Basal inferior	1.0±0	−19±3.1	-	2.45±0.51	−7.15±4.43	**0.56**

The numbers marked in bold show positive correlation (>0.50). AWMI: Anterior wall myocardial infarction, IWMI: Inferior wall myocardial infarction, WMSI: Wall motion score index, PSLS: Peak systolic longitudinal strain

Table 2: Correlation between 2D Simpson derived EF and strain derived EF

Group	EF 2D values ascertained by		Correlation coefficient
	Simpson	Strain method	
AWMI	39.1±8.1	38.8±10.9	0.87
IWMI	44.9±4.9	44.3±6.0	0.59

IWMI: Inferior wall myocardial infarction, AWMI: Anterior wall myocardial infarction, EF: Ejection fraction, 2D: Two-dimensional

also positive at 0.59 (Table 2). Individual risk factor analysis revealed that the presence or absence of a particular risk factor did not significantly affect the strain or WMSI as both groups revealed similar trends ($P > 0.05$).

DISCUSSION

Strain imaging measures tissue deformation rather than tissue velocity. It localizes regional wall motion abnormalities as does the conventional methods such as WMSI and Simpson method. Conventional methods are based on the principle of measuring tissue velocity. Tissue tethering is an inherent disadvantage of these methodologies and cannot be avoided because of the geometric orientation of the myocardial fibers. Hence strain imaging using PSLS in acute MI patients may be used to overcome this disadvantage and quantify both wall motion score and overall LV systolic function.

Strain can be measured in all three dimensions as the tissue deforms three-dimensionally. Thus the deformation in the longitudinal, radial and circumferential planes can be assessed in a patient with MI. However, the longitudinal fibers are the main fibers distributed in the subendocardial region, the region most susceptible for ischemia. Thus, measurement of longitudinal strain is more reasonable in a patient with acute myocardial ischemia.

The peak systolic strain is measured in this study because it is the magnitude parameter that corresponds with regional EF. We depend on the EF derived by the Q-Lab software based on the tissue deformation of individual myocardial segments. Hence, the assessment of peak systolic strain is ideal rather than end-systolic strain which is both timing and magnitude parameter that lacks information about the rate of contraction of individual myocardial fibers.

The results of the study show that the longitudinal strain in the myocardial segments shows good correlation with the previously well-evaluated methods such as WMSI and Simpson's method.

Even though the correlation was not uniform as some of the segments, namely, the mid septum and apical septum and apex showed no statistical correlation, the overall values were reduced in these segments. Similarly, in the IWMI group, only the basal septal, basal mid and apical inferior segments showed a positive correlation. The basal septum is supplied by the right coronary artery and is not involved in AWMI. The strain pattern is not affected in this segment that correlates with the WMSI of such patients.

In the study by Edvardsen and Skulstad[6] 17 patients undergoing angioplasty of the left anterior descending coronary artery (LAD) were studied. LV longitudinal wall motion was assessed by tissue Doppler echocardiography (TDE) and strain Doppler echocardiography (SDE) from the apical four-chamber view before, during and after angioplasty from multiple myocardial segments simultaneously. Segments not supplied by LAD remained unchanged. TDE showed reduced velocities in all septal segments ($P = 0.05$) during angioplasty WMSI increased during ischemia ($P = 0.05$). It was concluded that the new SDE approach might be a more accurate marker than TDE for detecting systolic regional myocardial dysfunction induced by LAD occlusion. The results of our study correlate well with that of this study mentioned. The ischemia was induced voluntarily in the study by Edvardsen and Skulstad whereas we have studied the patients who presented with acute STEMI. This was one of the pioneering studies by the authors early in 2001 regarding the utility of the new modality at that point of time.

In the study by Rosendahl *et al.*[7] in 2010, it was shown that longitudinal peak strain detects a smaller risk area than visual assessment of wall motion in AMI; in this study, tissue Doppler analysis (peak strain, displacement, and mitral annular movement) was compared with visual assessment for the study of the correlation of measurements of global, regional and segmental function with final infarct size and transmurality. It was concluded that in patients with acute STEMI, WMSI, EF, strain, and displacement showed significant changes between the pre- and post-percutaneous coronary intervention exam. In a receiver operating characteristic analysis, strain had 64% sensitivity at 80% specificity and WMSI around 90% sensitivity at 80% specificity for the detection of the scar with transmurality.

Prognostic importance of strain and strain rate after AMI was studied by Antoni[8] in their study of 659 patients after AMI. Patients were evaluated using strain, WMSI and LVEF. Strain was independently related to all endpoints and was found to be superior to LVEF and WMSI patients with global strain and strain rate higher than - 15.1% and $-1.06\ s^{-1}$ demonstrated hazard ratio of 4.5 (95% confidence interval [CI]: 2.1-9.7) and 4.4 (95% CI: 2.0-9.5) for all-cause mortality, respectively. Conclusion was that strain and strain rate provide strong prognostic information in patients after AMI. These novel parameters were superior to LVEF and WMSI in the risk stratification for long-term outcome. This study reiterates the importance of strain imaging in patients with AMI.

Armstrong *et al.*[9] studied the use of peak systolic strain as an index of regional LV function. It was concluded that myocardial tissue Doppler velocity is an objective measure of regional LV responses to inotropic stimulation and ischemia, but is affected by tethering from adjacent segments and translational movement.

Limitations

Limitations in this study are that:

1. Angiographic correlation of region involved was not done
2. Correlation was positive (>0.50) in many of the variables compared. However, a very strong positive correlation (>0.80) was not obtained in many of the segments
3. The study is a single point study and follow-up of regional and overall LV function was not compared.

CONCLUSION

Echocardiography, done using two methods-subjective assessment of wall motion as well as objective measurement of deformation (strain), in patients with AMI detected myocardial regions involved as well as the overall LV function. These measurements, the WMSI and strain correlated with each other with regard to the regional as well as global LV function. Analysis based on the coefficient of correlation showed PSLS as good as WMSI in this prediction. Thus, advanced technological analysis of wall motion using strain imaging did contribute additional value compared with a conventional assessment such as WMSI and Simpson's method.

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