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Two- Dimensional Speckle –Tracking Echocardiography Assessment of Left Ventricular Remodeling in Patients after Myocardial Infarction and Percutaneous Coronary Intervention

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Abstract

Background: Left ventricular remodeling (LVR) is prognostically important consequence of Acute Myocardial Infarction (AMI). However, data regarding the role of STE based parameters for predicting LVR in patients after MI who undergo PCI have been lacking. *Aims and Objectives:* To evaluate the role of STE in the prediction of LVR in patients after PCI in AMI and the factors associated with LVR after successful PCI. *Material and Methods:* This is a prospective study conducted in a tertiary care hospital in patients with AMI. Patients were analyzed pre and post intervention (PCI) using STE in 100 patients. *Results:* LVR was found in 39% of AMI patients. Among cases with successful reperfusion within 2 hours from symptom onset none had LVR, 18.75% cases with time to reperfusion 2hrs to one day had LVR, 32.65% of cases with time to reperfusion within 1-7 days had LVR and 64.52% of cases with time to reperfusion >7 days had LVR. There was a significant improvement in circumferential strain in different LV segments following PCI. LVEF and STE parameters LVGLS, LVGCS (basal and apical), regional LVLSR, regional LVCS at baseline and at one month were predictors of LVR. *Conclusions:* LVR was common in AMI patients even after successful PCI and was strongly associated with the time to reperfusion. The STE parameters of global longitudinal strain, regional longitudinal strain rate, basal and apical global and regional circumferential strain at baseline and 30 days after the PCI were predictors of LVR at 3 months post PCI.

Keywords: STE–Speckle Tracking Echocardiography; LVR- Left Ventricular Remodeling; LVGLS- Left Ventricular Global Longitudinal Strain; LVGCS-Left Ventricular Global Circumferential Strain; AMI- Acute Myocardial Infarction; PCI Percutaneous Coronary Intervention.

Introduction

Left ventricular remodeling (LVR) is prognostically important consequence of Acute Myocardial Infarction (AMI)[1]. LVR is a disadvantageous process resulting in progressive enlargement and changing the shape of the LV cavity with systolic dysfunction and is associated with worse outcomes, predisposing to heart failure and death [2]. The phenomenon is complex, related to macro and microscopic changes in the structure and function of cardiomyocytes [3]. Two dimensional speckle-tracking echocardiography (STE) is being used nowadays to assess ventricular systolic functions, as it permits more comprehensive evaluation of myocardial contractile function [4,5].

Because of scattering, reflection and interference of the ultrasound beam in myocardial tissue, speckles appear in grey scale 2-D echocardiographic images. These speckles represent tissue markers that can be tracked, by tracking the displacement of speckles during the cardiac cycle, STE allows semi-automated elaboration of myocardial deformation in three spatial directions: longitudinal, radial and circumferential. In addition, STE offers an evaluation of the occurrence, direction and velocity of LV rotation [6,7]. Previous publications show normal strain to vary from 16% to 19% [8,9]. Despite studies evaluating various clinical factors and routine echocardiographic parameters predisposing to LVR as a consequence of myocardial infarction, there are still gaps in our data.

However, data regarding the role and long-term prognostic value of such STE based strain and strain rate imaging, either longitudinal or circumferential, for predicting LVR in patients after MI who undergo PCI have been lacking

Aims and Objectives

- To evaluate the role of STE in the prediction of LVR in patients after PCI in AMI.
- To evaluate the factors associated with LVR after successful PCI.

Material and Methods

This a prospective study conducted in a tertiary care hospital in patients with AMI (STEMI and NSTEMI) from September 2015 to September 2016. Patients were analysed pre and post intervention (PCI) using STE in 100 patients who were more than 18 years, both males and females and consented for study. Excluded from the study were patients who had prior MI, cardiomyopathy, hemodynamically unstable and poor image quality.

Patients visiting cardiology OPD or emergency with the diagnosis of AMI scheduled for PCI were thoroughly examined after taking detailed history and were subjected to routine hematological and biochemical investigations.

Transthoracic echocardiographic examination was done on Philips IE 33 (Philips Medical Systems USA) machine and STE was done and recorded pre PCI , 3 days, 30 days and 90 days after the procedure. Both 2D Transthoracic Echocardiography (TTE) with the routine parameters and 2D-STE were ECG-gated and performed during each of the visits. All the patients were examined in the left lateral decubitus position using a 3.5 MHz transducer in the standard views: parasternal (long axis and short axis – basal and apical level) and apical four-chamber. STE was done and recorded. Ventricular strain and strain rate were derived from apical four chamber and short axis (basal and apical level) views.

The LVR was defined as ≥ 20% increase in LV end-diastolic volume (EDV) and/or LV end-systolic volume (ESV) at 3-month follow-up compared with the baseline examination [10].

All the patients included had typical chest pain and significantly increased Troponin I. All AMIs were classified as STEMI or NSTEMI with location determination according to electrocardiography (ECG) and echocardiography.

Statistical Analysis

The results are presented in mean±SD and percentages. The Chi-square test or Fisher's exact test was used to compare the categorical variables at the baseline between patients with and without LVR. The Unpaired t-test was used to compare discrete variables from baseline to follow up among patients with and without LVR. Repeated measure of ANOVA was used for comparison of more than two samples. Regression analysis was done to find the predictors of the outcome i.e. LVR. The p-value<0.05 was considered significant. All the analysis was carried out by using SPSS 16.0 version (Chicago, Inc., USA).

Observations and Results

Patients were grouped into 2 categories; those with LVR and those without LVR based on echocardiographic parameters at 3 months post PCI follow up.

LV remodeling (LVR) was most commonly seen in patients between 41-50 years of age (61.9%) & LVR was more commonly observed among female patients (55% of all females), the difference in both cases was not statistically significant. There was no significant difference between the group developing LVR Versus no LVR in baseline characteristics (Table 1).

No significant association was seen between the clinical presentation of AMI, extent of CAD, the IRA involved and future development of LVR.There was a statistically significant association between time to reperfusion from symptom onset and risk of LVR development. Among cases with successful reperfusion within 2 hours from symptom onset none had LVR, 18.75% cases with time to reperfusion 2 hrs to one day had LVR, 32.65% of cases with time to reperfusion within 1-7 days had LVR and 64.52% of cases with time to reperfusion >7 days had LVR (Table 2).

Table 3. Shows the comparison of LV speckled tracking (GL strain)from baseline to follow-ups

among the cases with and without LVR. A significantly lower LVGLS was observed among cases with LVR compared to those without LVR from baseline to 3rd day to one month and post three months.

There was a significant improvement in circumferential strain in different LV segments as assessed by STE at 3rd day, one month and three months after PCI (Table 4).

Multivariate logistic regression analysis showed that LVEF and STE parameters LVGLS, LVGCS (basal and apical), regional LVLSR, regional LVCS at baseline and at one month were predictors of LVR (Table 5).

Table 1: Baseline Characteristics of patients with and without LVR

Parameter	LVR+		LVR-		p value[1]
	No.	%	No.	%	
Age in years					
30-40	2	28.57	5	71.43	p= 0.096
41-50	13	61.9	8	38.1	
51-60	13	37.14	22	62.86	
>60	11	29.73	26	70.27	
Gender					
Male	28	35	52	65	p= 0.10
Female	11	55	9	45	
Hypertension					
Present	14	35	26	65	p= 0.5
Absent	25	41.7	35	58.3	
Diabetes Mellitus (DM)					
Present	18	41.9	25	58.1	p= 0.61
Absent	21	36.8	36	63.2	
Smoking					
Present	13	41.9	18	58.1	p= 0.68
Absent	26	37.7	43	62.3	
Dyslipidemia					p= 0.83
Present	20	40	30	60	
Absent	19	38	31	62	
Family History					
Present	7	41.2	10	58.8	p=0.84
Absent	32	38.6	51	61.4	

[1]Chi-square test

Table 2: AMI related parameters in patients with and without LVR

Parameter	LVR+		LVR-		p value[1]
	No.	%	No.	%	
Type of MI					
STEMI	27	42.86	36	57.14	p= 0.30
NSTEMI	12	32.43	25	67.57	
MI Location					
AWMI	15	44.12	19	55.88	p= 0.71
IWMI	9	39.13	14	60.87	
LWMI	3	50	3	50	
NSTEMI	12	32.43	25	67.57	
Extent of CAD					
SVD	26	48.1	28	51.9	p=0.07
DVD	6	22.2	21	77.8	
TVD	7	36.8	12	63.2	
IRA					
LAD	17	41.5	24	58.5	p=0.83
LCX	12	40	18	60	
RCA	10	34.5	19	65.5	
Time to Reperfusion					
Within 2 hrs	0	0	4	100	
2hrs to 1 day	3	18.75	13	81.25	p= 0.002 [(2)]
1-7 days	16	32.65	33	67.35	
>7 days	20	64.52	11	35.48	
Extent of Revascularization					
IRA only	33	44	42	56	p=0.07
Multi-vessel PCI	6	24	19	76	

[1]Chi-square test, [2]Fisher's exact test

Table 3: STE LV Longitudinal strain in patients with and without LVR

Parameter	LVR+	LVR-	p Value[1]
LVGLS -Baseline (Mean+/-S.D.)			
Baseline	-11.36±2.96	-15.39±2.79	<0.001
3rd day	-13.62±2.93	-17.48±3.03	<0.001
One month	-16.13±3.30	-19.31±2.54	<0.001
Three months	-17.87±2.88	-20.56±2.29	<0.001
LVGLS-Basal (Mean+/-S.D.)			
Baseline	-10.85±2.17	-15.36±3.89	<0.001
3rd day	-13.15±3.51	-17.69±4.52	<0.001
One month	-14.87±2.98	-20.56±3.96	<0.001
Three months	-16.92±2.61	-23.57±3.40	<0.001
LVGLS-Apical (Mean+/-S.D.)			
Baseline	-11.15±2.47	-13.44±3.55	<0.001
3rd day	-12.89±2.37	-15.75±3.75	<0.001
One month	-14.30±2.02	-18.68±4.18	<0.001
Three months	-16.17±1.23	-22.32±3.58	<0.001

[1] Independent student t-test
ð LVGLS- Left ventricular global longitudinal strain

Table 4: Comparison of speckled tracking parameters in different LV segments

LVCS in different Segments (Mean+/-S.D.)		LVR+	LVR-	p-value[1]
BAS¶	Baseline	-11.79±2.19	-15.96±4.77	<0.001
	3rd day	-13.12±2.06	-17.45±6.55	<0.001
	One month	-14.46±1.83	-20.06±5.14	<0.001
	Three months	-15.43±1.60	-22.49±5.03	<0.001
BA†	Baseline	-12.05±2.40	-14.01±3.45	0.003
	3rd day	-12.58±2.25	-15.83±3.78	<0.001
	One month	-14.35±2.08	-18.70±5.08	<0.001
	Three months	-15.61±1.44	-21.24±4.35	<0.001
BAL‡‡	Baseline	-13.38±2.45	-14.67±4.01	0.075
	3rd day	-13.56±2.42	-16.36±4.18	<0.001
	One month	-14.56±1.99	-19.83±4.61	<0.001
	Three months	-15.66±1.76	-22.50±4.67	<0.001
BIL	Baseline	-12.53±2.73	-14.75±4.91	0.012
	3rd day	-13.28±2.89	-17.08±4.95	<0.001
	One month	-14.38±1.83	-19.65±5.04	<0.001
	Three months	-15.38±1.51	-22.75±5.12	<0.001
BI¶¶	Baseline	-13.12±2.93	-15.00±3.79	0.010
	3rd day	-13.66±2.43	-16.95±4.42	<0.001
	One month	-14.35±2.24	-19.21±4.27	<0.001
	Three months	-15.30±1.85	-22.27±4.09	<0.001
BIS††	Baseline	-11.79±2.29	-14.85±5.44	0.001
	3rd day	-13.12±2.78	-17.16±5.03	<0.001
	One month	-13.82±1.97	-19.70±5.18	<0.001
	Three months	-14.89±1.74	-22.01±4.67	<0.001

[1] Independent student t-test, ð **LVCS**-Left Ventricular circumferential strain, ¶ BAS-Basal anteroseptal, †BA-Basal anterior, ‡‡ BAL-Basal anterolateral, ððð BIL-Basal inferolateral, ¶¶ BI-Basal inferior, †††BIS-Basal inferoseptal

Table 5: Multivariate logistic regression analysis: baseline and at one month echocardiographic parameters and left ventricle remodeling

Parameter	Multivariate regression							
	At baseline				At one month			
	P value	OR	95% CI		P value	OR	95% CI	
WMSI	0.693	1.206	0.476	3.058	-	-	-	-
LVEF ¶	0.065	0.946	0.891	1.003	0.013	0.894	0.819	0.977
LVGLS†	0.002	1.383	1.131	1.692	0.015	1.284	0.949	1.737
LVGCS basal ‡	0.001	1.435	1.149	1.792	0.002	1.992	1.293	3.069
LVGCS apex	0.015	1.283	1.049	1.569	0.002	1.851	1.244	2.753
		R Square 0.47				R Square 0.62		

ð WMSI- Wall motion score index, ¶ LVEF- Left ventricular ejection fraction, †LVGLS –Left ventricular global longitudinal strain, ‡ LVGCS- Left ventricular global circumferential strain

Discussion

In the present study, we assessed the value of STE in the prediction of LVR after PCI in 100 patients with AMI. We also evaluated the factors associated with LVR after successful PCI. We found that both longitudinal and circumferential function evaluated by speckle-tracking based deformation imaging were strong predictors of LVR after percutaneous angioplasty in patients with acute MI. Time to reperfusion was found to be an important factor associated with LVR.

In our study, the rate of LVR was 39%, which is comparable to other observations [11]. Although various criteria and definitions have been used in the literature, we used at least 20% increase in LV EDV and/or ESV assessed 3 months after the MI who had undergone successful PCI.

At baseline, we found decreased LVEF with no significant difference in WMSI (Wall Motion Score Index) between LVR+ and LVR– groups. In the present study, we did not observe any relations between the MI location and LVR. We neither found any relation between STEMI v/s NSTEMI and LVR nor between single v/s multi-vessel disease with LVR.

There was a significantly longer time to reperfusion in patients with LVR, as compared to those without LVR; which was also reported in some studies [12,13]. An early and successful reperfusion of the IRA seems to be the major factor for preventing unfavourable changes in LV structure and function.

We found that the LV global longitudinal strain was significantly impaired in LVR group & global longitudinal strain at baseline and at one month after PCI is a reliable predictor of LVR at three months. The similar observations were made by D'Andrea et al where they found that the averaged strain obtained in all LV segments is a reliable predictor of LVR [14].

In the present study parasternal short-axis global circumferential strain was found significantly impaired in the LVR group. Both LVGCS at baseline and at one month were found to be predictive of LVR at three months after PCI. In the study by Hung C et al[15] circumferential analysis was found to be predictive of LVR.

In the present study we evaluated for various modifiable and non-modifiable risk factors for CAD and its association with LVR using STE. There was no significant association found between these factors with LVR.

Limitations

Our study, in line with the literature, confirms that different STE parameters are useful diagnostic tool for assessing LV function, but it's prognostic value and the impact on major cardiac adverse events has to be confirmed with further studies based on long-term follow-up data.

Another limitation of the study is that it is based on a small population and majority of patients were males. Our results have to be confirmed on a larger sample size with more homogenous gender distribution

Conclusions

LVR was found in a relatively significant number of patients after AMI (39%) after successful PCI and was strongly associated with the time to reperfusion. Our results suggest that STE performed early at the 3rd day and 1 month and three months after the MI reveals LV strain impairment and may provide important predictive value in identifying patients at high risk for LVR. The various important STE predictors of LVR were global longitudinal strain, regional longitudinal strain rate, basal and apical global and regional circumferential strain at baseline and 30 days after the PCI. Early LVR suspicion based on these predictors enables us to select individuals requiring more detailed and frequent follow-up or aggressive secondary prevention.

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