

# Assessment of Right Ventricular Function Using Strain and Strain Rate in Patient with Acute Anterior ST Segment Elevation Myocardial Infarction

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## Abstract

**Introduction:** Anterior ST-segment elevation myocardial infarctions (STEMI) are those involving the anterior ECG leads of the heart as a result of transmural ischaemia. They can be subdivided according to their extension into anteroseptal and anterolateral infarctions. **Objective:** The aim of this study is assessment of right ventricular function using strain and strain rate imaging in patients with anterior ST segment elevated myocardial infarction (STEMI). **Methods:** This prospective study was conducted on 35 patients with anterior ST segment elevated myocardial infarction (STEMI) who were admitted to ER and CCU department in National Heart Institute from May 2018 to May 2019. **Results:** Comparison between groups regarding longitudinal strain showed that there is highly statistically significant difference between them in lateral wall (all segments), septum (all segments) and global LS of right ventricle. Comparison between studied groups regarding circumferential strain revealed that there is highly statistically significant difference between them in all segments of right ventricle. **Conclusions:** Strain and strain rate imaging are feasible and reproducible tools in assessment of right ventricular function in patients with anterior ST segment elevated myocardial infarction (STEMI).

## Keywords

Myocardial Infarction, STEMI, Strain and Strain Rate Imaging

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## 1. Introduction

Anterior ST-segment elevation myocardial infarctions (STEMI) are those involving the anterior ECG leads of the heart as a result of transmural ischaemia. They can be subdivided according to their extension into anteroseptal and anterolateral infarctions [1].

Assessment of left ventricular (LV) function has become standard practice after MI. It is known that the left ventricular function is a predictor of cardiovascular morbidity and mortality after MI [2]. In contrast, assessment of the right ventricular (RV) function after MI is still uncommon. Some studies suggest that RV function is an independent predictor of mortality and development of heart failure (HF) in patients with known LV dysfunction due to MI [3].

In practice, clinicians largely rely on non-invasive imaging methods for assessment of RV function. Two-dimensional (2-D) echocardiography is the mainstay for analysis of RV function, but recently alternative techniques have been proposed, including tissue Doppler imaging (TDI) techniques, three dimensional (3-D) echocardiography, magnetic resonance imaging (MRI) and speckle tracking echocardiography (STE) [4].

Speckle tracking allows the assessment of myocardial strain and strain rate. Myocardial strain is a dimensionless index of tissue deformation expressed as a fraction or percent change. Myocardial lengthening gives a positive and shortening gives a negative strain value. Strain rate (SR) measures the local rate of deformation per unit time. Two-dimensional (2-D) strain and strain rate (SR) analyses are valuable Doppler-independent techniques to obtain measurements of myocardial movement and deformation [5].

We designed this work to study the right ventricular function using echocardiographic 2-D speckle tracking in patients that experienced anterior ST segment elevation myocardial infarction (STEMI).

## 2. Methods

This prospective study was conducted on 35 patients with Anterior ST segment Elevated myocardial infarction (STEMI) who were admitted to ER and CCU Department in National Heart Institute from May 2018 to May 2019.

### 2.1. Inclusion Criteria

Patients, with STEMI with symptoms onset less than 12 h, who underwent successful primary PCI in the first 24 h from hospital admission, were included.

Diagnosis of acute myocardial infarction was made on the basis of typical ECG changes (new ST-segment elevation at the J point in  $\geq 2$  contiguous leads ( $\geq 0.2$  mV in V1 through V3 and  $\geq 0.1$  mV in other leads)) and ischemic chest pain associated with elevation of cardiac biomarkers.

### 2.2. Exclusion Criteria

- Thrombolytic treatment within 24 hours.

- Patients with preexisting severe depression of left ventricular systolic function (EF < 25%), age younger than 18 years and bad echocardiographic windows.

Data were collected including history, general and full cardiovascular assessments. Investigations included ECG, coronary angiography and echocardiography including conventional echocardiographic measurements, tissue Doppler-Derived Strain and Strain-Rate Imaging and two dimensional (2-D) speckle tracking echocardiography for all patients.

### **2.3. Tissue Doppler-Derived Strain and Strain-Rate Imaging**

Tissue Doppler imaging (TDI), also known as tissue velocity imaging (TVI), is currently accepted as a sensitive and sufficiently accurate echocardiographic tool for quantitative assessment of cardiac function. Several tissue Doppler velocity parameters appeared to be useful for the diagnosis and prediction of long-term prognosis in major cardiac diseases. Myocardial time-velocity curves can be obtained either online as spectral pulsed TDI, known as pulsed wave TDI (PW-TDI), or reconstructed offline from two-dimensional (2D) color coded TDI images, known as color TDI (C-TDI) loops [6].

### **2.4. Two Dimensional (2-D) Speckle Tracking Echocardiography**

Three LV apical long axis views; apical four-chambers, two chambers, and apical three chambers views were acquired at frame rates ranging between 50 - 90 frame/s. Three consecutive cardiac cycles were acquired at end-expiration breath hold and digitally stored on CDs for offline analysis. In order to measure the timing of cardiac events, LV inflow (mitral) and outflow (aortic) velocities were recorded using pulsed-wave Doppler.

Using 2D strain software, the RV and LV endocardial borders of the endsystolic frame were manually traced. On the basis of this line, the computer automatically created a region of interest (ROI) including the entire transmural wall, and the software selected suitable natural acoustic markers (speckles) moving with the tissue for tracking.

### **2.5. Statistical Analysis of Data**

The collected data organized, tabulated and statistically analyzed using statistical package for social sciences (SPSS) version 22 (SPSS Inc., Chicago, USA). For qualitative data, frequency and percent distributions was calculated. For quantitative data, mean, standard error (SE), minimum and maximum were calculated. Statistical significance was defined as P value < 0.05.

## **3. Results**

There was no statistically significant difference between two groups regarding neither demographic data as (age, sex) nor risk factors as (dyslipidemia, smoking, DM or HTN). Mean  $\pm$  SD of patients age  $60.09 \pm 9.78$  VS  $59 \pm 10$  years of

control. Regarding percent of DM (28.6% of patients VS 40.0% of control) (P-value 0.355). Regarding percent of HTN (34.3% of patients VS 24.0% of control) (P-value 0.391). Regarding percent of smoking (34.3% of patients VS 36.0% of control) (P-value 0.891). Regarding percent of dyslipidemia (20.0% of patients VS 28.0% of control) (P-value 0.470) (**Table 1**).

Comparison between groups regarding longitudinal strain showed that there is highly statistically significant difference between them in lateral wall (all segments), septum (all segments) and global LS of right ventricle. Regional strain of lateral wall (Mean  $\pm$  SD of patients  $-13.91 \pm 2.80$  VS  $-28.30 \pm 0.82$  of control) (P-value  $< 0.001$ ). Regional strain of septum (Mean  $\pm$  SD of patients  $-15.39 \pm 1.57$  VS  $-23.45 \pm 1.29$  of control) (P-value  $< 0.001$ ). Global longitudinal strain of RV (Mean  $\pm$  SD of patients  $-14.65 \pm 2.04$  VS  $-25.88 \pm 0.63$  of control) (P-value  $< 0.001$ ) (**Table 2**).

Comparison between studied groups regarding circumferential strain revealed that there is highly statistically significant difference between them in all segments of right ventricle. Anterior circumferential strain (Mean  $\pm$  SD of patients  $-14.57 \pm 1.63$  VS  $-16.80 \pm 2.12$  of control) (P-value  $< 0.001$ ). Lateral circumferential strain (Mean  $\pm$  SD of patients  $-13.60 \pm 2.67$  VS  $-16.16 \pm 2.70$  of control) (P-value  $< 0.001$ ). Inferior circumferential strain (Mean  $\pm$  SD of patients  $-10.74 \pm 1.99$  VS  $-15.96 \pm 2.96$  of control) (P-value  $< 0.001$ ). Regional circumferential strain (Mean  $\pm$  SD of patients  $-12.97 \pm 1.52$  VS  $-15.98 \pm 1.06$  of control) (P-value  $< 0.001$ ) (**Table 3**).

100% of patients had significant lesion in left anterior descending artery and only 31.4% had significant lesion in LCX (left circumflex artery) while majority 68.6% had no significant lesion in LCX (**Figure 1** and **Figure 2**).

**Table 1.** Comparison between study groups regarding demographic data and risk factors.

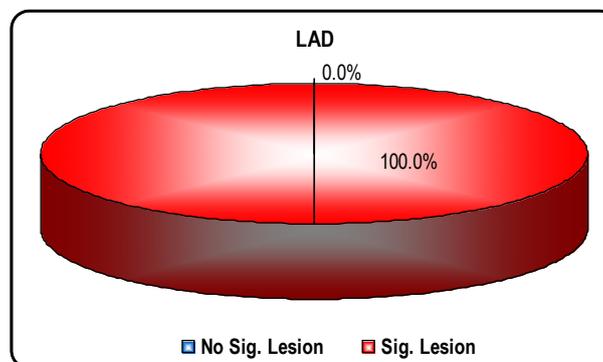
Patient's Data		Patients		Control		Total		Tests	
		N	%	N	%	N	%	t or X <sup>2</sup>	P-value
Sex	Female	16	45.7	10	40.0	26	43.3	0.194	0.660
	Male	19	54.3	15	60.0	34	56.7		
Age (years)	Range	39 - 74		40 - 72				0.420	0.676
	Mean $\pm$ SD	60.09 $\pm$ 9.78		59 $\pm$ 10					
Weight (kg)	Range	55 - 95		67 - 93				1.246	0.218
	Mean $\pm$ SD	78.29 $\pm$ 11.11		81.64 $\pm$ 8.99					
	DM	10	28.6	10	40.0	20	33.3	0.857	0.355
	Smoker	12	34.3	9	36.0	21	35.0	0.019	0.891
	HTN	12	34.3	6	24.0	18	30.0	0.735	0.391
	FH	6	17.1	3	12.0	9	15.0	0.303	0.582
	Dyslipidemia	7	20.0	7	28.0	14	23.3	0.522	0.470

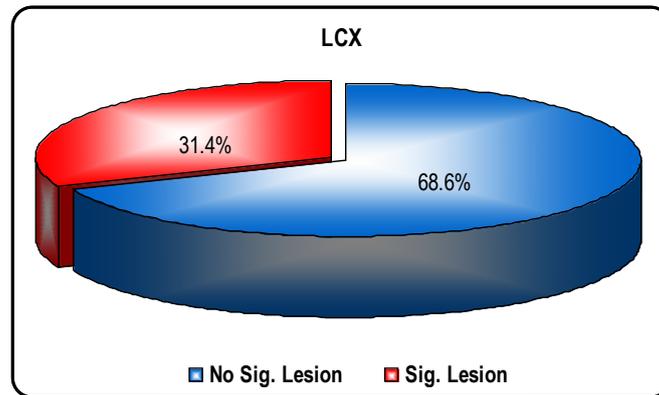
**Table 2.** Comparison between study groups regarding longitudinal strain.

Longitudinal Strain	Groups	Patients	Control	T-test		
				T	P-value	
Lateral	Basal	Range	-21.00 - 17.00	-31.00 - -27.00	11.162	<0.001**
		Mean ± SD	-15.23 ± 6.11	-29.16 ± 1.43		
	Mid	Range	-22.00 - -8.00	-31.00 - -24.00	20.130	<0.001**
		Mean ± SD	-14.14 ± 3.21	-28.60 ± 1.89		
	Apical	Range	-23.00 - -5.00	-30.00 - -24.00	20.462	<0.001**
		Mean ± SD	-11.40 ± 3.64	-27.16 ± 1.46		
Regional	Range	-22.00 - -8.66	-29.66 - -27.00	24.897	<0.001**	
	Mean ± SD	-13.91 ± 2.80	-28.30 ± 0.82			
Septum	Basal	Range	-19.00 - -12.00	-25.00 - -17.00	9.219	<0.001**
		Mean ± SD	-16.51 ± 1.52	-20.56 ± 1.87		
	Mid	Range	-23.00 - -11.00	-29.00 - -19.00	10.653	<0.001**
		Mean ± SD	-15.77 ± 2.50	-23.44 ± 3.07		
	Apical	Range	-21.00 - -11.00	-28.00 - -21.00	20.248	<0.001**
		Mean ± SD	-13.89 ± 2.75	-26.32 ± 1.60		
Regional	Range	-21.00 - -12.00	-26.00 - -21.66	21.041	<0.001**	
	Mean ± SD	-15.39 ± 1.57	-23.45 ± 1.29			
Global LS of RV	Range	-19.83 - -10.33	-27.00 - -25.00	26.562	<0.001**	
	Mean ± SD	-14.65 ± 2.04	-25.88 ± 0.63			

**Table 3.** Comparison between study groups regarding circumferential strain.

Circumferential Strain	Groups	Patients	Control	T-test	
				t	P-value
Ant	Range	-18.00 - -11.00	-21.00 - -13.00	4.599	<0.001**
	Mean ± SD	-14.57 ± 1.63	-16.80 ± 2.12		
Lat	Range	-21.00 - -6.00	-22.00 - -10.00	3.643	<0.001**
	Mean ± SD	-13.60 ± 2.67	-16.16 ± 2.70		
Inf	Range	-15.00 - -6.00	-23.00 - -12.00	8.161	<0.001**
	Mean ± SD	-10.74 ± 1.99	-15.96 ± 2.96		
Regional	Range	-16.00 - -9.30	-18.33 - -13.55	8.518	<0.001**
	Mean ± SD	-12.97 ± 1.52	-15.98 ± 1.06		

**Figure 1.** Distribution of significant lesions in left anterior descending artery.



**Figure 2.** Distribution of significant lesions in left circumflex artery.

Correlation between the site of lesion and LAD (left anterior descending artery) and LCX artery with impaired right ventricle function found that there is statistically significant difference between mid segment (P-value 0.037) and apical segment (P-value 0.024) of lateral wall and LAD; also there is statistical significant difference between apical segments of the septum (P-value 0.040), while there is statistical significant difference between anterior (P-value 0.041), lateral (P-value 0.035), Inferior (P-value 0.003) and regional (P-value 0.003) parts of the right ventricle and circumflex artery (**Table 4**).

#### 4. Discussion

ST-elevation myocardial infarction (STEMI) is characterized by a loss of contractile tissue and a change in ventricle geometry that causes substantial impairment of the ventricular systolic and diastolic functions [7].

RV-STEMI has been reported in 10 to 60% of patients with inferior STEMI. The co-existence of inferior STEMI and RV-STEMI has been shown to increase morbidity and mortality rates [8].

Speckle tracking allows the assessment of myocardial strain and strain rate. Myocardial strain is a dimensionless index of tissue deformation expressed as a fraction or percent change. Myocardial lengthening gives a positive and shortening gives a negative strain value. Strain rate (SR) measures the local rate of deformation per unit time [9].

Our study showed that demographic characteristics of the participants patients and control groups revealed that majority of cases were male 54.3%, Mean  $\pm$  SD of age of cases is  $60.09 \pm 9.78$  and in control is  $59 \pm 10$  years old, Mean  $\pm$  SD of weight is  $78.29 \pm 11.11$  and  $81.64 \pm 8.99$  kg in cases and control respectively, and there was no statistically significant difference between two groups regarding neither demographic data as (age, sex) nor risk factors as (dyslipidemia, smoking, DM or HTN).

This is coped with the study of Monaster *et al.* (2014) in which regarding demographics and risk factors of the study population, there were no significant differences between the studied groups [10].

**Table 4.** Correlation between site of lesion as regarding of LAD and LCX artery with impaired right ventricle function.

		LAD		LCX	
		r	P-value	R	P-value
Lateral	Basal	0.115	0.509	0.495	0.122
	Mid	0.347	0.037*	0.132	0.699
	Apical	0.332	0.024*	0.451	0.164
	Regional	0.192	0.268	0.419	0.200
Septum	Basal	0.232	0.181	0.229	0.498
	Mid	0.098	0.575	0.013	0.970
	Apical	0.349	0.040*	0.385	0.242
	Regional	0.220	0.205	0.100	0.771
Global LS of RV		0.222	0.200	0.356	0.282
	Ant	0.156	0.372	0.622	0.041*
	Lat	0.044	0.802	0.638	0.035*
	Inf	0.184	0.291	0.797	0.003*
	Regional	0.108	0.537	0.806	0.003*

The present study found that there is highly statistically significant difference between them in lateral wall (all segments), septum (all segments) and global LS of right ventricle.

Peak RV longitudinal strain, which quantifies the maximal shortening in the RV free wall from apex to base, is likely to be a good estimator of RV function because 80% of the stroke volume is generated by longitudinal shortening of the RV free wall [11]. In the study of Gul *et al.* (2016), RV-free-S and RV-free-SR means were similar in the early period. Mean regional and mean RV free wall strain/strain rates observed at the one-month follow up were significantly increased compared to the pre-PCI period within each individual group [12].

In agreement with our results, the study of Elnoamany *et al.* (2014) assessed the strain of the RV free wall and showed statistically highly significant difference among the studied groups [13]. Consistent with our result Sachdev *et al.* (2011) have shown that noninvasive assessment of RV longitudinal systolic strain and strain rate independently predicts future right-sided heart failure and clinical deterioration [14].

Additionally, the study on the hand compared between studied groups regarding circumferential strain and revealed that there is highly statistically significant difference between them in all segments of right ventricle.

Hamada-Harimura *et al.* (2018) studied 692 patients hospitalized for acute decompensated HF with predischarge clinical, laboratory, and echocardiographic examinations, the latter including LV global longitudinal strain and LV global circumferential strain, and RV free wall strain (3 segments) and RV global

longitudinal strain (free wall plus 3 septal segments). Echocardiographically, those with events had decreased free wall and global RV strain in addition to a larger left atrial volume index, more severe secondary mitral regurgitation, increased E/e', tricuspid regurgitant velocity, and inferior vena cava diameter, and lower tricuspid annular plane systolic excursion. Surprisingly, there were no differences in LV ejection fraction, LV global longitudinal strain and LV circumferential strain [15].

On the other hand, the present study found that 100% of patients had significant lesion in left anterior descending artery and only 31.4% had significant lesion in LCX (circumflex artery) while majority 68.6% had no Sig. Lesion by coronary angiography.

Finally, the present study assessed the correlation between the site of lesion and LAD and LCX artery with impaired right ventricle function and found that there is statistically significant difference between mid and apical segment of lateral wall and LAD; also there is statistically significant difference between apical segments of the septum, while there is statistically significant difference between anterior, lateral, inferior and regional parts of the right ventricle and circumflex artery.

Abdeltawab *et al.* (2019) found that patients with proximal or mid LCX lesions as well as patients with no reflow and worse procedural events to be correlated with RV dysfunction [16].

In the study of Medhat *et al.* (2016), they revealed that angiography revealed that RCA was the IRA in 96.7% of RVMI patients and LCX was the IRA in 3.3% of RVMI patients. This means that occlusion of the RCA proximal to the acute marginal branch suggests RVMI, while more proximal occlusions usually suggest more extensive necrosis of the posterior. In patients with left coronary artery dominance, a left circumflex coronary artery (LCX) occlusion may also be found [17].

Therefore, myocardial strain should be preferred to velocity information because it is less influenced by tethering effects and over all cardiac function. Nevertheless, Doppler-derived tissue velocity imaging, the most commonly used method for the assessment of LV strain, is angle dependent [18].

## 5. Conclusions

- Strain and strain rate imaging are feasible and reproducible tools in assessment of right ventricular function in patients with anterior ST segment elevated myocardial infarction (STEMI).
- Further attention should be given to the evaluation of RV function in post MI patients as it plays a significant role in patient symptomatology and a determinant of clinical outcome. Also septal contribution to RV function should be studied in more detail.
- More effort should be exerted in the near future to solve the technical problems and pitfalls of the strain and strain rate imaging.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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