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Predictors of Contractile Recovery After Successful Primary Percutaneous Coronary Intervention

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ABSTRACT

Background: Accurate diagnosis, characterization, and quantification of myocardial infarction (MI) are essential to assess the impact of therapy and to aid in predicting prognosis of patients with ischaemic heart disease.

Objective: This study aimed to define different parameters regarding prediction of myocardial functional recovery following successful reperfusion of acute ST segment elevation myocardial infarction (STEMI).

Patients and methods: This prospective study was carried out in Zagazig University and National Heart Institute (NHI) of Egypt during the period from June 2020 to June 2021. The study included 48 patients admitted with first acute STEMI. All patients were subjected to demographic data taking, electrocardiography and echocardiography examination (two examinations were done, the first was immediately after reperfusion and the second was 3 months from primary percutaneous coronary intervention (PCI).

Results: There was no statistically significant difference between demographic data and risk factors except smoking habit. Regarding laboratory findings there were significant lower troponin value, peak CKMB value compared to patients had remolding (p=0.0001, p=0.027 respectively). Regarding ECG parameters, there was no statistical significant difference between the study groups regarding sum ST elevation and MI territory (p value > 0.05), but there was highly statistically significant difference between the study groups regarding 90 min ST resolution among contractile recovery (group I) p=0.0001.

Conclusions: In this study patients affected by AMI with ST segment elevation and treated by primary PCI showed contractile recovery in 60.4% of the patients, while the remodeling of the LV has been observed in 39.6%.

Keywords: ST-segment elevation myocardial infarction (STEMI), Myocardial infarction, ECG, CHD.

INTRODUCTION

Coronary heart disease (CHD) is a major cause of death and disability in developed countries. Although CHD mortality rates worldwide have declined over the past four decades, CHD remains responsible for about one-third or more of all deaths in individuals over age 35 [(1)].

Acute myocardial infarction (AMI) is a leading cause of morbidity and mortality in the world [(2)]. Reperfusion strategies are the current standard therapy for AMI [(3)]. Accurate diagnosis, characterization, and quantification of myocardial infarction (MI) are essential to assess the impact of therapy and to aid in predicting prognosis of patients with ischaemic heart disease. After MI, the alteration of global and regional LV function and the presence of myocardial viability depend on both infarct size (IS) and transmural extension of necrosis [(4)]. Clinical outcomes after an acute myocardial infarction (AMI) are determined by the initial morphological and functional alterations resulting from myocardial necrosis [(5)]. Infarct size is a major determinant of mortality, **Pislaru *et al.*** [(6)] and **Reffelmann *et al.*** [(7)] and transmural infarcts are associated with a worse prognosis and more adverse cardiac events [(8)]. Therefore, accurate assessment of IS and the identification of segments with transmural extent of necrosis plays a central role in the prediction of prognosis [(9)].

A successful restoration of epicardial coronary artery blood flow after primary percutaneous coronary intervention (PPCI) for ST-segment elevation myocardial infarction (STEMI) does not always lead to adequate myocardial perfusion or optimal outcome. Prior studies have shown that microvascular obstruction (MVO) is present in up to 50% of patients with STEMI even after timely reperfusion by PPCI and independently associated with ventricular remodeling and adverse clinical outcomes [(10)].

Measurement of myocardial deformation by strain has emerged as a promising tool to evaluate normal and ischemic myocardium in order to evaluate regional and LV global function. Strain determines regional myocardial function and can be measured by Doppler or speckle tracking [(11)]. Global longitudinal strain (GLS) is considered an effective parameter for quantifying left-ventricular function [(12)] more sensitive than LVEF assessed by 2D echocardiography and their role in large MI has been previously reported [(13)]. Two-dimensional speckle-tracking echocardiography (2DSTE) is emerging as a novel technique to allow the assessment of LV systolic and diastolic function through the

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quantification of active myocardial deformation [14]. The global longitudinal strain (GLS) assessed with 2DSTE, which evaluates the longitudinal myocardial deformation is more reproducible than left ventricular ejection fraction (LVEF) or wall motion score index (WMSI). It is advantageous over the color kinesis technique and is proven to be effective in detecting the LV myocardial ischemia [15]**.** Moreover in patients with cardiovascular disease, myocardial dysfunction occurs even if overall LVEF is preserved, and that may be associated with impaired LV longitudinal deformation [16].

In the present study, we aimed to define different (on admission) parameters regarding prediction of myocardial functional recovery following successful reperfusion of acute STEMI.

PATIENTS AND METHODS

This prospective study was carried out in Zagazig University and National Heart Institute (NHI) of Egypt during the period from June 2020 to June 2021. All patients diagnosed as recent STEMI eligible for reperfusion therapy by primary PCI were recruited. The study included 48 patients 40 males and 8 females. Their age ranged from 28 to 70 years with mean age 47.3 ± 9.7 years.

Ethical consent: An approval of the study was obtained from Zagazig University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Inclusion criteria: Patients with first acute ST elevation myocardial infarction with successful reperfusion by primary PCI.

Exclusion criteria: History of myocardial infarction. Failed reperfusion or revascularization. History of heart muscle diseases (cardiomyopathies). History of previous PCI or CABG. History of significant valvular diseases. Thrombolytic therapy during ST-segment elevation myocardial infarction (pharmaco-invasive strategy). Significant arrhythmias (including atrial fibrillation and frequent extrasystoles). Previous pacemaker or cardioverter-defibrillator implantation. Poor echocardiographic conditions to analyze the results of speckle-tracking echocardiography.

Patients were divided into two groups according to percentage of changes in LVED volume at admission and three month follow up, The study included 48 patients who were divided into two groups according to percentage of change in LVED volume: Group I (29 patients) included patients with contractile recovery. (No LV remodeling). Group II (19 patients) included patients with LV remodeling. After that patients who showed ≥ 20% increase in LVED volume were defined to have LV remodeling while patients who showed < 20% increase in LVED volume have contractile recovery.

All patients were subjected to demographic data taking, full general and local examination. Electrocardiography was used to record standard 12-lead ECGs. They were recorded at a paper speed of 25 mm/ second (s) and a 10 mm/mv calibration. Twelve-lead electrocardiography was performed directly before and 90 min after reperfusion of infarct related artery (IRA). Sum of STR was calculated as sum of ST-segment elevation on the first ECG minus the sum of the ST-segment elevation on the second ECG divided by the sum of ST segment elevation on the first ECG and expressed as a percentage. The ST segment resolution (STR) was categorized as complete (≥ 70%) and incomplete (≤`70%).

$$\text{STR} = \frac{\text{Initial } (\sum \text{STE}) - (\sum \text{STE}) \text{ on the second ECG}}{\text{Initial } (\sum \text{STE})}$$

Markers of necrosis upon admission and after 12, and 24 hours, cardiac creatine kinase and troponin I were collected using the immuneinhibition and immunoenzymatic quantitative methods.

Echocardiography examination: Two examinations were done, the first was immediately after reperfusion and the second was 3 months from primary PCI**.** Resting echocardiography was performed using the Vivid 9 system (GE Vingmed Ultrasound AS, Horten, Norway). Three apical scans of the left ventricle in the three-chamber, four-chamber, and two-chamber views with ECG triggering according to the guidelines of the American Society of Echocardiography were performed [17]**.**

We measured the following parameters LV volumes and Ejection fraction (EF): using the modified Simpson biplane technique. It is calculated also from the formula: EF= [(EDV- ESV) ⁄ EDV] ×100. Normally, it is 50 - 70%.

We measured the following parameters: LV volumes and Ejection fraction (EF) using the modified Simpson biplane technique. Global longitudinal strain (GLS) using the speckle tracking technique. Reperfusion of acute STEMI was done in all patients using primary PCI. Myocardial blush was graded according to the dye density score proposed by **Van't Hof *et al.*** for patients with TIMI III.

Statistic analysis

The collected data were coded, processed and analyzed using the SPSS (Statistical Package for Social Sciences) version 22 for Windows® (IBM

SPSS Inc. Chicago, IL, USA). Continuous variables were expressed as mean ± SD. Categorical variables were expressed as numbers and percentages. A chi-square test was used to see a relationship between two categorical variables (association between qualitative variables).

The paired- samples T test was used to compare the means between two groups. One-way analysis of variance (ANOVA) test was used for comparison between the three components in ST resolution variable. The correlation was done using Pearson correlation. The threshold of significance was fixed at 5% level (P value). P value ≤ 0.05 was considered significant.

RESULTS

Table (1) showed that there was no statistically significant difference between demographic data and risk factors except smoking habit. There was higher percent of smokers had remolding, p=0.012. Also there was statistically highly significant difference regarding pain to balloon time which was higher in remolding group (p<0.001).

Table (1): Demographic data and risk factors of the study groups

Variables	**Outcome after successful primary percutaneous coronary intervention**				**Test of significance**	**P-value**
	Group I Contractile recovery n.29		**Group II Remolding n.19**			
Age (years)	45.1 ± 9.05		50.68 ± 10.16		T 1.99	0.053
Gender M n (%) **F n (%)**	23 6	79.3% 20.7%	17 2	89.5% 10.5%	f	0.45
Hypertension	13	44.8%	9	47.3%	0.03	0.86
Diabetes mellitus	9	31%	11	57.9%	3.4	0.065
Dyslipidemia	18	62%	15	78.9%	1.5	0.22
Smoking	14	48.3%	16	84.2%	6.03	0.012 (s)
Family History	11	37.9%	12	63.2%	2.9	0.087
Pain to balloon (min) Mean ±SD	144.3 ± 62.3		223.6 ± 83.4		t 3.7	<0.001 * (HS)

U=Mann Whitney u test significant p<0.05

Patients with contractile recovery had significantly lower troponin value, peak CKMB value compared to patients had remolding (p=0.0001, p=0.027 respectively) (table 2).

Table (2): The levels of cardiac biomarkers of the studied groups

variables	**Outcome after successful primary percutaneous coronary intervention**		**u**	**p-value**
	Group I Contractile recovery n.29	**Group II Remolding n.19**		
Troponin Median	4	18	4.014	0.0001
Peak CK MB Median	156	289	2.215	0.027

U=Mann Whitney u test significant p<0.05 highly significant p<0.001

Table (3) showed that there was no statistical significant difference between the study groups regarding sum ST elevation and MI territory (p > 0.05), but there was highly statistically significant difference between the study groups regarding 90 min ST resolution among contractile recovery (group I) (p=0.0001).

Table (3): ECG data of the studied groups

variables	Outcome after successful primary percutaneous coronary intervention				χ^2	p-value
	Group I Contractile recovery (N.29)		GROUP II Remolding (N.19)			
MI territory:	.	.	.	.		
Anterior	17	58.6%	9	47.4%	0.61	0.74
Anterolateral	4	13.8%	3	15.8%		
Anteroseptal	8	27.6%	7	36.8%		
90 min.ST resolution	0.79±0.082		0.59±0.07		8.71	0.0001
Sum ST elevation	15.34±3.32		16.94±2.48		1.79	0.079

χ^2 Chi square test No significant p>0.05

Patients with contractile recovery had highly statistically significant difference in EDV, ESV and ESVI within 24 hours compared to patients had remolding ($p<0.001$). Whereas patients with contractile recovery had statistically significant difference in EF and GLS within 24 hours compared to patients had remolding ($p<0.05$) (table 4).

Table (4): Admission time EDV, ESV, EF, ESVI, GLS: in the study groups

Admission time	Outcome after successful primary percutaneous coronary intervention		T	p-value
	Group I Contractile recovery n.29	GROUP II Remolding n.19		
EDV Mean ±SD	118.31±24.28	152.78±28.44	4.495	0.0001
ESV Mean ±SD	53.27±14.51	81.84±21.68	5.477	0.0001
EF Mean ±SD	54.32±8.83	46.76±8.25	2.975	0.005
ESVI Mean ±SD	28.75±8.26	41.16±10.59	4.544	0.0001
GLS Mean ±SD	-14.25±3.57	-12.33±2.53	2.027	0.048

EF, ejection fraction; EDV, end diastolic volume; ESV, end systolic volume; ESVI, end systolic volume index; GLS; global longitudinal strain.

Continuous variables between two groups were compared with independent t test.

Table (5) showed that there was highly statistically significant difference between the study groups regarding, EDV, ESV, EF, ESVI and GLS after 3 months compared to patients had remolding ($p< 0.001$).

Table (5): 3 months fellow up EDV, ESV, EF, ESVI, GLS: in the study groups

3 month follow up	Outcome after successful primary percutaneous coronary intervention		t	p-value
	Group I Contractile recovery (n.29)	GROUP II Remolding (n.19)		
EDV (Mean ±SD)	115.96±21.66	183.57±33.06	8.577	0.0001
ESV (Mean ±SD)	49.69±13.5	102.63±23.93	9.799	0.0001
EF (Mean ±SD)	56.89±8.23	43.9±5.88	5.944	0.0001
ESVI (Mean ±SD)	26.86±7.53	51.84±11.35	9.182	0.0001
GLS (Mean ±SD)	-15.15±3.4	-11.52±2.36	4.061	0.0001

EF, ejection fraction; EDV, end diastolic volume; ESV, end systolic volume; ESVI, end systolic volume index; GLS; global longitudinal strain.

Continuous variables between two groups were compared with independent t test.

DISCUSSION

This study showed that There was statistically non-significant difference between the study groups regarding age (P.: 0. 053) and gender (P.: 0. 45). This is concordant with **Oh *et al.*** [18], **Zaliaduonyte-Peksiene *et al.*** [19]**,** and **Ma *et al.*** [20]**.**

Also, there was non-significant difference between both groups regarding the risk factors of coronary artery disease like hypertension (P 0.86), diabetes mellitus (P 0.065), dyslipidemia (P 0.22) and family history (P= 0.087). This agrees with **López Haldón *et al.*** [21] who found no significant difference between both groups regarding cardiac risk factors. But On the other hand, there was significant difference regarding smoking (P=0.012), in favor of **Group II (**Patients with LV Remodeling) [21]**.**

Patients with contractile recovery had significantly shorter time to pain to balloon, compared to patients had remolding (144.3 ± 62.3 min, versus 223.6 ± 83.4 min) with highly significant statistical difference (P <0.001**). This is in in agreement with **Park *et al.*** [22] who reported that Patients in remodeling group had longer symptom onset to balloon time. Also, **Koul *et al.*** showed that first medical contact FMC-to-PCI delay of more than 60 minutes resulted in a statistically significant adjusted increase in severe left ventricular dysfunction at discharge and reported an overall significant association between increasing symptom-to-PCI delays and 1-year mortality [23]**.** So, a goal of FMC-to-PCI of less than 1 hour might save patient lives.

These results showed that, patients with contractile recovery had significantly lower troponin value and peak CKMB value (P 0.0001* and 0.02) compared to patients had remolding. This is concordant with **Ma *et al.*** [20], who stated that, the remodeling group had a higher peak troponin T and creatine kinase-MB (CK-MB) level than the contractile recovery group.

The present study showed no statistical significant difference between the study groups regarding sum ST elevation and MI territory (P 0.079 and 0.74). This is concordant with **Khurelsukh *et al.*** [24] who found non-significant difference between the study group regarding culprit MI territory whether anterior or non-anterior STEMI. On the contrary this was discordant with **Lustosa *et al.*** [25] who found that, the regional values of MWI and MWE in the culprit vessel territory of LAD and LCx were significantly lower in patients with early LV remodeling compared to patients without early LV remodeling. These discrepancies with our study might be explained by the small sample size of our study design. But, there was highly statistically significant difference between the study groups regarding 90 min ST resolution among contractile recovery (group I) (P.0.0001), which is in agreement **Yusuf *et al.*** [26] .

The absence of ST-segment elevation resolution after PPCI was also associated with a lack of left ventricular function recovery and has been associated with poor outcomes, including larger infarct size and increased mortality [27]**.**

This was powered by the strong negative correlation between sum STR and LV remodeling (r= - 0.529, p< 0.001). This finding is concordant with **Amaya *et al.*** [28] who found, a significant inverse correlation between the degree of STR and ΔLVEDV (r= -0.576, p0.01). This agrees with the fact that impaired microcirculation and indeed sum STR may reflect the extent of myocardial damage.

Regarding admission time EDV, ESV, ESVI, EF and GLS, the present study showed significant difference between the study groups during the acute STEMI. However all parameters in both groups denote impaired systolic LV function during acute STEMI (myocardial Stunning). This agrees with **Bordejevic *et al.*** [29], while was concordant with **Oh *et al.*** [18] who reported that patients who had a baseline LVEF of less than 45% soon after acute MI, left ventricular systolic dysfunction was recovered (follow-up LVEF ≥45%) in almost 50% (group II) after a median follow-up.

The cut-off value of GLS that predict LV remolding was -14.7 % (AUC= 0.91, CI 95% (ranged from 0.845 to 0.991, sensitivity= 88.6%, specificity= 80%).

Regarding EDV, ESV, ESVI, EF and GLS 3 months follow-up after MI, the present study showed statistical significant difference between the study groups regarding EDV, ESV, ESVI, EF, and GLS. We noticed that patients in **group I** had highly significant improvement of EF (P 0.0001) during follow-up, and significant improvement of ESV, ESVI and GLS (P 0.01) compared to the admission time (basal) echocardiographic study. This is concordant with **Bonios *et al.*** [30] who showed significant difference between his study groups regarding 3 months follow up EDV and EF.

Interestingly, the present study showed high statistical significant difference between the study groups regarding post PPCI MBG with higher incidence of MBG II & III, 89.3% in contractile recovery group (I) versus only 10.7% in LV remodeling group (II) denoting that although group (II) who showed higher incidence of TIMI III post PPCI (restored epicardial reperfusion). Indeed showed lower incidence of MBG II & III (failed to restore microvascular and myocytes reperfusion). This finding is concordant with **Bastawy *et al.*** [31] who found significant difference in his study groups regarding MBG II & III with worsened MBG post PPCI in LV remodeling group.

CONCLUSION

In this study patients affected by AMI with ST segment elevation and treated by primary PCI, the contractile recovery has been observed in 60.4% of the patients affected by AMI, while the remodeling of the LV has been observed in 39.6%. The present study recommend using STR and MBG as predictor of contractile recovery and might be considered indicators of myocardial and microvascular reperfusion. We recommend further multicenter studies addressing large sample size.

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