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Predictors of myocardial functional recovery after successful reperfusion of acute St elevation myocardial infarction using speckle tracking echocardiography

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Abstract
Background: In those suffering from acute ST elevation myocardial infarction (STEMI), even after the restoration of blood flow in large blood vessels, the perfusion of tissue in the affected region often remains disturbed. The presence of long-lasting microcirculatory dysfunction is linked to inadequate restoration of contractile ability and unfavourable clinical results. The objective of this study was to identify the factors that may predict the restoration of myocardial function after reperfusion of acute STEMI utilising various reperfusion strategies. The assessment of myocardial function was based on the measurement of global longitudinal strain (GLS) at the 3-month mark.
Methods: This prospective non-randomized cohort work had been performed on 100 participants diagnosed with acute STEMI undergoing successful reperfusion with either primary percutaneous coronary intervention (PCI), thrombolytic therapy or pharmaco-invasive strategies, Phase I: baseline clinical characteristics and echocardiographic evaluation of left ventricular function using GLS, ejection fraction (EF), myocardial performance index (MPI), systolic myocardial excursion in all patients presented with STEMI after successful perfusion. phase II: 3 months after the index procedure clinical evaluation of the patients, assessment of GLS, LV systolic function by echocardiography, systolic myocardial excursion, myocardial performance index and detection of occurrence of any major adverse cardiac events (MACE).
Results: Regarding the left ventricular recovery assessed by GLS post 3 months of index procedure, there was better improvement in LV function in primary PCI group with GLS% ranged from -8% to -22% with mean -17.76±4.0%, while thrombolytic therapy ranged from -8% to -19% with mean -14.12±3.43%, pharmaco-invasive strategy GLS% ranged from -7% to -22% with mean -16.47±4.13%. Multivariate analyses identified that baseline EF (p<0.001, OR= -0.158), MPI (P= 0.004, OR=12.634), GLS post reperfusion (P = 0.049, OR= 0.256) are independent predictors of the myocardial recovery.
Conclusions: Baseline ejection fraction, MPI, GLS post reperfusion were identified as an independent predictor of the myocardial recovery following acute myocardial infraction.

Keywords: Global longitudinal strain, left ventricular recovery, acute myocardial infraction

Introduction

After revascularization of those with acute ST elevation myocardial infarction (STEMI), even when the flow in the main blood vessels is restored, the perfusion of tissue in the affected region often remains reduced. The presence of long-lasting microcirculatory dysfunction is linked to inadequate restoration of contractile ability and unfavourable clinical results. Therefore, just reopening large blood vessels cannot ensure the full restoration of blood flow, and it is also necessary to provide enough blood flow to the microvasculature in order to achieve optimum recuperation [1].

Primary percutaneous coronary revascularization is often used for individuals with acute myocardial infarction (AMI) to quickly restore blood flow to the cardiac muscle. Nevertheless, even satisfactory restoration of blood flow to the coronary artery injured by an ischemic attack does not necessarily ensure sufficient salvage of the cardiac muscle [2].

The myocardium, which is supplied by the coronary artery affected by the infarct, may remain motionless due to temporary stunning or permanent nonviability, even if reperfusion therapy is efficient. Additionally, the core of the infarct may experience limited reperfusion due to damage to the microvasculature and subsequent blockage [3].

Global longitudinal strain is a reliable measure for assessing left-ventricular function, which is more sensitive than left ventricular EF measured using 2-D echocardiography. Previous studies have shown its significance in cases of large MI, including those who have relatively preserved LV function following acute MI [4]. However, there is a dearth of early knowledge about the factors that potentially impact LV functional recovery in patients admitted for STEMI [5].

Patients and Methods

This prospective non-randomized cohort had been performed on a number of 100 patients diagnosed with acute STEMI undergoing successful reperfusion with either primary PCI, thrombolytic therapy or pharmaco-invasive strategies in cardiovascular disease department, Tanta University from august 2021 to august 2023, following permission from the Ethics Committee Tanta University Hospitals, Tanta, Egypt. All subjects provided a well-informed written consent. Criteria for exclusion were failed reperfusion or revascularization, patients presented with previous STEMI, patients having cardiomyopathy, individuals who had prior coronary artery bypass graft (CABG). Phase I: individuals presented with acute ST segment elevation myocardial infraction will receive emergency care according to recent ESC guidelines, reperfusion strategy will be either thrombolytic therapy, primary PCI or pharmaco-invasive strategy.

The study sample was subjected to the following: demographic data and clinical examination Transthoracic Echocardiography (GE Vivid E9 with M5S probe) colour doppler, continuous-wave doppler, pulsed-wave doppler, tissue doppler and M-mode echocardiography. All study members were evaluated at two-time interval, the first after successful reperfusion and the second one was 3 months later. The echocardiographic evaluation necessitated the use of GLS with ECG gating to accurately time events during the cardiac cycle. It needed an ECG signal that was optimum and had minimum variability in heart rate (HR). Speckle tracking echocardiography is used to analyse and calculate the LV GLS by examining three different apical views: the apical four chamber (A4CH), apical two chamber (A2CH), and apical three chamber views. The GLS was calculated by taking the average of the regional strains. Longitudinal strain refers to the alteration in length of the myocardium along the long axis of the left ventricle (from base to apex) during systole, which is shown by a negative strain value. The ΔGLS (percentage change in GLS) was computed by comparing the GLS values at baseline and follow-up visits. A GLS bull's eye map was generated to visualise the variations in GLS values, and the mean GLS values have been determined at each stage. We evaluated the LV systolic function utilising Simpson's approach in the apical 4 and apical 2 views. Additionally, we measured the LV volumes and internal dimensions. Evaluation Segmental motion of the wall anomalies and global wall motion are assessed by measuring systolic myocardial excursion (S′) at the septal mitral annulus employing tissue Doppler imaging (TDI), Myocardial performance index (Tei index). Phase II: second assessment at 3 months after the index procedure, the observational outcomes were clinical evaluation of the patients, assessment of LV systolic function recovery by echocardiography using GLS, Ejection fraction, MPI, systolic myocardial excursion, and detection of incidence of any major adverse cardiac events (MACE).

Statistical analysis

The data were inputted into the computer and analysed employing IBM SPSS software package version 20.0. (IBM Corp, Armonk, NY). Qualitative data were represented utilising numerical values and percentages. The Shapiro-Wilk test was employed to confirm the normality of the distribution. The quantitative data was described utilising several statistical measures, including the range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

Results

Demographic data, risk factors distribution and type of myocardial infraction at presentation were insignificantly different between the three groups. Table 1

Table 1: Demographic characteristics, risk factors distribution and type of myocardial infraction at presentation between the studied groups

		Mode of reperfusion			
		Thrombolytic (n = 33)	**Primary PCI (n = 33)**	**Pharmaco-invasive (n = 34)**	**p**
Age (years)		58.33±9.87	60.0±10.11	57.38±8.85	
Sex	Female	10(30.3%)	13(39.4%)	15(44.1%)	0.497
	Male	23(69.7%)	20(60.6%)	19(55.9%)	
Risk Factors	Diabetes	23(69.7%)	16(48.5%)	19(55.9%)	0.208
	HTN	17(51.5%)	17(51.5%)	12(35.3%)	0.305
	Dyslipidemia	11(33.3%)	13(39.4%)	20(58.8%)	0.089
	Family history of coronary disease	14(42.4%)	16(48.5%)	11(32.4%)	0.398
	Smoking	19(57.6%)	18(54.5%)	17(50.0%)	0.822
Type of STEMI	Anterior	17(51.5%)	20(60.6%)	22(64.7%)	0.262
	Inferior	7(21.2%)	11(33.3%)	9(26.5%)	
	Lateral	2(6.1%)	1(3.0%)	1(2.9%)	
	Inferior + Right + Posterior	3(9.1%)	0(0.0%)	1(2.9%)	
	Inferior + Right	4(12.1%)	0(0.0%)	1(2.9%)	
	Inferior + posterior	0(0.0%)	1(3.0%)	0(0.0%)	

Data are presented as mean±SD or frequency (%). HTN: hypertension, STEMI: ST-Segment Elevation Myocardial Infarction.

EF (%) and global longitudinal strain post reperfusion were insignificantly difference between groups, while significant difference post 3 months. Table 2

Table 2: Comparison between the three studied groups according to ejection fraction and global longitudinal strain (%)

	Mode of reperfusion			P
	Thrombolytic (n = 33)	Primary PCI (n = 33)	Pharmaco-invasive (n = 34)	
Ejection fraction (%)				
Post Reperfusion	46.06±6.04	45.76±6.05	45.0±6.54	0.772
After 3 months	45.15±9.69	51.58±10.10	48.50±8.82	0.027*
Sig. bet. Grps.	p_1=0.020*, p_2=0.327, p_3=0.388			
Global longitudinal strain				
Post Reperfusion	-13.42±1.73	-13.48±1.68	-13.09±1.80	0.603
After 3 months	-14.12±3.43	-17.76±4.0	-16.47±4.13	0.001*
Sig. bet. Grps.	p_1=0.001*, p_2=0.038*, p_3=0.365			

Data are presented as mean±SD. * significant p value <0.05, p1: p value for comparing between Thrombolytic and Primary PCI, p2: p value for comparing between Thrombolytic and Pharmaco-invasive, p3: p value for comparing between Primary PCI and Pharmaco-invasive.

An analysis was conducted to compare the three groups that were investigated based on the percentage of change in various metrics after a period of three months. Table 3

Table 3: Comparison between the three studied groups based on percentage of alteration on different parameters after 3 months

	Mode of reperfusion			P
	Thrombolytic (n = 33)	Primary PCI (n = 33)	Pharmaco-invasive (n = 34)	
Ejection fraction (%)	-2.47±13.0	12.91±18.55	7.99±15.59	<0.001*
	p_1<0.001*, p_2=0.011*, p_3=0.137			
Global longitudinal strain (%)	4.71±20.60	32.07±28.74	25.66±27.27	<0.001*
	p_1<0.001*, p_2<0.001*, p_3=0.442			
Systolic myocardial excursion S (cm/sec)	5.10±23.40	23.18±22.17	19.34±36.0	0.009*
	p_1=0.003*, p_2=0.052, p_3=0.273			
MPI	12.07±16.28	0.50±15.82	-0.28±14.07	<0.001*
	p_1=0.001*, p_2<0.001*, p_3=0.821			
End systolic diameter (mm)	4.76±10.51	-1.47±14.41	-2.10±16.0	0.014*
	p_1=0.013*, p_2=0.010*, p_3=0.943			
End diastolic diameter (mm)	3.67±10.27	1.71±9.74	0.49±8.92	0.057

Data are presented as mean±SD. * significant p value <0.05, p1: p value for comparing between Thrombolytic and Primary PCI, p2: p value for comparing between Thrombolytic and Pharmaco-invasive, p3: p value for comparing between Primary PCI and Pharmaco-invasive, MPI: Myocardial Perfusion Imaging.

Univariate and multivariate linear regression analysis for the variables affecting GLS after 3 months of successful reperfusion. Table 4

Table 4: Univariate and multivariate linear regression analysis for the parameters affecting GLS (post 3 months)

	Univariate		#Multivariate	
	p	B (LL – UL 95%C.I)	p	B (LL – UL 95%C. I)
Ejection fraction post reperfusion	<0.001*	-0.363(-0.405 – -0.321)	0.036*	-0.035(-0.068–-0.002)
Onset of symptoms to hospital (hours)	0.021*	0.252(0.038 – 0.467)	0.137	0.078(-0.025–0.180)
Door to perfusion time (minutes)	0.019*	0.015(0.003 – 0.028)	0.117	-0.013(-0.029–0.003)
Systolic myocardial excursion (cm/sec)	<0.001*	-0.981(-1.195 – -0.768)	0.062	-0.174(-0.357–0.009)
MPI	<0.001*	41.497(35.738 – 47.256)	<0.001*	15.990(7.705–24.276)
End systolic diameter (mm)	<0.001*	0.442(0.369 – 0.515)	0.083	0.082(-0.011–0.175)
End diastolic diameter (mm)	<0.001*	0.407(0.331 – 0.483)	0.254	0.049(-0.036–0.134)
Primary PCI	0.005*	-2.444(-4.118 – -0.770)	0.193	-1.597(-4.019–0.825)
GLS post Reperfusion	<0.001*	1.206(0.795 – 1.617)	0.049*	0.256(0.002–0.511)

C.I: Confidence interval, LL: Lower limit, UL: Upper Limit, MPI: Myocardial Perfusion Imaging, PCI: Percutaneous coronary intervention, GLS: Global longitudinal strain.

Discussion

LV myocardial dysfunction is one of the most common complications post myocardial infraction, it can be transient defined as myocardial stunning or persistent depending on the duration of ischemic insult and successfulness of reperfusion strategy [6].

The data from the cardiovascular disease in Norway Project, which included 86,771 participants who had their first AMI between 2001 and 2009 and had no history of HF, revealed that 18.7% of the participants either had HF at admission or acquired it throughout their hospital stay. Furthermore, the prevalence of HF was shown to be positively correlated with age [7]. As heart failure has major impact on mortality and morbidity multiple studies were conducted trying to identify predictors of myocardial recovery post MI, in our study conducted in Tanta university hospitals we tried to identify factors affecting and predicting myocardial recovery post MI.

In our study males represented 62%, while females represented 38% of the patient presented by STEMI. The work population aging from 39-76 years. A work performed by Jia H *et al.* [8] in which 79.6% of the study populations were males that came with agreement with the study that conducted by Megaly M *et al.* [9] in which 70% of the patients presented with STEMI had been men. Coronary heart disease is far more prevalent in males, with a 3 to 5 times higher likelihood compared to women. However, the likelihood of women experiencing risks rises beyond menopause. Prior to menopause, it seems that women are somewhat shielded against stroke and coronary heart disease due to the presence of natural oestrogen. However, younger women have a lower likelihood of receiving revascularization for STEMI and have greater rates of death during their hospital stay in contrast to younger males [10].

Regarding risk factors for developing STEMI, in our work 58 participants were diabetic (58%), 46 patients were hypertensive (46%), 44 patients were dyslipidemic (44%), 41 patients have family history of CAD (41%), 54 patients were smokers (54%). In the work performed with Quyyumi A *et al*. [11] found that a significant improvement was existed in ejection fraction in patients had primary PCI strategy as compared to other groups, the percent of ejection fraction change was variables between the three groups, In thrombolytic therapy group percent of change was -2.47±13.0%, in primary PCI group it was 12.91±18.55%, while in pharmaco-invasive strategy group it was 7.99±15.59%. There was clinical significance difference between groups under study based on percent of change in ejection fraction (P <0.001). Also a clinically significant variation was existed among the three groups as regarding post three month ejection fraction, in thrombolytic therapy group EF it ranged from 30-60% with mean of 45.15±9.69%, in primary PCI group EF ranged from 30-65% with mean of 51.58±10.10%, while in pharmaco-invasive strategy group it ranged from 25-60% with mean of 48.50±8.82%, with P value (0.027).

That aligns with the work performed with Valizadeh A. *et al*. [12] showed that EF values had a significantly greater mean level in individuals treated by PCI (46.25 ± 9.08%) in contrast to streptokinase ones (42.48 ± 11.11%). In contrast, study conducted with Van der Bijl *et al*. [13] revealed that no significant change was existed in the LVEF between baseline EF and post 3 months EF in patients that had primary PCI post STEMI.

In our study primary PCI group had better improvement in GLS percent than other two groups with a mean GLS post 3 months -17.76±4.0%, while pharmaco-invasive group mean GLS post 3 months was -16.47±4.13%, while thrombolytic therapy group has the least GLS measurements with a mean GLS -14.12±3.43% post three months. A clinically significant variation was existed among the groups under the study in terms of GLS post 3 months (P=0.01). Also, we found that GLS percent of change between baseline and post three months varied between groups, in thrombolytic therapy group it was 4.71±20.60%, in primary PCI group was 32.07±28.74%, while in pharmaco-invasive strategy group it was 25.66±27.27% There was clinical significance difference between studied groups according to percent of change in GLS (*P*<0.001). This aligns with the study performed with Paul A. *et al*. [14] found that PPCI group had better recovery than pharmaco-invasive group early post reperfusion with a mean GLS −11% versus −9% in pharmaco-invasive group (P= 0.03). Also, the work performed with Meimoun P. *et al*. [15] found that a significant improvement of GLS was existed in the study population who had primary PCI, with baseline mean GLS -9.6±2.9% and -17.6±4% at follow up.

In our study there we found that post 3 months mean systolic myocardial excursion by tissue doppler was significantly different between the studied groups, in thrombolytic therapy group it was 9.82±2.44 cm/sec, in primary PCI it was mean 12.55±2.54 cm/sec, while it was 10.65±2.94 cm/sec in pharmaco-invasive group. A clinically significant variation was existed among the groups under the study in terms of post 3 months systolic myocardial excursion with P <0.001.

In our study the porportion of change in systolic myocardial excursion was maximum in primary PCI group with 23.18±22.17%, in pharmaco-invasive group was 19.34±36.0% while in thrombolytic therapy group was 5.10±23.40%. There was clinical significance difference between studied groups according to percent of change in systolic myocardial excursion.

That came with agreement in the work performed by Mayer A. *et al*. [16] revealed that systolic myocardial excursion measurement was independently anticipates long-term prognosis after STEMI. Additionally, systolic myocardial excursion provided significantly greater prognostic implication in contrast to conventional LVEF measurements.

In the work performed with Saputra B. *et al*. [17] MAPSE and TDI Systolic myocardial excursion can be used as alternative modality in determining subclinical LV systolic dysfunction in asymptomatic type 2 DM patients. In the study conducted with Holzknecht M. *et al*. [18] found that LVEF, systolic myocardial excursion were significantly correlateed with MACE, the prognostic value of systolic myocardial excursion, and GLS was incremental to LVEF.

In our study in thrombolytic therapy group MPI ranged 0.33 – 0.63 with mean 0.48±0.09 post 3 months, in primary PCI group it ranged 0.37 – 0.59 with mean 0.43±0.07 post 3 months. In pharmaco-invasive group, ranged 0.36 – 0.60 with mean 0.44±0.07 post 3 months. But when comparing percentage of change in MPI in the three groups we found that in thrombolytic therapy group percent of change was 12.07±16.28%, in primary PCI group it was 0.50±15.82%, while in pharmaco-invasive strategy group it was -0.28±14.07%. There was clinical significance difference between studied groups according to% of change in MPI (*P*<0.001). That came with the study conducted with Moller J. *et al*. [19] demonstrated that the myocardial performance index is a robust indicator of cardiac mortality that enhances the predictive value of echocardiographic measures of LV function following AMI. In the study conducted with In their study, Carluccio E. *et al*. [20] examine the alterations in Doppler MPI among individuals with chronic ischemic cardiomyopathy and viable myocardium prior to and subsequent to revascularization. They find that the intrinsic enhancement of cardiac performance following revascularization is strongly correlated with the enhancement of MPI during the follow-up period. Therefore, MPI can accurately indicate the variations in the overall function of the left ventricle over a period of time.

In our study we found that primary PCI group mean LVESD was 37.0±4.88 after reperfusion, with mean LVESD 36.58±7.86 mm post 3 months, while in pharmaco-invasive group mean LVESD after reperfusion was 40.12±5.15, with mean 39.09±7.12 mm post 3 months, in thrombolytic therapy group LVESD baseline mean 38.70±4.82, with mean 40.48±6.12 mm post 3 months. So, it was evident that there is a reduction in mean LVESD was in primary PCI and pharmaco-invasive group between baseline after reperfusion and after three months. There was clinical significance variation among the studied group in terms of baseline LVESD with p value=0.034. when comparing the percentage of change in LVESD between the studied groups we found that in thrombolytic therapy group percent of change was 4.76±10.51%, in primary PCI, it was -1.47±14.41%, while in pharmaco-invasive group it was -2.10±16.0%. There was clinical significance difference between studied groups according to% of change in ESD (P=0.014). In the work performed with Abtahi F. *et al.* [21] on the effect of cardiac rehabilitation following successful primary PCI among individuals presented with STEMI, denoted significant improvement in LVEF also in mean LVESD which was 42.76±3.60mm at baseline and 39.72±4.77mm in the follow up after 6 months with P value < 0.001.

Parameters as EF post reperfusion, onset of symptoms to hospital, door to perfusion time, systolic myocardial excursion, MPI, LVESD, LVEDD, Primary PCI, GLS after reperfusion were identified as univariate predictors of myocardial recovery.

Multivariate analyses identified that baseline EF (p <0.001, OR= -0.158), MPI (P= 0.004, OR=12.634), GLS post reperfusion (*P*<0.049, OR= 0.256) independent predictors of the myocardial recovery. In the work performed by Khaled *et al.* [22] revealed that, there was a substantial correlation (P < 0.001) between GLS and subsequent improvement in left ventricular systolic function. The ROC analysis conducted on the early GLS values revealed that values over 9% had a sensitivity of 100% and specificity of 88% in predicting a larger than 5% rise in LVEF throughout the next 3-6 months following PCI. GLS has the potential to provide a significant and precise assessment of global left ventricular systolic performance. It may also serve as a practical and valuable predictor of future myocardial recovery.

Conflict of Interest

Not available

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Not available

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