

## MODIFIED SELVESTER QRS SCORE REDUCTION FOR PREDICTION OF MYOCARDIAL SALVAGE FOLLOWING SUCCESSFUL REPERFUSION OF ACUTE ST ELEVATION MYOCARDIAL INFARCTION

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### ABSTRACT

**Background:** Achieving optimal angiographic coronary flow after acute ST elevation myocardial infarction (STEMI) isn't the best parameter of success. Perfusion of the microvasculature is more important. QRS score plays an important role for early risk stratification for STEMI. It is a simple electrocardiographic (ECG) parameter for assuring the presence or absence of microvascular obstruction.

**Aim of the work:** The aim of this clinical study is to validate the 90 minutes modified Selvester QRS score reduction as a reliable predictor of myocardial salvage, represented by 3 months global longitudinal strain (GLS) value, following successful reperfusion of acute STEMI.

**Material/Methods:** The study population included 400 patients presented with first acute STEMI with successful reperfusion by thrombolysis (Group I- 200 patients: mean age=57.1 ± 11.6 years) or primary percutaneous intervention (PPCI) (Group II- 200 patients: mean age=58.2±9.8 years). Basal and 90 minutes after reperfusion electrocardiography was done with assessment of ST resolution and modified Selvester QRS score. Basal and 3 months follow up echocardiography was performed with assessment of ejection fraction (EF) and GLS as an indicator for myocardial salvage with its impact on long-term clinical outcome.

**Results:** 90 minutes ST resolution and QRS score reduction were significantly higher in PPCI group (P.: 0.04\*, 0.03\*). Patients in group I had non-significant improvement of EF (P.: 0.22) during follow-up, but highly significant improvement of GLS (P.: <0.001\*\*) compared to the basal echocardiographic study. Patients in group II had significant improvement of EF (P.: 0.01\*) during follow-up, and highly significant improvement of GLS (P.: <0.001\*\*) compared to the basal echocardiographic study. As regarding correlation with 3 months GLS value, there was highly significant negative correlation between 3months GLS and (ST resolution and QRS score reduction) (P.: <0.001\*\*). Receiver operating characteristics (ROC) curve analysis shows that 90 minutes QRS score reduction has the best cut off value of 70% to predict 3months GLS improvement with 80% sensitivity and 79% specificity.

**Conclusions:** Modified Selvester QRS score reduction 90 minutes after reperfusion is a cheap bedside ECG parameter added to ST resolution, can be considered as a reliable predictor of future myocardial salvage with its impact on long-term clinical outcome and modifying management strategies.

**Keywords:** Modified Selvester QRS score • Myocardial infarction • Myocardial salvage

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### INTRODUCTION

Achieving optimal angiographic coronary flow after acute ST elevation myocardial infarction (STEMI) isn't the best parameter of success. Perfusion of the microvasculature is more important. Poor tissue perfusion has poor prognostic impact <sup>(1)</sup>. QRS score appears to be important in the early risk stratification for STEMI <sup>(2)</sup>. QRS score derived from simple and widely available electrocardiogram (ECG) may be a useful parameter for assuring the presence of microvascular obstruction <sup>(3)</sup>. The modified Selvester QRS score (Table 1) based on ECG

criteria capable of generating a total of 29 points with each point in the score corresponding to 3% of the left ventricular (LV) mass <sup>(4)</sup>.

Global longitudinal strain (GLS) is considered an effective tool to assess LV systolic function better than LV ejection fraction (EF) assessed by two-dimensional (2D) echocardiography <sup>(5)</sup>, even in diastolic heart failure after acute MI <sup>(6)</sup>. *Vartdal et al. (2007)* <sup>(7)</sup> showed that global strain is correlated with final infarction size.

Global longitudinal strain (GLS) is calculated as the range of the values of different LV segments from the three apical views <sup>(8)</sup>. GLS measures less than (-20%) is considered abnormal <sup>(9)</sup>.

The aim of this clinical study is to validate the 90 minutes modified Selvester QRS score reduction as a reliable predictor of myocardial salvage, represented by 3 months GLS value, following successful reperfusion of acute STEMI.

### SUBJECTS AND METHODS

#### Study design and population:

This clinical study included 400 patients with first time acute STEMI who were admitted to the coronary care unit (CCU) and cathlab. units of cardiology department at Zagazig University, Egypt and Kaohsiung Chang Gung Memorial Hospital, Taiwan during the period from November 2015 to November 2017.

#### Inclusion criteria of the study:

We included patients who were admitted with first acute STEMI with successful reperfusion either by PPCI or thrombolytic therapy.

#### Exclusion criteria of the study:

- Failed reperfusion or revascularization.
- History of myocardial infarction.
- History of previous PCI or coronary artery bypass graft (CABG).
- History of heart muscle diseases (cardiomyopathies).
- History of significant valvular diseases.
- Significant arrhythmias (including atrial fibrillation and frequent extra-systoles).
- Previous pacemaker or cardioverter-defibrillator implantation.
- Very poor image quality.

#### Ethical consideration:

Consent was obtained from every patient after explanation of the procedure.

Medical research and ethics committee approved the study.

#### Patient groups:

We categorized patients into 2 groups:

**Group I (200 patients):** Patients with first acute STEMI with successful reperfusion by thrombolytic therapy.

**Group II (200 patients):** Patients with first acute STEMI with successful reperfusion by PPCI.

Successful reperfusion was documented by more than 70% resolution of ST segment elevation 90 minutes after revascularization <sup>(10)</sup>.

#### Data collection:

*Data were collected for all patients including:*

- **Complete history taking:** Including name, age, gender, special habits, menstrual state, drug history and previous hospital admission with special consideration to history of risk factors to ischemic heart disease (Hypertension: HTN, diabetes mellitus: DM, smoking, dyslipidemia) and co-morbid conditions.

#### Thorough clinical examination:

All patients were subjected to thorough clinical general and local cardiac examination with special emphasis on hypotension and elevated jugular venous pulse in the presence of clear lung fields.

#### Electrocardiography (ECG):

ECG machine (BTL-08 SD1, BTL Industries Inc., USA and MAC 5500 GE Healthcare MUSE v8, USA) was used to record standard 12-lead ECGs. They were recorded at a paper speed of 25 mm/ second (s) and a gain of 10 mm/mv.

Twelve-lead ECG was performed directly before and 90 min after reperfusion. We analyzed the sum of elevations of ST segments in all leads and the modified Selvester QRS score (Table 1) based on ECG criteria capable of generating a total of 29 points with each point in the score corresponding to 3% of the left ventricular (LV) mass.

**Table (1): Modified Selvester QRS scoring system <sup>(11)</sup>.**

- **Echocardiography:**

Resting transthoracic echocardiography was performed for all patients using the Vivid 9 system (GE Vingmed Ultrasound AS, Horten, Norway). Images were taken while the patient is supine or in left lateral position. 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

Lead	Duration (msec.)	Points	Amplitude Ratios	Points	Max Leads Points
<b>I</b>	Q $\geq$ 30	(1)	R/Q $\leq$ 1	(1)	<b>2</b>
<b>II</b>	Q $\geq$ 40 Q $\geq$ 30	(2) (1)			<b>2</b>
<b>AVL</b>	Q $\geq$ 30	(1)	R/Q $\leq$ 1	(1)	<b>2</b>
<b>AVF</b>	Q $\geq$ 50 Q $\geq$ 40 Q $\geq$ 30	(3) (2) (1)	R/Q $\leq$ 1  R/Q $\leq$ 2	(2)  (1)	<b>5</b>
<b>V1</b>	Any Q Q $\geq$ 50 Q $\geq$ 40	(1) (2) (1)	  R/S $\geq$ 1	  (1)	<b>4</b>
<b>V2</b>	Any Q or R $\leq$ 20 R $\geq$ 60 R $\geq$ 50	(1) (2) (1)	  R/S $\geq$ 1.5	  (1)	<b>4</b>
<b>V3</b>	Any Q or R $\leq$ 30	(1)			<b>1</b>
<b>V4</b>	Q $\geq$ 20	(1)	R/Q or R/S $\leq$ 0.5 R/Q or R/S $\leq$ 1	(2) (1)	<b>3</b>
<b>V5</b>	Q $\geq$ 30	(1)	R/Q or R/S $\leq$ 1 R/Q or R/S $\leq$ 2	(2) (1)	<b>3</b>
<b>V6</b>	Q $\geq$ 30	(1)	R/Q or R/S $\leq$ 1 R/Q or R/S $\leq$ 3	(2) (1)	<b>3</b>

Echocardiography were performed<sup>(11)</sup>. Two examinations were done, the first is immediately after reperfusion and the second is 3 months later.

**The following measurements were taken:**

(A) **Ejection fraction (EF):** The LV volumes and ejection fraction (EF) were determined using the modified Simpson biplane technique from the apical 4- and 2-chamber views.

It is calculated also from the formula:

$$EF = [(EDV - ESV) / EDV] \times 100$$

Normally it is 50 - 70 %<sup>(11)</sup>.

(B) **Strain echocardiography using the speckle tracking technique (STE):**

STE is an echocardiographic, non-Doppler method that analyzes the longitudinal strain (LS) of LV segments by assessing the deformation of an object relative to its original length. STE is performed in typical apical views with frame rate of 60 to 90 frames/sec, and strain will be automatically measured. We exclude patients whom more than four segments can't be analyzed due to poor image quality. The system generates curves of LS for each segment of the left ventricle, from which we estimate peak longitudinal strain (LS) during the cardiac cycle. Peak systolic strain was defined as the peak negative strain value during systole<sup>(14)</sup>.

Global longitudinal strain (GLS) is calculated as the range of the values of different LV segments from the three apical views<sup>(8)</sup>. GLS measures less than (-20%) is considered abnormal<sup>(4)</sup>.

- **Reperfusion of acute STEMI:**

Reperfusion of acute STEMI was done in all patients using thrombolytic therapy or primary PCI. Primary PCI was done using femoral or radial access. Imaging the non-infarct related artery (non-IRA) was done first. Then, IRA angiogram was done, thrombus aspiration and glycoprotein IIb-IIIa inhibitors infusion was done in high thrombus burden lesions. TIMI III flow, grade III myocardial blush and corrected TIMI frame count (CTFC) less than 27 were achieved in all patients.

### STATISTICAL ANALYSIS

Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) software for analysis. Quantitative data were expressed as means  $\pm$  SD and qualitative data were expressed as absolute frequencies (number) & relative frequencies (percentage). Differences between means in two parametric groups were compared by Student's t test. Non-parametric data by Chi-square test. Bivariate correlation was used to study association between two continuous variables. Multivariate Logistic regression analysis was used to detect independent predictor of certain parameter. P value was set at <0.05 for significant results & <0.001 for high significant results <sup>(15)</sup>.

### RESULTS

In our study, we enrolled 400 patients with first time acute STEMI who were admitted to the coronary care unit (CCU) and cathlab. units of cardiology department at Zagazig University, Egypt and Kaohsiung Chang Gung Memorial Hospital, Taiwan during the period from November 2015 to November 2017.

**Table (2): Demographic data and risk Factors in study groups**

Variable	Group I (Thrombolysis) (N=200)	Group II (PPCI) (N=200)	t-test (t)	Chi-Square test ( $\chi^2$ )	P value
Age(years) Mean $\pm$ SD	57.1 $\pm$ 11.6	58.2 $\pm$ 9.8	0.6		0.042 (NS)
Gender	Male	130 (65 %)	120 (60 %)	0.3	0.27 (NS)
	Female	70 (35%)	80 (40%)		
Hypertension	Yes	124 (62%)	120 (60%)	0.2	0.51 (NS)
	No	76 (38%)	80 (40%)		
Diabetes Mellitus	Yes	140 (70%)	134 (67%)	0.2	0.33 (NS)
	No	60 (30%)	66 (33%)		
Smoking	Yes	160 (80%)	154 (77%)	0.1	0.38 (NS)
	No	40 (20%)	46 (23%)		
Dyslipidemia	Yes	123 (61.5%)	53 (26.5%)	5.6	0.01* (S)
	No	77 (38.5%)	147 (73.5%)		

Table (3): Comparison of the percentage (%) of ST resolution and QRS score reduction in the study groups

Variable	Group I (Thrombolysis) (N=200)	Group II (PPCI) (N=200)	t-test (t)	P value
90 min. ST resolution Mean $\pm$ SD	0.70 $\pm$ 0.1	0.85 $\pm$ 0.2	0.6	0.04* (S)
90 min. QRS score reduction Mean $\pm$ SD	0.4 $\pm$ 0.1	0.6 $\pm$ 0.2	6.7	0.03* (S)

Table (4): shows the results of (Paired t-test) comparing the basal and follow-up echocardiographic parameters in each of the studied groups.

Variable	Group I (Thrombolysis) (n=200) p-value	Group II (PPCI) (n=200) p-value	t-test (t)
(Basal-3mo.) EF	0.22 (NS)	0.01* (S)	3.3
(Basal-3mo.) GLS	<0.001** (HS)	<0.001** (HS)	0.4

Table (5): Spearman Correlation between 3 months GLS value and different parameters in the study groups

Variable Mean $\pm$ SD	Group I (Thrombolysis) (N=200)	Group II (PPCI) (N=200)
ST resolution	-0.6	<0.001** (HS)
QRS score reduction	-0.4	<0.001** (HS)

Table (6): shows Receiving Operator Characteristic (ROC) analysis of the measured parameters showing, AUC, best cutoff, Sensitivity and specificity values (Diagnostic Accuracy) of the 90 minutes QRS score reduction for prediction of 3months GLS improvement.

Area	Std. Error	Asymptotic Sig.	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.599	.055	.098	.491	.707

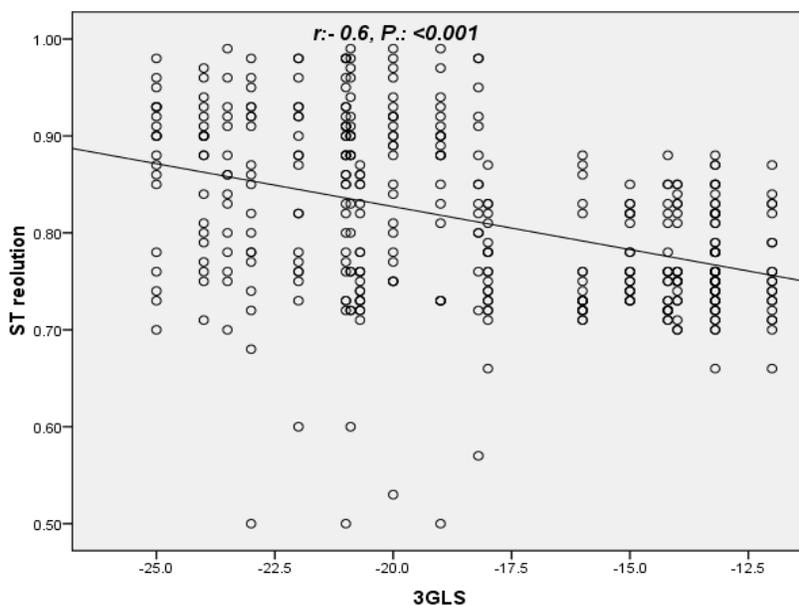


Figure (1): shows highly significant negative correlation between ST resolution and 3mo. GLS (r: -0.6, P.: <0.001\*\*)

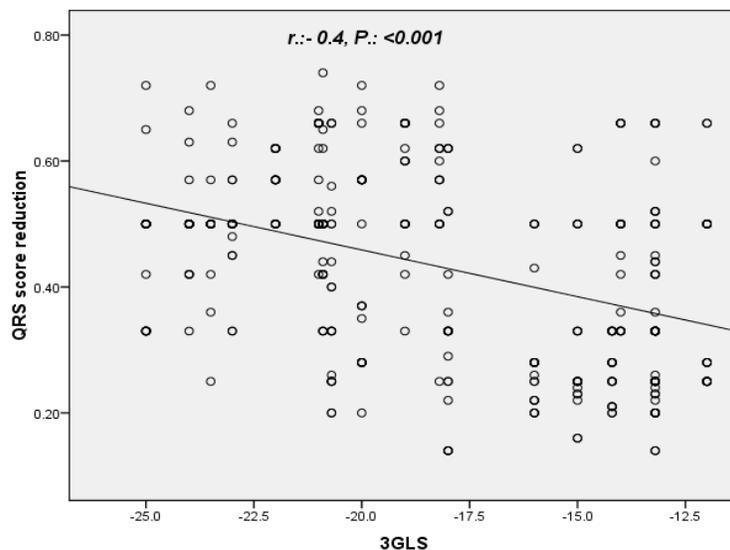
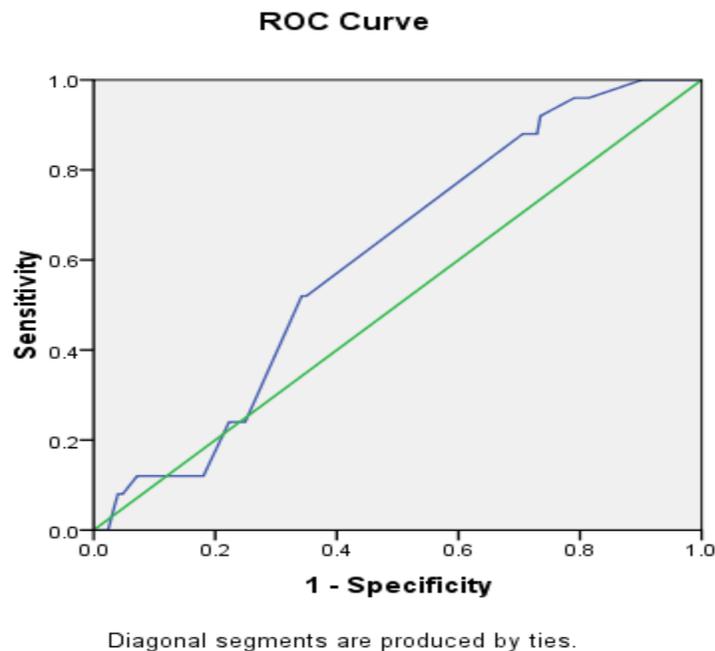


Figure (2): shows highly significant negative correlation between QRS score reduction and 3mo. GLS (r: -0.4, P.: <0.001\*\*)



**Figure (3):** shows Receiving Operator Characteristic (ROC) analysis of the measured parameters showing, AUC, best cutoff, Sensitivity and specificity values (Diagnostic Accuracy) of the 90 minutes QRS score reduction for prediction of 3months GLS improvement.

As regarding **demographic data** and **risk Factors**, there was non-significant difference between patients of both groups regarding age (P.: 0.42) and gender (P.: 0.27). Also, there was non-significant difference between both groups regarding the risk factors of coronary artery disease like hypertension (P.: 0.51), diabetes mellitus (P.: 0.33) and smoking (P.: 0.38). But there was significant statistical difference between both groups regarding dyslipidemia (P.: 0.01).

As regarding **ECG data**, 90 minutes ST resolution and QRS score reduction were significantly higher in PPCI group (P.: 0.04\*, 0.03\*).

As regarding **echocardiographic data**, patients in group I had non-significant improvement of EF (P.: 0.22) during follow-up, but highly significant improvement of GLS (P.: <0.001\*\*) compared to the basal echocardiographic study.

Patients in group II had significant improvement of EF (P.: 0.01\*) during follow-

up, and highly significant improvement of GLS (P.: <0.001\*\*) compared to the basal echocardiographic study.

As regarding correlation with 3 months GLS value, there was highly significant negative correlation between 3mo. GLS and ST resolution (Figure 1) and QRS score reduction (Figure 2) (P.: <0.001\*\*).

ROC curve analysis shows that 90 minutes QRS score reduction has the best cut off value of 70% to predict 3months GLS improvement with 80% sensitivity and 79% specificity (Figure 3).

### DISCUSSION

QRS score plays an important role for early risk stratification for STEMI (2). High QRS score is considered as an independent predictor of incomplete ST recovery and 30-day MACE in STEMI treated with primary PCI (16).

Relying on GLS for estimation of infarct size after PCI of STEMI patients was more accurate than LVEF. As GLS is a cheap

simple bedside test, it has a better economic value<sup>(17)</sup>.

Our study showed that there was non-significant difference between patients of both groups regarding age (P.: 0.42) and gender (P.: 0.27). Also, there was non-significant difference between both groups regarding the risk factors of coronary artery disease like hypertension (P.: 0.51), diabetes mellitus (P.: 0.33) and smoking (P.: 0.38), but significant regarding dyslipidemia (higher in thrombolysis group) (P.: 0.01).

Thus, our sample population is to an extent matched. we can notice that among our sample size, Taiwanese population had less incidence of dyslipidemia compared to Egyptian population. We attribute that to less caloric diet, more exercise program adoption and healthier lifestyle.

Our study showed that 90 minutes ST resolution was significantly higher in PPCI group (P.: 0.04\*) and this is in agreement with Rahman et al., 2016 which reported that ST-segment resolutions were significantly more in PPCI than thrombolysis at 90 minutes ( $73.15 \pm 18.76$  vs  $60.06 \pm 23.33\%$ ,  $p < 0.015$ )<sup>(18)</sup>.

Our study showed that 90 minutes QRS score reduction was significantly higher in PPCI (P.: 0.03\*).

**Abdel-Salam et al., 2010** reported that the mean QRS score was significantly lower in the ST resolution group compared to the non-resolution group ( $2.88 \pm 1.34$  vs  $5.93 \pm 1.56$ , respectively,  $p < 0.001$ )<sup>(19)</sup>.

Our results showed that, there was non-significant difference between echocardiographic parameters of the studied groups during the acute STEMI (P.: 0.08 for basal EF and 0.2 for basal GLS, however all parameters in both groups denote impaired systolic and diastolic LV function during acute STEMI (Stunning).

EF is a non-reliable marker of systolic function in early stage after MI<sup>(20)</sup> as stunning may overestimate the MI induced systolic dysfunction<sup>(21)</sup>.

But the follow-up parameters showed more significant improvement of LV function

in PPCI group (P.: 0.02\* for 3mo. EF,  $< 0.001^{**}$  for 3mo. GLS). Similar results were reported by **Ottervanger et al., 2001**<sup>(22)</sup>.

GLS as measured immediately after primary PCI is a reliable predictor of LV remodeling and long-term clinical outcomes represented by major adverse cardiac events (MACE)<sup>(23)</sup>.

**Liszka et al., 2014** suggested that impaired LV deformation indices measured 3 days and 30 days after AMI may provide important predictive value in LV remodeling and patients' prognosis<sup>(24)</sup>.

Our results showed highly significant negative correlation between 3months GLS and (ST resolution and QRS score reduction) (P.:  $< 0.001^{**}$ ).

The absence of ST-segment elevation resolution after PCI or fibrinolysis has been associated with poor prognosis, including larger infarct size and increased mortality<sup>(25)</sup>.

Also our results agree with **Watanabe et al., 2015** who indicated that the QRS score derived from simple and widely available ECG may be a useful parameter for confirming the presence or absence of microvascular obstruction<sup>(3)</sup>.

ROC curve analysis shows that 90 minutes QRS score reduction has the best cut off value of 70% to predict 3months GLS improvement with 80% sensitivity and 79% specificity (Figure 3).

It may be claimed that the primary endpoint is a subjective marker rather than a hard clinical endpoint. However, due to low event rate of MACE in the studied population, LV systolic function recovery represented by 3 months GLS improvement exemplifies a valid surrogate endpoint to detect the differences in outcomes of the treatment strategies adopted.

## CONCLUSIONS

GLS measurement (compared to EF) early after STEMI is a reliable predictor for myocardial functional recovery assessed 3 months later, which surely would be expressed on the clinical outcomes. PPCI leads to better myocardial salvage compared with fibrinolysis. Modified Selvester QRS score reduction 90

minutes after reperfusion is a cheap bedside ECG parameter added to ST resolution, can be considered as a reliable predictor of future myocardial salvage with its impact on long-term clinical outcome and modifying management strategies.

### Limitations

Due to low event rate in selected low-intermediate risk STEMI patient, we couldn't rely on major adverse cardiac event (MACE) as a hard clinical endpoint to validate the QRS score for prediction of long-term outcomes.

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