

## Correlation of QRS Duration with Myocardial Blush Grade as a Marker of Myocardial Reperfusion in Patients with ST Segment Elevation Myocardial Infarction Undergoing Revascularization

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### ABSTRACT

**Background:** Acute myocardial infarction represents a major cause of heart failure, arrhythmia, and mortality in patients with coronary artery disease and impaired microvascular reperfusion is an important prognostic determinant in patients undergoing revascularization with either primary percutaneous coronary intervention (PCI) or pharmaco-invasive strategy after ST-segment elevation myocardial infarction (STEMI).

**Objective:** The aim of the current work was to evaluate the outcome of patients presenting with acute ST-segment elevation myocardial infarction by determining the impact of correlation of QRS duration with myocardial blush grade of myocardium as a marker of myocardial reperfusion following revascularization procedures.

**Patients and Methods:** This prospective cohort study was conducted at Cardiology Department, Zagazig University Hospitals and National Heart Institute. We included 119 patients with acute ST-segment elevation myocardial infarction undergoing revascularization. Patients were divided into two groups according to the reperfusion strategy. Group I: included 70 patients with primary percutaneous coronary intervention (PCI) and Group II: included 49 patients with pharmaco-invasive strategy.

**Results:** Post catheter QRS duration of the studied patients was 82 msec, and it was significantly higher in group II (92 msec) than group I (74 msec) (P-value < 0.001). QRS duration 60 minutes post PCI was 83 msec, and it was significantly higher in group II (96 msec) than group I (73 msec) (P-value was < 0.001). The mean ST resolution was 51, and it was significantly higher in group I (61) than group II (36) (P-value < 0.001).

**Conclusions:** It could be concluded that longer QRS duration after angioplasty seemed to indicate the presence of impaired microvascular reperfusion in patients with STEMI.

**Keywords:** Primary angioplasty, Coronary flow, STEMI.

### INTRODUCTION

Revascularization with either primary percutaneous coronary intervention (PCI) or pharmaco-invasive strategy is the treatment of choice for patients presenting with ST-elevation myocardial infarction (STEMI). Patency of the infarct-related artery (IRA) along with a good microvascular flow is the goal of reperfusion therapy. However, restoration of the epicardial flow does not necessarily lead to restoration at the tissue level in all cases<sup>[1,2]</sup>.

Electrocardiographic (ECG) assessment of reperfusion therapy is mainly based on changes of the ST-segment, but the significance of the QRS duration is still not very well established. Prolonged QRS duration is associated with an increased risk of impaired ventricular systolic function and adverse effects<sup>[3]</sup>.

While ST-segment resolution is related to myocardial perfusion and cell membrane integrity, myocardial blush grade (MBG) reflects myocardial perfusion and microvascular patency. MBG has been found to be a predictor [independent of thrombolysis in myocardial infarction (TIMI) flow] of both in-hospital and long-term mortality in patients with acute myocardial infarction who underwent primary angioplasty<sup>[4]</sup>.

It is a qualitative visual assessment of the amount of contrast medium filling a territory supplied by an epicardial coronary artery. Studies are lacking that can assess the correlation between the noninvasive (QRS

duration) and the invasive marker (MBG) of myocardial reperfusion. Risk stratification using the Thrombolysis in Myocardial Infarction (TIMI) risk score for STEMI is a simple assessment tool based on clinical data of patients at hospital admission<sup>[5]</sup>.

It is applied to patients with acute STEMI to predict mortality and to identify patients at high risk of developing other Major Adverse Cardiac Events (MACE) as early prediction and expectations allows prompt and effective interventions and follow-up strategy.

The aim of the current work was to evaluate the outcome of patients presenting with acute ST-segment elevation myocardial infarction by determining the impact of correlation of QRS duration with myocardial blush grade of myocardium as a marker of myocardial reperfusion following revascularization procedures.

### PATIENTS AND METHODS

This prospective cohort study included a total of 119 patients with acute ST-segment elevation myocardial infarction undergoing revascularization, attending at the National Heart Institute during the period from September 2019 till September 2021.

**Inclusion criteria:** Patients presenting within 12 hours from the onset of symptoms of STEMI, which was defined as: characteristic chest pain lasting for at least

30 minutes, not responsive to nitrates, with electrocardiographic ST-segment elevation of at least 0.1 mV in two or more contiguous leads<sup>[6]</sup>.

#### **Exclusion criteria:**

Patients with previous history of PCI or old MI. Patients with bundle branch block or fascicular block. Patients with intraventricular conduction disturbances or second or third-degree atrioventricular block. Patients with electrolyte disturbances or cardiomyopathies. Patients with Paced Rhythm.

**Patients were divided into two groups according to the reperfusion strategy: Group I** consisted of 70 patients with Primary PCI, and **Group II** consisted of 49 patients with pharmacoinvasive strategy.

All patients were subjected to history taking, clinical examination, 12 leads electrocardiogram. Patients were loaded by 300 mg of Aspirin, 600 mg of Clopidogrel (or 300 mg of Clopidogrel in Pharmacoinvasive strategy) and 5000-10000 unit of unfractionated heparin. Reperfusion therapy with either Primary PCI or pharmaco-invasive strategy (Streptokinase followed by PCI within 3–24 h).

#### **Coronary angiography and PCI procedure:**

Coronary angiography was done in the standard fashion; after local infiltration anesthesia by 2% lignocaine, the right common femoral artery was punctured using seldinger's technique. Selective coronary angiography was performed. First the non-infarcted artery and then the infarct-related artery (IRA) was injected. Angiographic data of the patients were obtained, which included an average six left coronary and two right coronary artery injections giving sufficient data to enable quantitative angiography and identification of the culprit lesion, IRA was identified post angiography according to TIMI flow grade & Myocardial blush grade (MBG).

Heparin (70 U/kg) was administered after coronary anatomy was defined. Coronary artery stenosis >70% was considered clinically significant. Occlusion of the IRA was crossed by using a 0.014-inch guide wire. Direct stenting was implanted whenever possible, whereas balloon pre-dilatation was carried out in the remaining cases.

The type, number and size of the stents were left to the operator's discretion. In each patient who was treated with GP IIb/IIIa antagonist (Tirofiban) according to TIMI flow & thrombus burden as assessed by the operator, it was administered in the cath lab during the procedure. 100 µg nitroglycerine was injected intracoronary pre and post dilatation. Post PCI TIMI flow grade & Myocardial blush grade (MBG) were assessed by three independent interventional

cardiologists to assess mechanical restoration of antegrade flow and achieving the desired end results.

After angioplasty, all patients were admitted to the coronary care unit, where the conventional anti-ischemic therapies were continued.

Echocardiography was performed for each patient after primary PCI in the coronary care unit. All data were analyzed, at least 3 cardiac cycles for each parameter and the average results were obtained.

#### **Follow up:**

- In patient with stent thrombosis, was defined angiographically as a documented total occlusion<sup>[7]</sup>.
- Non-fatal myocardial infarction was defined as recurrent chest pain and/or development of new ECG changes accompanied by new rise  $\geq 20\%$  of cardiac biomarkers measured after the recurrent event<sup>[6]</sup>.
- Acute heart failure was defined as rapid onset of symptoms and signs secondary to abnormal cardiac function that was related to systolic or diastolic dysfunction, to abnormalities in cardiac rhythm, or to pre-load and after-load mismatch and which was life threatening and required urgent treatment<sup>[8]</sup>.
- In-hospital mortality, had to be verified death due to myocardial infarction, cardiac arrest or other cardiac causes.

#### **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 participation in 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.**

#### **Statistic analysis**

Data management and statistical analysis were done using SPSS version 25. (IBM, Armonk, New York, United States).

Quantitative data were assessed for normality using Kolmogorov–Smirnov test and direct data visualization methods.

Categorical data were summarized as numbers and percentages. Quantitative data were compared between study groups using independent t-test or Mann-Whitney U test for normally and non-normally distributed numerical variables, respectively. Categorical data were compared using the Chi-square test. Correlation analyses were done using Spearman's correlation. All statistical tests were two-sided. P values less than 0.05 were considered significant.

## RESULTS

The mean age of the studied patients was  $56 \pm 9$  years. There was a male predominance (72.3%). About half of the patients had diabetes (48.7%) or hypertension (47.1%). More than two-thirds of the studied patients were smokers (68.1%). No significant differences were noted between both groups regarding age (P-value = 0.114), gender (P-value = 0.557), diabetes (P-value = 0.667), hypertension (P-value = 0.027), or smoking (P-value = 0.589) (**Table 1**).

**Table (1): General characteristics in the studied patients**

		Total (n = 119)	Group I (n = 70)	Group II (n = 49)	P-value
<b>Age (years)</b>	Mean $\pm$ SD	$56 \pm 9$	$55 \pm 9$	$58 \pm 9$	0.114
<b>Gender</b>	Males n (%)	86 (72.3)	52 (74.3)	34 (69.4)	0.557
	Females n (%)	33 (27.7)	18 (25.7)	15 (30.6)	
<b>Diabetes mellitus</b>	n (%)	58 (48.7)	33 (47.1)	25 (51.0)	0.677
<b>Hypertension</b>	n (%)	56 (47.1)	27 (38.6)	29 (59.2)	0.274
<b>Smoking</b>	n (%)	81 (68.1)	49 (70.0)	32 (65.3)	0.589

Independent t-test was used for age. Chi-square test was used for categorical data

The mean LVEF of the studied patients was  $49 \pm 7$ , and it was significantly higher in group I (51%) than group II (47.0%) (P-value = 0.001). The mean QRS duration on admission was  $89 \pm 12$ , and no significant difference was observed between both groups (P-value = 0.074). The median TIMI score of the studied patients was 4 and ranged from 1 to 10, and it was significantly higher in group II (5) than group I (3) (P-value < 0.001) (**Table 2**).

**Table (2): ECG & TIMI risk score in the studied patients**

		Total (n = 119)	Group I (n = 70)	Group II (n = 49)	P-value
<b>LVEF (%)</b>	Mean $\pm$ SD	$49 \pm 7$	$51 \pm 7$	$47 \pm 5$	0.001
<b>QRS duration on admission (msec)</b>	Mean $\pm$ SD	$89 \pm 12$	$88 \pm 11$	$92 \pm 13$	0.074
<b>TIMI Risk Score</b>	Median (range)	4 (1 - 10)	3 (1 - 10)	5 (1 - 10)	<0.001

Independent t-test or Mann Whitney U test was used LVEF: Left ventricular ejection fraction

The mean pain to balloon time was 7 hours, and it was significantly higher in group II (9 hours) than group I (5.0) (P-value < 0.001). The mean door to balloon time was 48 minutes, and it was significantly higher in group II (58 minutes) than group I (42 minutes) (P-value < 0.001). The most frequent infarct-related artery in the studied patients was LAD (51.3%), and no significant difference was noted between both groups (P-value = 0.164). The median TIMI flow grade of the studied patients was 2, and it was significantly higher in group I (3) than group II (1) (P-value < 0.001). The most frequent lesion site was mid (42.0%), and no significant difference was noted between the studied groups (P-value = 0.678) (**Table 3**).

**Table (3): Procedure characteristics in the studied patients**

		Total (n = 119)	Group I (n = 70)	Group II (n = 49)	P-value
<b>Pain to balloon time (hours)</b>	Mean ±SD	7 ±1.4	5 ±1.1	9 ±2.1	<0.001
<b>Door to balloon time (min)</b>	Mean ±SD	48 ±11.2	42 ±10.1	58 ±12.3	<0.001
<b>Infarct related artery</b>	LAD n (%)	61 (51.3)	41 (58.6)	20 (40.8)	0.164
	LCX n (%)	13 (10.9)	6 (8.6)	7 (14.3)	
	RCA n (%)	45 (37.8)	23 (32.9)	22 (44.9)	
<b>TIMI flow grade</b>	Median (range)	2 (1 - 3)	3 (1 - 3)	1 (1 - 3)	<0.001
<b>Lesion site</b>	Distal n (%)	26 (21.8)	16 (22.9)	10 (20.4)	0.678
	Mid n (%)	50 (42.0)	27 (38.6)	23 (46.9)	
	Proximal n (%)	43 (36.10)	27 (38.6)	16 (32.7)	

Post catheter QRS duration of the studied patients was 82 msec, and it was significantly higher in group II (92 msec) than group I (74 msec) (P-value < 0.001). QRS duration 60 minutes post PCI was 83 msec, and it was significantly higher in group II (96 msec) than group I (73 msec) (P-value was < 0.001).

The mean ST resolution was 51, and it was significantly higher in group I (61) than group II (36) (P-value < 0.001). The median myocardial blush grade was 2, and it was significantly higher in group I (2) than group II (1) (P-value <0.001) (Table 4).

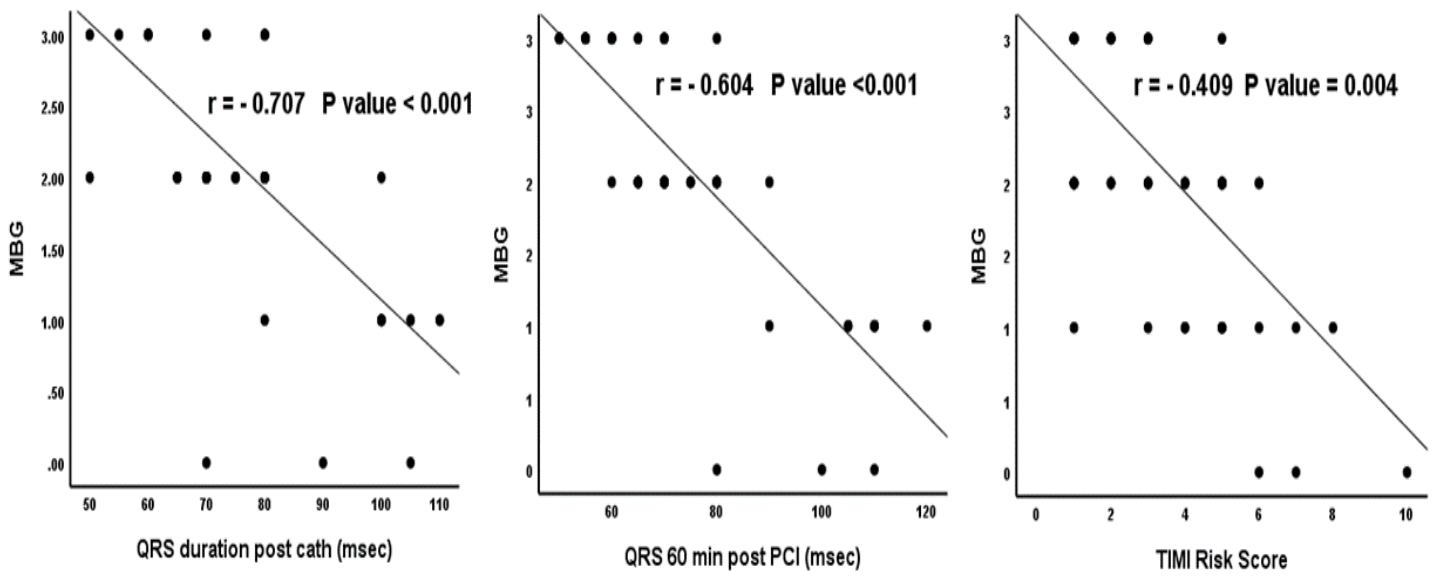
**Table (4): Outcome in the studied patients**

		<b>Total (n = 119)</b>	<b>Group I (n = 70)</b>	<b>Group II (n = 49)</b>	<b>P-value</b>
<b>QRS duration post PCI (msec)</b>	Mean ±SD	82 ±18	74 ±15	92 ±16	<0.001
<b>QRS duration 60 min post PCI (msec)</b>	Mean ±SD	83 ±18.2	73 ±18	96 ±20	<0.001
<b>ST resolution</b>	Mean ±SD	51 ±10.3	61 ±14.1	36 ±8.2	<0.001
<b>Myocardial blush grade</b>	Mean ±SD	2 ± 0.40	2 ± 0.31	1 ± 0.21	<0.001

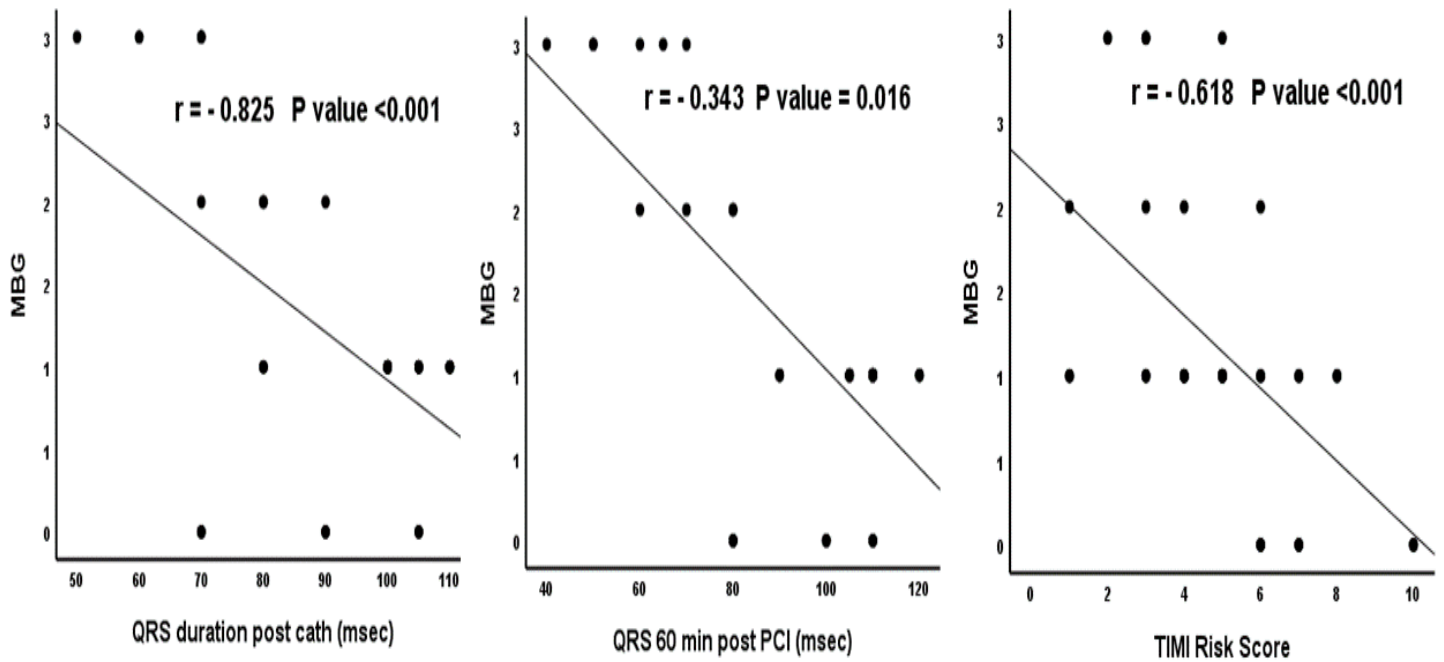
Independent t-test or Mann Whitney U test was used

In the whole studied patients, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.758$  &  $P\text{-value} < 0.001$ ), QRS duration 60 min post catheter ( $r = -0.850$  &  $P\text{-value} < 0.001$ ), and TIMI risk score ( $r = -0.669$  &  $P\text{-value} < 0.001$ ).

In group I, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.707$  &  $P\text{-value} < 0.001$ ), QRS duration 60 min post catheter ( $r = -0.825$  &  $P\text{-value} < 0.001$ ), and TIMI risk score ( $r = -0.604$  &  $P\text{-value} < 0.001$ ). In group II, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.343$  &  $P\text{-value} = 0.016$ ), QRS duration 60 min post PCI ( $r = -0.409$  &  $P\text{-value} = 0.004$ ), and TIMI risk score ( $r = -0.618$  &  $P\text{-value} < 0.001$ ) (**Figure 1a,b**).



**Figure (1a): Correlation between MBG and QRS duration and TIMI risk score in group I**



**Figure (1b): Correlation between MBG and QRS duration and TIMI risk score in group I.**

## DISCUSSION

In the current study, the mean age of the studied patients was  $56 \pm 9$  years. There was a male predominance (72.3%). About half of the patients had diabetes (48.7%) or hypertension (47.1%). More than two-thirds of the studied patients were smokers (68.1%). No significant differences were noted between both groups regarding age (P-value = 0.114), gender (P-value = 0.557), diabetes (P-value = 0.667), hypertension (P-value = 0.27), or smoking (P-value = 0.589).

In line with our results, **Tawfik et al.**<sup>[9]</sup> conducted a prospective observational study to evaluate the role of QRS duration change following primary angioplasty in patients presented with STEMI as a marker of microvascular reperfusion assessed by myocardial blush grade (MBG). Fifty patients with STEMI were included with this study, 37 males and 13 females, their age ranged between 32 to 74 years. ECG was done to all patients at presentation and after primary PCI to assess QRS duration change. Angiographic assessment of myocardium supplied by infarct related artery was performed using MBG. According to MBG patients were classified into two groups: group (1), with good myocardial reperfusion MBG (2-3) and group (2), with poor myocardial reperfusion MBG (0-1). The two groups were similar in terms of gender, hypertension, and diabetes status, ( $p > 0.05$ ). Whereas there was statistically significant difference between two groups as regard age being older age was present in group 2 patients with impaired perfusion ( $P = 0.049$ ).

In the present study, the mean LVEF of the studied patients was  $49 \pm 7$ , and it was significantly higher in group I patients with primary PCI (51%) than group II patients with pharmaco-invasive strategy (47.0%) (P-value = 0.001). The mean QRS duration on admission was  $89 \pm 12$ , and no significant difference was observed between both groups (P-value = 0.074). The median TIMI Risk score of the studied patients was 4 and ranged from 1 to 10, and it was significantly higher in group II (5) than group I (3) (P-value < 0.001).

In agreement with our results, **Tawfik et al.**<sup>[9]</sup> found that in terms of echocardiographic parameters, LVEF was significant lower in group 2 with poor myocardial reperfusion MBG (0-1). The patients in group 1 with good myocardial reperfusion MBG (2-3) had a mean LVEF of  $52.51 \pm 6.40$ , and group 2 with poor myocardial perfusion had  $44.77 \pm 2.59$  (P-value < 0.001).

Our results revealed that the mean pain to balloon time was 7 hours, and it was significantly higher in group II (9 hours) than group I (5 hours) (P-value < 0.001). The mean door to balloon time was 48 minutes, and it was significantly higher in group II (58 minutes) than group I (42 minutes) (P-value < 0.001).

In contrast, **Yusuf et al.**<sup>[10]</sup> showed that the two groups were statistically similar in terms of admission LVEF, and this can be attributed to the time of

echocardiography which was performed within 24 hour following angioplasty in our study.

Additionally, **Karahan et al.**<sup>[11]</sup> found that patients with impaired microvascular reperfusion had significantly longer pain-to-balloon time (P<0.001).

Our results are confirmed by **Tawfik et al.**<sup>[9]</sup> showed that the pain to balloon time and door to balloon time were significantly higher in group 2 with poor myocardial reperfusion in comparison with group 1 with good myocardial reperfusion ( $10.23 \pm 1.79$  hours vs  $4.41 \pm 1.38$  hours,  $61.23 \pm 18.18$  hours vs  $35.70 \pm 15.74$ , P-value < 0.001, respectively).

The current study showed that the median TIMI flow grade of the studied patients was 2, and it was significantly higher in group I patients with primary PCI (3) than group II patients with pharmaco-invasive strategy (1) (P-value < 0.001). The most frequent infarct-related artery in the studied patients was LAD (51.3%), RCA (37.8%) then LCX (10.9%) and no significant difference was noted between both groups (P-value = 0.164). The most frequent lesion site was mid (42.0%), and no significant difference was noted between the studied groups (P-value = 0.678).

In agreement with our results, **Tawfik et al.**<sup>[9]</sup> showed that the TIMI flow at the end of PCI was significantly higher in group 1 with good myocardial reperfusion in comparison with group 2 with poor myocardial reperfusion (P-value < 0.001). The most frequent infarct-related artery in the studied patients was LAD (62.2%), RCA (29.7%) then LCX (8.1%) and no significant difference was noted between both groups (P-value = 0.309).

Our results agree with those documented by **Yusuf et al.**<sup>[10]</sup> who showed that the TIMI flow at the end of PCI was significantly higher in group B with MBG of 2-3 (reperfusion group) than group A with MBG of 0-1 (impaired reperfusion) (P-value < 0.001). They also revealed that the most frequent infarct-related artery in the studied patients was LAD, 57 (71.2%) in group A and 70 (58.3%) in group B, and no significant difference was noted between both groups (P-value = 0.177).

In the present study, when the two groups were compared in terms of ECG parameters, that they had a similar QRS duration at admission ( $88 \pm 11$  msec vs  $92 \pm 13$  msec,  $P = 0.074$  respectively). Post PCI median QRS duration of the studied patients was 82 msec, and it was significantly higher in group II with pharmaco-invasive strategy (92 msec) than group I with primary PCI (74 msec) (P-value < 0.001). Mean QRS duration 60 minutes post PCI was 83 msec, and it was significantly higher in group II (96 msec) than group I (73 msec) (P-value < 0.001). The mean ST resolution was 51, and it was significantly higher in group I (61) than group II (36) (P-value < 0.001). The median myocardial blush grade was 2, and it was significantly

higher in group I with primary PCI (3) than group II with pharmaco-invasive strategy (1) (P-value <0.001).

In fact, a recent study supports our findings. **Tawfik et al.**<sup>[9]</sup> revealed that QRS duration was found to be longer in group 2 with poor myocardial perfusion compared to group 1 with good myocardial perfusion at both the immediate ECG ( $98.08 \pm 11.64$  msec vs  $69.59 \pm 10.70$  msec,  $p < 0.001$ , respectively) and at the 60th minute ECG ( $105.0 \pm 10.21$  msec vs  $67.16 \pm 9.76$  msec,  $p < 0.001$ , respectively) post angioplasty.

But **Tawfik et al.**<sup>[9]</sup> revealed that QRS duration at admission was longer in group 2 with poor myocardial reperfusion compared to group 1 with good myocardial reperfusion group ( $93.85 \pm 12.61$  m sec vs  $86.49 \pm 10.60$  msec,  $P = 0.024$ , respectively). The longer QRS duration at admission might have been caused primarily by extensive ischemia and poor metabolic state, rather than by myocardial fibrosis and increased myocardial mass, which are associated with persistent QRS prolongation.

Also, **Karahan et al.**<sup>[11]</sup> reported that the two groups were comparable in terms of QRS duration at presentation ( $P: 0.57$ ), patients with impaired microvascular reperfusion were found to have longer QRS duration at immediate post-procedure ( $P: 0.003$ ) and post-procedure 60 min ( $P < 0.001$ ). In other words, patients in the impaired ventricular reperfusion group had significantly longer QRS duration at postangioplasty compared with the patients in the normal reperfusion group. In addition, correlation analyses showed a positive correlation between the pain-to-balloon time and QRS duration at post-procedure 60 min ( $r: 0.137$  and  $P: 0.04$ ). They revealed that longer QRS duration after intervention indicating impaired myocardial reperfusion in patients with STEMI.

Our study demonstrated that in the whole studied patients, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.758$  &  $P\text{-value} < 0.001$ ), QRS duration 60 min post PCI ( $r = -0.850$  &  $P\text{-value} < 0.001$ ), and TIMI risk score ( $r = -0.669$  &  $P\text{-value} < 0.001$ ). In the present study, in group I, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.707$  &  $P\text{-value} < 0.001$ ), QRS duration 60 min post PCI ( $r = -0.825$  &  $P\text{-value} < 0.001$ ), and TIMI risk score ( $r = -0.604$  &  $P\text{-value} < 0.001$ ). The findings of the current study reported that in group II, myocardial blush grade showed a significant negative correlation with QRS duration post PCI ( $r = -0.343$  &  $P\text{-value} = 0.016$ ), QRS duration 60 min post PCI ( $r = -0.409$  &  $P\text{-value} = 0.004$ ), and TIMI risk score ( $r = -0.618$  &  $P\text{-value} < 0.001$ ).

In line with our results, **Tawfik et al.**<sup>[9]</sup> reported that QRS duration was found to be significantly longer in group 2 with poor myocardial perfusion compared to

group 1 with good myocardial perfusion at both the immediate ECG ( $98.08 \pm 11.64$  vs  $69.59 \pm 10.70$  msec,  $p < 0.001$ , respectively) and at the 60th minute ECG ( $105.0 \pm 10.21$  vs  $67.16 \pm 9.76$  msec,  $p < 0.001$ , respectively) post angioplasty. Also, there was highly statistically significance difference between the two groups regarding mean change in QRS duration immediately and 60 min after PCI. They observed a significant and positive correlation between QRS duration Change on admission and 1 hour post angioplasty and TIMI flow ( $r = 0.706$ ;  $p < 0.001$ ).

Also, **Umapathy et al.**<sup>[12]</sup> carried out a prospective observational study to evaluate the prognostic significance of fragmented QRS in patients with acute ST elevation myocardial infarction (STEMI) undergoing revascularization. Fragmented QRS (fQRS) is defined as the presence of an additional R wave (R') or notching in the nadir of the S wave or the presence of >1 R' (fragmentation) in two contiguous leads. They included 103 STEMI patients belonging to Killip class I and II who underwent revascularization. All patients underwent twelve lead standard ECG at admission before PCI. Serial ECG were done after PCI at 3 hours, 6 hours, 24 hours, 48 hours and at the time discharge for detecting the presence of fQRS and its change after revascularization. Patients developing fQRS within 48 hours of admission and with persistence of fQRS till discharge were included in "persistent fQRS" group. The mean ST resolution was  $66.7 \pm 19.8$  in group 1 with absence or resolution of fQRS, and  $52.1 \pm 20$  in group 2 with persistent fQRS and it was significantly higher in group 1 than group 2 ( $P\text{-value} < 0.001$ ). Persistent fQRS was significantly related to impaired myocardial reperfusion as assessed by percent of total ST segment resolution (ESTR) [adjusted odds ratio, 95% CI: 4.265 (1.034 – 17.58),  $p = 0.04$ ].

Consistently, **Magdy et al.**<sup>[13]</sup> found that the admission QRS duration didn't differ in the two groups ( $p=0.859$ ), and QRS complex duration was found to be significantly shorter in group A with normal reperfusion (MBG 2-3) at both 60- and 90-min post reperfusion ( $p < 0.001$  for both), and found a strong positive correlation between myocardial blush grade and QRS complex narrowing at both 60 min and 90 min post reperfusion respectively ( $r=0.731$ ,  $p < 0.001$  and  $r=0.739$ ,  $p < 0.001$ ).

Similarly, **Ozcan et al.**<sup>[14]</sup> performed a prospective and observational study to investigate the association of MBG after primary PCI with evolution of fQRS. The study consisted of 401 consecutive patients with STEMI who underwent primary PCI. Patients were categorized into two subgroups according to persistence or new onset of fQRS (Group 1) and absence or resolution of fQRS (Group 2) at 48 hours after primary PCI. The evolution of fQRS on pre- and post-PCI ECG and their relationship with myocardial reperfusion parameters were investigated. They found that



myocardial blush grade correlated negatively with fQRS ( $r = -0.335$ ,  $P < 0.001$ ).

Early reperfusion therapy, which could prevent necrosis of the ischemic myocardium and improve prognosis, is the preferred treatment option for STEMI. **Umopathy *et al.*** [12] used percent of total ST segment resolution ( $\Sigma$ STR) to evaluate the effect of reperfusion therapy. Despite TIMI 3 flow after reperfusion therapy, there were 19.8% of patients with  $\Sigma$ STR  $< 50\%$  (imperfect ST-segment resolution) in this cohort. This can be explained by “no-reflow phenomenon” due to microcirculation embolism, microvascular spasm, microcirculation reperfusion injury, and microvascular stunning. ST-segment resolution which is dependent on microcirculation reperfusion can be regarded as an indicator of myocardial reperfusion. Imperfect ST-segment resolution after PCI was independently associated with cardiac dysfunction, cardiac death, and short- and long-term clinical prognosis in patients with STEMI.

## CONCLUSION

It could be concluded that longer QRS duration after angioplasty seemed to indicate the presence of impaired microvascular reperfusion in patients with STEMI. The QRS duration may be recommended as a novel marker of impaired microvascular reperfusion in patients with STEMI. Further, analysis of MBG is helpful in predicting the time course and magnitude of LV function recovery and the symptom status.

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