The Predictive Value of Fragmented QRS and QRS Distortion for High-Risk Patients with STEMI and for the Reperfusion Success

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Background: QRS fragmentation (fQRS) and QRS distortion were separately shown to be related to increased cardiovascular mortality and morbidity. To our knowledge, no study so far evaluated both parameters together in ST segment elevation myocardial infarction (STEMI). The main goal of our study is to find out if fQRS and QRS distortion can help us to determine high-risk STEMI patients, and the success of reperfusion.

Methods: Two hundred forty-eight eligible patients with acute STEMI that underwent coronary angiography consecutively between January 1, 2009, and July 1, 2011, were enrolled in this study. Twelve-lead electrocardiography (ECG) of the patients taken in the first 48 hours were analyzed. Patients with fQRS formed group 1, without fQRS formed group 2; with QRS distortion formed group 3, and without QRS distortion formed group 4.

Results: Group 1 have lower left ventricular ejection fraction (LVEF; $P < 0.001$), higher maximum troponin levels ($P < 0.001$), lower ST segment resolution ($P < 0.001$), more frequent proximal lesions ($P < 0.001$) when compared to group 2. Similar findings were observed in group 3 in comparison to group 4. Group 1 had also more frequent three vessels disease ($P < 0.001$), and higher rates of failed thrombolysis ($P < 0.001$). In-hospital mortality was found to be higher in group 1 and group 3.

Conclusion: fQRS and QRS distortion may be useful for identifying patients at higher cardiac risk. fQRS can foresee thrombolytic therapy failure and three vessels disease whereas QRS distortion does not possess such quality. These findings may guide the physician deciding initial treatment modality in STEMI.

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ST elevated myocardial infarction; fragmented QRS; QRS distortion

Despite major advances in cardiac imaging techniques, the standard 12-lead electrocardiogram (ECG) continues to be the most used tool for the diagnosis, early risk stratification, triage, and determination of appropriate therapies in patients with acute ST-segment elevation myocardial infarction (STEMI).¹ Recent studies have shown that some of the newer ECG parameters can also be used to determine if patients are at higher risk. The

most important of these new ECG parameters are fragmented QRS (fQRS) and QRS distortion.

In a recent publication, Das et al.² extensively described fQRS. The authors explained that fQRS originates from abnormal ventricular depolarization caused by the nonhomogeneous electrical activation of ischemic and/or injured ventricular myocardium. The associations between fQRS and increased morbidity and mortality,

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sudden cardiac death, cardiac arrhythmia, and adverse cardiac events have been investigated in previous studies.³⁻⁵

Distortion of the QRS complex revealed by ECG taken at admission reflects profound ischemia, which can affect the Purkinje fibers. Regional myocardial ischemia can cause delayed conduction in the local Purkinje fibers, which reduces the degree of cancellation and results in an increase in the R-wave and a decrease in the S-wave amplitude on the surface ECG.^{6,7} It is also associated with larger infarcts, increased mortality, and poor prognosis in patients undergoing reperfusion therapy for STEMI.⁸⁻¹¹

It has been reported that terminal QRS distortion on admission and fQRS in 48-hour ECG independently predict that there will be a failure to achieve myocardial reperfusion as assessed electrocardiographically and angiographically after primary percutaneous coronary intervention (PCI).^{11,12} However, the relationship between these two parameters with the success of electrocardiographic reperfusion has not previously been demonstrated in acute STEMI patients receiving thrombolytic therapy.

To our knowledge, there has been no study comparing fQRS and QRS distortion with coronary angiographic findings in acute STEMI patients (thrombolytic + primary PCI). Therefore, the aim of this study is to compare fQRS and QRS distortion with clinical and angiographic findings in a large patient population and to determine the conditions for which these two parameters vary. In addition, we will investigate the relationship of fQRS and QRS distortion with electrocardiographic reperfusion and determine their effectiveness in determining the appropriate treatment for acute STEMI patients who underwent thrombolytic treatment.

METHODS

Patient Selection

The archived records of 316 patients who were admitted to the Dokuz Eylül University Hospital Coronary Intensive Care Unit between January 1, 2009, and July 1, 2011, with the diagnosis of first acute STEMI and who were treated with primary PCI or thrombolytic—were retrospectively evaluated.

The diagnosis of STEMI and ST elevation criteria were based on the European Society of Cardiology (ESC) 2012 STEMI guidelines.¹³ Therefore, we confirmed the previous diagnoses by reexamination the ECGs according to the new guidelines. Four patients were excluded from the study because their ECGs did not satisfy the new guideline criteria.

Patients were included in the study if they were admitted with acute STEMI for the first time and were older than 18 years of age. However, 18 patients with complete bundle branch block, seven patients with incomplete right bundle branch block, and one patient with pacemaker rhythm were excluded from the study. In addition, 17 patients with a history of coronary artery bypass grafting (CABG), seven patients whose ECG records could not be obtained in the archive, and 14 patients who could not undergo coronary angiography (CAG) were also excluded from the study. As a result, our study group consisted of 248 patients who were admitted due to acute STEMI for the first time, whose ECG records were available for investigation, and whose coronary angiographies were conducted in our clinic.

Electrocardiography

Twelve-lead ECG were taken from all patients at admission, at the beginning of the thrombolytic treatment, 30, 60, 90, and 120 minutes after thrombolytic treatment, after primary PCI, and at the 24th and 48th hours after admission. Reperfusion indicators in patients receiving thrombolytic treatment included more than a 50% decrease in ST elevation in ECG at the end of thrombolytic treatment and the loss of chest pain. ECG monitoring was performed with chest leads and leads on the standard extremities with a 0.16-100 Hz filter range, 25 mm/s speed, and 10 mm/mV height. Electrocardiographic examinations were performed with the naked eye by two independent physicians. The presence of fQRS and QRS distortion was investigated on surface ECG.

The fQRS was defined by the presence of various RSR' patterns (QRS duration <120 milliseconds) with or without Q wave. These patterns included an additional R wave (R' prime), a notching of the R wave or S wave, or the presence of more than one R prime (fragmentation) without a typical

bundle branch block in two contiguous leads corresponding to a major lead set for the major coronary artery territory.² In this study we had no patient with known fQRS before MI. Patients who had fQRS still after 48 hours (patients with persistent fQRS) were defined as group 1, and those who did not develop fQRS were defined as group 2. Patients with fQRS were also subclassified as transient fQRS if they developed fQRS within the first 48 hours but resolved after 48 hours. The number of leads detected with fQRS were also recorded.

Distortion of the terminal portion of the QRS complex on ECG at admission was defined as: (1) emergence of the J point at $\geq 50\%$ of the R wave in leads with a qR configuration, and/or (2) disappearance of the S wave in leads with an rS configuration (leads V_1 - V_3).⁸ Patients whose QRS distortion was detected in ECG at the time of admission were defined as group 3, and those whose QRS distortion was not detected were defined as group 4.

Coronary Angiography

Coronary angiography was conducted through the femoral/radial axis using the standard Judkins technique. Digital angiograms were evaluated by two independent physicians. The infarct-related artery responsible for myocardial infarction was determined. Each lesion in the epicardial coronary artery was classified as proximal, mid, or distal according to coronary segments defined by American College of Cardiology and American Heart Association.^{14,15} The presence of stenosis $\geq 50\%$ in the left main coronary artery and $\geq 70\%$ in the other major epicardial coronary arteries was considered critical stenosis.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows version 15.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were defined as means $\pm$ standard deviations and categorical variables were defined as percentages. Continuous variables were compared with a Student's t-test and categorical variables between two groups were compared with a chi-square test. Pearson's correlation coefficient was used for correlation analysis. A value of $P < 0.05$ was considered statistically significant.

RESULTS

The mean age of the patients included in this study was 63.2 ± 11.9 years. One hundred and thirty-two patients underwent primary PCI, whereas 116 patients underwent thrombolytic treatment. fQRS was detected in 91 (36.7%) patients, QRS distortion was detected in 98 (39.5%) patients, and both fQRS and QRS distortion were detected in 51 (20.6%) patients. Transient fQRS was detected in 31 (12.5%) patients. The average number of fQRS derivations in patients with fQRS was 2.8 ± 1 . When group 1 was compared to group 2, basal demographic characteristics, duration of chest pain during application, and MI localization were not significantly different. Left ventricular ejection fraction (LVEF) was significantly lower in group 1 than in group 2 (34.8 ± 6.8 vs 46.8 ± 6.2 ; $P < 0.001$, respectively). In addition, group 1 had higher levels of white blood cell count (WBC; 12.958 ± 3.066 vs 10.780 ± 3.379 ; $P < 0.001$, respectively), higher peak troponin levels (62.8 ± 53.5 vs 29.7 ± 16.2 ; $P < 0.001$, respectively), but lower ST segment resolution (46.3 ± 20.4 vs 70.2 ± 13.5 ; $P < 0.001$, respectively) than group 2 (Table 1). As the number of fQRS derivation increased, ST segment resolution and LVEF decreased significantly ($r = -0.57$, $P < 0.001$, and $r = -0.63$, $P < 0.001$, respectively).

Patients in group 3 had lower LVEF ($39.0 \pm 8.6\%$ vs $44.7 \pm 7.9\%$; $P < 0.001$), higher WBC (12.101 ± 3.509 vs 11.226 ± 3.339 ; $P = 0.049$), higher peak troponin levels (54.5 ± 52.6 vs 33.5 ± 21.2 ; $P < 0.001$), and lower ST segment resolution (57.1 ± 18.7 vs 64.2 ± 20.4 ; $P = 0.006$) than group 4 (Table 2).

The rate of three vessels disease was 31.9% whereas the incidence of infarct-related proximal lesion was 54%. Group 1 had higher infarct related proximal lesion (81.3% vs 38.2%; $P < 0.001$) and higher 3 vessels disease (61.5% vs 14.6%; $P < 0.001$) than group 2 (Table 1). As the number of fQRS derivation increased, the number of vessels with critical stenosis also increased significantly ($r = 0.50$, $P < 0.001$). When group 3 was compared to group 4, there was no significant difference in terms of 3 vessels disease (33.7% vs 30.7%; $P = 0.119$), but the incidence of infarct-related proximal lesion was significantly higher in group 3 (68.4% vs 44.7%; $P < 0.001$; Table 2).

The in-hospital mortality due to all causes was 8.1%. In-hospital mortality in group 1 was higher

Table 1. Comparison of Demographic, Electrocardiographic, and Angiographic Characteristics in Patients with/without Fragmented QRS

	Group 1 (n = 91)	Group 2 (n = 157)	P
Age	64.8 ± 12.7	62.3 ± 11.4	0.102
Gender M/F	69/22	120/37	0.914
Hypertension (%)	48 (52.7)	72 (45.9)	0.296
Diabetes mellitus (%)	21 (23.1)	29 (18.5)	0.384
Hyperlipidemia (%)	27 (29.7)	32 (20.4)	0.098
Duration of chest pain on admission (min.)	194.6 ± 174.0	165.2 ± 171.5	0.196
Primary PCI (%)	46 (50.5)	86 (54.8)	0.520
Thrombolytic treatment (%)	45 (49.5)	71 (45.2)	0.520
LVEF (%)	34.8 ± 6.8	46.8 ± 6.2	<0.001
Hemoglobin (g/dL)	13.23 ± 1.93	13.5 ± 2.0	0.355
WBC ($\times 10^3/\mu\text{L}$)	12.958 ± 3.066	10.780 ± 3.379	<0.001
PLT ($\times 10^3/\mu\text{L}$)	227.89 ± 63.43	217.8 ± 71.7	0.266
Creatinine (mg/dL)	1.00 ± 0.48	0.94 ± 0.35	0.202
LDL-cholesterol (mg/dL)	121.8 ± 31.1	122.0 ± 31.1	0.968
Maximum troponin (ng/mL)	62.8 ± 53.5	29.7 ± 16.2	<0.001
QRS duration (milliseconds)	107.9 ± 9.0	102.8 ± 9.2	<0.001
QRS distortion (%)	51 (56)	47 (29.9)	<0.001
MI localization			0.300
Anterior MI (%)	35 (38.5)	71 (45.2)	
Other MI (%)	56 (61.5)	86 (54.8)	
Total ST resolution (%)	46.3 ± 20.4	70.2 ± 13.5	<0.001
Infarct-related artery			0.387
LAD (%)	34 (37.4)	72 (45.9)	
Cx (%)	11 (12.1)	19 (12.1)	
RCA (%)	46 (50.5)	66 (42)	
Proximal vascular disease (%)	74 (81.3)	60 (38.2)	<0.001
Three vessels disease (%)	56 (61.5)	23 (14.6)	<0.001
In-hospital mortality (%)	13 (14.3)	7 (4.5)	0.006

Group 1, fQRS (+); Group 2, fQRS (-); M = male; F = female; min = minute; PCI = percutaneous coronary intervention; LVEF = left ventricular ejection fraction; WBC = white blood cell; PLT = platelet; LDL = low-density lipoprotein; MI = myocardial infarction; LAD = left anterior descending artery; Cx = circumflex artery; RCA = right coronary artery.

than group 2 (14.3% vs 4.5%; $P = 0.006$; Table 1). Similarly, the in-hospital mortality of group 3 was significantly higher than group 4 (13.3% vs 4.7%; $p = 0.015$; Table 2). Patients with transient fQRS had significantly lower rates of three vessels disease, proximal vascular disease at infarct related artery, and in-hospital mortality when compared to patients in group 1. Their results were similar to group 2 (Fig. 1).

One hundred sixteen (46.8%) patients underwent thrombolytic treatment. fQRS was detected in 45 of the patients (38.8%) who underwent thrombolytic treatment and QRS distortion was detected in 48 of these patients (41.4%). There were no differences in terms of chest pain duration at the time of admission and door-to-needle time in the patients with fQRS and QRS. ST segment resolution after thrombolytic treatment was lower (44.3 ± 20.6 vs 68.3 ± 16.3 ; $P < 0.001$)

and the number of patients without recanalization was significantly higher (40% vs 4.2%; $P < 0.001$) in group 1 (Table 3). As the number of fQRS derivation increased, ST segment resolution decreased significantly ($r = -0.54$, $P < 0.001$). There was no significant relationship between QRS distortion and the success of thrombolytic treatment (Table 3). We determined that fQRS would develop in patients after thrombolytic therapy who had a remaining sum of ST segment elevations of 3.5 mm and more with a 68.9% sensitivity and 71.8% specificity (Fig. 2).

Fifty-one patients (20.6%) had both fQRS and QRS distortion. These patients had similar clinical and angiographic results as did the patients having only fQRS or QRS distortion. We determined that having both fQRS and QRS distortion does not contribute anything more than the presence of fQRS.

Table 2. Comparison of Demographic, Electrocardiographic, and Angiographic Characteristics in Patients with/without QRS Distortion

	Group 3 (n = 98)	Group 4 (n = 150)	P
Age	63.93 ± 11.17	62.73 ± 12.37	0.438
Gender M/F	75/23	114/36	0.924
Hypertension (%)	53 (54.1)	67 (44.7)	0.147
Diabetes mellitus (%)	22 (22.4)	28 (18.7)	0.468
Hyperlipidemia (%)	20 (20.4)	39 (26)	0.312
Duration of chest pain on admission (min.)	177.14 ± 181.34	175.23 ± 167.36	0.932
Primary PCI (%)	50 (51)	82 (54.7)	0.574
Thrombolytic treatment (%)	48 (49)	68 (45.3)	0.574
LVEF (%)	38.97 ± 8.60	44.70 ± 7.85	<0.001
Hemoglobin (gr/dL)	13.36 ± 2.20	13.40 ± 1.87	0.886
WBC ($\times 10^3/\mu\text{L}$)	12.101 ± 3.509	11.226 ± 3.339	0.049
PLT ($\times 10^3/\mu\text{L}$)	226.12 ± 62.33	218.46 ± 72.85	0.392
Creatinine (mg/dL)	1.02 ± 0.49	0.92 ± 0.32	0.067
LDL-cholesterol (mg/dL)	118.97 ± 30.37	123.76 ± 31.40	0.245
Maximum troponin (ng/mL)	54.54 ± 52.55	33.54 ± 21.22	<0.001
QRS duration (msn)	104.49 ± 9.67	104.73 ± 9.28	0.843
Presence of fragmented QRS (%)	51 (52)	40 (26.7)	<0.001
MI localization			0.414
Anterior MI (%)	45 (45.9)	61 (40.7)	
Other MI (%)	53 (54.1)	89 (59.3)	
Total ST resolution (%)	57.1 ± 18.7	64.2 ± 20.4	0.006
Infarct-related artery			0.467
LAD (%)	45 (45.9)	61 (40.7)	
Cx (%)	9 (9.2)	21 (14)	
RCA (%)	44 (44.9)	68 (45.3)	
Proximal vascular disease (%)	67 (68.4)	67 (44.7)	<0.001
Three vessels disease (%)	33 (33.7)	46 (30.7)	0.119
In-hospital mortality	13 (13.3)	7 (4.7)	0.015

Group 1, fQRS (+); Group 2, fQRS (-); M = male; F = female; min = minute; PCI = percutaneous coronary intervention; LVEF = left ventricular ejection fraction; WBC = white blood cell; PLT = platelet; LDL = low-density lipoprotein; MI = myocardial infarction; LAD = left anterior descending artery; Cx = circumflex artery; RCA = right coronary artery.

Figure 1. The comparison of patients with persistent fQRS, transient fQRS, and without fQRS regarding proximal vascular disease at infarct related artery, three vessels disease, and in-hospital mortality.

DISCUSSION

We investigated the relationship between fQRS and QRS distortion with angiographic findings and thrombolytic treatment success in patients with

first STEMI for whom we thought that the QRS segment had not been degraded before. Because patients with a previous history of MI may have prolonged fQRS on surface ECG, only patients with acute STEMI for the first time were included in this

Table 3. Data Associated with the Presence of fQRS or QRS Distortion in Patients Receiving Thrombolytic Treatment

	Group 1 (n = 45)	Group 2 (n = 71)	P	Group 3 (n = 48)	Group 4 (n = 68)	P
Duration of chest pain on admission (minutes)	181.7 ± 151.8	168.9 ± 175.3	0.688	188.5 ± 179.2	163.5 ± 156.6	0.425
Door to needle time (minutes)	29.11 ± 9.4	26.90 ± 8.1	0.181	28.9 ± 10.3	27.0 ± 7.3	0.254
ST segment resolution (%)	44.3 ± 20.6	68.3 ± 16.3	<0.001	56.3 ± 20.5	60.9 ± 22.2	0.259
Thrombolytic failure (%)	18 (40)	3 (4.2)	<0.001	10 (20.8)	11 (16.2)	0.521

Group 1, fQRS (+); Group 2, fQRS (-); Group 3, QRS distortion (+); Group 4, QRS distortion (-); min, minute.

Figure 2. ROC curve of sum of ST elevations after thrombolytic treatment in patients with fQRS.

study. This was done to increase the credibility of our study and to reduce speculations. During this study, we evaluated all findings of the first ECG and the 48-hour ECG together. fQRS was detected in 36.7% of patients and QRS distortion was detected in 39.5% of patients. These results were similar to those obtained in previously reported studies.^{2,16-18} LVEF and ST segment resolution rates were lower, whereas peak troponin levels, WBC, and proximally placed infarct related lesion incidence was higher in patients for whom fQRS and QRS distortion were detected separately. In addition, the QRS time was longer, the three vessels disease incidence was higher, and thrombolytic treatment success was lower in patients with fQRS.

The in-hospital mortality due to all causes was 8.1% in our patient group. Although the treatment

modalities were the same, the mortality rates were approximately three times higher in the group 1 (14.3% vs 4.5%) or group 3 (13.3% vs 4.7%) than in the groups 2 or 4. Previous studies have shown a relationship between fQRS and QRS distortion with mortality.^{8,19} This may be because patients with fQRS and/or QRS distortion often have larger infarct area, poor left ventricular function, higher incidence in three vessels disease, and widely triggered inflammatory processes.

One of the remarkable findings of our study is the relationship between fQRS and the success of thrombolytic treatment. We observed that patients in group 1 undergoing thrombolytic treatment had lower ST segment resolution, therefore recanalization did not occur in a higher number of patients. As the number of fQRS derivations increased, ST segment resolution decreased. There was no such relationship in patients with QRS distortion. The relationship of fQRS with electrocardiographic and angiographic reperfusion parameters was investigated in a previous study,²⁰ which showed that angiographic reperfusion was lower in patients with fQRS. However, to our knowledge, ours is the first study to demonstrate the relationship of fQRS with electrocardiographic reperfusion and thrombolytic treatment failure. These results indicate that acute STEMI patients who had fQRS at the time of admission get less benefit from thrombolytic treatment. Because reperfusion assessment was conducted according to the electrocardiographic criteria in our study, this ECG finding might be significant in centers providing only thrombolytic treatment. Because our findings suggest that fQRS may be a warning ECG finding in patients with acute STEMI, guiding the physicians to choose primary PCI initially.

Another important finding of our study is the relationship between three vessels disease and fQRS. Although three vessels disease was significantly

higher in group 1, there was no such relationship between QRS distortion and three vessels disease, as has been previously reported.^{10,21,22} Our study confirms the relationship between fQRS and three vessels disease first reported by Stavileci et al.²² In contrast to our findings, Ari et al.²³ reported that there was no relationship between fQRS and three vessels disease. This may be because that study had a lower number of patients (85 patients) and only included patients who underwent primary PCI.

Previous studies¹⁰⁻¹² have shown that fQRS and QRS distortion are associated with the extent of myocardial scar tissue and the prevalence of coronary artery disease. In our study, the extent of infarcted myocardium was assessed by measuring the maximum troponin levels. We found that fQRS and/or QRS distortion are related to the extent of infarcted myocardium. In addition, because patients with fQRS and/or QRS distortion had higher leucocyte counts in our study, systemic inflammation may also be associated with the development of these parameters and the extent of infarct areas. Furthermore, the fact that proximal vessel disease was observed more frequently in patients with fQRS or QRS distortion strengthens the relationship of these parameters with the prevalence of coronary artery disease. In conclusion, the possible underlying reasons for worse outcomes and increased mortality in patients with fQRS or QRS distortion are increased systemic inflammation, extent of myocardial scar tissue, and the widespread presence of coronary artery disease.

The fundamental treatment strategy for acute STEMI is fibrinolytic treatment or primary PCI. Patients who underwent both primary PCI and thrombolytic treatment were investigated in our study. When all patients were considered together, the total ST segment resolution was lower in group 1 and/or group 3 than in patients without these features. In contrast to our findings, Wolak et al.¹¹ found that both electrocardiographic and angiographic reperfusion were worse in the STEMI patients who had QRS distortion and underwent primary PCI, and Kocaman et al.¹² found the same in STEMI patients with fQRS who underwent primary PCI. These aforementioned studies, together with this study, indicate that acute STEMI patients with fQRS and/or QRS distortion may continue to have reperfusion disorder at the cellular level, even though vessel patency is maintained, regardless of the treatment.

In this study 20.6% of the patients had both fQRS and QRS distortion. The positive predictive value and negative predictive value for in-hospital mortality of patients with both fQRS and QRS distortion (15.7% and 93.9%, respectively) was similar to those of the patients with fQRS (14.3% and 95.8%, respectively). There were no additional contributions from both ECG parameters when compared with the contributions from just one.

Although fQRS and QRS distortion occurs with different mechanisms at the cellular level, both are helpful in determining high-risk cardiac patients in acute STEMI. Unlike QRS distortion, which is evaluated by ECG at the time of admission and is an acute finding, fQRS can also occur during follow-up. Therefore, serial ECG assessments should be continued within the first 48 hours in patients with acute STEMI. However, expecting to see both parameters together might cause one to overlook some patients with high risk because both parameters are observed in a small patient population (20.6%). For this reason, physicians should remember that even the presence of single parameter might provide significant information regarding patients with acute STEMI.

LIMITATIONS

One of the major limitations of our study is the small number of patients in the group who underwent thrombolytic treatment and were not recanalized. Another limitation is that we did not use any angiographic myocardial reperfusion criteria, such as thrombolysis in myocardial infarction (TIMI) flow number and TIMI myocardial perfusion degree. Finally, the results might not be representative of patients with large QRS because the patients whose QRS duration less than 120 milliseconds were included in our study.

CONCLUSION

The detailed assessment of fQRS and QRS distortion by surface ECG is a simple, widely available, and noninvasive modality that may be useful for identifying patients at higher cardiac risk. This assessment can identify patients with larger areas of necrotic myocardium and can be helpful in choosing an appropriate treatment for patients with acute STEMI. The presence of both fQRS and QRS distortion is associated

with worse prognostic events and increased in-hospital mortality. fQRS may be used as a simple predictive parameter to show electrocardiographically inadequate reperfusion and three vessels disease in patients with acute STEMI undergoing thrombolytic treatment.

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