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Original Article

The relation of frontal QRS-T angle with syntax score in patients with ST segment elevation myocardial infarction

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Abstract

Aim: Current data regarding the relation between the Frontal QRS-T (FQRST) angle and the atherosclerotic burden is limited. This study purposed to investigate the relation between FQRST angle and the Syntax (SX) score in subjects presenting with STEMI.
Material and Methods: Forty-nine patients who were admitted to the coronary care unit of a tertiary-care hospital for acute STEMI and underwent successful revascularization of the infarct related artery were included in this retrospective analysis. FQRST angle, QTc, and T peak- T end (TpTe) intervals were obtained from the presenting electrocardiogram (ECG). ECG was repeated 30 minutes after revascularization. The SX score was calculated using dedicated software. The study population was then divided into 3 tertiles based on the SYNTAX trial results as follows: SX score ≤ 22 (Low SX score, n=34), SX score ≥ 23 and < 33 (Intermediate SX score, n=8), and those with an SX score ≥ 33(High SX score, n=7).
Results: Median FQRST angle of the subjects with an SX score ≥ 33 was significantly wider than those with an SX score < 33. Subjects with SX score between 22 and 33 points also had a higher FQRST angle compared to those with SX score ≤ 22 points. Subjects with SX score > 22 had a longer TpTe interval than those with an SX score ≤ 22 points. SX score was significantly correlated with the FQRST angle (r=0.691, p< 0.001) and TpTe interval (r=0.579, p< 0.001).
Conclusion: FQRST angle obtained from the admission surface ECG of the subjects with acute STEMI might reflect the extent and severity of the CAD, as demonstrated by the SX score. Moreover, FQRST angle may be useful in determination of the success of the revascularization in STEMI subjects.

Keywords: Frontal QRS-T angle; revascularization; ST segment elevation myocardial infarction; SYNTAX score

INTRODUCTION

Ischemic heart disease is by far the most common cause of death worldwide despite the recent advances in antithrombotic therapy, interventional techniques and sophisticated emergency networks(1).Many risk factors including age, Killip class, time delay to treatment, previous myocardial infarction, presence of diabetes or hypertension and left ventricular systolic function influence the outcome of subjects presenting with ST-elevation myocardial infarction (STEMI)(2).Atherosclerotic burden, severity of the coronary artery disease (CAD), and presence of multivessel CAD has also been reported to impact the cardiovascular outcomes in subjects with STEMI(3,4).

Several scoring systems has been developed not only to estimate the overall cardiovascular risk of the subjects with STEMI but also to predict the outcome of the forthcoming revascularization procedure in these patients. SYNTAX (SX) score allows risk stratification in terms of functional and anatomical aspects of the CAD(5). SX score is therefore believed to better anticipate the risks of percutaneous or surgical revascularization in subjects with STEMI (6,7). However, simple, non-invasive correlates of SX score derived from surface electrocardiogram may also provide clues regarding the complexity of the CAD in subjects with STEMI, where early risk stratification is critical for determining optimal management strategy.

Several simple surrogates derived from the 12 lead surface electrocardiogram (ECG), including the degree and the extent of the ST segment elevation, distortion of the terminal portion of the QRS complex, and QT dispersion have been reported to be useful in risk stratifying in subjects with STEMI (8,9).Frontal QRS-T angle (FQRST), which is defined as the absolute value of difference between the QRS axis and the T-wave axis on an ECG has been described as a novel marker of ventricular repolarization heterogeneity (10,11). Previous studies have reported that FQRST angle might be a predictor for the prognosis

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in patients presenting with an acute coronary syndrome (12). However, current data regarding the association between the FQRST angle and the atherosclerotic burden is limited.

This study purposed to investigate the relation between FQRST angle and the SX score in subjects presenting with STEMI.

MATERIAL and METHODS

This retrospective study was conducted on 49 patients who were admitted to the coronary care unit of a tertiary-care hospital for acute STEMI and underwent successful revascularization of the infarct related artery between January 2019 and December 2019. The study was approved by the Institutional Review Board and was conducted in accordance with the Helsinki declaration. Subjects with preexisting left bundle branch block, atrial fibrillation, paced rhythm on ECG, or left ventricular hypertrophy by ECG criteria were not included in the study. Admission blood test results were retrieved from the institutional digital database. Demographic features of the study subjects were obtained from the patients charts. STEMI was diagnosed in the presence of elevated cardiac biomarkers and ≥ 0.2 mV ST segment elevation in leads V1 to V3or 0.1 mV in all other leads with these changes being present in at least two contiguous leads (13).In our institute subjects presenting with acute chest pain undergo 12-lead electrocardiogram within the first ten minutes of presentation with the patient in the supine resting position. 12-lead electrocardiograms obtained upon admission were retrieved from patient charts. Frontal plane QRS-axis and T-wave axis were included in the reports of the automated ECG machine. The absolute difference between the frontal QRS wave axis and T-wave axis was defined as frontal planar QRS/T angle. In case of a difference exceeding 180 degrees, the difference was calculated by subtracting from 360 degrees to obtain a continuous variable ranging from 0 to 180 (12).QT intervals were measured only from ECGs on which the end of the T wave was clearly discernable. QT intervals were corrected for heart rate using Bazett's correction (QTc), per standard clinical practice. The Tangent method was used for T peak- T end (TpTe)interval measurement from leads with a T wave amplitude >1.5 mm, and Bazett formula was used for corrected TpTe interval measurement. For this purpose, the time from the peak of the T wave to the intersection between the tangent at the steepest point of the T wave and the isoelectric line was measured digitally in milliseconds with the software Cardio Calipers Version 3.3 (Iconico, Inc., New York, NY, USA)(14). Following percutaneous revascularization, 12-leaad ECG was repeated in all subjects. Post-interventional FQRST angle, QTc, and TpTe intervals were recorded.

Coronary angiography images were retrieved from the institutional digital database. An experienced investigator unaware of the study hypothesis, blinded to the patients' clinical and ECG data analyzed the angiography images and calculated SX scores for each subject. The SX score was calculated using dedicated software that integrates the number of lesions with their specific weighting factors based on the amount of myocardium distal to the lesion (15). The study population was then divided into 3 tertiles based on the SYNTAX trial results as follows: SX score ≤ 22 (Low SX score, n=34), SXscore ≥ 23 and < 33 (Intermediate SX score, n=8), and those with an SXscore ≥ 33(High SX score, n=7)(16).

The differences in FQRST angle, QTc, and TpTe intervals in subjects with different SX scores and the association between the SX score and the FQRST angle, QTc, and TpTe interval were the primary outcomes of the study. The change in FQRST angle, QTc, and TpTe interval following revascularization was the secondary outcome of this study.

Ethics

This study was approved by the local Clinical Research Ethics Committee of Harran University (HRU/20.04.08 -04/24.02.2020). The study was approved by the Institutional Review Board and was conducted in accordance with the Helsinki declaration. Informed consent was obtained from all individual participants included in the study.

Statistical analysis

All analyses were performed on SPSS v21 (SPSS Inc., Chicago, IL, USA). Shapiro-Wilk test was used to test data distribution. The homogeneity of variances was assessed with the Levene test. Data are presented as mean ± standard deviation for normally distributed variables and as median (minimum value-maximum value) for non-normally distributed variables. Categorical variables were presented as frequency (percentage). Comparison of the continuous variables among different SX scores was performed either with Kruskall-Wallis test or one-way ANOVA. Categorical variables were compared using the Pearson chi-square test. Tamhane's T2 and Tukey tests were sued for posthoc analyses. Mann Whitney U test was employed for comparing pre- and post-interventional FQRST angle, QTc, and TpTe intervals. Correlation analysis was performed to demonstrate whether there is an association between the SX score and FQRST angle, QTc, and TpTe intervals. P values less < 0.05 were defined statistically significant.

RESULTS

A total of 49 patients with STEMI were included in the study (mean age 61.4 ± 13.2 years, 51 % male). The mean SX score of the study group was 19.7 ± 7.6. Demographic features, time from symptom onset to balloon inflation, stent diameter, and stent length were similar in subjects with different SX score tertiles. The median FQRST angle was 84º (33-112). Median FQRST angle of the subjects with an SX score ≥ 33 was significantly higher than those with an SX score < 33. Subjects with SX score between 22 and 33 points also had a wider FQRST angle compared to those with SX score ≤ 22 points (Figure 1).

Table 1. Comparison of baseline characteristics and electrocardiographic features of the study subjects with respect to their Syntax scores				
	Low Syntax Score (<22) n=34	Intermediate Syntax Score (23-32) n=8	High Syntax score (≥ 33) n=7	P Value
Age, years	66 (31-81)	58 (35-74)	64 (41-78)	0.769
Male gender, n	19 (56%)	3 (38%)	3 (43%)	0.579
Smoking, n	89 (53%)	3 (38%)	3 (43%)	0.691
Diabetes, n	8 (24%)	3 (38%)	2 (29%)	0.717
Hypertension, n	12 (35%)	2 (25%)	(28%)	0.829
Creatinine, mg/dl	1.1 ± 0.2	1.1 ± 0.3	1.1 ± 0.2	0.910
Leukocyte count, x $10^3/mm^3$	11 (7-24)	9 (7-12)	10 (8-12)	0.058
Hemoglobin, g/dl	12 (10-15)	13 (11-15)	12 (10-14)	0.503
FQRST angle (admission), degree	75 (33-106)[a]	92 (78-106)[b]	104 (99-112)[c]	<0.001
QTc interval, ms	399 ± 22	398 ± 16	411 ± 15	0.290
T_{peak}-T_{end} interval, ms	90 ± 8a	99 ± 7[b]	98 ± 8[b]	0.006
Triglyceride, mg/dl	268 (128-456)	289 (234-387)	251 (187-345)	0.411
HDL cholesterol, mg/dl	37 (24-56)	37 (27-52)	45 (36-56)	0.161
LDL cholesterol, mg/dl	160 (105-253)	156 (120-212)	167 (112-189)	0.939
Time to balloon, minutes	102.1 ± 16.3	97.6 ± 15.8	102.4 ± 19.5	0.782
Infarct related artery				
LAD, n	15 (44%)	2 (25%)	1 (14%)	0.219
Circumflex artery, n	11 (33%)	2 (25%)	3 (43%)	0.765
RCA, n	8 (24%)	4 (50%)	3 (43%)	0.488
Stent diameter, mm	2.83 ± 0.3	2.78 ± 0.4	2.75 ± 0.3	0.813
Stent length, mm	18.7 ± 0.5	20.1 ± 5.6	20.5 ± 6.8	0.696
In-hosptial mortality, n	2 (6%)	0 (0%)	0 (0%)	0.651

Data are presented as mean ± standard deviation; HDL = High-density lipoprotein, LDL = Low-density lipoprotein

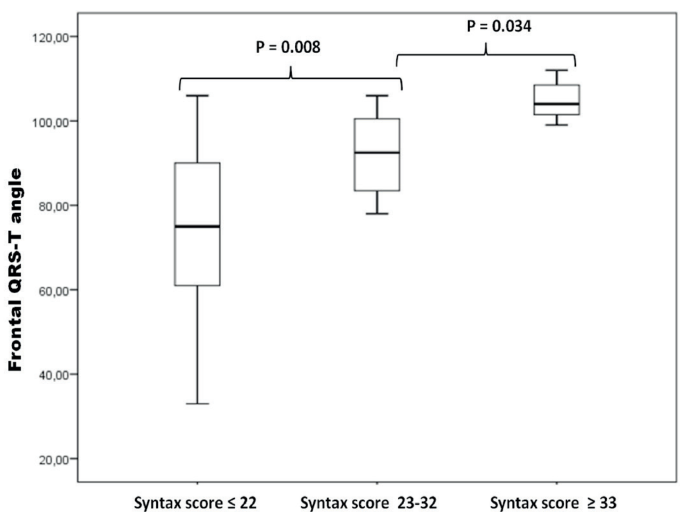

Figure 1. Frontal QRS-T angles recorded from admission electrocardiograms of STEMI subjects with low, intermediate, and high Syntax scores

The mean TpTe interval of the study group was 93 ± 8 ms. Subjects with SX score > 22 had a longer TpTe interval than those with an SXscore ≤ 22 points. However, in-hospital mortality rate was similar in subjects with different SX score tertiles (Table 1). There were no significant correlations between the FQRST and in-hosptial mortality (r=0.12, p=0.916). SX score was significantly correlated with the FQRST angle (r=0.691, p< 0.001) and TpTe interval (r=0.579, p< 0.001)(Table 2).

Table 2. Correlation analyses demonstrating the association between the SX score and FQRST angle, QTc, and T peak- T end intervals		
	Correlation coefficient (r)	P value
FQRST angle (admission)	0.691	<0.001
QTc interval	0.241	0.096
Tpeak-Tend interval	0.579	<0.001
Tpeak-Tend interval / QTc interval	0.376	0.008

FQRST angle significantly decreased following restoration of the blood flow in infarct related artery (84º [33-112] vs. 75º [32-106], p< 0.001). Mean TpTe interval also decreased significantly subsequent to successful revascularization of the infarct related artery (93 ± 8 ms vs. 85 ± 8 ms, p< 0.001).

DISCUSSION

The present study demonstrates that among subjects presenting with STEMI, those with a high SX score have a wider FQRST angle compared to others with intermediate or low SX score. Our findings indicate that FQRST angle is strongly correlated with the atherosclerotic burden determined by SX score in subjects admitted with STEMI. In addition, FQRST angle decreases significantly following the restoration of the low in the infarct related artery.

QRS-T angle is a marker of the deviations between ventricular depolarization and repolarization (17).Spatial and frontal QRS-T angles are two different forms of QRS-T angle. Spatial QRS-T angle is defined as the difference between the QRS axis and the T-wave axis in three-dimensional space, and frontal QRS-T angle is the projection of spatial QRS-T angle onto the frontal plane (18). While spatial QRS-T angle calculation requires special software, FQRST angle can be calculated by regular ECG devices. Several studies have shown that FQRST angle may be used as the substitute of the spatial QRS-T angle in risk prediction(19).

In normal conditions, the myocardial depolarization and repolarization directions are similar in orientation. Accordingly, the FQRST angle is usually < 45º (10). A wider FQRST angle is an indicator of discordance between ventricular depolarization and repolarization (18). The widening of the FQRST angle has been found in association with impaired outcomes in several clinical settings (20). However, data concerning the FQRST angle in subjects with STEMI is limited. Previously, the study of Raposeiras-Roubin et al., which included 467 STEMI patients with LV systolic dysfunction, revealed that a FQRST angle >90°was predictive for long-term mortality independent from the location of the myocardial infarction (21). In a recent retrospective study, Colluoglu et al. have investigated the 248 patients presenting with first acute STEMI. The authors have reported that FQRST angle measured at 90 min of the thrombolytic agent was significantly lower in patients with successful thrombolysis compared to those with failed thrombolysis (22). Moreover, successful thrombolysis was associated with a significant decrease in FQRST angle. They also reported that STEMI patients with a FQRST angle ≥ 95.6° had significantly higher in-hospital mortality rate was also significantly wider in subjects who died during the index hospitalization.

The relation between FQRST angle and the severity of the coronary artery disease was also investigated in some of the previous studies. Palaniswamy and colleagues investigated the frequency of 2- or 3-vessel obstructive CAD in 1229 subjects undergoing coronary angiography (23). The authors reported that the prevalence of 2- or 3-vessel obstructive was significantly higher in subject with a planar QRS-T angle of > 90º compared to those with a planar QRS-T angle of < 90º. Similar to that Colluoglu et al. has also found that acute STEMI subjects with three-vessel disease had a wider FQRST angle on presenting ECG compared to subjects with single-vessel or 2-vessel CAD. More recently, Dogan et al. studied the relation between the FQRST angle and SX score in subjects presenting with STEMI. The authors have reported that FQRST angle was an independent predictor for an intermediate-high SX score (24).

Corrected QT interval is a measure of the combination of cardiac depolarization and repolarization. QT interval dispersion, defined as the difference between the longest (QTmax) and the shortest (QTmin) QT intervals within a 12-lead ECG, has been shown to be correlated with the severity of coronary artery disease as assessed by SYNTAX score (8). However, little is known concerning the relation between the QTc interval and the extent of the coronary artery disease. Our findings show that there is no significant correlation between the QTc interval and the severity of coronary artery disease as assessed by SYNTAX score.

Findings of the present study are consistent with the majority of the previous data. As shown in previous studies, we found that pre-interventional FQRST angle is higher in subjects with a high SX score, and there is a linear correlation between the FQRST angle and the SX score. These findings confirm the results of the study conducted by Dogan et al. which demonstrated a significant association between the FQRST angle and the extent and severity of coronary artery disease in patients presenting with acute STEMI. Moreover, our findings demonstrate that FQRST angle decreases significantly following the revascularization of the infarct related artery. This finding is consistent with the evidence provided by Colluoglu et al, where the authors found a significant decrease in FQRST angle following successful thrombolysis in patients with STEMI. From this point of view, FQRST angle might also be used as a simple and reliable marker of successful revascularization in subjects with acute STEMI.

There are also some limitations concerning this study. This study provides retrospective, single-center data, which could lead to bias in the assessment and the analysis of the data. Study population is relatively small. Establishment of the association between the FQRST angle and several hard end-points such as in-hospital and long term mortality, and major adverse cardiovascular events necessitates further prospective research with larger sample size.

CONCLUSION

FQRST angle obtained from the admission surface ECG of the subjects with acute STEMI might reflect the extent and severity of the CAD, as demonstrated by the SX score. Moreover, FQRST angle decreases significantly following successful revascularization of the infarct related artery. In this context, FQRST may provide extensive information regarding the atherosclerotic burden and the success of the revascularization in subjects with STEMI.

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REFERENCES

1. Vogel B, Claessen BE, Arnold SV, et al. ST-segment elevation myocardial infarction. Nat Rev Dis Primers 2019;5:39.
2. Buccheri S, Capranzano P, Condorelli A, et al. Risk stratification after ST-segment elevation myocardial infarction. Expert Rev Cardiovasc Ther 2016;14:1349-60.
3. de Waha S, Eitel I, Desch S, et al. Impact of multivessel coronary artery disease on reperfusion success in patients with ST-elevation myocardial infarction: A substudy of the AIDA STEMI trial. Eur Heart J Acute Cardiovasc Care 2017;6:592-600.
4. Pineda AM, Carvalho N, Gowani SA, et al. Managing Multivessel Coronary Artery Disease in Patients With ST-Elevation Myocardial Infarction: A Comprehensive Review. Cardiol Rev 2017;25:179-88.
5. Bundhun PK, Sookharee Y, Bholee A, et al. Application of the SYNTAX score in interventional cardiology: A systematic review and meta-analysis. Medicine (Baltimore) 2017;96:7410.
6. Farooq V, Brugaletta S, Serruys PW. The SYNTAX score and SYNTAX-based clinical risk scores. Semin Thorac Cardiovasc Surg 2011;23:99-105.
7. Farooq V, Head SJ, Kappetein AP, et al. Widening clinical applications of the SYNTAX Score. Heart 2014;100:276-87.
8. Helmy H, Abdel-Galeel A, Taha Kishk Y, et al. Correlation of corrected QT dispersion with the severity of coronary artery disease detected by SYNTAX score in non-diabetic patients with STEMI. Egypt Heart J 2017;69:111-7.
9. Schweitzer P, Keller S. The role of the initial 12-lead ECG in risk stratification of patients with acute coronary syndrome. Bratisl Lek Listy 2001;102:406-11.
10. Gungor M, Celik M, Yalcinkaya E, et al. The Value of Frontal Planar QRS-T Angle in Patients without Angiographically Apparent Atherosclerosis. Med Princ Pract 2017;26:125-31.
11. Lau LY, So EK, Chow PC, et al. Frontal QRS-T angle and ventricular mechanics in congenital heart disease. Heart Vessels 2020.
12. Lown MT, Munyombwe T, Harrison W, et al. Association of frontal QRS-T angle–age risk score on admission electrocardiogram with mortality in patients admitted with an acute coronary syndrome. Am J Cardiol 2012;109:307-13.
13. Thygesen K, Alpert JS, White HD, et al. Universal definition of myocardial infarction. Circulation 2007;116:2634-53.
14. Antzelevitch C. Tpeak–Tend interval as an index of transmural dispersion of repolarization. European journal of clinical investigation 2001;31:555-7.
15. Sianos G, Morel M-A, Kappetein AP, et al. The SYNTAX Score: an angiographic tool grading the complexity of coronary artery disease. EuroIntervention 2005;1:219-27.
16. Mohr FW, Morice M-C, Kappetein AP, et al. Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. The lancet 2013;381:629-38.
17. Oehler A, Feldman T, Henrikson CA, et al. QRS-T angle: a review. Ann Noninvasive Electrocardiol 2014;19:534-42.
18. Zhang X, Zhu Q, Zhu L, et al. Spatial/Frontal QRS-T Angle Predicts All-Cause Mortality and Cardiac Mortality: A Meta-Analysis. PLoS One 2015;10:0136174.
19. Zhang Z-m, Prineas RJ, Case D, et al. Comparison of the prognostic significance of the electrocardiographic QRS/T angles in predicting incident coronary heart disease and total mortality (from the atherosclerosis risk in communities study). Am J Cardiol 2007;100:844-9.
20. Pavri BB, Hillis MB, Subacius H, et al. Prognostic value and temporal behavior of the planar QRS-T angle in patients with nonischemic cardiomyopathy. Circulation 2008;117:3181-6.
21. Raposeiras-Roubin S, Virgos-Lamela A, Bouzas-Cruz N, et al. Usefulness of the QRS-T angle to improve long-term risk stratification of patients with acute myocardial infarction and depressed left ventricular ejection fraction. Am J Cardiol 2014;113:1312-9.
22. Colluoglu T, Tanriverdi Z, Unal B, et al. The role of baseline and post-procedural frontal plane QRS-T angles for cardiac risk assessment in patients with acute STEMI. Ann Noninvasive Electrocardiol 2018;23:12558.
23. Palaniswamy C, Singh T, Aronow WS, et al. A planar QRS-T angle >90 degrees is associated with multivessel coronary artery disease in patients undergoing coronary angiography. Med Sci Monit 2009;15:31-4.
24. Dogan A, Kahraman S. Frontal QRS-T angle predicts coronary atherosclerotic burden in patients with ST segment elevation myocardial infarction. J Electrocardiol 2020;58:155-9.