ORIGINAL ARTICLE *Van Medical Journal*

Van Med J 31 (4):282-290, 2024
DOI: [10.5505/vmj.2024.09719](10.5505/vmj.2024.09719)

Is the Frontal QRS-T Angle Successful in Differentiating Acute Coronary Syndromes?

Mehmet Göktuğ Efgan, Efe Kanter, Tutku Duman Şahan, Süleyman Kırık, Umut Payza

İzmir Katip Çelebi University, Faculty of Medicine, Department of Emergency Medicine, Izmir, Türkiye

Abstract

Introduction: Acute coronary syndromes (ACS) encompass a spectrum of clinical conditions that result from a sudden occlusion or severe narrowing of the coronary arteries, leading to myocardial ischemia. Early and accurate diagnosis of ACS is critical to improve patient outcomes. The frontal QRS-T angle, a parameter measured on the electrocardiogram (ECG), has been proposed as a potential marker for cardiovascular events. This study aims to evaluate the effectiveness of the frontal QRS-T angle in differentiating between various subtypes of ACS (STEMI, non-STEMI, USAP) and stable angina pectoris (SAP).

Materials and Methods: A prospective observational study was conducted on patients admitted to the emergency department between January 9, 2023, and January 3, 2024. The study population included patients diagnosed with ACS or SAP and a control group without cardiac pathology. The frontal QRS-T angle was calculated from 12-lead ECGs. Statistical analyses, including Kruskal-Wallis and ROC curve analysis, were performed to assess the diagnostic utility of the QRS-T angle.

Results: The study included 169 patients, with a mean age of 61.96±13.90 years. The frontal QRS-T angle was significantly higher in the STEMI group compared to other groups. ROC analysis demonstrated that the QRS-T angle could significantly differentiate between non-cardiac patients and those with STEMI, non-STEMI, and USAP. The cutoff value for differentiating non-cardiac patients from those with STEMI was >30, with an AUC of 0.784, sensitivity of 81.25%, and specificity of 66.67%. The frontal QRS-T angle was also significant in predicting mortality, with a cutoff value of 58.00, AUC of 0.825, sensitivity of 84.20%, and specificity of 72.00%.

Conclusion: The frontal QRS-T angle is a significant marker for distinguishing between different ACS subtypes and non-cardiac patients. Its role in identifying STEMI and predicting mortality highlights its potential utility in clinical practice. Further studies are needed to validate these findings and explore the broader implications of the QRS-T angle in cardiovascular diagnosis and management.

Key words: Frontal QRS-T angle; acute coronary syndrome (ACS); electrocardiogram (ECG); cardiac ischemia.

Introduction

The term "acute coronary syndromes" (ACS) refers to a group of medical diseases that need immediate attention and arise from a sudden blockage or severe constriction of the coronary arteries (1). Myocardial ischaemia is the cause of ACS, which, if left untreated, can have major and even deadly effects including myocardial infarction (2). Therefore, in order to maximize patients' chances of survival and minimize consequences, early detection of ACS and prompt intervention are essential (3). The three primary subtypes of acute coronary syndrome (ACS) are unstable angina pectoris (USAP), non-ST-segment elevation myocardial infarction (non-STEMI), and ST-segment elevation myocardial infarction (STEMI) (4). A significant ST-segment elevation on the electrocardiogram (ECG) and more extensive and severe myocardial injury are the hallmarks of STEMI. A myocardial infarction classified as non-STEMI has elevated troponin levels but no ST-segment elevation. Unlike stable angina pectoris, USAP is characterized by chest pain that is usually not associated with a significant shift on the ECG, occurs at rest or during mild physical activity, and signals a more severe clinical picture. Conversely, bouts of chest pain that are typically brought on by exercise, eased by rest, and connected to a stable narrowing in the coronary artery are known as stable angina pectoris. The angle on the electrocardiogram (ECG) between the QRS complex and the T wave is represented by the frontal QRS-T angle (5). ECG equipment can determine this angle in two dimensions, and it can be utilized as a marker for cardiovascular diseases. It is believed that mortality and ischemia may be connected to an increase in this angle. Prior research has demonstrated a potential correlation between the frontal QRS-T angle and mortality as well as

*Corresponding Author: Tutku Duman Şahan Department of Emergency Medicine, Izmir Katip Çelebi University Faculty of Medicine, Izmir, Türkiye **E-mail:** tutkuduman75@gmail.com **Orcid:** Mehmet Göktuğ Efgan 0000-0002-0794-1239, Efe Kanter 0000-0002-0208-950X, Tutku Duman Şahan 0000-0001-9641-4176, Süleyman Kırık 0000-0003-1477-6363, Umut Payza 0000-0002-5297-1066

Received: 28.08.2024, Accepted: 09.10.2024

cardiovascular events, including coronary artery disease (6,7).

This study sought to determine whether the frontal QRS-T angle could be used to distinguish between more stable situations such stable angina pectoris and all subtypes of acute coronary syndromes (ACS). It will be determined whether the frontal QRS-T angle can aid in the early and precise differentiation between ACS subtypes such as STEMI, non-STEMI, USAP, and stable angina by analyzing ECG recordings. The purpose of this study's findings is to provide further insight into the overall usefulness of the frontal QRS-T angle as a diagnostic marker in clinical situations such stable angina pectoris and ACS. The contribution of this study to the literature is the identification of the frontal QRS-T angle as a potential biomarker for distinguishing between subtypes of acute coronary syndromes and non-cardiac patients, particularly in the diagnosis of STEMI and in predicting mortality.

Materials and Methods

Study design: A prospective observational study was conducted including patients admitted to the emergency room between January 9, 2023, and January 3, 2024. The study received ethical clearance from the local ethics committee prior to initiation.Study population: The study included patients aged 18 years and older diagnosed with acute coronary syndrome (ACS) at the emergency department. We also included patients diagnosed with stable angina pectoris after a cardiology consultation, requiring outpatient follow-up. Additionally, we enrolled patients with no known cardiac history who presented to the emergency department for other reasons and met inclusion/exclusion criteria after ECG assessment. Patients with additional conditions potentially causing chest pain (e.g., pulmonary embolism, aortic dissection), pregnant or nursing women, patients with incomplete data, and those presenting under the influence of substances were excluded. Furthermore, patients with no available outcome data or those referred to external centers were also excluded. The numbers of included and excluded patients are shown in the flow chart (Figure 1).

Variables: Primary outcome variable: Frontal QRS-T angle.

Definition: The frontal QRS-T angle was calculated as the difference between the QRS and T axes. If the difference exceeded 180°, the angle was determined as 360° minus the absolute value of the difference between the frontal QRS axis and the T axis.

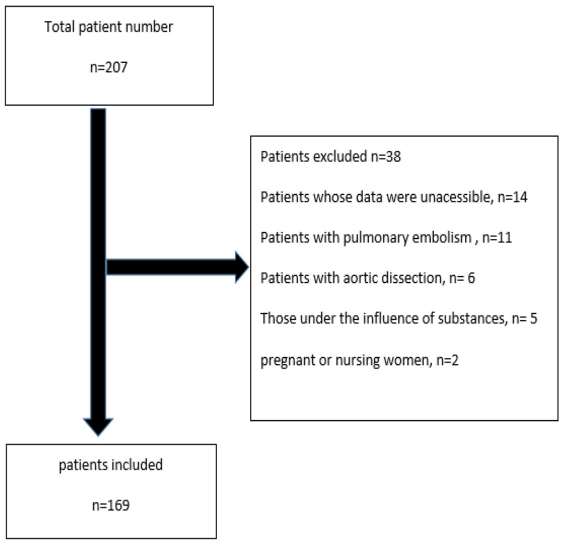

Figure 1: Flow chart

Measurement: This angle was measured from the standard 12-lead ECG performed in all patients at a paper speed of 25 mm/s and a calibration of 10 mm/mV.

Secondary variables: Troponin levels: Quantitative values measured using high-sensitivity assays to differentiate non-STEMI from other groups.

ECG changes: Presence or absence of ST-segment elevation or depression, used to classify patients into STEMI or other ACS types.

Heart rate: Recorded from the ECG, used to compare across subgroups.

Ejection fraction (EF): Measured via echocardiogram, providing insight into cardiac function and correlating with outcomes.

Comorbidities: Collected from patient records, including hypertension, diabetes, and previous cardiac history, influencing the clinical course of ACS.

Chest pain duration and characteristics: Documented through patient interviews and clinical evaluation, differentiating between unstable angina, stable angina, and non-cardiac causes.

Data collection: The study included all patients who met the inclusion criteria and showed up at the emergency department within the investigators' working hours. For every patient, an informed consent form was collected. The data recording form had notes on every detail about the patients who were included. ECGs that were scanned on the system provided the ECG data. Every ECG was downloaded in PDF format from the system, and it was stored with the same number as the case report form.

Group definition: The study resulted in the formation of five subgroups. Patients having ST segment elevation on an ECG examination at the time of emergency room presentation made comprised the STEMI group. Patients in the nonSTEMI group had high troponin levels and no change in their ECG. Patients with unstable angina pectoris-defined as unstable angina pectoris without an ECG change or troponin elevation-who, following a cardiology consultation, were deemed to require coronary angiography due to acute coronary syndrome made up the USAP group. The SAP group consisted of patients with chest pain and related symptoms who were diagnosed by cardiologists as acute coronary syndrome. These patients were not considered for emergency coronary angiography, but rather were called to the outpatient clinic due to heart pain. The ECGs of volunteer patients who did not have a history of cardiac disease or drug use, whose final diagnosis was not cardiac, and whose cause for presenting to the emergency room was not suggestive of cardiac diseases were used to establish the fifth group. Additionally, the fifth group was identified as non-cardiac.

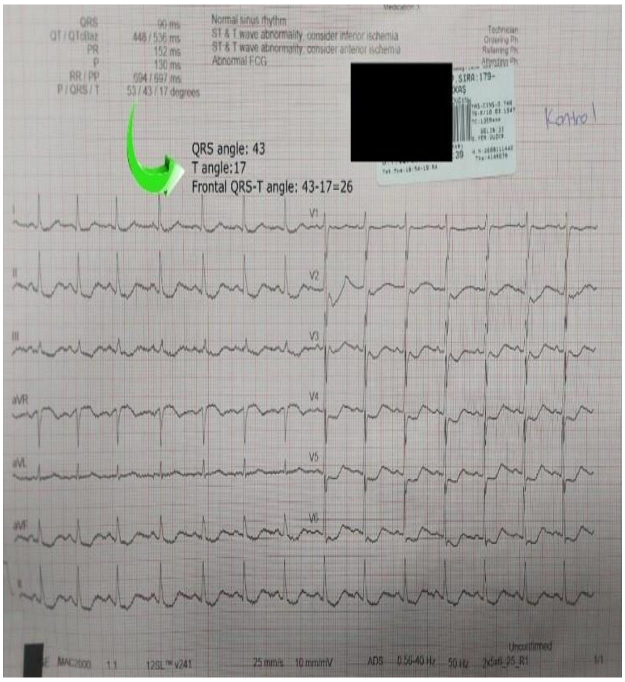

Figure 2: A sample ECG in which the QRS-T angle was calculated

Outcomes: This study's main goal was to determine whether the frontal QRS-T angle could be used to distinguish between each group individually. The evaluation of the frontal QRS-T angle's potential as a mortality predictor across all disorders was the secondary goal.

Frontal QRS-T angle: Using a typical ECG paper speed of 25 mm/s and a voltage calibration of 10 mm/mV, each patient's 12-lead ECG was recorded while they were supine (Schiller, Germany-Bavaria). The angles noted on the ECG strip acquired for each case were used in the study to compute the frontal QRS-T angle. The difference between the QRS and T axes was used to compute the frontal QRS-T angle (Figure 2). This angle was determined as 360° minus the absolute value of the difference between the frontal plane QRS axis and the T axis when the QRS-T angle difference exceeded 180°.

Ethical approval: Before starting the study, ethics committee approval was obtained from the university's local ethics committee. This study was approved by Izmir Katip Çelebi University Non-Interventional Clinical Studies Ethics Committee on 20 July 2023 with decision number 0317.

Statistical analysis: Number of units (n), percentage (%), mean ± standard deviation, median (M), minimum (min), maximum (max), and interquartile range (IQR) values were provided for descriptive statistics. The Shapiro Wilk normality test was used to determine whether the numerical variables had a normal distribution. Using Levene's test, the homogeneity of variances was assessed. The Kruskal-Wallis test was used to compare the data based on ACS kinds because the data did not meet the requirements for a parametric test. The Kruskal-Wallis test employed the Dunn-Bonferroni test as a multiple comparison test. The exact tests of Pearson and Fisher were utilized to determine relationships between categorical variables. ROC analysis was per formed to cut off value fort the considered variables. Statistically significance level was considered as 5% and IBM SPSS (Statistics Standard Concurrent User V 27 (IBM Corp., Armonk, New York, USA) was used to all statistical computations.

Results

64 (37.9) of the 169 patients that were part of the study were female. The computed mean age was 61.96±13.90 years. Nineteen individuals experienced an exitus, out of the 150 who were discharged. For the entire cohort, the mean frontal QRS-T angle was 52.33±45.17. Table 1 displays the patients' descriptive statistics. Five groups of patients were created based on the diagnosis of acute coronary event. Between the groups, other variables were compared. Table 2

Table 1: Descriptive Statistics

Variables	*n*	%
Age	61.96±13.90 63 (21-90)	
Gender		
Female	64	37.9
Male	105	62.1
ACS type		
STEMI	48	28.4
NonSTEMI	30	17.8
USAP	20	11.8
SAP	35	20.7
Normal	36	21.3
QRS angle	21.37±43.51 25 (-75-135)	
T angle	59.04±42.10 59 (-80-168)	
Frontal QRS-T angle	52.33±45.17 39 (0-205)	
QRS interval	93.30±21.50 88 (58-170)	
QTc Baz	435.24±36.28 428 (366-573)	
Heart Rate	78.24±17.71 74 (44-158)	
Troponin*	836.83±2769.57 15.6 (0.7-27181)	
BUN*	17.67±7.92 16 (8-64)	
Kreatinin*	1.10±0.42 0.98 (0.61-3.66)	
AST*	34.71±45.50 24 (12-381)	
ALT*	24.03±38.87 17 (3-439)	
WBC*	9.62±3.58 9.44 (3.79-31.97)	
NEU*	6.17±3.17 5.68 (1.96-27.35)	

Values are given as mean±standard deviation and median (min-max) or n (%). ***:** Missing data were noted.

shows comparisons between all groups. To determine whether the frontal QRS-T angle could distinguish between patients with acute coronary syndrome and those without, ROC curve analysis was carried out. It was determined that its application was statistically significant in distinguishing the non-cardiac group from the STEMI, Non-STEMI, and USAP groups. Its application, meanwhile, did not yield statistically significant differences between the SAP group and the non-cardiac group. Table 3 presents the findings. The frontal QRS-T angle's capacity to differentiate the SAP group from the STEMI, Non-STEMI, and USAP groups was assessed using ROC curve analysis. It was determined that its use was statistically significant in distinguishing the SAP group from the STEMI group. Its application, however, did not statistically significantly separate the SAP group from the NonSTEMI and USAP groups. Table 4 presents the findings. The USAP and nonSTEMI groups were assessed collectively for comparison with the SAP group, and ROC curve analysis was carried out to employ the frontal QRS-T angle as a means of distinguishing between these two groups. Frontal QRS-T angle was, however, statistically not significant when used for this purpose. STEMI, NonSTEMI, and USAP groups were assessed collectively in order to compare with the SAP group. ROC curve analysis was used to use the frontal QRS-T angle to distinguish between these two groups. It was discovered that the

Table 1: Descriptive Statistics (Continuation)

Variables	***n***	**%**
Hemoglobin*	13.52±2.04 13.6 (8.1-17.8)	
PLT*	251.35±71.76 250 (36-466)	
CAD*		
None	88	66.2
Present	45	33.8
DM*		
None	92	69.2
Present	41	30.8
HT*		
None	73	54.9
Present	60	45.1
CHF*		
None	125	94.0
Present	8	6.0
CKF*		
None	124	93.2
Present	9	6.8
COPD*		
None	131	98.5
Present	2	1.5
HL*		
None	124	93.2
Present	9	6.8
ED Outcome		
Discharged	73	43.2
Admitted	5	3.0
ICU	88	52.1
Exitus	3	1.8
Outcome		
Alive	150	88.8
Exitus	19	11.2

Values are given as mean±standard deviation and median (min-max) or n (%). ***:** Missing data were noted.

Table 2: Comparison of variables between groups

	All Groups					**Test Statistics**	
	Stemi	**Non Stemi**	**Usap**	**Sap**	**Non-cardiac**	**Test value**	***p* value**
Age	61 (14)	66.5 (20)	61.5 (25)	60 (25)	64.5 (23)	*H*=3.817	0.431
Gender							
Female	11 (22.9)	13 (43.3)	8 (40.0)	14 (40.0)	18 (50.0)	χ^2=7.300	0.121
Male	37 (77.1)	17 (56.7)	12 (60.0)	21 (60.0)	18 (50.0)		
QRS angle	28 (89)^{a}	13 (66)^{a}	-3.5 (68)^{a}	13 (58)^{a}	45 (50)^{b}	*H*=17.417	0.002
T angle	95 (60)^{a}	66 (57)^{ab}	53.5 (43)^{b}	38 (31)^{b}	54.5 (34)^{b}	*H*=25.219	0.001
Frontal QRS-T angle	61 (66)^{a}	41.5 (66)^{ab}	35.5 (91)^{ab}	37 (39)^{b}	25 (32)^{bc}	*H*=20.189	0.001
QRS interval	92 (21)^{a}	82 (13)^{b}	102 (31)^{a}	88 (14)^{b}	82 (18)^{b}	*H*=22.783	0.001
QTc Baz	423 (33)	445.5 (43)	422.5 (72)	423 (48)	424 (33)	*H*=7.384	0.117
ED Outcome	1 (2.1)^{a}						
Discharged	1 (2.1)^{a}	1 (3.3)^{a}	0 (0.0)^{a}	35 (100.0)^{b}	36 (100.0)^{b}		
Admitted	44	1 (3.3)^{a}	3 (15.0)^{a}	0 (0.0)^{a}	0 (0.0)^{a}	χ^2=198.533	0.001
ICU	(91.7)^{a}	27 (90.0)^{a}	17 (85.0)^{a}	0 (0.0)^{b}	0 (0.0)^{b}		
Exitus	2 (4.2)^{a}	1 (3.3)^{a}	0 (0.0)^{a}	0 (0.0)^{a}	0 (0.0)^{b}		
Outcome	36						
Alive	(75.0)^{a}					χ^2=19.582	0.001
Exitus	12	25 (83.3)^{ab}	18 (90.0)^{ab}	35 (100.0)^{b}	36 (100.0)^{b}		
	(25.0)^{a}	5 (16.7)^{ab}	2 (10.0)^{ab}	0 (0.0)^{b}	0 (0.0)^{b}		

Values are given as mean±standard deviation and median (min-max) or n (%). ***:** Missing data were noted. ***H*:** Kruskal Wallis H testi

Table 3: Cutoff Scores, AUC Value, Sensitivity, Selectivity and Statistical Significance of Frontal QRS-t Angle for discrimination between non-cardiac patient group and other groups

Variables	Youden Index	Cut off value	AUC	SE	p	Asymptotic 95% Confidence Interval		Sensitivity (%)	Specificity (%)
						L. Bound	U. Bound		
Non-cardiac - STEMI	0.479	>30	0.784	0.049	0.001	0.681	0.866	81.25	66.67
Non-cardiac - NonSTEMI	0.311	>70	0.664	0.068	0.015	0.537	0.776	36.67	94.40
Non-cardiac - USAP	0.372	>77	0.678	0.076	0.020	0.540	0.796	40.0	97.22
Non-cardiac - SAP	0.238	>29	0.615	0.067	0.087	0.492	0.728	60.0	63.89

AUC: Area under the curve, ***CI***: Confidence interval, ***SE***: Standard error

Table 4: Cutoff Scores, AUC Value, Sensitivity, Selectivity and Statistical Significance of Frontal QRS-t Angle for discrimination between SAP group and other groups

Variables	Youden Index	Cutoff	AUC	SE	p	Asymptotic 95% Confidence Interval		Sensitivity (%)	Specificity (%)
						L. Bound	U. Bound		
SAP - STEMI	0.292	>54	0.671	0.059	0.004	0.559	0.770	52.08	77.14
SAP - NonSTEMI	0.219	>76	0.571	0.073	0.330	0.442	0.693	33.33	88.57
SAP- USAP	0.285	>76	0.576	0.083	0.366	0.435	0.708	40.0	88.57

AUC: Area under the curve, ***CI***: Confidence interval, ***SE***: Standard error

Table 5: Cutoff Scores, AUC Value, Sensitivity, Selectivity and Statistical Significance of Frontal QRS-t Angle for discrimination between SAP group and NonSTEMI/USAP and SAP- STEMI/NonSTEMI/USAP groups

Variables	Youden Index	Cut off value	AUC	SE	p	Asymptotic 95% Confidence Interval		Sensitivity (%)	Specificity (%)
						L. Bound	U. Bound		
SAP – NonSTEMI/USAP	0.245	>76	0.573	0.062	0.244	0.461	0.680	36.0	88.57
SAP-STEMI/NonSTEMI/USAP	0.240	>54	0.621	0.053	0.023	0.533	0.704	46.94	77.14

AUC: Area under the curve, ***CI***: Confidence interval, ***SE***: Standard error

Table 6: Cutoff Scores, AUC Value, Sensitivity, Selectivity and Statistical Significance of the variables for predicting mortality status in all patients

Test Result Variables	Cut off value	AUC	SE	p	Asymptotic 95% Confidence Interval		Sensitivity (%)	Specificity (%)
					Lower Bound	Upper Bound		
QRS angle	13.50	0.259	0.070	0.001	0.122	0.397	26.3	40.00
T angle	65.50	0.709	0.072	0.003	0.569	0.850	68.40	60.70
Frontal QRS-T angle	58.00	0.825	0.064	0.000	0.700	0.950	84.20	72.00
QRS interval	91.00	0.691	0.073	0.007	0.548	0.835	68.40	60.70
QTc (Baz)	431.00	0.679	0.067	0.011	0.548	0.809	63.20	55.30

AUC: Area under the curve, ***CI***: Confidence interval, ***SE***: Standard error

frontal QRS-T angle was statistically significant and may be used to distinguish between these two groups. Table 5 presents the findings. For each patient included in the study, ROC curve analysis was used to predict the mortality status of the QRS angle, T angle, frontal QRS-T angle, and QRS duration QTc (base) duration variables. It was appropriate and statistically significant to utilize every variable in the mortality prediction process. Table 6 and Figure 3 display all of the results.

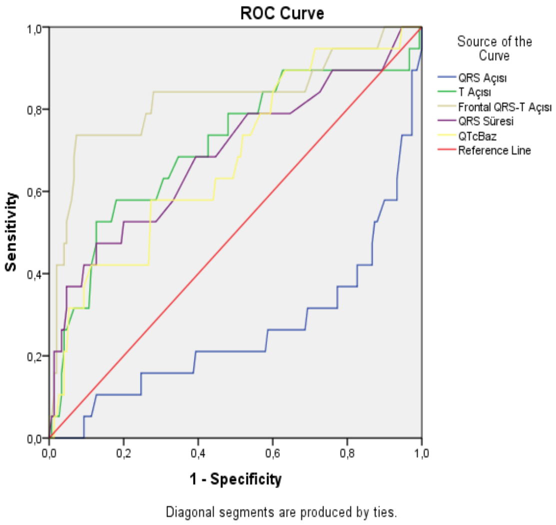

Figure 3: ROC curve analysis of variables plotted to predict mortality in all patients

Discussion

This study looked into how the frontal QRS-T angle might be used to distinguish between stable angina pectoris and different types of acute coronary crises. According to our findings, the frontal QRS-T angle can be used as a statistically significant indicator to differentiate between non-cardiac patients and ACS subtypes including STEMI, non-STEMI, and USAP. Given that the STEMI group's frontal QRS-T angle was much higher than that of the other groups, it is possible that this measure is more important in the diagnosis of STEMI. Additionally, it was discovered that this characteristic helped distinguish between patients in the acute coronary syndrome spectrum and those with stable angina. In all patient groups, frontal QRS-T angle was also found to be helpful in predicting mortality. Since the frontal QRS-T angle may be used to predict mortality and differentiate the groups from one another, we believe it to be a valuable marker for acute coronary syndromes, one of the most significant patient groups seen in the emergency room. Similar findings were found when comparing the frontal QRS-T angle to earlier research in the diagnosis of ACS (8). For instance, Zhang et al.'s study (9) demonstrated a correlation between coronary artery disease and other cardiovascular diseases and frontal QRS-T angle. Furthermore, in individuals with stable coronary artery disease, a broadened frontal QRS-T angle was linked to an increased risk of cardiovascular death, according to Karadeniz et al. (2009) (10). These results corroborate our study's findings and suggest that the frontal QRS-T angle may be useful in clinically distinguishing between ACS subtypes. The QRS-T angle has been shown to be a valuable marker in the prediction of cardiovascular events by Kusumoto et al. in another investigation (11). In patients with ST-segment elevation myocardial infarction, frontal QRS-T angle was found to be an independent predictor of coronary atherosclerotic burden by Dogan et al. (12). Furthermore, this outcome agrees with what we discovered. It was discovered that frontal QRS-T angles were greater, particularly in STEMI patients. Frontal QRS-T angle is a helpful measure in acute coronary syndromes and their subgroups, according to our research and the literature. The association between the frontal QRS-T angle and cardiac mortality has been extensively discussed in the literature. Several studies have demonstrated that a widened frontal QRS-T angle is correlated with an increased risk of cardiac mortality. Zhu-ming Zhang et al. (13) reported a significant correlation between a broader frontal QRS-T angle and the risk of cardiac mortality, highlighting the potential value of this parameter in cardiovascular risk stratification. Similarly, Lown et al. (14) demonstrated that the frontal QRS-T angle serves as a significant predictor of cardiac mortality. These findings are consistent with the study's findings, which suggest that the frontal QRS-T angle may be useful in identifying patients who are at risk of cardiac mortality. Furthermore, a meta-analysis revealed that the QRS-T angle is a strong predictor of both all-cause mortality and cardiac death, supporting its role in cardiovascular risk prediction (9). In patients with ST-elevation myocardial infarction (STEMI), the frontal QRS-T angle has been identified as an independent predictor of coronary atherosclerotic burden, further confirming its utility in high-risk patient populations(5, 15). Given its predictive value, the widening of the frontal QRS-T angle should be closely monitored, as it may indicate underlying myocardial ischemia and increased risk of adverse cardiac outcomes.The study's most significant finding is the correlation between frontal QRS-T angle and ACS-related death. Our study's results are in line with earlier research that showed a frontal QRS-T angle was linked to a higher risk of death (9). Frontal QRS-T angle was revealed to be a significant predictor of ACS-related mortality in our investigation. This metric was found to be relevant in terms of mortality prediction, particularly in the non-STEMI and USAP groups. This shows that when it comes to early intervention and treatment plans for patients with ACS, the frontal QRS-T angle may be crucial.

Ultimately, additional research on the frontal QRS-T angle in a sizable patient population is warranted based on our findings regarding its applicability as a diagnostic tool in conditions like ACS and stable angina pectoris. Widening of the frontal QRS-T angle has been shown to be a significant predictor of long-term outcomes in individuals with coronary artery disease, as demonstrated by Aro et al. (16). Furthermore, recent studies have supported this association, showing that a wider QRS-T angle is correlated with higher one-year mortality in patients with ST-elevation myocardial infarction (STEMI), even after undergoing reperfusion therapies (17). A meta-analysis further confirmed that both all-cause and cardiac mortality are strongly predicted by the frontal QRS-T angle across various populations (9). These findings align with our study and suggest that the QRS-T angle could be utilized in a broader range of clinical applications, including risk stratification in high-risk cardiovascular patients. More comprehensive studies are required to refine its diagnostic precision and explore its therapeutic potential. Future research could further elucidate the role of the frontal QRS-T angle in improving outcomes during the management of ACS (9,17).

Study Limitations: The results of this study had limited generalizability because they were based on data from a single center. Furthermore, because the study sample was relatively small, additional research on bigger and more diverse patient groups is necessary to confirm the findings. Potential technical errors in frontal QRS-T angle measurement could compromise the accuracy of the findings. Some analyses may have been restricted in their scope due to missing data observations in the study. Finally, since long-term outcomes were not evaluated, studies investigating long-term outcomes are needed to accurately determine the prognostic significance of the frontal QRS-T angle.

Conclusion

According to this study, the frontal QRS-T angle may be a useful diagnostic tool for identifying various acute coronary syndrome subtypes as well as other cardiac disorders such stable angina pectoris. Particularly in cases of STEMI, the frontal QRS-T angle is a notable signal that may aid in the diagnostic process. Furthermore, this parameter might be crucial in estimating the chance of dying from ACS. According to our research, the frontal QRS-T angle may aid in the early detection of individuals who are at danger of cardiac mortality, which could lead to the improvement of treatment plans. To assess the routine application of the frontal QRS-T angle in clinical practice and to validate these findings in larger and more diverse groups, additional research is necessary. In summary, frontal QRS-T angle may represent a significant advancement in emergency department patient care practices as a prognostic biomarker for the management of ACS.

Ethical approval: Before starting the study, ethics committee approval was obtained from the university's local ethics committee.

Conflict of interest: The authors have no conflict of interest related to this study.

Financial disclosure: No financial support has been received for this study.

Author contributions: Concept (MGE, UP, EK), Design (MGE, EK, SK, TDŞ), Data Collection and/or Processing (SK, EK, TDŞ), Analysis and/or Interpretation (MGE, UP, TDŞ, SK)

References

1. Rautaharju PM, Surawicz B, Gettes LS, Bailey JJ, Childers R, Deal BJ, et al. AHA/ACCF/HRS recommendations for the standardization and interpretation of the electrocardiogram: part IV: the ST segment, T and U waves, and the QT interval: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society: endorsed by the International Society for Computerized Electrocardiology Circulation 2009;119(10);235-240.
2. Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al. Fourth Universal Definition of Myocardial Infarction (2018). J Am Coll Cardiol 2018;72(18):2231-2264.
3. Lazarus G, Kirchner H, Siswanto B. Prehospital tele-electrocardiographic triage improves the management of acute coronary syndrome in rural populations: A systematic review and meta-analysis. J Telemed Telecare 2020;28:632-641.
4. Collet JP, Thiele H, Barbato E, Barthélémy O, Bauersachs J, Bhatt DL, et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Eur Heart J 2021;42(14):1289-1367.

5. Gotsman I, Shauer A, Elizur Y, Zwas D, Lotan C, Keren A. Temporal changes in electrocardiographic frontal QRS-T angle and survival in patients with heart failure. PLoS ONE. 2018;13;1-10.
6. May O, Graversen C, Johansen M, Arildsen H. A large frontal QRS-T angle is a strong predictor of the long-term risk of myocardial infarction and all-cause mortality in the diabetic population. J Diabetes Complications 2017;31(3):551-555.
7. Küçük U, Arslan K, Özpınar U, Altun B. Relationship of Frontal QRS-T Angle with Coronary Flow Grade and Adverse Events Before Percutaneous Coronary Intervention in Patients with Non-ST-Elevation Myocardial Infarction. Turk Kardiyol Dern Ars 2023;51(4):256-265.
8. Hassan H, Arshad E, Musharraf MS, Ahmad Z, Aslam MZ, Anwer Z. Evaluation of Mortality Among Patients of Acute Coronary Syndrome with Frontal QRS-T Angle > 100 Presenting to Tertiary Care Hospital. apmc [Internet]. 2020Sep.30 [cited 2024Oct.10];14(3):196-9 .
9. Zhang X, Zhu Q, Zhu L, Jiang H, Xie J, Huang W, et al. Spatial/Frontal QRS-T Angle Predicts All-Cause Mortality and Cardiac Mortality: A Meta-Analysis. PLoS ONE 2015;10;1-18.
10. Karadeniz F, Altuntaş E. Correlation between frontal QRS-T angle, Tp-e interval, and Tp-e/QT ratio to coronary artery severity assessed with SYNTAX score in stable coronary artery disease patients. J Arrhythmia 2022;38:783-789.
11. Kusumoto FM, Schoenfeld MH, Barrett C, et al. 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2019;74(7); 382-482.
12. Dogan A, Kahraman S. Frontal QRS-T angle predicts coronary atherosclerotic burden in patients with ST segment elevation myocardial infarction. J Electrocardiol 2019;58:155-159.
13. Zhang Z, Prineas R, Case D, Soliman E, Rautaharju P. 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(5):844-849.
14. Lown MT, Munyombwe T, Harrison W, West RM, Hall CA, Morrell C, 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(3):307-313.
15. Tastan E, İnci Ü. The Relationship Between In-Hospital Mortality and Frontal QRS-T Angle in Patients With COVID-19. Cureus 2022;14(8):e28506.
16. Aro AL, Huikuri HV, Tikkanen JT, Junttila MJ, Rissanen HA, Reunanen A, et al. QRS-T angle as a predictor of sudden cardiac death in a middle-aged general population. Europace 2012;14(6):872-876.
17. Sawant AC, Bhardwaj A, Srivatsa S, Sridhara S, Prakash MPH, Kanwar N, et al. Prognostic value of frontal QRS-T angle in predicting survival after primary percutaneous coronary revascularization/coronary artery bypass grafting for ST-elevation myocardial infarction. Indian Heart J 2019;71(6):481-487.