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Frontal QRS-T Angle in Predicting Short-Term Mortality in Patients with SARS-CoV 2 Infection in Emergency Service: An Analytical Study

SARS-CoV 2 Enfeksiyonlu Hastalarda Kısa Dönem Mortaliteyi Tahmin Etmede Frontal QRS-T Açısı: Bir Analitik Çalışma

İbrahim ALTUNOK[1], Serdar ÖZDEMIR[1], Abuzer ÖZKAN[2], Hatice Şeyma AKÇA[3], Gökhan İŞAT[1], Hande AKBAL KAHRAMAN[4], Ercan GÜRLEVIK[4]

[1]University of Health Sciences Umraniye Training and Research Hospital, Department of Emergency Medicine, Istanbul, Turkey
[2]University of Health Sciences Bağcılar Training and Research Hospital, Department of Emergency Medicine, Istanbul, Turkey
[3]Karamanoğlu Mehmet Bey University, Department of Emergency Medicine, Istanbul, Turkey
[4]University of Health Sciences Sancaktepe Şehit Prof. Dr. İlhan Varank Training and Research Hospital, Department of Emergency Medicine, Istanbul, Turkey

ORCID ID: İbrahim Altunok 0000-0002-9312-1025, Serdar Özdemir 0000-0002-6186-6110, Abuzer Özkan 0000-0003-4284-0086, Hatice Şeyma Akça 0000-0003-2823-9577, Gökhan İşat 0000-0002-3790-288x, Hande Akbal Kahraman 0000-0002-8013-4898, Ercan Gürlevik 0000-0001-8891-2562

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Corresponding Author
Serdar Özdemir

E-mail
dr.serdar55@hotmail.com

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ABSTRACT

Aim: Current study sought to examine relationship of frontal QRS-T angle with mortality and its ability to predict mortality.

Material and Methods: This retrospective study was made in an education hospital with SARS-CoV 2 infected patients admitted to emergency service between 01/01/2021 and 07/01/2021. Patients were grouped as survivor and died according to 30-day all-cause mortality data. Groups were matched in footings of comorbidities, demographics, laboratory parameters and ECG findings. Receiver operating characteristic examination was used for evaluation of the ability of frontal QRS-T angle to predict short-term mortality.

Results: The frontal QRS-T angle was greater in died group compared to the survivors (53 (25.5-115.5) vs 28 (13-52) p<0.001). According to the receiver operating characteristic analysis, the cut-off and area under the curve were determined as 41.5 (sensitivity: 62.2%, specificity: 64.7%) and 0.659 (95% confidence interval: 0.606-0.713), respectively for frontal QRS-T angle for 30-day mortality. The odds ratio of frontal QRS-T angle (≥41.5) was determined as 3.03 (95% confidence interval: 2.08-4.42).

Conclusion: Frontal QRS-T angle is a predictor with high specificity for short-term mortality in the emergency department in with patients SARS-CoV 2 infection.

Keywords: COVID -19, SARS -CoV-2, electrocardiogram, frontal QRS-T angle, mortality, emergency services

ÖZ

Amaç: Çalışmada frontal QRS-T açısının mortalite ile ilişkisi ve mortaliteyi tahmin etme yeteneği araştırıldı.

Gereç ve Yöntemler: Bu retrospektif çalışma, bir eğitim hastanesinde 01/01/2021 ile 07/01/2021 tarihleri arasında acil servise başvuran SARS-CoV 2 enfekte hastaları ile yapılmıştır. Hastalar 30 günlük

tüm nedenlere bağlı ölüm verilerine göre hayatta kalanlar ve ölenler olarak gruplandırıldı. Gruplar, komorbiditeler, demografik özellikler, laboratuvar parametreleri ve EKG bulguları temelinde eşleştirildi. Frontal QRS-T açısının kısa dönem mortaliteyi tahmin etme yeteneğinin değerlendirilmesinde alıcı işletim karakteristik incelemesi kullanıldı.

Bulgular: Frontal QRS-T açısı ölen grupta yaşayanlara göre daha büyüktü (53 (25,5-115,5) ve 28 (13-52) p< 0,001). Alıcı işletim karakteristik analizine göre frontal QRS- için kesme değeri ve eğri altında kalan alan sırasıyla 41,5 (duyarlılık: %62,2, özgüllük: %64,7) ve 0,659 (%95 güven aralığı: 0,606-0,713) olarak belirlendi. Otuz günlük mortalite için frontal QRS-T açısı (≥41,5) olasılık oranı 3,03 olarak belirlendi (%95 güven aralığı: 2,08-4,42).

Sonuç: Frontal QRS-T açısı, acil serviste SARS-CoV 2 enfeksiyonu olan hastalarda kısa dönem mortalite için yüksek özgüllüğe sahip bir belirleyicidir.

Anahtar Sözcükler: COVID -19, SARS -CoV-2, elektrokardiyogram, frontal QRS-T açısı, mortalite, acil servisler

INTRODUCTION

An increased spatial QRS-T angle was revealed to be related with increased mortality. Calculation of spatial QRS-T angle cannot be computed in standard 12 -lead electrocardiography (ECG) and requires specialized software (1). Frontal QRS-T angle is an electrocardiographic finding showing distribution of cardiac depolarization and repolarization. Frontal QRS-T angle can be easily computed with regular 12 -lead ECGs (2). Studies have shown a strong correlation between the frontal QRS-T angle and spatial QRS-T angle (3). Whether the QRS-T angle is measured frontal or spatial, it differs according to age and gender. Generally, this angle is smaller in women than in men and increases with age in both sexes. The normal frontal angle is usually smaller than the normal spatial angle. Frontal QRS-T angle is calculated by finding the difference between the QRS axis and the T axis on a standard 12 -lead ECG. If this difference exceeds 180, this value can be deducted from 360 to determine the QRS-T axis difference (4). The enlarged QRS-T angle is strongly related with a greater frequency of all-cause death and major adverse cardiac events in all populations, as well as general population heart failure patients (4). In a study of non-ST-elevation myocardial infarction patients, they concluded that the QRS-T angle was a prognosticator of coronary artery disease intensity (5).

With the increase in the burden on the health system with the pandemic, many parameters have been studied for the prognosis in order to use the resources effectively. Vital parameters, routine hematological and biochemical parameters, some specific biomarkers and scores generated by machine learning are some of them (6,7). In current study, we sought to examine the association of frontal QRS-T angle with mortality and its ability to forecast mortality in patients with SARS-CoV 2 infection in emergency department.

MATERIAL and METHODS

The study was accompanied retrospectively in the emergency service of a teaching hospital with 1237 emergency service admissions per day during study period.

Ethics committee consent was obtained from the Ümraniye Training and Research Hospital Clinical Research Ethics Committee for our current study. It has been reported to the ethics board that the retrospective design of my study and personal information will not be used. Consent was not obtained from the cases within the knowledge of the ethics committee.

The study included rt-PCR-confirmed in patients with SARS-CoV 2 infection admitted to the Ümraniye Training and Research Hospital emergency service between January 1, 2021, and July 1, 2021. Patients whose recorded ECGs could not be reached and whose mortality data could not be reached were excluded from study (Figure 1).

Demographic data of patients, emergency department outcomes, comorbidities, laboratory parameters, and ECG images were obtained from the computer-based health data system of hospital. Short-term all-cause mortality information (30 days) was obtained using the national death notification request. Comorbidities were noted as hyperlipidemia, chronic obstructive lung disease, cerebro vascular disease history, heart failure, diabetes mellitus, malignancy history, hypertension, and coronar artery disease.

Electrocardiographic Examination

Twelve lead ECG by a paper speed of 25mm/second, the stature of 10 mm/ mV and the strainer assortment of 0.16 -100 Hz, within 5 minutes at the latest, after resting in supine position later resting for at least 10 minutes, by marking the ECG point binding points of all patients at the time of admission to our service. Shiller Cordiovit AT-102 plus was used for ECG.

ECG evaluation was performed by four investigators blinded to patient data. To reduce calculation errors, ECGs were visualized on a digital platform. QRS duration was computed from the beginning of QR S complex to the end of QR S complex, the QT interval was computed from the beginning of the QRS complex to end of T wave, and corrected QT interval (QT c) was computed due to Bazett' s (formula: QT c = QT / √RR). Tp-e/ QT and Tp-e/ QTc were obtained from these measurements. QT dispersion was found by meas-

uring the QT duration in 12 leads and calculating the difference between longest and shortest QT durations. Frontal plane QRS-T angle was analyzed as the total change between the T wave axis, and the QRS axis obtained from the automatic report part of the ECG expedient. Calculated by subtracting from 360° if the angle exceeds 180°. The QRS axis and T axis obtained from the programmed report section of the 12-lead ECG expedient and the computation method of the frontal plane QRS-T angle since these data are shown in Figure 2.

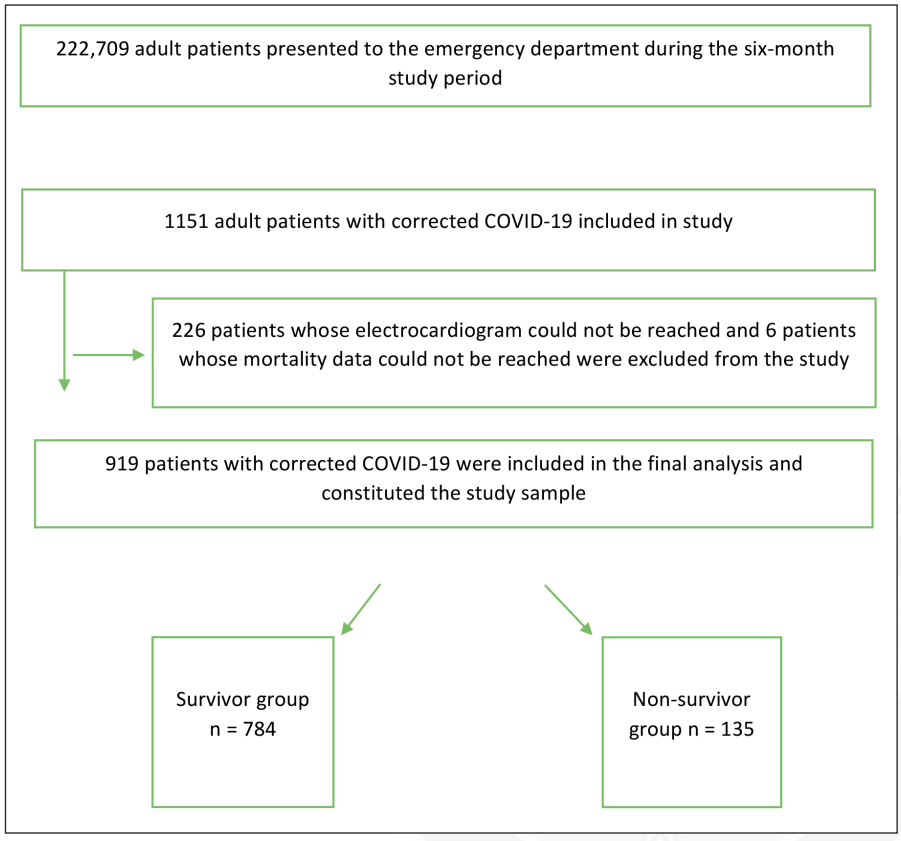

Figure 1: Flowchart of the study.

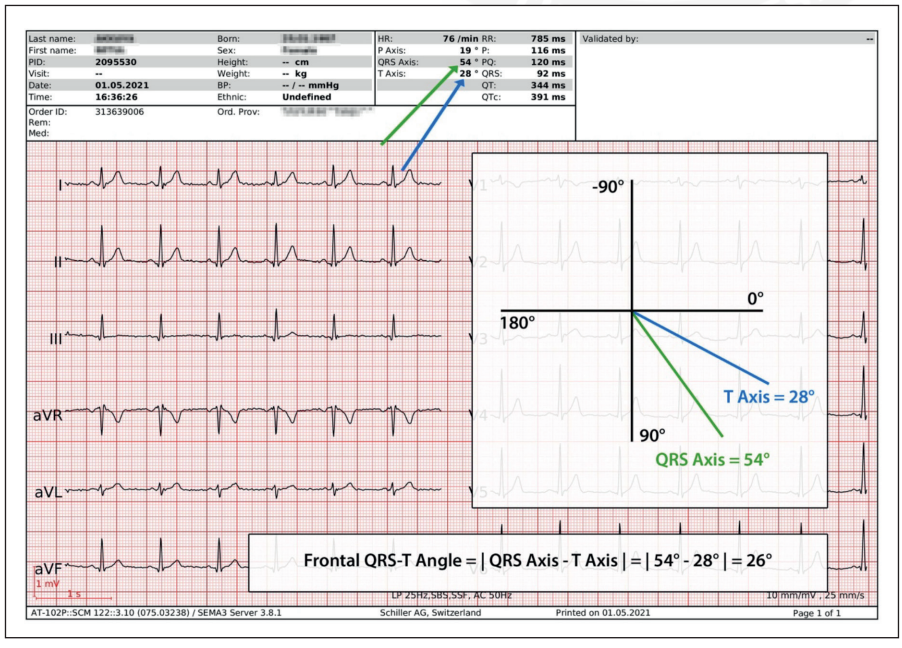

Figure 2: Calculation of frontal QRS-T angle.

Statistical Analysis

Imaginative statistics were used on behalf of the continuous variables and mean standard deviation data and frequency and percentages (%) of categorical variables were calculated. The conformity of the data to the normal distribution was evaluated with the Shapiro Wilk test. Since the data were not normally distributed, descriptive data were expressed as median and 25th and 75th percentile values, and categorical variables as numbers and percentages. T-test and test of Mann–Whitney U were made for corporation of continuous variables between the 2 groups. Test of Pearson Chi-square was used to compare continuous variables belonging to more than two groups. Pearson Chi-square test was used to compare qualitative data in patient groups. ROC analysis was used to determine the ability of parameters to predict mortality. Statistical Package for Social Sciences software (version 21.0, IBM SPSS) used for analysis. A statistically meaningful alteration was deliberated when p value was less than 0.05.

RESULTS

Of the 919 patients with SARS-CoV 2 infection presented to the emergency service included in the study, 473 (51.5%) were female. Median age of simple was 57 (25th -75th percentiles: 46-69) years. One hundred thirty-five patients died within 30 -day of emergency service presentation. Mortality rate of all-cause 30 -day mortality was 14.6% for our simple. Five hundred and eighty-nine (64.1%) of the patients were discharged from the emergency department, 276 (30%) of them were hospitalized to the ward, 54 (5.9%) of them were hospitalized to the intensive care unit. The Table 1 shows demographics, comorbid diseases, and laboratory parameters and the assessment of these variables among the survivor and died groups. The Table 2 shows the ECG parameters and the assessment of these variables between the survivor and died groups.

The ROC curve examination was accomplished to determine the discriminative ability of frontal QRS-T angle for 30-day mortality. Figure 3 presents ROC examination of frontal QRS-T angle for short term mortality. Due to best Youden's index, AUC values and the cut -off were determined as 0.659 (95% confidence interval: 0.606-0.713), and 41.5 (sensitivity: 62.2%, specificity: 64.7%) respectively for frontal QRS-T angle for 30-day mortality (p<0.001). The likelihood ratio negative was 0.58 and likelihood ratio positive was 1.77. The odds ratio of frontal QRS-T angle (≥41.5) was determined as 3.03 (95% confidence interval: 2.08-4.42).

DISCUSSION

It will be a great convenience that mortality can be predicted in SARS-CoV 2 infection with the parameters of the repolarization indicator calculated on the ECG, that is an easy to access and interpret test. Current study sought to test the association of frontal QRS-T angle with mortality and its ability to predict mortality. According to the outcomes of the current study, the frontal QRS-T angle can be used to predict mortality in the emergency service in patients with SARS-CoV 2 infection. As far as we know our study is the first to test the ability of frontal QRS-T angle prediction of 30-day all-cause death in SARS-CoV 2 infection in the emergency service. In addition, it is the study with the largest sample evaluating the frontal QRS-T angle in SARS-CoV 2 infection.

Researchers sought the answer to the question of which parameters should be used in the management of SARS-CoV 2 infected patients due to the additional burden that the pandemic has placed on the health system. For this, the ability of many parameters to predict poor outcome, such as vital parameters, laboratory parameters, early warning systems, radiologic findings, and pneumonia severity scores, was tested (8-12). Some of these studies were conducted on electrocardiographic findings (13-20). In their study, Bergamaschi et al. investigated relationship between the ECG changes at the initial ECG and ECG in the seventh day of hospitalization and poor outcome. As a secondary outcome they tested relationship between abnormal ECG findings (such as ST-T segment alterations, left ventricular hypertrophy, arrhythmias and any new AV, bundle blocks or significant morphology alterations) at admission and poor outcome. Results of Bergamaschi et al.'s study showed that ECG changes within seven days and abnormal ECG findings at admission could predict poor outcome (13). In a study conducted at the New York University School of Medicine, Chorin et al. reported that ECG repolarization abnormalities might be related to disease severity (14). In a study

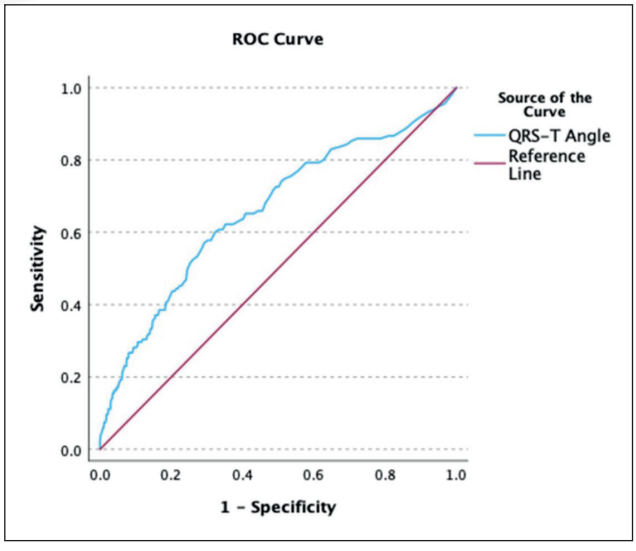

Figure 3: The ROC curve examination.

Table 1: Baseline characteristics and laboratory parameters of the enrolled patients and their comparison between the survivor and non-survivor groups.

Variables	Total (n=919)	Survivor (n=784)	Non-survivor (n=135)	p
Age, n (%)	57 (46-69)	55 (45-66.5)	72 (61-83)	**<0.001**[a]
Gender, n (%)				
Female	473 (51.5)	411 (86.9)	62 (13.1)	
Male	446 (48.5)	373 (83.6)	73 (16.4)	0.163[b]
Comorbidities, n (%)				
Chronic obstructive pulmonary disease	42 (4.6)	27 (64.3)	15 (35.7)	**0.001**[b]
Hypertension	167 (18.2)	121 (72.5)	46 (27.5)	**<0.001**[b]
Diabetes mellitus	90 (9.8)	69 (76.7)	21 (23.3)	**0.015**[b]
Coronary artery disease	91 (9.9)	70 (76.9)	21 (23.1)	**0.017**[b]
Congestive heart failure	33 (3.6)	21 (63.6)	12 (36.4)	**<0.001**[b]
History of malignancy	25 (2.7)	16 (64.0)	9 (36.0)	**0.002**[b]
Hyperlipidemia	103 (11.2)	77 (74.8)	26 (25.2)	**0.001**[b]
History of cerebrovascular disease	29 (3.2)	17 (58.6)	12 (41.4)	**<0.001**[b]
Laboratory parameters*				
White blood cell count (/μL)	6.23 (4.78-8.11)	6.11 (4.7-7.82)	7.38 (5.37-10.6)	**<0.001**[a]
Neutrophil count (/μL)	4.34 (3.15-6.18)	4.21 (3.01-5.83)	5.76 (3.94-8.95)	**<0.001**[a]
Lymphocyte count (/μL)	1.17 (0.81-1.62)	1.23 (0.86-1.65)	0.95 (0.57-1.45)	**<0.001**[a]
Hemoglobin (gr/dL)	13.0 (11.8-14.25)	13.1 (12-14.3)	12.2 (10.9-13.8)	**<0.001**[a]
Hematocrit (%)	39.6 (36.3-43.3)	39.9 (36.9-43.5)	37.75 (34.4-42.1)	**<0.001**[a]
Platelet count (10^3/μL)	199 (156-259)	200 (156-259)	189.5 (157-260)	0.747[a]
Mean platelet volume (fL)	9.8 (9.0-10.5)	9.75 (9-10.5)	9.8 (9.1-10.7)	0.302[a]
Blood urea nitrogen (mg/dL)	31.3 (22.2-44.9)	28.9 (21.4-39.9)	51.9 (36.1-84)	**<0.001**[a]
Creatinine (mg/dL)	0.88 (0.69-1.12)	0.85 (0.68-1.05)	1.17 (0.84-1.75)	**<0.001**[a]
C-reactive protein. (mg/L)	12.83 (40.33-101.47)	34.01 (10.16-79.94)	109.01 (39.71-161.99)	**<0.001**[a]
Albumin (g/dL)	35.0 (38.3-41.4)	39 (36-42)	35 (32-38)	**<0.001**[a]
Lactate (mmol/L)	1.7 (1.3-2.3)	1.6 (1.2-2.1)	2.2 (1.5-3)	**<0.001**[a]
Sodium (mEq/L)	136.0 (133.7-138.6)	136.1 (134-138.4)	135.1 (131.2-139.1)	0.079[a]
Potassium (mEq/L)	4.3 (4.0-4.6)	4.27 (3.99-4.52)	4.41 (4.1-4.82)	**0.003**[a]
Calcium (mEq/L)	8.3 (8.0-8.7)	8.37 (8.1-8.72)	8.07 (7.78-8.48)	**<0.001**[a]

***** Median (25^{th}-75^{th} percentiles), [a] Mann–Whitney U test, [b] Chi-square test.

Table 2: Electrocardiographic findings of patients with SARS CoV 2.

Variables*	Total (n=919)	Survivor (n=784)	Non-survivor (n=135)	p
Heart Rate /min.	92 (80-103)	91 (79-101)	100 (86-112)	**<0.001**[a]
RR Interval (ms)	655 (583-748)	662 (593-756)	602 (534-700)	**<0.001**[a]
P Interval (ms)	102 (88-112)	104 (90-114)	92 (0-108)	**<0.001**[a]
PQ Interval (ms)	142 (124-158)	142 (126-160)	130 (0-156)	**<0.001**[a]
QRS Interval (ms)	86 (78-96)	86 (78-94)	90 (82-108)	**<0.001**[a]
QT Interval (ms)	352 (328-378)	352 (328-378)	352 (318-378)	0.302[a]
QTc Interval (ms)	433 (414-459)	430 (413-455)	454 (429-483)	**<0.001**[a]
P Axis (°)	33 (1-47)	34 (14-47)	2 (0-39)	**<0.001**[a]
QRS Axis (°)	11 (-14 – 36)	13 (-12-37)	-1 (-24-31)	**0.010**[a]
T Axis (°)	29 (14-53)	28 (13-49)	47 (24-84)	**<0.001**[a]
QRS-T Angle	31 (14-60)	28 (13-52)	53 (25-117)	**<0.001**[a]

* Median (25^{th}-75^{th} percentiles), [a] Mann–Whitney U test

conducted in Iran, a non-sinus rhythm in the admission ECG was shown to be a predictor of mortality. As a result of the Iran study, the authors recommended SARS-CoV 2 infected patients be continuously monitored for ECG alterations, as this might provide crucial prognostic data (15).

There are a few studies in the literature evaluating the association among SARS-CoV 2 infection and frontal QRS-T angle. For the first time, Ocak et al. investigated this association in a study of 130 patients with SARS-CoV 2 infection. They showed rise in frontal QRS-T angle values in patients with SARS-CoV 2 infection when matched with the control group. Additionally, they reported that frontal QRS-T angle values increased in patients with severe SARS-CoV 2 infection due to CURB-65 when matched with non-severe group and suggested 44.5° as the cutoff point (16). Gündüz et al. investigated the association among SARS-CoV 2 infection and frontal QRS-T angle with 329 hospitalized patients. In the study of Gündüz et al., the primary endpoints were the need for mechanical ventilation and in-hospital mortality. They reported that patients with increased frontal QRS-T angle (>90°) values required 60 mechanical ventilator positions and in-hospital mortality (17). Taştan and İnci analyzed data from 532 hospitalized SARS-CoV 2 infected patients. In the study of Taştan and İnci, the primary endpoint was in-hospital mortality. They found a larger frontal QRS-T angle in the in-hospital mortality group, but the odds ratio they reported was 1.01 (95% confidence interval: 1.01-1.02) (18). Tassone et al. from Italy emphasized the relationship with 30-day mortality in their study using the data of 309 residents with SARS-CoV 2 infection in Long-Term Care Facility. On the other hand, in their subgroup analysis, they reported that this relationship was very weak above the age of 75, contrary to the general information in the literature (19). A logical explanation for this relationship in the literature regarding frontal QRS-T angle in SARS-CoV 2 infection may be as follows. In patients with SARS-CoV 2 infection, especially in patients with severe infection, normal ventricular repolarization is affected due to hypoxic damage, cytokine storm, direct myocardial damage of the virus, and micro thrombus (20-22). Thus, it may cause an increase in the angle between depolarization and repolarization and, consequently, an increase in frontal QRS-T angle.

There are several important limitations of our study. First, the retrospective design is the most important limitation. As in other retrospective studies, confounding factors could not be controlled (23). Coronary artery disease and heart failure, which were important confounding factors for this study, were different between the two groups. Therefore, our results may have been affected by this difference. Although our sample size is large, the single-center nature of our study is an important factor affecting the generalizability of our results.

In conclusion, according to analysis of the present study, frontal QRS-T angle is a predictor with high specificity for short-term mortality in the emergency service in patients with SARS-CoV-2 infection.

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Author Contributions

Concept: **İbrahim Altunok, Serdar Özdemir, Abuzer Özkan, Hatice Şeyma Akça, Gökhan İşat, Hande Akbal Kahraman, Ercan Gürlevik,** Design: **İbrahim Altunok, Serdar Özdemir, Abuzer Özkan,** Data Collection or Processing: **Serdar Özdemir, Abuzer Özkan, Hatice Şeyma Akça, Gökhan İşat, Hande Akbal Kahraman,** Analysis or Interpretation: **Abuzer Özkan, Hatice Şeyma Akça, Gökhan İşat, Hande Akbal Kahraman,** Literature search: **İbrahim Altunok, Serdar Özdemir, Abuzer Özkan, Hatice Şeyma Akça, Gökhan İşat,** Writing: **İbrahim Altunok, Serdar Özdemir, Abuzer Özkan, Hatice Şeyma Akça, Gökhan İşat, Hande Akbal Kahraman, Ercan Gürlevik.**

Conflicts of Interest

The authors of this article declare no conflicts of interest.

Financial Support

No financial support was used for this study.

Ethical Approval and Informed Consent

Prior to the study, approval was obtained from the Ümraniye Training and Research Hospital Clinical Research Ethics Committee (Date: 06.23.2022, Decision No: 214) and the study was conducted in accordance with the “Helsinki Declaration”. Consent was not obtained from the cases within the knowledge of the ethics committee.

Review Process

Extremely peer-reviewed and accepted.

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