

Prognostic Value of Frontal QRS/T Angle in COVID-19 Pneumonia Patients Presenting to the Emergency Department

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ABSTRACT

Objective: COVID-19 pneumonia is associated not only with respiratory failure but also with an increased risk of cardiac involvement and mortality. The frontal QRS/T angle, automatically obtained from a standard ECG, reflects the electrical difference between ventricular depolarization and repolarization. This study aimed to investigate the prognostic value of the frontal QRS/T angle in patients presenting to the emergency department with COVID-19 pneumonia.

Materials and Methods: In this retrospective study, 288 adult patients who presented to the emergency department with a diagnosis of COVID-19 pneumonia were included. Demographic, clinical, and laboratory data, along with frontal QRS/T angles obtained from initial ECGs, were analyzed. Clinical outcomes (discharge, ICU admission, mortality) were compared with laboratory and ECG parameters.

Results: ROC analysis identified $>47.5^\circ$ as the optimal threshold for fQRS/T (AUC=0.628; sensitivity 55.9%; specificity 72.6%). In-hospital mortality was approximately three times higher in patients with fQRS/T $>47.5^\circ$ compared to those with $\leq 47.5^\circ$. The fQRS/T angle showed positive correlations with troponin, CK-MB, BUN, creatinine, and CRP. Logistic regression analysis revealed that pulse rate and length of hospital stay were independently associated with mortality.

Conclusion: A widened fQRS/T angle is associated with increased mortality in COVID-19 pneumonia and may serve as a noninvasive marker of systemic inflammation. Due to its simplicity, cost-effectiveness, and rapid applicability, it may be a valuable parameter for early risk stratification in emergency departments. Prospective multicenter studies are needed to validate these findings.

Keywords: COVID-19, ECG, emergency department, frontal, pneumonia, QRS/T angle

How to cite this article: Ermete Güler E, Kırık S, Çınaroğlu D, Efgan MG. Prognostic Value of Frontal QRS/T Angle in COVID-19 Pneumonia Patients Presenting to the Emergency Department. *Compreh Med* 2026;18(2):121-130

INTRODUCTION

The COVID-19 pandemic has impacted millions globally, resulting in substantial morbidity and mortality, with pneumonia cases involving pulmonary compromise posing a major clinical management challenge. Pneumonia caused by SARS-CoV-2 typically begins with symptoms such as dyspnea, hypoxemia, fever, and cough, and in some patients, it can rapidly progress to acute respiratory failure.^[1,2] COVID-19 pneumonia not only affects the respiratory system but also leads to cardiovascular complications, thereby worsening the prognosis of the disease.^[3,4]

Predicting the clinical course and prognosis in pneumonia cases is of critical importance for accurate risk stratification in the emergency department (ED). For this purpose, various clinical scoring systems (such as CURB-65 and PSI), biochemical markers (such as CRP, procalcitonin, and lactate), and radiological findings are used. However, there remains a need for new prognostic parameters that are easy to apply, rapid, inexpensive, and reliable. Electrocardiography (ECG), in addition to evaluating cardiac pathologies, is a practical method that can be utilized to predict the severity of systemic diseases.^[5]



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Received date: 14.11.2025

Revised date: 22.12.2025

Accepted date: 23.12.2025

Online date: 13.03.2026



In recent years, the frontal QRS/T angle automatically derived from ECG has attracted attention as a parameter reflecting electrical heterogeneity by indicating the difference between ventricular depolarization and repolarization axes.^[6] The fQRS/T angle, which is normally narrow ($<45^\circ$), widens in the presence of repolarization abnormalities and reflects cardiac electrical instability. Multiple investigations have reported an association between an increased fQRS/T angle and the development of cardiac arrhythmias, sudden cardiac death, and overall mortality. Beyond cardiovascular diseases, it has also been linked to disease severity and mortality in non-cardiac conditions such as chronic kidney disease, COPD, and sepsis.^[7-11]

Studies conducted in patients with COVID-19 pneumonia have reported that a widened fQRS/T angle independently predicts in-hospital mortality and that specific cut-off values provide significant prognostic accuracy.^[4,11] Similarly, in patients with acute coronary syndrome and NSTEMI, the fQRS/T angle has been shown to correlate with disease severity and poor prognosis.^[6] These findings suggest that the fQRS/T angle may possess prognostic value not only in cardiac pathologies but also in systemic inflammatory processes.^[12]

In this regard, the current study sought to assess the predictive importance of the frontal QRS/T angle derived from initial ECGs of patients who presented to the emergency room with a diagnosis of COVID-19 pneumonia. We investigated the potential usefulness of this metric for early risk classification in patients with COVID-19 pneumonia by looking at its relationship with hospital length of stay, intensive care unit (ICU) necessity, and mortality. The study is expected to help identify high-risk individuals early on and contribute to clinical decision-making procedures.

MATERIALS and METHODS

Study Design and Setting

This study was conducted in a tertiary ED located in the province of Izmir, using a retrospective and observational design. The study received ethical permission from Izmir Katip Celebi University's Non-interventional Clinical Research Ethics Committee (permission No: 0161, Date: April 8, 2025). Adult patients diagnosed with COVID-19 pneumonia who visited the emergency room between March 2020 and March 2022 and were at least eighteen years old were included in the study. The work was carried out in accordance with the Helsinki Declaration.

Study Population

The study included patients who were hospitalized with a diagnosis of COVID-19 pneumonia after visiting the emergency room between March 2020 and March 2022. Thoracic computed tomography (CT) imaging, PCR test results, and clinical observations were used to establish the diagnosis. Included were adult patients who were 18 years of age or older, had a confirmed diagnosis of COVID-19 pneumonia, and had an accessible first 12-lead ECG taken during their ER stay. The study excluded patients with Wolff-Parkinson-White syndrome, QRS duration ≥ 120 ms, history of persistent arrhythmia, inadequate medical data (such as missing ECG recordings, unavailable laboratory results, or incomplete clinical documentation), or known severe cardiac conduction anomalies (such as total bundle branch block or pacemaker rhythm). Patients with negative PCR but CT findings strongly suggestive of COVID-19 pneumonia (consistent with national and international diagnostic guidelines during the pandemic) were included when supported by compatible clinical presentation.

Data Collection

Retrospective patient data were gathered via electronic medical records and the hospital information management system (HIMS). Vital signs, laboratory data, thoracic CT results, length of hospital stay, need for an ICU, demographics (age, sex, and comorbidities), and mortality outcomes were examined. All patients' twelve-lead ECG recordings from the moment they arrived at the emergency room were examined. The automated ECG device reports were used to extract the frontal QRS/T angle. A standardized data-collecting form created specifically for the study was filled out with all of the information gathered.

Frontal QRS/T Angle Measurement

In all electrocardiographic recordings, settings of 25 mm/s for paper speed and 10 mm/mV for voltage calibration were used to record twelve-lead ECGs while the patient was supine. The axis values automatically recorded on the ECG strip were used to compute the frontal QRS/T angle for each subject. The frontal QRS/T angle was defined as the absolute difference between the QRS and T axes. If the separation between the frontal QRS and T axes was greater than 180° , the fQRS/T angle was obtained by subtracting the absolute difference of these axes from 360° .

Statistical Analysis

IBM SPSS Statistics Standard Concurrent User Version 27 (IBM Corp., Armonk, New York, USA) was used to analyze the

data. Descriptive statistics were displayed as mean±standard deviation, percentage (%), and number of cases (n). Normal distribution of numerical variables was examined using the Shapiro-Wilk test. When comparing two groups, the Mann-Whitney U test was utilized for non-normally distributed data, and the independent samples t-test for normally distributed data. One-way analysis of variance (ANOVA) was utilized for normally distributed data when comparing more than two categorical variables, whereas the Kruskal-Wallis H test was employed for non-parametric distributions. The Dunn-Bonferroni test was employed for post-hoc multiple comparisons where variance analysis indicated significance. Spearman's correlation coefficient was used to assess correlations between numerical variables. Receiver Operating Characteristic (ROC) curve analysis was used to evaluate the predictive performance of variables with respect to clinical outcomes. Using logistic regression analysis, the impact of factors on patient outcomes was investigated. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

A total of 288 patients were included in the study, with a mean age of 62±20.2 years; 54.17% were female. At presentation, the mean systolic blood pressure (SBP) was 132.43±16 mmHg, diastolic blood pressure (DBP) 75.38±11.97 mmHg, heart rate 85.65±18.83 beats/min, and respiratory rate 18.08±4.39 breaths/min.

Laboratory findings revealed a mean leukocyte count of $8.38 \pm 4.79 \times 10^3/\mu\text{L}$, neutrophil count $6.04 \pm 4.51 \times 10^3/\mu\text{L}$, lymphocyte count $1.59 \pm 1.34 \times 10^3/\mu\text{L}$, hemoglobin 12.63±9.06 g/dL, and hematocrit 37.81±23.34%. Among biochemical parameters, the mean troponin level was 234.58±1899.59 ng/L, CK-MB 2.43±4.9 ng/mL, BUN 24.99±22 mg/dL, and creatinine 1.37±1.2 mg/dL. Electrolyte analysis showed sodium 136.16±4.85 mmol/L, potassium 4.31±0.57 mmol/L, and calcium 8.66±0.71 mg/dL. The mean CRP level, as an inflammatory marker, was 56.45±71.6 mg/L. The mean frontal QRS/T angle calculated from the admission ECGs was 46.99±51.86°.

Regarding clinical outcomes, 183 patients (64.44%) were discharged directly from the ED, 65 (22.89%) were admitted to hospital wards, and 36 (12.68%) required intensive care unit admission. During hospitalization, 241 patients (87.64%) were discharged, whereas 34 patients (12.4%) died. The mean length of hospital stay was 2.81±7.38 days.

When patients were categorized into three groups based on their ED outcomes (discharged, admitted to the ward, and admitted to the ICU), significant differences were observed

in several clinical and laboratory parameters ($p < 0.05$). The mean age was 59.83±20.85 years in the discharged group, 62.54±19.06 years in the ward group, and 70.19±16.96 years in the ICU group, indicating that advanced age was associated with an increased need for intensive care ($p = 0.018$). DBP values also differed significantly among the groups: 77.17±11.55 mmHg in the discharged group, 74.54±11.6 mmHg in the ward group, and 69.28±10.1 mmHg in the ICU group ($p = 0.001$). Similarly, the mean heart rate was 82.34±15.9 bpm in discharged patients, 88.35±19.23 bpm in ward patients, and 93.75±24.85 bpm in ICU patients, showing a clear trend of increased pulse rate among higher-risk patients ($p = 0.003$) (Table 1).

When laboratory parameters were examined, the white blood cell (WBC) count was $7.49 \pm 3.09 \times 10^3/\mu\text{L}$ in discharged patients, $9.15 \pm 5.21 \times 10^3/\mu\text{L}$ in those admitted to the ward, and $10.11 \pm 5.26 \times 10^3/\mu\text{L}$ in ICU patients, showing a statistically significant difference ($p = 0.005$). Similarly, neutrophil counts were $5.04 \pm 2.83 \times 10^3/\mu\text{L}$, $6.92 \pm 4.62 \times 10^3/\mu\text{L}$, and $8.13 \pm 5.38 \times 10^3/\mu\text{L}$ in the same groups, respectively ($p = 0.001$). Lymphocyte counts were significantly lower in the ICU group ($1.11 \pm 0.96 \times 10^3/\mu\text{L}$) compared to the discharged ($1.76 \pm 1.52 \times 10^3/\mu\text{L}$) and ward groups ($1.37 \pm 0.82 \times 10^3/\mu\text{L}$) ($p = 0.001$). Hemoglobin and hematocrit levels were also lowest in ICU patients (Hgb = 10.26±2.1 g/dL, Hct = 31.72±6.14%, $p = 0.001$). In biochemical analyses, troponin levels were significantly higher in the ICU group (226.69±593.66 ng/L, $p = 0.001$), and CK-MB levels followed a similar trend (3.53±4.02 ng/mL, $p = 0.002$). Among renal function tests, BUN levels were 20.29±14.88 mg/dL in the discharged group, 23.74±17.26 mg/dL in the ward group, and 43±36.01 mg/dL in the ICU group, with the highest levels observed in the latter ($p = 0.001$). Although creatinine levels were higher in the ICU group, statistical significance was borderline ($p = 0.079$). No significant differences were observed in sodium and potassium levels, whereas calcium levels were significantly lower in ICU patients (8.11±0.58 mg/dL, $p = 0.001$) (Table 1).

Among inflammatory markers, CRP levels were 38.12±54.1 mg/L in discharged patients, 87.23±89.4 mg/L in those admitted to the ward, and 77.87±74.31 mg/L in ICU patients, showing a statistically significant difference among the groups ($p = 0.001$).

Frontal QRS/T angle values were 41.71±47.77°, 58.67±59.35°, and 51.97±54.29° in the discharged, ward, and ICU groups, respectively, with no statistically significant difference between groups ($p = 0.303$). Finally, the mean length of hospital stay was 0.04±0.52 days in discharged patients, 6.34±5.65

Table 1. Comparison of variables according to emergency department outcomes

	Discharged	Hospital wards	ICU	Test statistics	p
Age	59.83±20.85 ^a	62.54±19.06 ^{ab}	70.19±16.96 ^b	8.039	0.018 ^ε
Systolic blood pressure	132.95±13.12	132.74±16.49	130.14±20.89	3.497	0.174 ^ε
Diastolic blood pressure	77.17±11.55 ^a	74.54±11.6 ^{ab}	69.28±10.1 ^b	13.969	0.001 ^ε
Pulse	82.34±15.9 ^a	88.35±19.23 ^b	93.75±24.85 ^b	11.424	0.003 ^ε
Respiratory rate	17.53±3.9	18.08±3.89	19.89±5.2	5.624	0.060 ^ε
WBC	7.49±3.09 ^a	9.15±5.21 ^b	10.11±5.26 ^b	10.723	0.005 ^ε
Neutrophil	5.04±2.83 ^a	6.92±4.62 ^b	8.13±5.38 ^b	17.234	0.001 ^ε
Lymphocyte	1.76±1.52 ^a	1.37±0.82 ^b	1.11±0.96 ^c	20.966	0.001 ^ε
Hemoglobin	12.82±5.98 ^a	13.56±16.12 ^a	10.26±2.1 ^b	26.001	0.001 ^ε
Hematocrit	37.87±7.86 ^a	41.33±47 ^a	31.72±6.14 ^b	24.117	0.001 ^ε
Troponin	85.21±558.97 ^a	707.77±4113.74 ^a	226.69±593.66 ^b	15.876	0.001 ^ε
CK-MB	2.21±5.41 ^a	1.93±1.81 ^a	3.53±4.02 ^b	13.004	0.002 ^ε
BUN	20.29±14.88 ^a	23.74±17.26 ^{ab}	43±36.01 ^b	13.281	0.001 ^ε
Creatinine	1.17±0.59	1.19±0.5	2.11±2.12	5.083	0.079 ^ε
Sodium	136.24±4.53	135.7±4.56	136.22±6.22	1.569	0.456 ^ε
Potassium	4.25±0.43	4.24±0.59	4.51±0.77	3.826	0.148 ^ε
Calcium	8.77±0.68 ^a	8.69±0.65 ^a	8.11±0.58 ^b	28.142	0.001 ^ε
CRP	38.12±54.1 ^a	87.23±89.4 ^b	77.87±74.31 ^b	29.501	0.001 ^ε
Frontal QRS/T angle	41.71±47.77	58.67±59.35	51.97±54.29	2.386	0.303 ^ε
Length of hospital stay	0.04±0.52 ^a	6.34±5.65 ^b	13.58±17.39 ^b	244.57	0.001 ^ε

Numerical variables are presented as mean±standard deviation. ^ε: Kruskal–Wallis test. ICU: Intensive care unit; CK-MB: Creatine kinase-MB; BUN: Blood urea nitrogen; CRP: C-reactive protein.

days in the ward group, and 13.58±17.39 days in the ICU group, and this parameter differed significantly among the groups (p=0.001) (Table 1).

The mean age of discharged patients was 60.67±20.48 years, while it was 67.85±18.85 years in deceased patients, showing a trend toward statistical significance (p=0.063). SBP was 133.3±14.93 mmHg in discharged patients and 126.24±21.5 mmHg in deceased ones (p=0.076). DBP was significantly lower in the deceased group (67.53±13.55 mmHg vs. 76.39±11.23 mmHg, p=0.001). Heart rate was notably higher in patients with fatal outcomes (101.38±24.16 bpm vs. 82.54±16.39 bpm, p=0.001). Respiratory rate was also elevated in the deceased group (19.88±5.67 vs. 17.73±4.03 breaths/min, p=0.046). Regarding laboratory parameters, white blood cell count (11.74±9.03 vs. 7.75±3.58×10³/μL, p=0.020) and neutrophil count (9.52±8.52 vs. 5.4±3.28×10³/μL, p=0.007) were significantly higher in deceased patients. Lymphocyte count was lower in the fatal group (1.39±1.14 vs. 1.63±1.38 × 10³/μL, p=0.027). Hemoglobin and hematocrit levels were similar between the groups (p>0.05). Although

troponin levels were higher in deceased patients, the difference was not statistically significant (516.9±1405.08 vs. 204.12±2004.95 ng/L, p=0.072). CK-MB levels were significantly higher in the deceased group (6.46±13.05 vs. 1.86±1.72 ng/mL, p=0.050). In terms of renal function, both BUN (39.97±33.72 vs. 21.77±17.71 mg/dL, p=0.009) and creatinine (2.24±2.18 vs. 1.25 ± 0.96 mg/dL, p=0.004) were markedly elevated in deceased patients. Sodium and calcium levels were comparable between groups (p>0.05), while potassium was higher in the deceased group but did not reach statistical significance (p=0.068). Among inflammatory markers, CRP levels were substantially elevated in deceased patients (119.74±106.73 vs. 46.16±59.87 mg/L, p=0.001). The frontal QRS/T angle was significantly wider in the deceased group (67.79±56.34° vs. 43.49±50.40°, p=0.016). Finally, the mean length of hospital stay was considerably longer in deceased patients (8.45±8.86 vs. 2.1±6.89 days, p=0.001) (Table 2).

Table 3 evaluates the effect of various parameters on in-hospital outcomes. Logistic regression analysis revealed that pulse rate, creatinine level, and length of hospital stay

Table 2. Comparison of variables according to in-hospital outcomes

	Discharged	Exitus	Test statistics	p
Age	60.67±20.48	67.85±18.85	-1.861	0.063 [†]
Systolic blood pressure	133.3±14.93	126.24±21.5	-1.773	0.076 [†]
Diastolic blood pressure	76.39±11.23	67.53±13.55	-3.188	0.001 [†]
Pulse	82.54±16.39	101.38±24.16	-4.604	0.001 [†]
Respiratory rate	17.73±4.03	19.88±5.67	-1.997	0.046 [†]
WBC	7.75±3.58	11.74±9.03	-2.333	0.020 [†]
Neutrophil	5.4±3.28	9.52±8.52	-2.699	0.007 [†]
Lymphocyte	1.63±1.38	1.39±1.14	-2.216	0.027 [†]
Hemoglobin	12.93±9.86	11.6±2.19	-1.157	0.247 [†]
Hematocrit	38.51±25.38	35.73±6.46	-0.889	0.374 [†]
Troponin	204.12±2004.95	516.9±1405.08	-1.800	0.072 [†]
CK-MB	1.86±1.72	6.46±13.05	-1.956	0.050 [†]
BUN	21.77±17.71	39.97±33.72	-2.631	0.009 [†]
Creatinine	1.25±0.96	2.24±2.18	-2.892	0.004 [†]
Sodium	136.2±4.61	136.79±5.69	-0.723	0.470 [†]
Potassium	4.24±0.45	4.66±0.98	-1.825	0.068 [†]
Calcium	8.71±0.69	8.48±0.84	-1.649	0.099 [†]
CRP	46.16±59.87	119.74±106.73	-4.236	0.001 [†]
Frontal QRS/T angle	43.49±50.40	67.79±56.34	-2.416	0.016 [†]
Length of hospital stay	2.1±6.89	8.45±8.86	-7.089	0.001 [†]

Data are presented as mean±standard deviation. [†]: Mann-Whitney U test. WBC: Wight blood cell; CK-MB: Creatine kinase-MB; BUN: Blood urea nitrogen; CRP: C-reactive protein.

Table 3. Evaluation of factors affecting in-hospital outcomes using binary logistic regression analysis

	β	SE	Wald statistics	p	Odds ratio	95% CI for odds ratio	
						Lower limit	Upper limit
Constant	-6.987	1.580	19.568	0.001	0.001		
Pulse	0.042	0.015	7.339	0.007	1.043	1.012	1.075
Neutrophil	0.122	0.071	2.933	0.087	1.130	0.982	1.300
CK-MB	0.232	0.124	3.495	0.062	1.261	0.989	1.608
BUN	0.038	0.022	3.021	0.082	1.038	0.995	1.083
Creatinine	-1.092	0.503	4.712	0.030	0.336	0.125	0.899
Length of hospital stay	0.093	0.037	6.170	0.013	1.097	1.020	1.180

β : Regression coefficient; CI: Confidence intervals; SE: Standard error; BUN: Blood urea nitrogen

were statistically significant predictors of in-hospital mortality. When odds ratios were examined, each unit increase in pulse rate was associated with a 1.043-fold higher risk of mortality (OR=1.043; 95% CI:1.012–1.075; p=0.007). Conversely, each unit increase in creatinine level was found to reduce the mortality risk by 0.336-fold, indicating a poten-

tial protective association (OR =0.336; 95% CI:0.125–0.899; p=0.030). Additionally, each extra day of hospitalization increased the mortality risk by 1.097-fold (OR =1.097; 95% CI:1.020–1.180; p=0.013).

A number of statistically significant relationships were observed in comparisons of the frontal QRS/T angle with

different clinical and laboratory markers (Table 4). Age and the frontal QRS/T angle showed a somewhat favorable connection ($\rho = 0.436$; $p = 0.001$). SBP showed a weak positive correlation ($\rho = 0.121$; $p = 0.040$), whereas DBP showed no significant link ($p = 0.966$). There were near-significant but statistically insignificant associations between the fQRS/T angle and respiratory rate ($p = 0.054$) and pulse rate ($p = 0.074$). White blood cell count ($\rho = 0.179$; $p = 0.003$) and neutrophil count ($\rho = 0.230$; $p = 0.001$) revealed positive connections among hematological parameters, while hemoglobin level exhibited a negative association ($\rho = -0.133$; $p = 0.026$). There was no significant correlation between hematocrit ($p = 0.156$) and lymphocytes ($p = 0.055$). In terms of cardiac indicators, the frontal QRS/T angle showed substantial positive relationships with troponin ($\rho = 0.276$; $p = 0.001$) and CK-MB ($\rho = 0.209$; $p = 0.002$) values. Renal function markers showed a strong positive correlation between the frontal QRS/T angle and both BUN ($\rho = 0.298$; $p = 0.001$) and creatinine ($\rho = 0.256$; $p = 0.001$) levels. Potassium ($p = 0.751$) and calcium ($p = 0.928$) levels did not exhibit any significant correlations, while electrolyte analysis showed a weak but significant positive correlation with sodium ($\rho = 0.156$; $p = 0.009$). CRP showed a slight but significant positive connection ($\rho = 0.175$; $p = 0.003$) with the frontal QRS/T angle among inflammatory markers. The length of hospital stay and the QRS/T angle did not show a statistically significant correlation ($p = 0.196$) (Fig. 1).

Table 5 shows that the area under the curve (AUC) was 0.628. With a sensitivity of 55.9% and a specificity of 72.6%, the ideal cutoff value for the frontal QRS/T angle was found to be $>47.5^\circ$. According to these results, the frontal QRS/T angle has a fairly discriminative and statistically significant ability to predict in-hospital mortality (Fig. 2). The Youden index corresponding to the optimal cutoff ($>47.5^\circ$) was calculated as 0.285, supporting the moderate discriminative performance of the fQRS/T angle.

Table 6 demonstrates the distribution of in-hospital outcomes [death vs. discharge] based on a threshold value of the frontal QRS/T angle (47.5°). When the cutoff was set at 47.5° , among 85 patients with an angle greater than this value, 19 died and 66 were discharged. In contrast, of the 190 patients with an fQRS/T angle $\leq 47.5^\circ$, 15 died and 175 were discharged. In total, among 275 evaluated patients, having a frontal QRS/T angle greater than 47.5° was significantly associated with higher in-hospital mortality. The mortality rate in patients with a frontal QRS/T angle $>47.5^\circ$ ($\approx 22.35\%$) was approximately three times higher than in those with an angle $\leq 47.5^\circ$ ($\approx 7.89\%$).

Table 4. Correlations between frontal QRS/T angle and other variables

		Frontal QRS/T Angle
Age	ρ	0.436**
	p	0.001
Systolic blood pressure	ρ	0.121*
	p	0.040
Diastolic blood pressure	ρ	-0.003
	p	0.966
Pulse	ρ	0.105
	p	0.074
Respiratory rate	ρ	0.114
	p	0.054
WBC	ρ	0.179**
	p	0.003
Neutrophil	ρ	0.230**
	p	0.001
Lymphocyte	ρ	-0.115
	p	0.055
Hemoglobin	ρ	-0.133*
	p	0.026
Hematocrit	ρ	-0.085
	p	0.156
Troponin	ρ	0.276**
	p	0.001
CK-MB	ρ	0.209**
	p	0.002
BUN	ρ	0.298**
	p	0.001
Creatinine	ρ	0.256**
	p	0.001
Sodium	ρ	0.156**
	p	0.009
Potassium	ρ	0.020
	p	0.751
Calcium	ρ	-0.005
	p	0.928
CRP	ρ	0.175**
	p	0.003
Length of hospital stay	ρ	0.079
	p	0.196

*, $p < 0.05$; **, $p < 0.001$. ρ : Spearman correlation coefficient; WBC: White blood cell; CK-MB: Creatine kinase-MB; BUN: Blood urea nitrogen; CRP: C-reactive protein

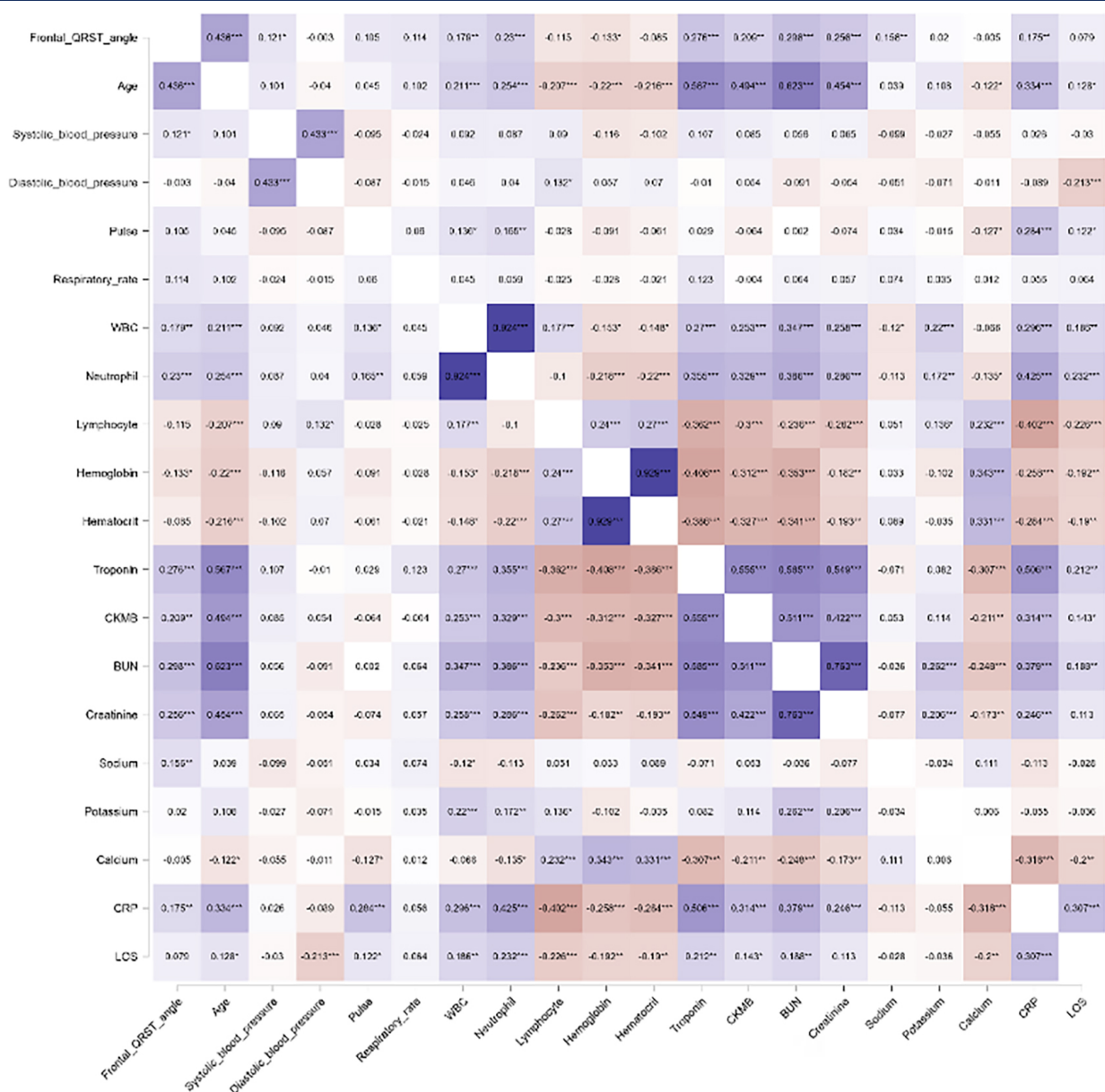


Figure 1. Heatmap illustrating the correlations between the frontal QRS/T angle and other clinical and laboratory parameters

DISCUSSION

This study assessed the predictive significance of the frontal QRS/T angle derived from the first ECG of ED patients with COVID-19 pneumonia. Patients with a cut-off value greater than 47.5° showed a significant increase in mortality, approximately three times higher in our population. The area under the ROC curve (AUC) indicated a moderate discriminative ability. These findings suggest that the fQRS/T angle carries prognostic significance not only in cardiovascular diseases but also in systemic infectious and inflammatory conditions.

In COVID-19 pneumonia, hypoxemia, inflammation, and myocardial stress may disrupt the balance of repolarization, leading to a widening of the frontal QRS/T angle. The observation of myocarditis and arrhythmic complications in other atypical pneumonia pathogens, such as Legionella and Mycoplasma, further supports this association.^[13,14] In this study, the positive correlations between the fQRS/T angle and parameters such as age, troponin, CK-MB, BUN, creatinine, and CRP suggest that repolarization abnormalities progress in parallel with multi-organ involvement. Similarly, Sandstedt et al.^[15] demonstrated that a widened

Table 5. Cutoff values, AUC, sensitivity, specificity and statistical significance of frontal QRS/T angle parameters according to in-hospital outcomes

Test result variables	Cutoff	AUC	SE	p	Asymptotic 95%CI		Sensitivity	Specificity
					Lower bound	Upper bound		
Frontal QRS/T angle	>47.5	0.628	0.053	0.017	0.522	0.733	55.9	72.6

AUC: Area under the curve; SE: Standard error; CI: confidence interval

Table 6. Distribution of in-hospital outcomes according to frontal QRS/T angle values

		In-hospital outcomes		
		Exitus	Discharged	Total
Frontal QRS/T angle	>47.5	19	66	85
	≤47.5	15	175	190
	Total	34	241	275

fQRS/T angle is associated with inflammatory and metabolic markers. Demirtakan et al.^[16] In parallel, in the prospective cohort study by Demirtakan et al.^[16] involving 252 patients with COVID-19 pneumonia, creatinine, AST, LDH, D-dimer, and CRP levels were significantly higher in the non-survivor group; the authors reported that deterioration in these parameters reflects systemic inflammation and multi-organ dysfunction. The correlations observed in this study align with this biochemical deterioration pattern. Considering that repolarization may be impaired in patients with elevated inflammatory markers and renal dysfunction, a widened fQRS/T angle could be regarded as an “electrical reflection” of systemic disease severity.

The effects of electrolyte imbalance and hypoxemia on myocardial repolarization have been widely examined in previous research, and multiple studies have shown a significant association between the widening of the frontal QRS/T angle and these pathophysiological processes.^[4,11,17] In this study, a weak but statistically significant positive correlation was found between serum sodium levels and the fQRS/T angle. Although respiratory hypoxia parameters (such as PaO₂ or SpO₂) were not assessed, the parallel increase observed between the fQRS/T angle and biochemical indicators of tissue hypoxia, including elevated creatinine and CRP levels, may be interpreted as an indirect marker of cardiac electrical instability secondary to hypoxia.

In logistic regression analyses, pulse rate and in-hospital length of stay were found to be independently associated with mortality, whereas creatinine levels suggested a pos-

sible interaction effect within the model. Data from ED cohorts of sepsis and severe infection patients indicate that the fQRS/T angle is independently related to short-term mortality, reinforcing its potential use as an ECG-based biomarker. This evidence aligns with previous ED studies reporting that the fQRS/T angle predicts 30-day mortality in sepsis patients regardless of the infection source.^[18] These findings highlight the clinical importance of closely monitoring or initiating early interventions in patients presenting with elevated fQRS/T angles on their admission ECG.

However, the discrepancy between the commonly reported fQRS/T cutoff values (e.g., >90°) and the 47.5° threshold identified in this study is noteworthy. This difference may be attributed to variations in the clinical spectrum of COVID-19 pneumonia (ranging from mild to severe cases), differences in the timing of measurement, patient demographics, or differences in device-based axis calculation methods. Therefore, population-specific recalibration and validation studies are recommended to improve the model’s predictive accuracy in different patient groups.^[19] Furthermore, some re-

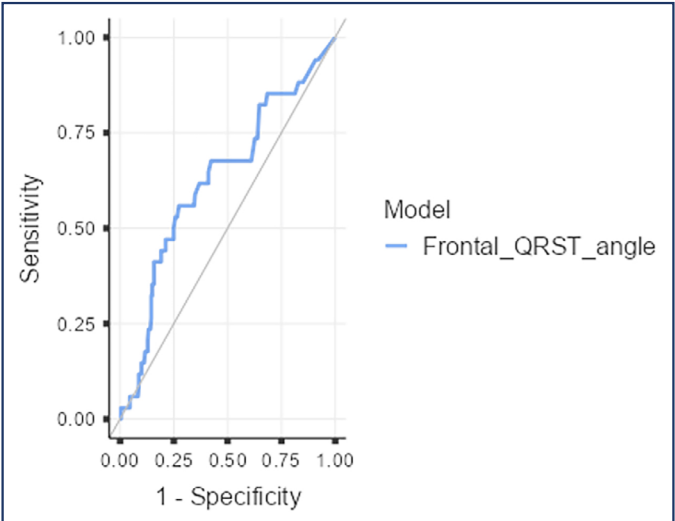


Figure 2. Receiver operating characteristic (ROC) curve demonstrating the predictive value of the frontal QRS/T angle for in-hospital mortality

ports have linked the fQRS/T angle to long-term arrhythmic events and sudden cardiac death.^[6,7] This finding suggests that patients with COVID-19 pneumonia who exhibit a widened fQRS/T angle may require not only mortality risk assessment but also long-term cardiac follow-up for potential arrhythmic complications.

From a clinical perspective, the advantage of the fQRS/T angle lies in its ability to be automatically obtained from a standard 12-lead ECG—making it a cost-free, objective, and rapid assessment tool in the ED. This feature is particularly valuable in scenarios where laboratory or imaging resources are limited, allowing for efficient early risk stratification.

Limitations

This study has several limitations. First, its single-center and retrospective design limits the generalizability of the results. In addition, parameters related to respiratory hypoxemia (such as PaO₂, SpO₂, or oxygen support), comorbid conditions, and medication use were not available, preventing full control of potential confounding factors that could influence myocardial repolarization and clinical outcomes. Furthermore, serial ECG recordings were not obtained, which made it impossible to evaluate the temporal dynamics of the frontal QRS/T angle in relation to disease progression or treatment response. Therefore, validation of these findings through prospective, multicenter studies incorporating serial ECG follow-up is warranted.

CONCLUSION

This study highlights the prognostic value of the frontal QRS/T angle in patients presenting to the ED with COVID-19 pneumonia. The findings indicate that a widened fQRS/T angle is associated with an increased risk of mortality, paralleling elevations in systemic inflammation, renal dysfunction, and cardiac biomarkers. The electrical alterations associated with myocardial repolarization stress and multiorgan involvement induced by COVID-19 infection suggest that the fQRS/T angle may serve as a noninvasive indicator reflecting disease severity. These results demonstrate that the frontal QRS/T angle, as an easily accessible, cost-effective, and objective ECG parameter, holds clinical value for early risk stratification. However, multicenter, prospective studies are warranted to validate the cutoff value in different populations, assess its temporal changes through serial ECGs, and explore its integration into clinical risk scoring systems.

Disclosures

Ethics Committee Approval: The study was approved by the Izmir Katip Celebi University's Non-Interventional Clinical Research Ethics Committee (No: 0161, Date: 08/04/2025).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Use of AI for Writing Assistance: All authors declare that no artificial intelligence-assisted technologies were used in the preparation of this manuscript.

Author Contributions: Concept – E.E.G., M.G.E.; Design – E.E.G., D.Ç.; Supervision – M.G.E., S.K.; Materials – E.E.G., D.Ç.; Data collection and/or processing – S.K., D.Ç.; Data analysis and/or interpretation – E.E.G., S.K.; Literature search – E.E.G., S.K.; Writing – E.E.G.; Critical review – M.G.E., S.K.

Peer-review: Externally peer-reviewed.

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