# **Original Article**

# Evaluation of Electrocardiographic Changes and Clinical Cardiac Complications in Critically Ill COVID-19 Patients

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## ABSTRACT

- *Background:* COVID-19 is associated with various cardiovascular manifestations and complications leading to even death. Electrocardiography (ECG), on the strength of its low cost and wide accessibility, is one of the leading approaches to assessing cardiac involvement and its extent. We aimed to investigate ECG abnormalities in patients with COVID-19.
- *Methods:* The present cross-sectional descriptive study was performed on 480 patients with COVID-19 admitted to the intensive care unit, where they underwent ECG recording. Mortality and cardiovascular events were assessed during hospitalization.
- *Results:* We evaluated 480 patients with confirmed COVID-19. Abnormal ECG findings were found among 351 patients (73.1%), with the most frequent ECG findings being sinus tachycardia (35%), ST depression (32.5%), T-wave inversion (23.8%), and ST elevation (18.8%). The most common cardiovascular event was acute coronary syndrome, reported in 216 patients (45%). Myocarditis and pericarditis were observed in 54 (11.3%) and 42 (8.8%) patients, respectively. Heart failure was reported in 138 patients (28.7). During hospitalization, 66 patients (13.8%) expired.
- *Conclusions:* Our results showed a high prevalence of rhythm and rate abnormalities and cardiovascular events among patients without a known history of cardiac diseases. *(Iranian Heart Journal 2023; 24(4): 70-75)*

KEYWORDS: Electrocardiogram, Arrhythmias, Coronavirus disease-2019, SARS-CoV-2, Rate abnormalities

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Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) caused the COVID-19 pandemic and resulted in unprecedented morbidity and mortality the world over. During the COVID-19 pandemic, the focus was the respiratory

system, although COVID-19 is a multifaceted disease capable of creating various complications, such as cardiac involvement. <sup>1-3</sup>

The cardiovascular manifestations of COVID-19 include acute myocardial injury,

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arrhythmias, acute coronary syndrome (ACS), acute myocardial injury, heart failure, and arterial and venous thrombosis, complications associated with poor outcomes like death.<sup>4</sup>

Electrocardiography (ECG) is inexpensive and widely accessible and, thus, one of the leading approaches to evaluating cardiac involvement and its extent in patients with particularly given COVID-19. the significance of the assessment of cardiac electrical activity in this group of patients.<sup>5</sup> It, therefore, seems judicious to determine the ECG findings of patients with COVID-19 in different populations and ethnicities.<sup>6</sup> In the present study, we sought to analyze the ECG findings of patients with confirmed COVID-19 and consequent cardiovascular events admitted to the intensive care unit (ICU) without a known history of cardiovascular disease. We hope that our results provide fresh insights into ECG assessment for screening cardiac events in SARS-CoV-2 infection.

### **METHODS**

### Population

The current descriptive cross-sectional study was conducted on patients with COVID-19 admitted to the ICU of Shariati Hospital, Tehran, Iran, between February 2020 and March 2021. Participants whose COVID-19 diagnosis was confirmed by real-time reverse transcriptase polymerase chain reaction (RT-PCR) on nasopharyngeal or oropharyngeal swabs were enrolled in this analysis. The study protocol was approved by the Ethics Committee of Tehran University Medical Sciences of (IR.TUMS.THC.REC.1400.036), and informed consent was obtained from all the participants.

The inclusion criteria consisted of confirmed COVID-19, age  $\geq$  18 years, and ICU admission. Patients with COVID-19 were

excluded if they had a known history of cardiovascular disease.

## **Data Collection**

Twelve-channel conventional ECGs at a speed of 25 mm/h were taken from the participants. At least 1 ECG was obtained from all the study participants. All ECGs were reviewed and interpreted by 2 independent cardiologists. The distance between 2 thin lines was 0.04 seconds, and the distance between 2 horizontal lines was 1 mm. Cardiac rhythm, rate, and axis, as well as PR interval, ORS duration, heart rate, T-wave changes, and corrected OT interval (OTc) were collected. OTc was calculated with the Bazett formula. In the event of atrial fibrillation, QT calculation was performed using the mean value of 10 consecutive beats. Heart rate was calculated by dividing 1500 by RR interval. The width, height, and characteristics of P and T waves were investigated and determined. Serum troponin levels were measured for all the patients. The study population was also evaluated regarding any previous lung computed tomography (CT) and evidence of SARS-CoV-2 findings.

Follow-up was performed during hospitalization, and any data on cardiovascular events and mortality were collected.

Finally, the collected data were tabulated using Microsoft Excel. Descriptive statistics were employed for analysis, and the data were presented as counts and percentages.

### RESULTS

The current study evaluated 480 patients with confirmed COVID-19 with a mean (SD) age of 65.3 (12.1) years. Men and women, respectively, comprised 68.1% and 31.9% of the study population. The frequencies of ECG changes in the studied patients are presented in Table 1. Abnormal ECG findings were found among 351 patients (73.1%). As presented in Table 1,

the most frequent ECG findings were sinus tachycardia (35%), ST depression (32.5%), T-wave inversion (23.8%), and ST elevation (18.8%). Moreover, positive troponin was detected among a considerable portion of the study participants (n = 306, 63.7%). All the patients underwent CT scans, revealing evidence of SARS-CoV-2 lung involvement in 240 patients (50%).

 
 Table 1: Distribution of ECG changes among ICUadmitted patients with COVID-19

ECG Change	Frequency (%) (n=480)
Abnormal ECG	351 (73.1%)
Sinus bradycardia	36 (7.5%)
Sinus tachycardia	168 (35%)
Arrhythmia	72 (15%)
QT interval >120 ms	42 (8.8%)
Heart block	42 (8.8%)
ST depression	156 (32.5%)
ST elevation	90 (18.8%)
T-wave inversion	114 (23.8%)

ECG: electrocardiography; ICU: intensive care unit

Considering cardiovascular events (Table 2), the most frequent one was ACS, reported in 216 patients (45%). Myocarditis and pericarditis were observed in 54 (11.3%) and 42 (8.8%) patients, respectively. Heart failure was reported in 138 patients (28.7%). During hospitalization, 66 patients (13.8%) expired.

 Table 2: Cardiac events in ICU-admitted patients with

 COVID-19

Cardiac Events	Frequency (%) (n=480)	
Myocarditis	54 (11.3%)	
Pericarditis	42 (8.8%)	
Heart failure	138 (28.7%)	
Acute coronary syndrome	216 (45%)	
Mortality	66 (13.8%)	

ICU: intensive care unit

#### DISCUSSION

We found a high prevalence rate of ECG abnormalities among our study participants (73.1%), with sinus tachycardia being the

most common ECG change (35%). Similarly, Wang et al <sup>7</sup> reported a high prevalence rate (86%) of ECG abnormalities in critically ill patients with COVID-19, and ST-T changes (48.5%), followed by sinus tachycardia (29.9%), constituted the most common abnormality. We found evidence of arrhythmias in about 15% of ICU-admitted patients.

A considerable proportion of our patients with COVID-19 admitted to the ICU exhibited evidence of ST abnormalities (51.25%). Acute ST abnormalities and ECG with evidence of prior myocardial infarctions were associated with the need for vasoactive treatment and mortality in ICUadmitted patients in a prior investigation.<sup>8</sup> The association between ST-T abnormalities and invasive ventilation or death has been confirmed previously.<sup>9</sup>

A cohort study of 756 participants with COVID-19 revealed an increased risk of death those with atrial premature among contractions, heart block, and T-wave inversion at hospital admission. <sup>10</sup> A long QT interval was reported in patients with COVID-19 compared with those without the infection. <sup>11</sup> We found prolonged OT intervals among 42 patients (8.8%). Multiple parameters have been contributed to prolonged QT intervals in SARS-CoV-2, and angiotensin Π overexpression and inflammation are major contributors. Inflammation can be systemic or localized to organ like the heart. an Furthermore, increased pro-inflammatory interleukin-6 (IL-6) levels in systemic inflammatory responses can cause electrophysiological effects on ion channels and create subsequent changes in action potential and QTc interval.<sup>12</sup>

COVID-19 can result in adverse outcomes related to the cardiovascular system. <sup>13</sup> The possible explanations for the association between cardiovascular disease and COVID-19 are direct myocardial damage due to cytokine storm, indirect myocardial injury caused by stress-induced arrhythmias, hypoxia-induced injury, thrombus inflammatory activity, renin-angiotensin system disruption, and endothelial damage. 14,15

Previous studies have also shown the association between ECG abnormalities and poor outcomes of COVID-19. In a prospective investigation conducted in Germany, 100 patients who had recently recovered from COVID-19 underwent cardiac magnetic resonance imaging tests. which demonstrated cardiac involvement in subjects and myocardial 78 (78%)inflammation in 60 (60%), regardless of underlying diseases, the severity and pattern of the acute disease, or the time elapsed since the initial diagnosis. These results highlight the need for further research into the potential long-term cardiovascular effects of COVID-19.<sup>16</sup>

We found evidence of adverse cardiac outcomes in patients with COVID-19 admitted to the ICU. COVID-19 seems to enhance the possibility of ischemic stroke and acute myocardial infarction.<sup>17</sup> ACS was reported in about 45% of the participants in the current investigation. COVID-19 may cause ACS by making plaques unstable and causing a supply-demand disequilibrium.<sup>18</sup> According to a report, the prevalence of myocarditis and pericarditis related to COVID-19 rose by about 15 times compared with the pre-COVID-19 period. <sup>19</sup> We found evidence of pericarditis and myocarditis in about 8.8% and 11.3% of our studied patients, respectively. A study of 530 patients with COVID-19 revealed that 75 subjects (14%) had pericardial effusion, although only 17 individuals (3.2%) met the criteria of acute pericarditis. <sup>20</sup> A recent meta-analysis on the chest computed tomography of 2693 patients with confirmed COVID-19 in hospitals revealed that 3% of the subjects had pericardial effusion.<sup>21</sup> Post-mortem studies

have also reported an approximate prevalence rate of 20% for pericarditis in patients from COVID-19. suffering А retrospective cohort study of 718,365 patients with COVID-19 reported 10,706 cases (1.5%) of new-onset pericarditis and 35,820 (5.0%) cases of myocarditis. Moreover, significantly higher mortality rates of myocarditis and pericarditis were seen in <sup>24</sup> SARS-CoV-2 critical care recipients. infection can cause pericarditis or possible myocarditis through some mechanisms. When the lungs are infected by SARS-CoV-2. extracellular vesicles containing the whole virus or its components are released, combined with a cytokine cascade composed of IL-1B, tumor necrosis factor-a, and IL-6. Extracellular vesicles may reach the heart via the blood or the lymph and infect cardiac cells. such as cardiomyocytes, mast cells, macrophages, and pericytes, expressing such crucial receptors as angiotensin-converting enzyme 2, neuropilin-1 receptor, and transmembrane serine protease-2. Further, in reaction to viruses and injured cardiac tissue, local antigen-presenting cells, such as dendritic cells, mast cells, and macrophages, activate a modifiable autoimmune response that results in myocarditis.

Our study has some limitations, first and foremost among which is that although we excluded patients with a history of cardiac diseases, some of our subjects may have had undiagnosed pre-existing heart diseases. Moreover, a single ECG was studied without data on follow-up ECG.

In conclusion, our data revealed high prevalence rates of ECG abnormalities among patients with COVID-19. Due to the high prevalence of ECG alterations in COVID-19, our findings suggest that infected patients should be continuously monitored regarding ECG abnormalities.

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# **Ethical Approval**

All the procedures performed in the current study were in accordance with the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Tehran University of Medical Sciences (TUMS) (No. IR.TUMS.THC.REC.1400.036). All the participants or their legal guardians were asked to provide written informed consent before data collection.

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