REVIEW ARTICLE

Folia Cardiologica 2022
vol. 17, no. 1, pages 35–39
DOI: 10.5603/FC.2022.0005

ISSN 2353–7752
e-ISSN 2353–7760

Electrocardiographic changes in patients with COVID-19

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Abstract

Electrocardiography is one of the basic diagnostic tests performed in hospitalized coronavirus disease 2019 (COVID-19) patients. Due to its wide availability and low cost, it is useful in the initial evaluation of COVID-19 patients with a history of cardiovascular disease, and patients with suspected cardiovascular complications in the course of the infection. Electrocardiographic findings seen in COVID-19 patients may include P wave and atrioventricular conduction abnormalities, QRS complex alterations including their fragmentation, evidence of right ventricular overload, ST-T changes, and QTc interval prolongation. The most common cardiac arrhythmias are supraventricular arrhythmias, particularly atrial fibrillation.

Key words: ECG, electrocardiogram, COVID-19, SARS-CoV-2, cardiac arrhythmia

Folia Cardiologica 2022; 17, 1: 35–39

Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), a RNA virus of the betacoronavirus genus. Its reservoir are infected persons, and its transmission is airborne, mostly by droplets, but likely also by aerosol and direct contact. The receptor used for viral entry into the cells is angiotensin converting enzyme type 2 (ACE2). The incubation period is typically 2 to 14 days but it may be prolonged up to 27 days. Infection may be asymptomatic or it may manifest with unspecific symptoms, such as decreased or elevated body temperature, fatigue, cough, rhinitis, smell and taste impairment, and headache. In some cases, pneumonia develops, or even acute respiratory distress syndrome (ARDS) or sepsis. Immune system response to viral antigens plays a major role in the pathomechanism of severe disease forms, with the release of proinflammatory cytokines and chemokines, leading to a systemic inflammatory reaction known as cytokine storm [1].

Although more severe forms of COVID-19 mostly affect the respiratory system, cardiovascular complications may also be important. In addition, patients with a history of cardiovascular disease are at increased risk of severe disease course [1, 2]. Cardiovascular complications related to COVID-19 may be divided into five categories:

- Myocardial damage (related to myocardial ischemia or myocarditis);
- Cardiac arrhythmia;
- New-onset heart failure or exacerbation of chronic heart failure;
- Thromboembolic complications;
- Cardiovascular complications related to COVID-19 therapies [3].

Electrocardiography (ECG) is one of the basic diagnostic tests performed in hospitalized COVID-19 patients. Due to its wide availability and low cost, it is useful in the initial evaluation of COVID-19 patients with a history of cardiovascular disease, and patients with suspected cardiovascular complications in the course of the infection. Since the beginning of the COVID-19 pandemic, numerous reports

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have been published on ECG changes in infected patients. These analyses and observations highlight the complexity and diversity of these changes, indicating a need for further studies looking for changes specific for COVID-19. Below, we report the types and characteristics of ECG changes reported by different authors.

P wave changes and atrioventricular conduction disturbances

P waves should be evaluated when analysing an ECG in a patient with COVID-19.

Yenerçağ et al. [4] evaluated P wave changes in 140 patients with newly diagnosed SARS-CoV-2, comparing their results to a gender- and age-matched control group. In the study group, an increased P wave dispersion was found that correlated with serum C-reactive protein (CRP) level. During further follow-up with the mean duration of 14 days, new-onset atrial fibrillation was noted in 13 (9.3%) of patients infected with SARS-CoV-2. Eleven patients in the latter subgroup required admission to an intensive care unit (ICU) [4].

Amaratunga et al. [5] reported a series of 4 patients with no history of bradyarrhythmia admitted to an intensive care unit, in whom transient sinus bradycardia with the minimal heart rate of 42-49 beats per minute (bpm) was observed during the hospitalization. Their heart rate on admission ranged from 66 to 88 bpm [5]. Babapoor-Farrokhran et al. [6] reported two female patients with COVID-19. One of them was a 69-year-old woman with a history of hypertension and diabetes type 2, in whom sinus rhythm with the rate of 78 bpm was noted in an ECG recorded on admission but transient 2:1 second degree atrioventricular block with the QRS rate of 40 bpm was observed during the hospitalization. The patient reported no symptoms associated with conduction disturbances. The other patient was an 89-year-old woman with a history of hypertension in whom sinus rhythm with the rate of 85 bpm and the evidence of left ventricular hypertrophy were noted in the baseline ECG. On the eight day of hospital stay, pauses up to 5.3 seconds due to sinus arrest were recorded during ECG monitoring. Over the next days, shorter pauses up to 2-3 seconds were observed, with their complete resolution by the tenth day of hospital stay [6].

QRS complex changes

Bertini et al. [7] analysed ECGs recorded on admission in 431 critically ill COVID-19 patients (hospitalization resulting in death or a need for mechanical ventilation). Changes suggesting an acute right ventricular pressure overload (RVPO) were noted in 130 (30%) patients, including the S1Q3T3 pattern in 43 (10%) patients, incomplete right bundle branch block (iRBBB) in 38 (9%) patients, and complete right bundle branch block (RBBB) in 49 (11%) patients [7].

In their study, Abrams et al. [8] included 133 patients with confirmed SARS-CoV-2 infection who died during the hospitalization. The most common changes noted in ECG on admission included cardiac axis deviation (25.8%) and RBBB (11.9%). Death due to cardiac arrhythmia occurred in 11 (8.3%) cases, and left bundle branch block (LBBB) and prolongation of corrected QT (QTc) interval were more frequently noted in baseline ECGs in this patient group [8].

Yıldırım et al. [9] analysed ECGs in patients with confirmed SARS-CoV-2 for the presence of fragmented QRS (fQRS). The study included 114 patients. ECG showed fQRS in 42 (36.8%) patients, and this group was characterized by a significantly longer duration of hospital stay, higher rate of admission to an intensive care unit, and higher all-cause and cardiovascular mortality. Longer QRS duration correlated with the length of hospital stay and showed an association with the need for admission to an intensive care unit, and all-cause and cardiovascular mortality [9].

ST-T changes

Li et al. [10] evaluated 135 hospitalized patients at the mean age of 64 years. The most commonly noted ECG abnormalities were ST-T changes, present in 40% of patients. Of all patients included in the analysis, 23 (17.0%) required admission to an intensive care unit. Significantly more common ECG findings in this group included ST-T changes, pathological Q wave, and QTc interval prolongation. A follow-up ECG during the hospitalization was recorded in 27 patients and new abnormalities were identified in 17 of them. Statistical analysis showed that ST-T changes in the admission ECG and a history of cardiovascular disease were associated with a significantly higher risk of admission to an ICU [10]. Angeli et al. [11] also noted frequent ST-T changes in COVID-19 patients. In their study, ST-T changes were present in the admission ECG in 30% of patients.

Wang et al. [12] analysed the characteristics of COVID-19 patients in relation to the clinical course of the disease. The study included 319 patients. Of these, 97 patients were critically ill, and the disease was severe in 222 patients. Among critically ill patients, ST-T changes, sinus tachycardia, atrial fibrillation, and atrial tachycardia were significantly more common compared to the patients with severe disease. Elevated troponin I and N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels were independent predictors of ST-T changes in ECG [12, 13].

QTc interval changes

QTc interval prolongation has been frequently reported in COVID-19. Its occurrence has been noted in the previously cited study by Li et al. [10]. Chen et al. [14] analysed the clinical course of the disease in 63 hospitalized patients

with a confirmed SARS-CoV-2 infection. Tests performed during the hospitalization included a standard 12-lead ECG and serum markers of myocardial damage (high-sensitivity troponin I, myoglobin, and creatine kinase isoform MB [CK-MB]). The patients were divided into groups with or without evidence of myocardial damage depending on whether an elevated serum level of at least one of the above biomarkers was identified. Overall, evidence of myocardial damage was found in 23 patients and this group was characterized by an increased mortality, and higher rates of QTc interval prolongation and T wave changes on ECG. In addition, QTc interval duration was found to be an independent predictor of myocardial damage, and the presence of T wave changes was an independent predictor of mortality [14].

Öztürk et al. [15] compared ECG parameters in 51 hospitalized COVID-19 patients and 40 age- and gender-matched controls. A significantly higher mean QTc interval duration was found in COVID-19 patients (410.8 ± 24.3 ms vs. 394.6 ± 20.3 ms, $p < 0.001$) [15].

QTc interval changes in COVID-19 patients should be always interpreted in the context of medications taken by the patients. In the study by van den Broek et al. [16], ECG changes were analysed in 95 patients receiving chloroquine for COVID-19. ECG was recorded at baseline and during treatment. Statistical analysis showed that the mean QTc interval prolongation was 35 ms. During the therapy, QTc interval increased to above 500 ms in 22 (23%) patients [16].

Previous therapeutic uses of chloroquine have included the treatment of malaria, systemic lupus erythematosus and rheumatoid arthritis. An anti-inflammatory effect and an *in vitro* antiviral effect have been noted among its key mechanisms of action. Use of chloroquine for the treatment of COVID-19 has been enthusiastically welcomed, with promising early reports of the treatment results. However, further studies did not confirm the expected benefits of chloroquine [17, 18].

Cardiac arrhythmia

Bhatla et al. [19] evaluated the incidence of cardiac arrhythmia in hospitalized COVID-19 patients. The study included 700 patients at the mean age of 50 ± 18 years. Admission to an intensive care unit was required in 11% of these patients. Over the course of the hospitalization, 53 episodes of new-onset arrhythmia were recorded, include 25 episodes of atrial fibrillation and 10 episodes on non-sustained ventricular tachycardia. In addition, 9 cardiac arrest events occurred, including 6 episodes of pulseless electrical activity, 2 episodes of asystole, and 1 episode of torsade de pointes. In statistical analysis, admission to an intensive care unit was associated with the occurrence of atrial fibrillation and non-sustained ventricular tachycardia episodes [19].

The analysis in a multicentre study by Coromilas et al. [20] included 4526 hospitalized patients with a confirmed SARS-CoV-2 infection. During the hospitalization, new-onset arrhythmia occurred in 827 patients. The mean age of this subgroup was 71.1 ± 14.1 years, higher compared to the mean age of the overall study population (62.8 ± ± 17.0 years). A history of cardiovascular disease was relatively frequent in this subgroup, with hypertension in 69%, heart failure in 30%, and coronary artery disease in 24%. Most patients with episode of arrhythmia during the hospitalization had no previous history of cardiac arrhythmia. In statistical analysis, episode of arrhythmia was associated with a significantly increased mortality rate. Of all patients with new-onset arrhythmia, 43% required mechanical ventilation, and only 51% survived until the hospital discharge. The most commonly recorded type of arrhythmia was atrial arrhythmia (81.8%), mainly atrial fibrillation and flutter. The incidence of ventricular arrhythmia was 21%, most commonly ventricular tachycardia (both sustained and non-sustained) and ventricular fibrillation [20]. In the study by Gopinathannair et al. [21] among hospitalized COVID-19 patients, the incidence of atrial fibrillation was 21%, of atrial flutter 5.4%, and of atrial tachycardia 5.7%. Ventricular arrhythmias were less common: the rates were 5.3% for monomorphic premature beats, 3.5% for polymorphic premature beats, 6.3% for non-sustained ventricular tachycardia, 3.8% for sustained monomorphic ventricular tachycardia, 3.5% for polymorphic ventricular tachycardia/*torsade de pointes*, and 4.8% for ventricular fibrillation [21].

Changes in ECG related to pulmonary embolism

Pulmonary embolism is a major complication of COVID-19, particularly in severely ill patients. Postulated mechanisms of an increased risk of venous thrombosis in COVID-19 include an increased activity of angiotensin II and related clotting system and platelet activation, cytokine-mediated activation of the clotting cascade, and a potential effect of the viral infection itself leading to local inflammation and focal thrombosis. Regarding the ECG findings in the acute phase of the disease, sinus tachycardia and atrial fibrillation with rapid ventricular response, as well as the evidence of right ventricular overload have been commonly reported. Other reported findings include negative T waves in the anterior wall leads and RBBB.

Kho et al. [22] reported a series of 15 pulmonary embolism cases in COVID-19 patients. Sinus tachycardia developed in 7 (47%) patients, and the evidence of right ventricular overload was present in 5 (33%) patients. The S1Q3T3 pattern on ECG was identified in only one patient [23, 24].

Table 1. Most common electrocardiogram changes in patients with coronavirus disease 2019

P wave and AV conduction disturbances	QRS complexes	Changes in the repolarization period	Cardiac arrhythmia
Increased P wave dispersion	Evidence of RVPO	ST-T changes	Atrial fibrillation and flutter
Sinus bradycardia	Intraventricular conduction disturbances	QTc interval prolongation	Ventricular arrhythmia
AV block	QRS complex fragmentation		

AV — atrioventricular; RVPO — right ventricular pressure overload

Summary

Electrocardiographic findings seen in COVID-19 patients may include P wave and atrioventricular conduction abnormalities, QRS complex alterations including their fragmentation, evidence of right ventricular overload, ST-T changes, and QTc interval prolongation (Table 1). The most common cardiac arrhythmias are supraventricular arrhythmias, particularly atrial fibrillation. These results are consistent with the authors' own observations. In our material, atrial fibrillation/flutter was present in 26% of patients, atrioventricular block in 13% of patients, intraventricular conduction disturbances in 26% of patients, ST-T changes in 48% of patients, and QTc interval prolongation in 46% of patients. Of note, none of the above changes are specific for SARS-CoV-2 infection, and precise determination of their prognostic value would require more studies to be performed in adequately large patient samples.

Conflict of interest

The authors declare no conflict of interests.

Funding

None.

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