Original Article

Electrocardiographic Manifestations in COVID-19 Patients — An Observational Study from a Tertiary Care Centre in North Eastern India

Manish Kapoor[1], Arun Kumar[2], Tony Ete[3], Star Pala[4], Vanlalmalsawmdangliana[5], Rinchin Dorjee Megeji[6], Taso Beyong[7]

Introduction : The Coronavirus disease 2019 (COVID-19) primarily involves respiratory system but may also affect the Cardiovascular System leading to abnormal ECGs. Its early recognition is crucial as it may be associated with increased mortality. Hence we aimed to find out various Electrocardiographic (ECG) manifestations of COVID-19 patients admitted in a Tertiary Care Hospital and its relation to disease severity.

Methods : We performed a hospital-based retrospective observational study between April, 2021 to November 2021 and analyzed the ECG changes at admission by three Cardiologists according to standard definitions and diagnostic criteria.

Results : Out of 579 patients, ECG of 473 was available for analysis. ECG was normal in 227 (48%) and abnormal in 246 (52%) patients. Most common abnormal ECG finding in COVID19 patients was Sinus Tachycardia(19.5%) and less common findings were Sinus Bradycardia (5.3%), Incomplete Right Bundle Branch Block (RBBB) (3.2%), atrial fibrillation (2.5%), complete RBBB (2.3%), atrial premature complexes (2.3%), S1Q1T3 pattern (2.1%), first degree AV block (1.5%), ST-T wave changes (1.3%), Atrial flutter (1.1%). In mechanically ventilated patients, incidence of acute Right Ventricular Pressure Overload (RVPO) related ECG findings were more frequent.

Conclusion : There is a wide spectrum of ECG manifestations in COVID-19 patients which varies depending upon the severity of COVID as well as prior Cardiovascular status, associated comorbidities and need for ventilatory support. Knowledge of ECG changes might help in risk stratification and triaging of COVID-19 patients.

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Key words **: COVID-19 India, 12 lead ECG, COVID severity, Medical Comorbidities, Tertiary Care Centre.**

COVID-19 pandemic started after the outburst from Wuhan, China in December 2019 and has spread across the whole World since. As of now, it has affected more than 200 Countries and 4.3 million deaths Globally. An early study from China indicated that 16.7% of hospitalized and 44.4% of ICU patients with COVID-19 had arrhythmias[1]. In addition, the SARS-CoV-2 virus has a specific predilection over Angiotensin-converting receptor-2 (ACE2)[2], a receptor that is the predominant receptor in the Cardiovascular System and the patients with comorbidities had a higher risk of severe cardiac injury[3,4]. As the pandemic continues to rage, wide variety of Arrhythmias, its mechanisms related to direct cardiac injury, hypoxia,

Editor's Comment :

- COVID-19 has affected millions of lives across the Globe. Many patients hospitalized with COVID-19 infection have developed cardiac abnormalities and related ECG changes. Identifying ECG patterns that might be related to COVID-19 is vital. This study tried to find out relevant ECG findings associated with COVID-19 and to correlate these Electrocardiographic abnormalities with their severity. Most common finding was sinus tachycardia but others included SVTs such as atrial fibrillation or flutter, ventricular arrhythmias such as VT or VF, bradycardia, interval and axis changes (QT prolongation) and ST-segment and T wave changes. Knowledge of these findings may assist clinicians in the evaluation, management and prognostication of COVID-19 infected patients. Larger studies comparing pre, post and follow-up ECGs of COVID-19 infected patients are needed for better management and treatment outcomes.

Department of Cardiology, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences, Shillong, Meghalaya 793018

[1]MBBS, MD, DNB (Cardiology), Additional Professor

[2]MBBS, MD, Post Doctoral Trainee (PDT)

[3]MBBS, MD, DM (Cardiology), Assistant Professor, Department of Cardiology, Tomo Riba Institute of Health and Medical Sciences (TRIHMS), Naharlagun, Arunachal Pradesh 791110 and Corresponding Author

[4]MBBS, MD, Additional Professor, Department of Community Medicine

[5]MBBS, MD, Senior Resident Doctor

[6]MBBS, MD, DM (Cardiology), Associate Professor, Department of Cardiology, Tomo Riba Institute of Health and Medical Sciences (TRIHMS), Naharlagun, Arunachal Pradesh 791110

[7]MBBS, MD, Associate Professor, Department of General Medicine, Tomo Riba Institute of Health and Medical Sciences (TRIHMS), Naharlagun, Arunachal Pradesh 791110

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electrolyte imbalance, endothelial injury and interaction with therapeutics (hydroxychloroquine, azithromycin) were identified[5]. It has also been reported that the incidence of cardiac arrest during hospital stay increased during this pandemic[6]. Data from earlier studies suggested that 27.8% of in-hospital COVID-19 patients had myocardial injury indicated by troponin elevation and a higher incidence of Malignant Arrhythmias[7]. So the identification of Electrocardiographic findings at the time of admission and during an in-hospital stay of COVID-19 patients may help in early risk stratification and management. The Heart Rhythm Society (HRS), American College of Cardiology (ACC) and the American Heart Association (AHA) released a joint statement with recommendations regarding exposure risks, triage, cardiac arrhythmias as well as how to manage electrophysiology procedures, clinic visits, and device interrogations during this pandemic[8]. Here we aimed to find out various Electrocardiographic (ECG) manifestations of COVID-19 patients and their relation to disease severity admitted in a Tertiary Care Hospital in North Eastern India.

Materials and Methods

A hospital-based retrospective observational study was carried out in the period between April, 2021 to November, 2021. The project was approved by the Institutional Scientific Advisory Committee as well as the Institutional Ethics Committee. The study protocol was approved by the Clinical Trial Screening and the Ethics Committee of the hospital. We assessed the ECG findings during admission and the severity of COVID-19, associated comorbid conditions were analyzed. Out of 579 patients admitted during that period only 473 patients had ECG. The inclusion criteria were age >18 years, positive for SARS-CoV2 infection, those patients had ECG at the time of admission. The exclusion criteria were pregnant patients, uncertain COVID-19 infection and unavailability of ECG. ECG analysis was independently performed by three Experienced Cardiologists according to standard definitions and diagnostic criteria according to Chou's Book of Electrocardiography[9]. According to our institutional protocol COVID-19 patients were classified into four categories namely (i) Category A- asymptomatic, (ii) Category B- symptomatic not requiring oxygen support, (iii) Category C-symptomatic requiring oxygen support, (iv) Category D-symptomatic requireng ventilator support.

Statistical analysis :

Descriptive analysis was used to describe the Socio-demographic characteristics of the study participants in frequency and percentage. Continuous variables were expressed as mean and standard deviation. Percentages were used for categorical variables. Statistical significance was defined as a p-value less than 0.05. Data entry and statistical analysis were done on SSPS version 23.0. A comparison was performed with a chi-square test between categorical variables.

Total patients-579 positive for SARS-COV-2 infection

Results

Inclusion criteria :

>18 years, ECG available

Exclusion criteria :

Pregnant women, ECG unavailability

473 patients ECG -analysed

Out of 579 patients admitted during this period, 473 patients' ECG was available (Fig 1). Among them,

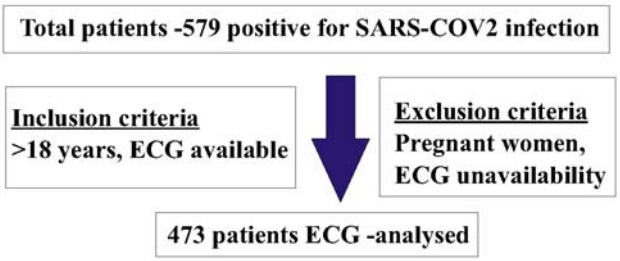

Fig 1 — Flow pathway of ECG in COVID-19 patients

288 patients (60.9%**)** were male and 185 (39.1%) were female. The mean age of the patient was 45 ± 16 years. Out of 473 patients, 59% (279) had no comorbidities and 41.9% (194) had comorbidities like Hypertension (HTN) and Diabetes Mellitus (DM) (18%), Chronic Obstructive Pulmonary Disease (6.6 %), Chronic Kidney Disease (5.1%), old Cerebrovascular Accident (2.8%), Coronary Artery Disease (2.3%), Hypothyroidism (1.3%). Depending on the COVID-19 severity they were classified into four categories Cat-A 186 patients (39.3%), Cat-B 110 patients (23.3%), Cat-C 121 patients (25.6%), Cat-D 56 patients (11.8%) (Fig 2)(Table 1).

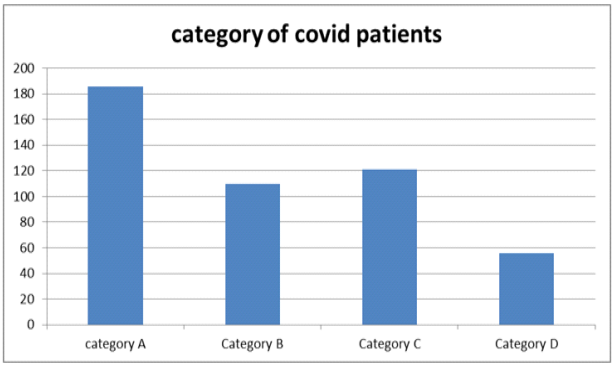

Fig 2 — Category of COVID-19 patients

Table 1 — *Baseline characteristics*		
Mean age	45+16 years	
Sex	Male 288 (60.9%)	Female 185 (39.1%)
Comorbidities	No 279 (59.1%)	Yes 193 (40.9%)
ECG changes	Normal 227 (48)	Abnormal 245 (52%)

Table 2 shows the various ECG findings in all categories of COVID-19 patients.

Among all patients, 365 survived (77.2%) while 108 patients (22.8%) succumbed to COVID-19 related complications. 32.6% of patients received mechanical (invasive and non-invasive) ventilation and 67.4% were not requiring any ventilatory assistance, just managed with oxygen support or without it. The ECG was normal in 48% and abnormal in 52% of the patients. Most common abnormal ECG finding was Sinus Tachycardia (19.5%) and less common findings were Sinus Bradycardia (5.3%), incomplete RBBB(3.2%), atrial fibrillation(2.5%), complete RBBB(2.3%), atrial premature complexes (2.3%), S1Q1T3 pattern (2.1%), first degree AV block (1.5%), ST-T wave changes (1.3%) with acute inferior wall MI was also reported (Fig 3).

In this retrospective single centre study of those patients with hospitalization, most common ECG finding with comorbidities was Sinus Tachycardia (19.5%) and without comorbidity was normal Sinus Rhythm (69.2%). Similar to other studies the patients with comorbidities had a higher incidence of Arrhythmias[3]. Except group Cat A all other groups showed Sinus Tachycardia (Cat-B 23.6% *versus* Cat-C 32.2% *versus* Cat-D 28.6%) and it was the most common ECG finding. There was a significant difference between ECG changes and COVID-19 severity (p<0.005). Most common ECG finding in both expired and alive group patients was Sinus Tachycardia (27.8% *versus* 17%)and significant differences were seen between these groups (p<0.005). Those patients who received mechanical ventilation and were critically ill, most frequent findings were sinus tachycardia(30.5%), Sinus Bradycardia(9.7%), Atrial Fibrillation (6.5%), S1Q3T3 pattern (5.8%), atrial complexes (4.5%), RBBB (4.5%) which is similar to other studies[15,16] and it was statistically significant (p<0.005).In our study, most of the patients were Asymptomatic (39.3%) and fewer patients were included in Cat-D (11.8%). Based on the median age (40 years), the older (>40 years)group had significant abnormal ECG findings compared to the younger group(<40 years) and it was statistically significant (p-value <0.005).

Table 2 — *ECG findings in all categories*						
ECG finding	Total	Cat A	Cat B	Cat C	Cat D	Frequency
Normal	227	151 (31.92)	59 (12.47)	15 (3.17)	2 (0.42)	48.0 %
Sinus Tachycardia	92	11(2.32)	26 (5.49)	39 (8.24)	16 (3.38)	19.5 %
Sinus Bradycardia	25	4 (0.85)	2 (0.42)	12 (2.53)	7 (1.47)	5.3 %
Complete RBBB	11	2 (0.42)	2 (0.42)	7 (1.47)	0 (0)	2.3 %
Incomplete RBBB	15	4 (0.85)	3 (0.63)	7 (1.47)	1 (0.21)	3.2 %
ST-T wave changes	6	3 (0.63)	1 (0.21)	1 (0.21)	1 (0.21)	1.3 %
Atrial fibrillation	12	1 (0.21)	0 (0)	6 (1.26)	5 (1.05)	2.5 %
Atrial flutter	5	0 (0)	0 (0)	1 (0.21)	4 (0.85)	1.1 %
APCs	11	2 (0.42)	2 (0.42)	5 (1.05)	2 (0.42)	2.3 %
QT prolongation	5	0 (0)	1 (0.21)	4 (0.85)	0 (0)	1.1 %
$S_1Q_3T_3$ pattern	10	0 (0)	1 (0.21)	6 (1.26)	3 (0.63)	2.1 %
AVNRT	4	2 (0.42)	0 (0)	0 (0)	2 (0.42)	0.8 %
1st degree AV block	7	1 (0.21)	2 (0.42)	3 (0.63)	1 (0.21)	1.5 %
LVH+LAD	3	0 (0)	0 (0)	3 (0.63)	0 (0)	0.6 %
LVH	13	1 (0.21)	4 (0.85)	5 (1.05)	3 (0.63)	2.7 %
IVCD	1	0 (0)	0 (0)	0 (0)	1 (0.21)	0.2 %
QS complex	8	2 (0.42)	2 (0.42)	1 (0.21)	3 (0.63)	1.7 %
Bifascicular block	2	0 (0)	0 (0)	1 (0.21)	1 (0.21)	0.4 %
RBBB strain	1	0 (0)	0 (0)	0 (0)	1 (0.21)	0.2 %
RBBB + P pulmonale	2	0 (0)	1 (0.21)	1 (0.21)	0 (0)	0.4 %
LBBB	1	0 (0)	0 (0)	1 (0.21)	0 (0)	0.2 %
P pulmonale	3	0 (0)	0 (0)	1 (0.21)	2 (0.42)	0.6 %
Low voltage	6	1 (0.21)	3 (0.63)	2 (0.42)	0 (0)	1.3 %
VPCs	1	0 (0)	1 (0.21)	0 (0)	0 (0)	0.2 %
RVH	1	1 (0.21)	0 (0)	0 (0)	0 (0)	0.2 %
Collapsed (Not available)	1	0 (0)	0 (0)	0 (0)	1 (0.21)	0.2 %
Total	473	186(39.3%)	110(23.3%)	121(25.6%)	56(11.8%)	100 %

Discussion

We present a detailed analysis of ECG findings of 473 COVID-19 patients, from the ECG done at the time of admission. Myocardial abnormalities, ECG changes, and arrhythmic responses in SARS-CoV2 infection might be due to hypoxic injury, Cytokine Storm (hyperinflammatory state), or direct myocardial injury while other contributory factors might be electrolyte abnormalities, myocardial depression, plaque rupture, coronary spasm, microthrombi or direct endothelial injury[10]. ECG finding was normal in 48% of all patients and it might be due to the patients in the study being younger and asymptomatic without any previous medical issues. As with other studies, ECG findings were not common in younger patients. In our study, the most common finding was presence of sinus tachycardia, and it was common across all categories including those on ventilators. Factors responsible for tachycardia might be elevated body temperature, hypoxia, hypovolemia, hypoperfusion, increased myocardial oxygen demand, or anxiety associated[11]. Barman, *et al* showed that Sinus Tachycardia

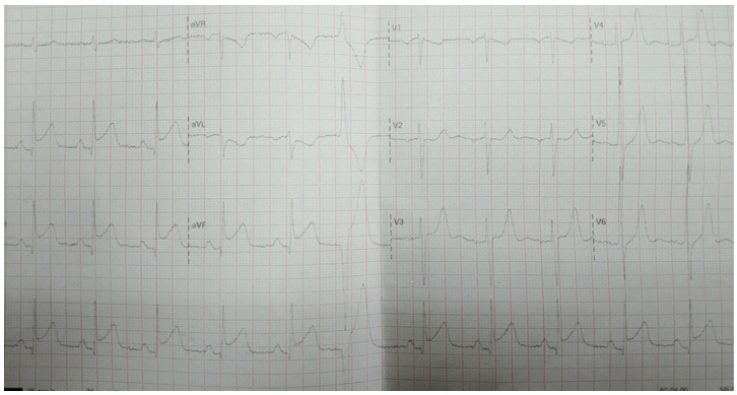

Fig 3 — ECG of a COVID 19 patient presented with acute STEMI-IWMI

was the most common finding[12]. Supraventricular tachycardias (AF, AFL, APCs, AVNRT) account for 6.7% of all patients. Yuan *et al* analyzed new ECG changes in 455 COVID-19 patients and found that 13% developed new-onset AF. Abrams, *et al* in their study has shown AF/AFL was seen in 14.3% of patients at the time of admission and was of new-onset in 10.1% during hospitali-zation[13]. In COVID-19 related illness and pulmonary embolism Sinus Tachycardia and/or atrial fibrillation with rapid ventricular response were commonly seen[14-17].

In our study Sinus Bradycardia was present in 5.3% of patients, however, no case of high-grade AV block was observed. A study showed that Bradyarrhythmias and atrioventricular block were less common when compared to Tachyarrythmias, but the incidence was reported up to 12%[18,19]. A recent case report in a COVID-19 patient showed first degree AV block progressing finally to third-degree AV block[18]. Similar to others, elderly patients with multiple risk factors had a higher risk of developing Bradyarrhythmias and AV block. These rhythm disturbances might be a marker of critically ill COVID-19 patients and in those having a high risk of Cardiovascular Collapse. In our patients, S1Q3T3 pattern, in isolation or associated with Right Bundle Branch Block (RBBB), or isolated RBBB (complete or incomplete) were considered signs of acute Right Ventricular Pressure Overload (RVPO), and 44 patients (9%) had signs of RVPO with p pulmonale (Fig 4).

RVPO related ECG changes may be due to prior reactive airway disease, hypoxia-induced vasoconstriction of pulmonary vessels, pulmonary vascular occlusion caused by the hypercoagulable state, higher PEEP related to ventilation. Similar to other studies, the ECG features of RVPO was more frequent in the patients receiving ventilation for severe COVID-19 Pneumonia which was statistically significant ($P<0.005$)[20]. Among all, 154 (32.6%) patients were put on ventilators and 26 patients (16.1%) had RVPO related ECG changes. The frequency of QTc prolongation in our patient population was less common (1.1%) as the mean age of the patients, comorbidities, and the incidence of drug toxicity were lower, and also as in other studies, the incidence of QTc prolongation is very low with the use of non-cardiovascular drugs (0.001%)[21]. In comparison to survivors (365), non-survivor (108) group had a lower incidence of ST-T-related ECG changes (4 patients *versus* 2 patients. It might be related to previous cardiac illness and this finding was contradictory to other studies, which showed that the ST depression detected in ECG is a marker of cardiac injury and can be used as an indicator of prognosis in these patients[12]. The incidence of low voltage complexes was also not specific (1.3%) and might be due to coexisting hypothyroidism, pre-existing obstructive airway disease or maybe due to invasive ventilation. The other ECG changes were seen like LVH, RVH, LBBB, QS complexes, VPCs, and IVCDs were incidental and might be pre-existing. As in other studies, in our study also the incidence of abnormal ECG findings was more common in the elderly group, with comorbidities, those who stayed more in the hospital, related to the severity of COVID-19 infection, received mechanical ventilation and in non-survivors. Limitations of this study is that its a single-center cross-sectional retrospective study comprising the population of less critically ill patients. Most of the patients in this study were asymptomatic, younger, without comorbidities and those with comorbidities at the time of hospitalization were not having their previous ECGs available for comparison and the ECG was taken at the time of admission lacking the follow-up data. However, available published literature has shown a low incidence of new ECG change in hospitalized COVID-19 patients. More rigorous studies of COVID-19 patients are imperative

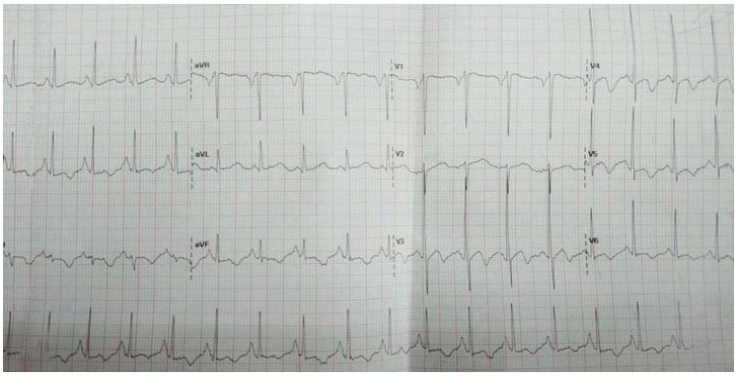

Fig 4 — ECG of a COVID-19 on mechanical ventilation shows Sinus tachycardia, acute RV pressure overload changes (P PULMONALE)

comparing pre-COVID ECGs (if available), with ECGs after getting infected with COVID and during follow-up to reveal the true impact of COVID related ECG changes on patient outcomes.

Conclusions

COVID-19 has affected millions of lives across the Globe. Many patients hospitalized with COVID-19 infection have developed cardiac abnormalities and related ECG changes. Identifying ECG patterns that might be related to COVID-19 is vital. This study tried to find out relevant ECG findings associated with COVID-19 and to correlate these Electrocardiographic abnormalities with their severity. Most common finding was sinus tachycardia but others included SVTs such as Atrial fibrillation or flutter, ventricular arrhythmias such as VT or VF, bradycardia, interval and axis changes (QT prolongation) and ST-segment and T wave changes. Knowledge of these findings may assist clinicians in the evaluation, management and prognostication of COVID-19 infected patients. Larger studies comparing pre, post and follow-up ECGs of COVID-19 infected patients are needed for better management and treatment outcomes.

Ethics Approval and Consent to Participate : The project was approved by the Institutional Scientific Advisory Committee as well as the Institutional Ethics Committee. The study protocol was approved by the Clinical Trial Screening and the Ethics Committee of the hospital.

Availability of data and material : The data underlying this article will be shared on reasonable request to the corresponding author.

Competing interests : none declared

Funding Statement : none

Authors' contributions : All authors were involved in patient care, drafting and editing of the manuscript.

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