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Arrhythmias and Electrocardiographic findings in Coronavirus disease 2019: A Systematic Review and Meta-analysis

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Running title: COVID-19 & ECG Meta-analysis

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Disclosure of Data Availability: The data that support the findings of this systematic review and meta-analysis are available in the studies listed in references.

Disclosure of funding source: The present systematic review and meta-analysis has not received any grants or financial support.

Disclosure of Conflict of interest: Nothing to declare.

Ethical approval: Our meta-analysis was based on published data and did not require approval from an Ethical committee.

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ABSTRACT

Background: Coronavirus disease 2019 (COVID-19) primarily causes lung infection, but recent studies have shown that cardiac involvement is associated with a worse prognosis.

Objectives: We conducted a systematic review and meta-analysis to examine the prevalence of cardiac arrhythmias detected by the electrocardiogram and their relationships with adverse outcomes in patients with COVID-19.

Methods: PubMed and Google were searched for studies that reported on cardiac arrhythmias and/or examined the relationship between arrhythmias and adverse outcomes.

Results: Thirty studies with 12,713 participants were included in the systematic review, and 28 studies (n=12,499) in the meta-analysis. The mean age was 61.3 ±16.8 years; 39.3% were female. In 25 studies with 7,578 patients, the overall prevalence of cardiac arrhythmias was 10.3% (95% confidence interval [CI]: 8.4% to 12.3%). The most common arrhythmias documented during hospitalization were supraventricular arrhythmias (6.2%, 95% CI: 4.4% to 8.1%) followed by ventricular arrhythmias (2.5%, 95% CI: 1.8% to 3.1%). The incidence of cardiac arrhythmias was higher among critically ill patients (relative risk [RR]: 12.1, 95% CI: 8.5 to 17.3) and among non-survivors (RR: 3.8, 95%, CI: 1.7 to 8.7). Eight studies reported changes in the QT interval. The prevalence of QTc >500 ms was 12.3% (95% CI: 6.9% to 17.8%). ST-segment deviation was reported in eight studies, with a pooled estimate of 8.7% (95% CI: 7.3% to 10.0%).

Conclusion: Our meta-analysis showed that QTc prolongation, ST-segment deviation, and various other cardiac arrhythmias were observed in patients hospitalized with COVID-19. The presence of cardiac arrhythmias was associated with a worse prognosis.

Keywords: COVID-19; ECG; atrial fibrillation; ventricular tachyarrhythmias

Registration: PROSPERO ID: CRD42020184448

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Key messages

What is already known about this subject?

Coronavirus disease-2019 (COVID-19) is a novel viral infection with a wide spectrum of presentations, ranging from asymptomatic or mild symptomatic to severe forms. Cardiac involvement during COVID-19 has been associated with significant morbidity and mortality. However, the frequency of cardiac arrhythmias or electrocardiographic abnormalities and their prognostic implications in patients with COVID-19 remains uncertain.

What does this study add?

We found that new-onset cardiac arrhythmias, ST-segment deviation, and QTc prolongation were common findings in hospitalized patients with COVID-19. These findings were seen in about one in ten patients and occurred more frequently in critical care patients. Supraventricular arrhythmias were the most common, but any type of arrhythmias were associated with a worse prognosis.

How might this impact clinical practice?

Our findings suggest that the electrocardiogram can be a useful tool in the risk stratification of hospitalized patients with COVID-19. Telemetry can also be considered for all critically ill patients to detect new-onset cardiac arrhythmias.

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a potentially life-threatening infection caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1,2] SARS-CoV-2 utilizes the angiotensin-converting enzyme 2 as the host receptor to gain entry into the cell. Recent studies have reported significant cardiac involvement in patients infected with COVID-19,[3,4] and this presence has been associated with a worse prognosis.[5,6] The surface electrocardiogram (ECG) is one of the leading tools to assess potential cardiac involvement in hospitalized patients with COVID-19.[4] Existing data shows that cardiac arrhythmias area common complication of a COVID-19 infection, although their association with adverse outcomes remains to be fully defined.[7] The aim of our systematic review and meta-analysis was to estimate the prevalence of ECG abnormalities and cardiac arrhythmias in hospitalized patients with COVID-19 and to further evaluate the association of arrhythmias with patient outcomes.

METHODS

Study design and data sources

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[8] The protocol was registered in the PROSPERO database of systematic reviews (registration number: CRD42020184448). PubMed was searched for studies that reported the prevalence of cardiac arrhythmias detected by the ECG and/or reported the relationship between cardiac arrhythmias and adverse outcomes in COVID-19. The search was performed from database inception to August 30, 2020 without language restrictions. Search terms used were: “COVID” AND (“electrocardiogram” OR “ECG” OR “QT” OR “fibrillation” OR “arrhythm*” OR “LBBB” OR “RBBB” OR “bundle branch block” OR “QRS”). Gray literature and bibliographies of included studies were also searched to extend the search coverage. The exclusion criteria were: case reports, case series, reviews, preclinical studies, and preprints publications. Once duplicates were removed, two reviewers (YL and SGZ) independently screened titles and abstracts to ensure the capture of all relevant studies. Disagreements were resolved by discussion to achieve consensus.

Data extraction and quality assessment

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Data were extracted into predetermined tables using a standardized protocol. The data extracted were: first author, country of study, number of included patients, study design, age of participants, gender, prevalence of risk factors, previous cardiovascular events, history of arrhythmias, pharmacological treatments for COVID-19, type of ECG changes or arrhythmias, complications, and mortality during hospitalization for COVID-19.

Two reviewers (GB and GT) independently completed a risk of bias assessment using the Newcastle–Ottawa scale (NOS).[9] The NOS point scoring scale uses a star system in which each study is judged based on three domains: selection of the study groups (four items); comparability of the groups (one item); and exposure (ascertainment of the outcome; three items). A study can be awarded a maximum of one star for each numbered item within the selection and exposure categories, and a maximum of two stars for comparability.

Patient and public involvement

We performed this meta-analysis based on published data, and there were no patients or public involvement in this project.

Statistical analysis

For the outcomes of interest, mean differences with 95% confidence interval (CI) were extracted and subsequently pooled.[10] If the standard error (SE) or 95% CIs were not reported, calculations were made using the following formula:

SE = √ prevalence (1-prevalence) / n, &

95% CI = p ± 1.96 X SE

where "n" is the sample size.

Heterogeneity across studies was determined using the variance between the studies (Tau-square, τ^2) and the I^2statistic. The I^2 statistic, determined from the standard chi-square test, describes the total variance explained by heterogeneity rather than chance. I^2 >50% was considered to reflect significant statistical heterogeneity. If I^2 <50%, a fixed effects model was used; otherwise, the random-effects model using the inverse variance heterogeneity method was used.[11-13] To identify the source of the heterogeneity, sensitivity analysis using the leave-one-out method was used. To assess for possible publication bias, funnel plots, Begg's, and Egger's test were used.[14] Data analysis was performed using Review Manager (RevMan) (Version 5.3) and Stata (Version 13.0).

RESULTS

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Study selection

The search identified 488 records. After the removal of duplicates (n=37), 451 records were screened based on titles and abstracts. Of these, 316 records were excluded because they were editorials, position papers from scientific societies, or reviews. Subsequently, full texts of 135 articles were reviewed. Of these, 102 articles were non related to the topic of interest; three articles were excluded because the ECG data were out of the scope of this review;[15-17] Pavri *et al*.[15] were excluded because they evaluated the PR interval in hospitalized patients with COVID-19; Shi *et al*.[16] were excluded because they described the frequencies of patients with abnormal ECG findings but did not further delineate the abnormalities observed; and Lei *et al*.[17] were excluded because they included all patients who underwent elective surgeries, but the diagnosis of COVID-19 was made after the procedure. Finally, 30 studies were included in the qualitative review (**Figure 1**). Of these, 19 studies reported relevant ECG and/or arrhythmia findings.[18-36] The other 11 studies only specified cardiac arrhythmias in general without further elaboration.[37-47] For the meta-analysis, two studies (from the 30 included studies) were excluded as they only provided qualitative data on QT intervals.[30,32] The quality assessment of the included studies are summarized in **Table S1**.

Characteristics of the included studies and study participants

We included 30 studies with 12,713 participants. The sample size varied from 16 to 5700 patients (median: 128 patients, interquartile range: 90 to 380). The mean age was 61.3 ±16.7 years, and 42.0% were female. All of the included studies were cohort studies, with the exception of Borba *et al*.[20] who reported the findings of a randomized controlled trial. Most studies originated from the United States (n=13) and China (n=11). All but one study[34] included adult patients, with most participants over 40 years of age. Samuel *et al*.[34] included pediatric and adolescent patients, with a mean age of 13 ±6 years.

All studies reported medical comorbidities. The most common was hypertension (45%), followed by obesity (34%), and diabetes mellitus (24%). Obesity was most commonly reported among patients from the United States.[18,19,25,27-29,32,33,37,41-43] Overall, 11% of the patients had coronary artery disease. There were variations in the mortality rates amongst the studies (12% ±2%, range: 0% to 27.2%). There were variations in the disease severity of COVID-19 -ranging from stable to severe or critical patients requiring mechanical ventilation or cardiac support- and differences in the treatments offered (**Table 1 and 2**).

In our meta-analysis of 28 studies,[18-29,31,33-47] a total of 12,499 patients (mean age: 61.3 ±16.8 years; 39.3% female) were included. Prior history of cardiac arrhythmias was

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only reported in 10 studies,[19-21,23,24,27,29,32,33,46] which showed a prevalence of 8.7% ±2.5% (**Table 1 and 2**). Atrial fibrillation was the most observed arrhythmia in eight of the mentioned studies.

The overall prevalence of cardiac arrhythmias during COVID-19 hospitalization was 10.3% (95% CI: 8.4% to 12.3%) amongst 25 studies (n=7578), though there was substantial heterogeneity between the studies (I^2= 100%) (**Figure 1A**).Sensitivity analysis, excluding data from pediatric and adolescent patients, did not significantly alter the overall frequency of arrhythmias (10%, 95% CI: 8.1% to 12%) (**Figure S1**).

Specific types of arrhythmias were reported by 15 studies (**Table 3**). The most common was supraventricular tachyarrhythmias (n=3395 from nine studies, 6.2%, 95% CI: 4.4% to 8.1%; I^2 = 100%) (**Figure 1B**),[18,19,21,23,25,28,33-35] followed by ventricular tachyarrhythmias (n=3485 from 11 studies, 2.5%, 95% CI: 1.8% to 3.1%; I^2 = 100%) (**Figure 1C**).[19-22,25-27,29,34-36] Bradyarrhythmias were the least common (n=1560 from four studies, 1.8%, 95% CI: 1.0% to 2.5%; I^2 = 100%) (**Figure S2**).[18,19,21,28]

ST-segment changes and QT interval prolongation

Changes in the QT interval during COVID-19 hospitalization were reported by 16 studies (**Table 4**).[18,20,22,27-36,41-43] The most frequent criteria to define substantial QTc prolongation was QTc duration >500 milliseconds (ms) when the QRS duration was <120 ms and QTc >550 ms when the QRS duration was ≥120 ms. Due to disparities in the reported data, only six studies (n=4812) were included in our meta-analysis for QT prolongation.[18,20,22,29,31,42] The overall prevalence of QTc >500 ms was 12.3% (95% CI: 6.9% to 17.8%; I^2 = 100%) (**Figure 2A**).

The presence or absence of ST-segment deviation was reported in eight studies (n=1598) with a pooled estimate of 8.7% (95% CI: 7.35% to 10.0%; I^2=100%) (**Figure 2B**).[18,21,23,24,27,34,37]

Relationship between cardiac arrhythmias and adverse outcomes

Eight studies reported the relationship between new-onset cardiac arrhythmias and adverse outcomes in patients with COVID-19 (n=2112, 56.1 ±17.8 years, 46.4% female).[19,21,23,25,36,44,46,47] Regarding the definition of disease severity, Bhatla *et al*.,[19] Colon *et al*.[23] Yenercag *et al*.[36] Wang *et al*.[44] and Zeng *et al*.[46] classified disease severity based on ICU admission, whereas Goyal *et al*.[25] classified it based on the need for mechanical ventilation. Chen *et al*.[21] and Zhang *et al*.[47] classified disease

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severity based on ICU admission and/or other clinical parameters, including oxygen saturation ≤93%, respiratory rate ≥30 times per minute, or severe respiratory distress.

Critically ill patients showed a higher risk of developing cardiac arrhythmias compared to those who were not critically ill (risk ratio [RR]: 12.1, 95% CI: 8.5 to 17.3; I^2 = 0%) (**Figure 2C**), both for ventricular arrhythmias (RR: 10.5, 95% CI: 3.9 to 27.9; I^2 = 0% (**Figure S3**) and supraventricular arrhythmias (RR: 10.1, 95% CI: 5.7 to 17.2; I^2 = 0%) (**Figure S4**).

The relationship between cardiac arrhythmias and inpatient mortality was only reported by three studies (n=1197, 62 ±16 years old, 45.0% female).[28,36,45] Non-survivors were more likely to develop cardiac arrhythmias compared to survivors during their inpatient stay (RR: 3.8,95% CI: 1.7 to 8.7; I^2=76%) (**Figure 2D**). Of these three studies, only one reported the specific type of arrhythmias observed, which was supraventricular arrhythmias observed in all patients.[28] In this study, non-survivors were also found to be at a higher risk of developing supraventricular arrhythmias (RR: 2.3, 95% CI: 1.2 to 4.5) (**Figure S5**).

In **Figure 4**, we have summarized the main findings our study relating to cardiac arrhythmias and ECG abnormalities among hospitalized COVID-19.

Regarding potential publication bias between analyzed studies, a visual inspection of funnel plots suggested an asymmetric distribution of the occurrence of cardiac arrhythmias in hospitalized COVID-19 patients (**Figure S6**). The Begg's test suggested no significant publication bias (z=1.38; p=0.17). The Egger test demonstrated significant asymmetry (t-value -3.0; p=0.006) (**Figure S7**). Sensitivity analysis, excluding one study at a time (leave-one-out method), did not reduce the heterogeneity of the results.

DISCUSSION

The main findings of this systematic review and meta-analysis are: i) cardiac arrhythmias are a common complication among hospitalized COVID-19 patients, and ii) cardiac arrhythmias can be considered a marker of worsening prognosis.

To the best of our knowledge, this is the largest meta-analysis reporting on the prevalence of ECG findings in hospitalized COVID-19 patients. We found that the frequency of cardiac arrhythmias showed a wide range across the studies, which could be attributable to the differences in the patients' comorbidities and variations seen across disease severity and treatments offered. In our study, premature beats were excluded in order to avoid an overestimation of the clinically significant arrhythmias. Among specific arrhythmias reported across the studies, supraventricular arrhythmias were the most frequent, followed by

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ventricular arrhythmias. In contrast, bradyarrhythmias were the least observed arrhythmias. Furthermore, the risk of cardiac arrhythmias was higher among non-survivors and critically ill patients hospitalized with COVID-19.

ST-segment changes were the most frequently reported ECG finding. This is a significant ECG abnormality caused by different pathologies such as pericarditis, Takotsubo cardiomyopathy, and acute coronary syndrome. Additionally, QTc prolongation is a significant concern during COVID-19 infection and could be largely attributable to drugs that cause delayed repolarization.[3] However, we were unable to fully evaluate the prognostic implications of ST-segment changes and QT prolongation due to the significant disparities in the reported data across the studies.

Cardiac involvement in COVID-19 has a wide spectrum, and contemporary high sensitivity troponin tests might be elevated in critically ill patients even without apparent myocardial involvement.[48.49] Nevertheless, previous studies have linked cardiac involvement with a worse prognosis in COVID-19.[50] ECG abnormalities are intrinsically related to cardiac pathology, and our findings are in agreement with these observations.

Limitations

Our study has important limitations. Firstly, about half of the included articles did not report the types of arrhythmias observed. We were, therefore, unable to accurately estimate the incidence and prevalence of electrocardiographic abnormalities in hospitalized patients with COVID-19. Secondly, we could not investigate the relationship between specific types of arrhythmias and the severity of COVID-19 infection. This information was not consistently reported across the included studies, likely because most studies did not examine cardiac arrhythmias as a specific risk factor for adverse outcomes. Finally, we found high heterogeneity for most comparisons except for the occurrence of arrhythmias in critically ill patients. Nevertheless, such heterogeneity could have a clinical origin due to the differences in the study cohorts amongst the included studies.

CONCLUSION

Our systematic review and meta-analysis showed that QTc prolongation, ST-segment deviation, and other forms of cardiac arrhythmias were observed in patients hospitalized with COVID-19. The presence of cardiac arrhythmias was associated with a worse prognosis.

Future studies are needed to explore the possible role of arrhythmias in relation to patient outcomes.

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References

1) Ruan Q, Yang K, Wang W, Jiang L, Song J. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. *Intensive Care Med*. 2020;46(5):846–8. DOI: 10.1007/s00134-020-05991-x

2) Li X, Guan B, Su T, Wei L, Mengyao C, Bin Waleed K, et al. Impact of cardiovascular disease and cardiac injury on in-hospital mortality in patients with COVID-19: A systematic review and meta-analysis. *Heart*. 2020;106(15):1142–7. DOI: 10.1136/heartjnl-2020-317062

3) Haseeb S, GulEE, ÇinierG, Bazoukis G, Alvarez-Garcia J, Garcia-Zamora S, et al. Value of electrocardiography in coronavirus disease 2019 (COVID-19). *J Electrocardiol*. 2020;62:39-45. DOI: 10.1016/j.jelectrocard.2020.08.007

4) Fried JA, Ramasubbu K, Bhatt R, Topkara VK, Clerkin KJ, Horn E, et al. The Variety of Cardiovascular Presentations of COVID-19. *Circulation*. 2020;141(23):1930–6. DOI: 10.1161/CIRCULATIONAHA.120.047164

5) Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential Effects of Coronaviruses on the Cardiovascular System: A Review. *JAMA Cardiol*. 2020;5(7):831-840.DOI: 10.1001/jamacardio.2020.1286

6) Wang Y, Roever L, Tse G, Liu T. 2019-Novel Coronavirus-Related Acute Cardiac Injury Cannot Be Ignored. *CurrAtheroscler Rep*. 2020;22(3):14. DOI: 10.1007/s11883-020-00842-y

7) Jain V, Yuan J-M. Predictive symptoms and comorbidities for severe COVID-19 and intensive care unit admission: A systematic review and meta-analysis. *Int J Public Health*. 2020;65(5):533–46. DOI: 10.1007/s00038-020-01390-7

8) Moher D, Liberati A, Tetzlaff J, Altman DG. PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. 2009;6(7):e1000097. DOI: 10.1371/journal.pmed.1000097

9) Wells A, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analysis. http://www.ohri.ca/ programs/clinical_epidemiology/oxford.asp n.d.

Accepted Article

10) Wang X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol*. 2014;14:135. DOI: 10.1186/1471-2288-14-135

11) Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21(11):1539–58. DOI: 10.1002/sim.1186

12) Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557–60. DOI: 10.1136/bmj.327.7414.557

13) DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7(3):177–88. DOI: 10.1016/0197-2456(86)90046-2

14) Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org n.d.

15) Pavri BB, Kloo J, Farzad D, Riley JM. Behavior of the PR interval with increasing heart rate in patients with COVID-19. *Heart Rhythm*. 2020;17(9):1434-8. DOI: 10.1016/j.hrthm.2020.06.009

16) Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F, et al. Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. *JAMA Cardiol*. 2020;5(7):802:10. DOI: 10.1001/jamacardio.2020.0950

17) Lei S, Jiang F, Su W, Chen C, Chen J, Mei W, et al. Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. *EClinicalMedicine*2020;21:100331. DOI: 10.1016/j.eclinm.2020.100331

18) Angeli F, Spanevello A, De Ponti R, Visca D, Marazzato J, Palmiotto G, et al. Electrocardiographic features of patients with COVID-19 pneumonia. *Eur J Intern Med*. 2020;78:101–6. DOI: 10.1016/j.ejim.2020.06.015

19) Bhatla A, Mayer MM, Adusumalli S, Hyman MC, Oh E, Tierney A, et al. COVID-19 and cardiac arrhythmias. *Heart Rhythm*. 2020;17(9)1439-44. DOI: 10.1016/j.hrthm.2020.06.016

20) Borba MGS, Val FFA, Sampaio VS, Alexandre MAA, Melo GC, Brito M, et al. Effect of High vs Low Doses of Chloroquine Diphosphate as Adjunctive Therapy for Patients Hospitalized With Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)

Accepted Article

Infection: A Randomized Clinical Trial. *JAMA Netw Open*. 2020;3(4): e208857. DOI: 10.1001/jamanetworkopen.2020.8857

21) Chen Q, Xu L, Dai Y, Ling Y, Mao J, Qian J, et al. Cardiovascular manifestations in severe and critical patients with COVID-19. *Clin Cardiol*. 2020;43(7):796-802. DOI: 10.1002/clc.23384

22) Chorin E, Wadhwani L, Magnani S, Dai M, Shulman E, Nadeau-Routhier C, et al. QT interval prolongation and torsade de pointes in patients with COVID-19 treated with hydroxychloroquine/azithromycin. *Heart Rhythm*. 2020;17(9):1425-33. DOI: 10.1016/j.hrthm.2020.05.014

23) Colon CM, Barrios JG, Chiles JW, McElwee SK, Russell DW, Maddox WR, et al. Atrial Arrhythmias in COVID-19 Patients. *JACC Clin Electrophysiol*. 2020;6(9):1189–1190. DOI: 10.1016/j.jacep.2020.05.015

24) Deng Q, Hu B, Zhang Y, Wang H, Zhou X, Hu W, et al. Suspected myocardial injury in patients with COVID-19: Evidence from front-line clinical observation in Wuhan, China. *Int J Cardiol*. 2020;311:116–21. DOI: 10.1016/j.ijcard.2020.03.087

25) Goyal P, Choi JJ, Pinheiro LC, Schenck EJ, Chen R, Jabri A,et al. Clinical Characteristics of COVID-19 in New York City. *N Engl J Med*. 2020;382(24):2372–4. DOI: 10.1056/NEJMc2010419

26) Guo T, Fan Y, Chen M, Wu X, Zhang L, He T, et al. Cardiovascular Implications of Fatal Outcomes of Patients With Coronavirus Disease 2019 (COVID-19). *JAMA Cardiol*. 2020;5(7):1-8. DOI: 10.1001/jamacardio.2020.1017

27) Jain S, Workman V, Ganeshan R, Obasare ER, Burr A, DeBiasi RM, et al. Enhanced electrocardiographic monitoring of patients with Coronavirus Disease 2019. *Heart Rhythm*. 2020;17(9):1417-22. DOI: 10.1016/j.hrthm.2020.04.047

28) McCullough SA, Goyal P, Krishnan U, Choi JJ, Safford MM, Okin PM.. Electrocardiographic Findings in Coronavirus Disease-19: Insights on Mortality and Underlying Myocardial Processes. *J Card Fail*. 2020;26(7):626–32. DOI: 10.1016/j.cardfail.2020.06.005

29) Mercuro NJ, Yen CF, Shim DJ, Maher TR, McCoy CM, Zimetbaum PJ, et al. Risk of QT Interval Prolongation Associated With Use of Hydroxychloroquine With or Without Concomitant Azithromycin Among Hospitalized Patients Testing Positive for Coronavirus

Accepted Article

Disease 2019 (COVID-19). *JAMA Cardiol*. 2020;5(9):1036-1041. DOI: 10.1001/jamacardio.2020.1834

30) Öztürk F, Karaduman M, Çoldur R, İncecik Ş, Güneş Y, Tuncer M. Interpretation of arrhythmogenic effects of COVID-19 disease through ECG. *Aging Male*. 2020:1–4. DOI: 10.1080/13685538.2020.1769058

31) Ramireddy A, Chugh H, Reinier K, Ebinger J, Park E, Thompson M, et al. Experience With Hydroxychloroquine and Azithromycin in the Coronavirus Disease 2019 Pandemic: Implications for QT Interval Monitoring. *J Am Heart Assoc*. 2020;9(12):e017144. DOI: 10.1161/JAHA.120.017144

32) Rath D, Petersen-Uribe Á, Avdiu A, Witzel K, Jaeger P, Zdanyte M, et al. Impaired cardiac function is associated with mortality in patients with acute COVID-19 infection. *Clin Res Cardiol*. 2020 ;1-9. DOI: 10.1007/s00392-020-01683-0

33) Sala S, Peretto G, De Luca G, Farina N, Campochiaro C, Tresoldi M, et al. Low prevalence of arrhythmias in clinically stable COVID-19 patients. *Pacing Clin Electrophysiol*. 2020;10.1111/pace.13987. DOI: 10.1111/pace.13987

34) Samuel S, Friedman RA, Sharma C, Ganigara M, Mitchell E, Schleien C, et al. Incidence of arrhythmias and electrocardiographic abnormalities in symptomatic pediatric patients with PCR-positive SARS-CoV-2 infection, including drug-induced changes in the corrected QT interval. *Heart Rhythm*. 2020;17(11):1960-1966. DOI: 10.1016/j.hrthm.2020.06.033

35) Si D, Du B, Ni L, Yang B, Sun H, Jiang N, et al. Death, discharge and arrhythmias among patients with COVID-19 and cardiac injury. *CMAJ*. 2020;192(28):E791-E798. DOI: 10.1503/cmaj.200879

36) Yenerçağ M, Arslan U, Doğduş M, Günal Ö, Öztürk ÇE, Aksan G, et al. Evaluation of electrocardiographic ventricular repolarization variables in patients with newly diagnosed COVID-19. *J Electrocardiol*. 2020;62:5–9. DOI: 10.1016/j.jelectrocard.2020.07.005

37) Aggarwal S, Garcia-Telles N, Aggarwal G, Lavie C, Lippi G, Henry BM. Clinical features, laboratory characteristics, and outcomes of patients hospitalized with coronavirus disease 2019 (COVID-19): Early report from the United States. *Diagnosis (Berl).* 2020;7(2):91–6. DOI: 10.1515/dx-2020-0046

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38) Cao J, Tu W-J, Cheng W, Yu L, Liu YK, Hu X, et al. Clinical Features and Short-term Outcomes of 102 Patients with Coronavirus Disease 2019 in Wuhan, China. *Clin Infect Dis*. 2020;71(15):748–55. DOI: 10.1093/cid/ciaa243

39) Du Y, Tu L, Zhu P, Mu M, Wang R, Yang P, et al. Clinical Features of 85 Fatal Cases of COVID-19 from Wuhan. A Retrospective Observational Study. *Am J Respir Crit Care Med*. 2020;201(11):1372–9. DOI: 10.1164/rccm.202003-0543OC

40) Hou W, Zhang W, Jin R, Liang L, Xu B, Hu Z. Risk factors for disease progression in hospitalized patients with COVID-19: a retrospective cohort study. *Infect Dis (Lond)*. 2020;52(7):498–505. DOI: 10.1080/23744235.2020.1759817

41) Mani VR, Kalabin A, Valdivieso SC, Murray-Ramcharan M, Donaldson B. At the epicenter of the American Coronavirus outbreak - New York inner city hospital COVID-19 experience and current data: a retrospective analysis. *J Med Internet Res*. 2020;22(9):e20548.. DOI: 10.2196/20548

42) Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. *JAMA*. 2020;323(20):2052-9. DOI: 10.1001/jama.2020.6775

43) Rosenberg ES, Dufort EM, Udo T, Wilberschied LA, Kumar J, Tesoriero J, et al. Association of Treatment With Hydroxychloroquine or Azithromycin With In-Hospital Mortality in Patients With COVID-19 in New York State. *JAMA*. 2020;323(24):2493-2502. DOI: 10.1001/jama.2020.8630

44) Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *JAMA*. 2020;323(11):1061-1069. DOI: 10.1001/jama.2020.1585

45) Wang L, He W, Yu X, Hu D, Bao M, Liu H, et al. Coronavirus disease 2019 in elderly patients: Characteristics and prognostic factors based on 4-week follow-up. *J Infect*. 2020;80(6):639–45. DOI: 10.1016/j.jinf.2020.03.019

46) Zeng JH, Wu W-B, Qu JX, Wang Y, Dong CF, Luo YF, et al. Cardiac manifestations of COVID-19 in Shenzhen, China. *Infection*. 2020;1-10. DOI: 10.1007/s15010-020-01473-w

Accepted Article

47) Zhang G, Hu C, Luo L, Fang F, Chen Y, Li J, et al. Clinical features and short-term outcomes of 221 patients with COVID-19 in Wuhan, China. *J Clin Virol*. 2020;127:104364. DOI: 10.1016/j.jcv.2020.104364

48) Momtazmanesh S, Shobeiri P, Hanaei S, Mahmoud-Elsayed H, Dalvi B, Malakan Rad E. Cardiovascular disease in COVID-19: a systematic review and meta-analysis of 10,898 patients and proposal of a triage risk stratification tool. *Egypt Heart J*. 2020;72(1):41. DOI: 10.1186/s43044-020-00075-z

49) Newby LK, Jesse RL, Babb JD, Christenson RH, De Fer TM, Diamond GA, et al. ACCF 2012 expert consensus document on practical clinical considerations in the interpretation of troponin elevations: a report of the American College of Cardiology Foundation task force on Clinical Expert Consensus Documents. *J Am Coll Cardiol*. 2012;60(23):2427–63. DOI: 10.1016/j.jacc.2012.08.969

50) Li JW, Han TW, Woodward M, Anderson CS, Zhou H, Chen YD, et al. The impact of 2019 novel coronavirus on heart injury: A Systematic review and Meta-analysis. *Prog Cardiovasc Dis*. 2020;63(4):518-524. DOI: 10.1016/j.pcad.2020.04.008

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LEGENDS FOR THE FIGURES AND TABLES

Figure 1: Flow diagram of included studies.

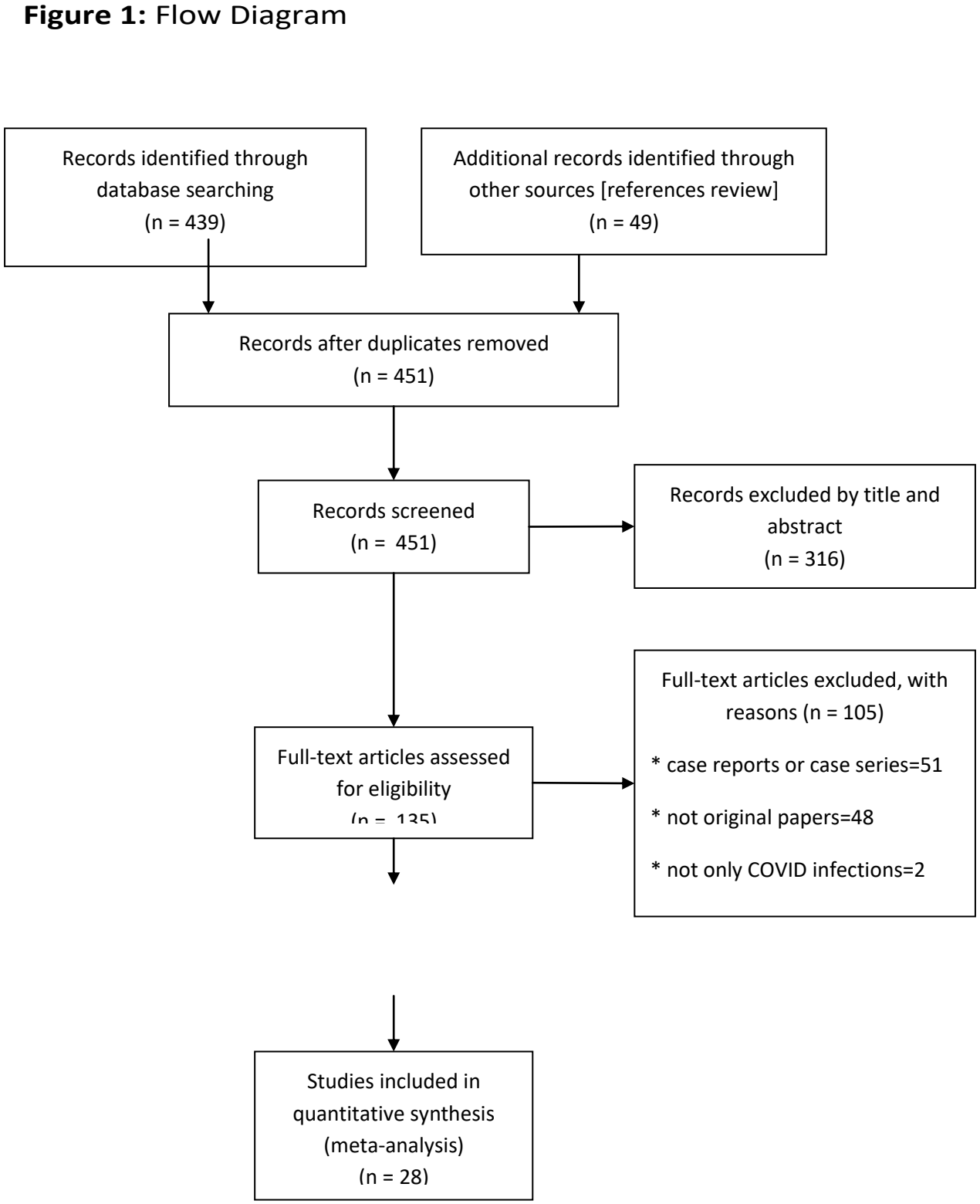

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Figure 2: Forest plot of the prevalence of arrhythmias in hospitalized patients with COVID-19.

A: prevalence of arrhythmias in analyzed studies; **B:** prevalence of supraventricular arrhythmias; **C:** prevalence of ventricular arrhythmias.

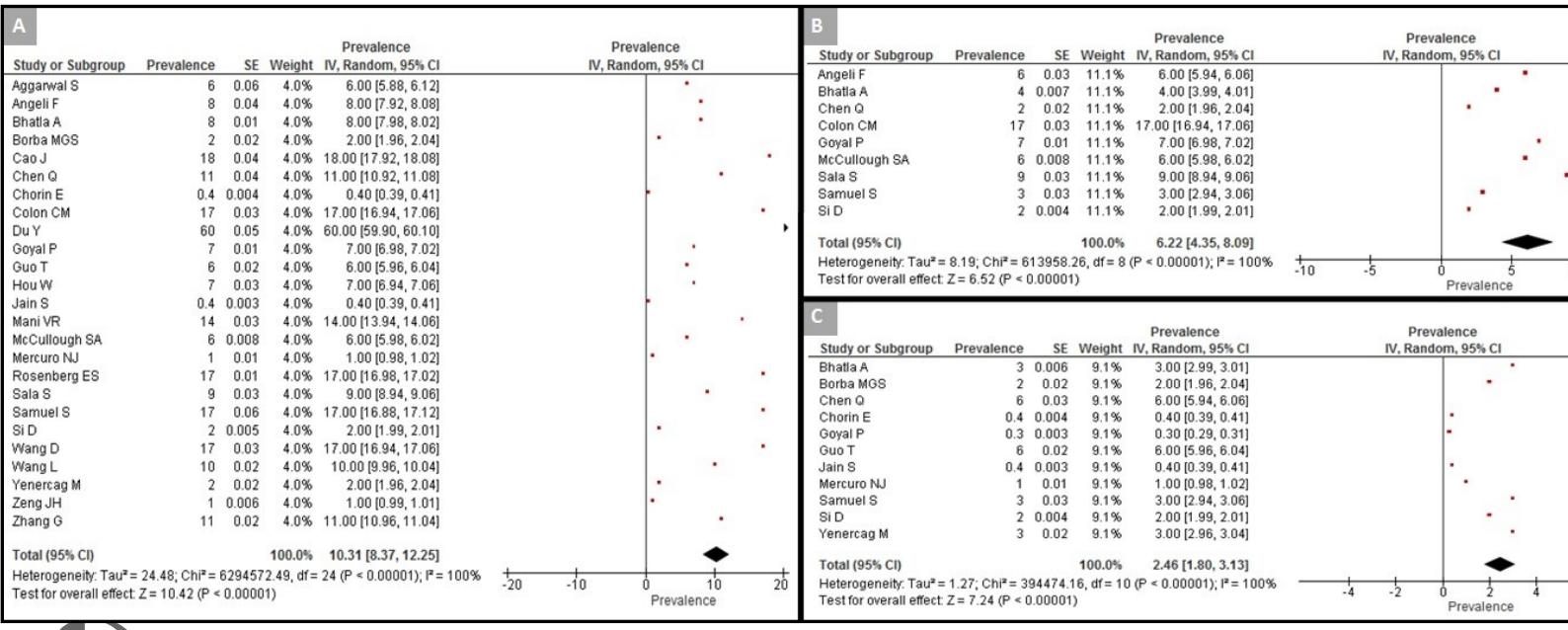

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Figure 3: Forest plot for QT prolongation, ST prevalence, and arrhythmias among hospitalized patients with COVID-19.

A: prevalence of corrected QT >500 milliseconds; **B:** prevalence of ST-segment deviation; **C:** prevalence of arrhythmias in critical and non-critical patients; **D:** prevalence of arrhythmias in survivors and non-survivors of COVID-19.

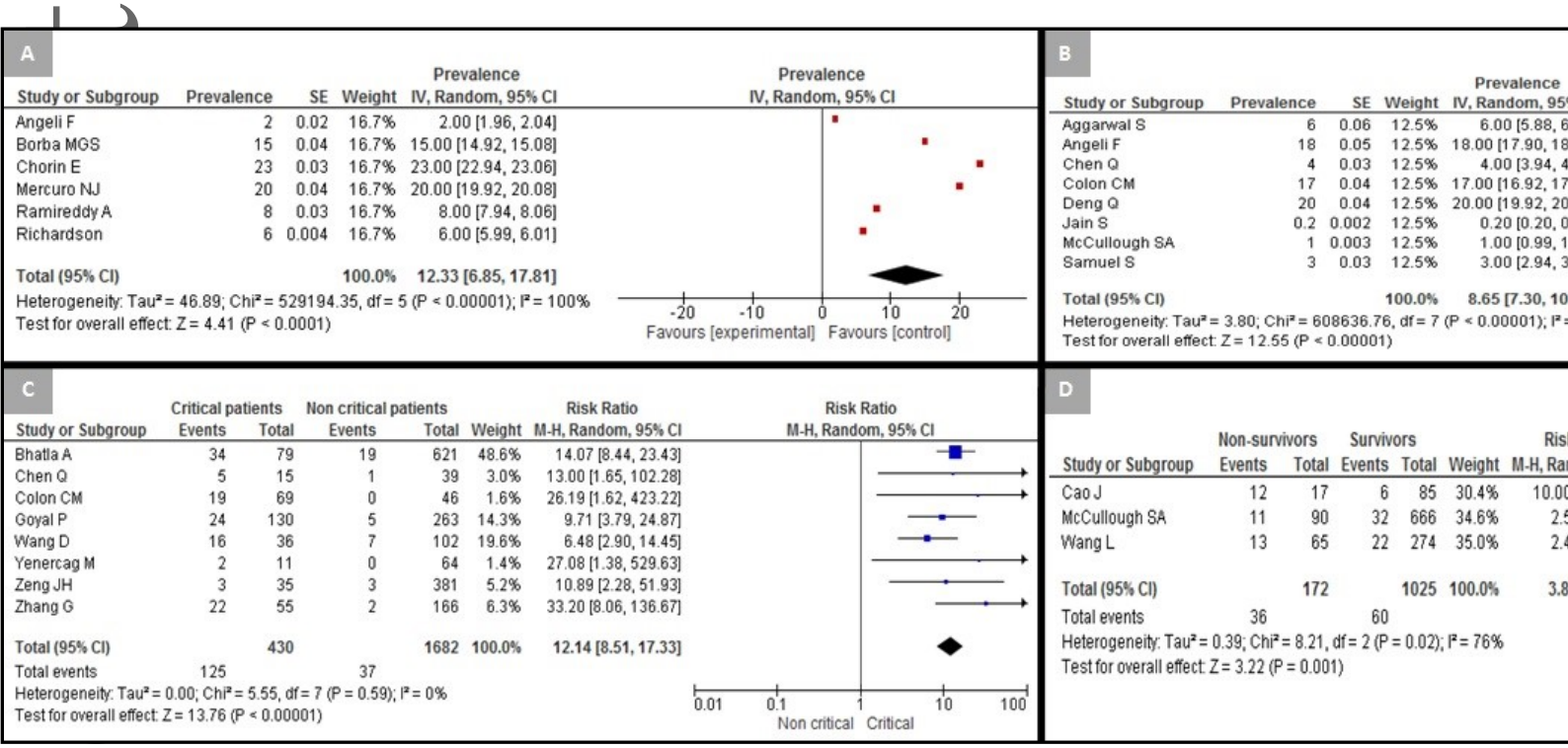

Figure 4: Cardiac arrhythmias and electrocardiographic abnormalities in hospitalized patients with COVID-19.

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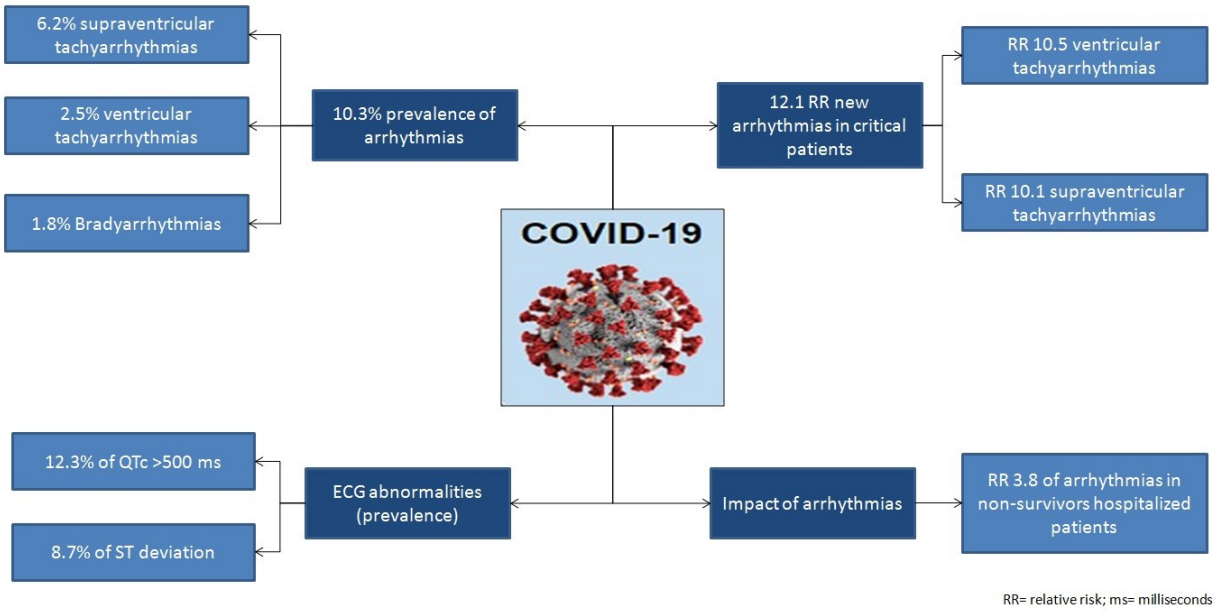

RR= relative risk; ms= milliseconds

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Table 1: Demographic and baseline characteristics of included studies with electrocardiographic data.

Author	Sample size	Country	Age	Female sex	Risk factors/Comorbidities	Prior CV events & Arrhythmias	Tr
Angeli F[18]	50	Italy	64 ±15	38%	BMI 26.8±4,4 kg/m^2; 50% HTN; 12% DM; 2% COPD; 10% smoker	10% CAD; 6% CHF;	82% 56% 54%
Bhatla A[19]	700	United States	50 ±18	55%	BMI 31±9 kg/m^2; 50% HTN; 26% DM; 9% COPD; 11% CKD; 9% smoker	11% CAD; 13% CHF; 6% AF	25% 8% R
Borba MGS[20]	81	Brazil	51.1±13.9	24.7%	45.5% HTN; 25.5% DM; 7.4% CKD; 8.3% smoker	3.6% CAD; 3.6% CHF; 1.9% Atrioventricular block	100% 100% 86.4%
Chen Q[21]	54	China	56.1 ±13.5 61.7 ±9.6$^{\lambda}$	33.3%	29.6% HTN; 46.3% DM; 0% COPD	11.1% CAD; 0% CHF; 1.9% CeVD; 1.9% AF	
Chorin E[22]	251	United States & Italy	64 ±13	25%	54% HTN; 27% DM; 7% COPD; 11% CKD	12% CAD; 3% CHF	100% 100%
Colon CM[23]	115	United States	56 ±17	46%	70% HTN; 39% DM; 13% COPD; 14% CKD; 42% smoker$^{\epsilon}$	16% CAD; 4.4% AF	6.1% 43.5% 7% R
Deng Q[24]	112	China	65 (49-70.8)	49.1%	32.1% HTN; 17% DM; 3.6% COPD	13.4% CAD; 3.6% AF	
Goyal P[25]	393	United States	62,2 (48.6-73.7)	39.4%	35.8% obesity; 50.1% HTN; 25.2% DM; 5.1% COPD; 5.1% smoker	13,7% CAD	64% 4.3%
Guo T[26]	187	China	58.5 ±14.7	51.3%	32.6% HTN; 15% DM; 3.2% CKD	11.2% CAD; 4.3% CHF	98% 89%
Jain S[27]	459	United States	68.2 ±15.2	37.9%	16.5% morbid obesity; 59.2% HTN; 48.5% DM; 31.1% CKD	18.4% CAD; 15.5% CHF; 13.6% CeVD; 19.4% AF/AFL	90.4% 2.9%

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							20.5% 5.7%
McCullough SA[28]	756	United States	63.3 ±16	36.8%	37.3% obesity; 56.5% HTN; 29.4% DM; 18.8% pulmonary disease; 9.5% renal disease	14.4% CAD; 7.3% CHF; 7.3% CeVD	None
Mercuro NJ[29]	90	United States	60.1 ±16.7	48.9%	BMI 31.5 ±6.6 kg/m^2; 53.3% HTN; 28.9% DM; 20% COPD	11.1% CAD; 10% CHF; 13.3% AF	100% 58.9%
Öztürk F[30]	91[£]	Turkey	49.2 ±16.7	43.1%	11.8% HTN; 11.7% DM; other risk factors excluded	Prior CV disease and arrhythmias excluded	
Ramireddy A[31]	98	United States	62.3 ±17	39%	60% HTN; 22% DM; 26% COPD; 14% CKD	20% CHF; prior arrhythmias excluded	72.5% 89.8%
Rath D[32]	123	Germany	68 ±15	37.4%	19.5% obesity; 69.9% HTN; 24.4% DM; 11.4% CKD; 0.8% smoker[€]	22.8% CAD 22.8% AF	
Sala S[33]	132	Italy	65 ±14	NA	14% obesity; 45% HTN; 20% DM; 6% COPD	7% CAD 12% AF; 0,9% PSVT	100% 100%
Samuel S[34]	36	United States	12.6 ±6	44,4%	5.5% obesity; 17% malignancy; 8% asthma; 11% sickle cell;	55.5% on home medications; 8% cerebral palsy /seizures	69.4% 25% 5.6%
Si D[35]	1159	China	61.5 (32-69) vs 64 (24-70)[Ω]	45,3%	55.9% HTN; 21.8% DM; 5.3% CKD; 6.5% COPD	17.7% CAD; 3.5% CeVD	
Yenercag M[36]	75	Turkey	55.5 ±17.1	48%	BMI 24.1 ±3.5 kg/m^2; 52% HTN; 36% DM; 37% smoker	CAD, CHF, AF, CeVD and CKD were excluded	

Abbreviations: BMI= body mass index; HTN= hypertension; DM= diabetes mellitus; COPD= chronic obstructive pulmonary disease; CAD= coronary artery disease; CHF= congestive heart failure; HCQ=hydroxycloroquine; ICU= intensive care units; CKD= chronic kidney disease; AF= atrial fibrillation; RDV= Remdesivir; CeVD= cerebrovascular disease; AFL= atrial flutter; PSVT= paroxysmal supraventricular tachycardia; vs= versus; IQR= interquartile range; NA= not available; CVD= cardiovascular disease; CV= cardiovascular.

[1]Any one of the following: respiratory failure and an artificial airway required for invasive mechanical ventilation; shock; combining failure of other organs which requires ICU monitoring and treatment.

[2]Reported only for a subset of patients

[λ]Severe and critical patients, respective. *Could be slightly overestimated due to some treatments were reported in combination. [€]Current or former smoker. [£]51 COVID-19 patients and 40 controls. [Ω]Discharged alive and died in hospital, respective.

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Table 2: Demographic and baseline characteristics of included studies without electrocardiographic data.

Author	Sample size	Country	Age	Female sex	Risk factors / Comorbidities	Prior CV events	Tr
Aggarwal S[37]	16	United States	67 (38-95)	25%	50% obesity; 57% HTN; 31% DM; 38% CKD; 13% COPD; 0% smoker	19% CAD; 25% CHF; 13% CeVD	69% 43%
Cao J[38]	102	China	54 (37-67)	48%	BMI IQR 21.8-26; 27.5% HTN; 10.8% DM; 3.9% CKD; 9.8% respiratory disease	4.9% CVD disease; 5.9% CeVD	99% 98%
Du Y[39]	85	China	65.8 ±14.2	27.1%	37.6% HTN; 22.4% DM; 3.5% CKD; 2.4% COPD	11.8% CVD; 8.2% CeVD	90.6% 91.8%
Hou W[40]	101	China	50.9 ±20.1	56.4%	20.8% HTN; 5.9% DM; 4% COPD	10.9% CAD; 3% CeVD	34.7%
Mani VR[41]	184	United States	64.7 ±14.9	39.7%	38.6% obesity; 65.8% HTN; 43.5% DM; 17.4% CKD; 9.2% COPD	20.1% CAD	70.7% 61.4%
Richardson S[42]	5700	United States	63 (52-75)	39.7%	41.7% obesity; 56.6% HTN; 33.8% DM; 5% CKD; 5.4% COPD; 15.6% smoker[€]	11.1% CAD; 6.9% CHF	
Rosenberg ES[43]	1438	United States	63.4 (IQR NA)	40.3%	30.5% obesity; 56.8% HTN; 35.1% DM; 13% CKD; 18% respiratory disease	12% CAD; 6.7% CHF	69.9% 65.8%
Wang D[44]	138	China	56 (42-68)	45.7%	31.2% HTN; 10.1% DM; 2.9% CKD; 2.9% COPD	14.5% CVD; 5.1% CeVD	18.1% 89.9%
Wang L[45]	339	China	69 (65-76)	51%	40.8% HTN; 16% DM; 3.8% CKD; 6.2% COPD	15.7% CVD; 6.2% CeVD	
Zeng JH[46]	416	China	45 (33-57) 64 (60-68)[¥]	52.4%	14.4% HTN; 5.5% DM; 0.5% CKD; 1.2% COPD	3.1% CAD; 1% prior arrhythmias	
Zhang G[47]	221	China	55 (39-66.5)	51.1%	24.4% HTN; 10% DM; 2.7% CKD; 2.7% COPD	10% CVD; 6.8% CeVD	88.7%

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Abbreviations: BMI= body mass index; HTN= hypertension; DM= diabetes mellitus; COPD= chronic obstructive pulmonary disease; CAD= coronary artery disease; CHF= congestive heart failure; HCQ=hydroxychloroquine; ICU= intensive care units; CKD= chronic kidney disease; RDV= Remdesivir; CeVD= cerebrovascular disease; IQR= interquartile range; NA= not available; CVD= cardiovascular disease; CV= cardiovascular.

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Table 3: Arrhythmias observed in the included studies.

Study	Supraventricular	Ventricular	Bradyarrhythmias	Combined
AngeliF[18]	3 AF	-	1 tachy/brady	-
BhatlaA[19]	25 incident AF	9 cardiac arrests, 10 NSVTs	9 bradyarrhythmias	-
BorbaMGS[20]	-	2 VT	-	-
Chen Q[21]	1 AF 1	3 VT	2 complete AV block	-
ChorinE[22]	-	1 TdP	-	-
Colon CM[23]	12 AF, 6 AFL, 1AT	-	-	-
Goyal P[25]	28*	1 VT	-	-
Guo T[26]	-	11 VT/VF	-	-
Jain S[27]	-	2 VT	-	-
McCullough SA[28]	42 AF or AFL	-	1 complete AV block	-
Mercuro NJ[29]	-	1 TdP	-	-
Sala S[33]	8 AF, 3 AT & 1 PSVT	-	-	-
Samuel S[34]	1 AT	5 VT	-	-
Si D[35]	22 AT/AF	3 VT/VF	-	3 AT/AF + VT/VF
Yenercag M[36]	-	2 VT	-	-

Abbreviations: AF= atrial fibrillation; tachy/brady= tachycardia-bradycardia syndrome; NSVT= non sustained ventricular tachycardia; VT= ventricular tachycardia; AV block= Atrioventricular block; VF= ventricular fibrillation; TdP= torsade de pointes; AFL= atrial flutter; AT= atrial tachycardia.

* declared as “Atrial arrhythmia”

Table 4: QTc information in the included studies.

Author	Baseline QTc (ms)	SD (+/-)	Comments
AngeliF[18]	428	26 ms	1 patient with QTc >500 ms
BorbaMGS[20]	424.7	27.4	15.1% QTc >500 ms
ChorinE[22]	439	29	23% QTc >500 ms
Jain S[27]	22.4% patients with QT prolongation[£]. No episodes of torsades de pointes. 2 episodes of VT.		
Mani VR[41]	Isolated QT prolongation in 3.8% of the patients and sinus tachycardia with QT prolongation in 1.9% of the patients		
McCullough SA[28]	449	144 ms	No differences in QTc between survivors and non-survivors of COVID-19.
MercuroNJ[29]	455	430-474	20% QTc >500 ms
ÖztürkF[30]	410.4	24.5 ms	3 patients died, all with QTc <430 ms
RamireddyA[31]	448	29	Prolonged QTc in 12% of the patients post-treatment (QTc >500 ms if QRS <120 ms& QTc >550 ms if QRS ≥120 ms OR QTc >60 ms from baseline)
Rath D[32]	445	33 ms	No differences in QTc between survivors and non-survivors of COVID-19
Richardson S[42]	6.1% of patients with QTc >500 ms over 4250 patients (from automated ECG reading)		
Rosenberg ES[43]	11% of QTc prolongation with HCQ+AZN; 14.4% QTc prolongation with HCQ alone; 7.1% QTc prolongation with AZN alone & 5.9% QTc prolongation with neither drug (p=0.006)		
Sala S[33]	No patients with QTc interval > 450 ms, despite drugs administered for COVID-19 treatment		
Samuel S[34]	412	19 ms	Use of HCQ with or without AZN was associated with QTc prolongation (411±19 ms versus 426±15 ms, p<0.0001). QTc was not different in patients with and without arrhythmias (425±15 ms versus 425 ±15 ms, p=1.0)
Si D[35]	QTc interval was measured in 35 patients and was prolonged by an average of 45 ms in those treated with QT-prolonging medications (455 ms [423-480] versus 410 ms [364-430], p=0.01). Fatal VT/VF occurred in6 patients, but only 2 had ECGs recorded before death (1 with QTc prolongation and the other with normal QTc)		
Yenercag M[36]	411.1	23.9 ms	Patients using QT-prolonging medications were excluded

Abbreviations: QTc= corrected QT interval; ms= milliseconds; SD= standard deviation; VT= ventricular tachycardia; HCQ= Hydroxychloroquine; AZN= Azithromycin; VF= ventricular fibrillation.

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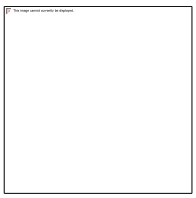
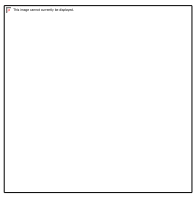
£QTc interval >470 ms for QRS duration ≤120 ms or QTc interval > 500 ms for QRS duration >120 ms.





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