Incidence and implications of atrial fibrillation in patients hospitalized for COVID compared to non-COVID pneumonia: A multicenter cohort study

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BACKGROUND Atrial fibrillation (AF) has been reported to occur with coronavirus disease 2019 (COVID-19), but whether it is related to myocarditis or lung injury is unclear.

OBJECTIVES The purpose of this study was to compare incident AF in patients with pneumonia/ adult respiratory distress syndrome (ARDS) with and without COVID.

METHODS This retrospective multicenter cohort study from 17 hospitals (March 2020 to December 2021) utilizing the University of California COVID Research Data Set (CORDS) included patients aged ≥18 years with primary diagnosis of pneumonia or ARDS during hospitalization. Patients with a history of AF were excluded. All subjects had documented COVID test results. Cohorts were compared using the χ² test for categorical variables and the Wilcoxon rank test for continuous variables. Multivariable logistic regression models were used to investigate the association between COVID and development of new AF.

RESULTS Of the 39,415 subjects, 12.2% had COVID. The COVID cohort consisted predominantly of younger males with more comorbidities. Incident AF was lower in the COVID+ group than in the non-COVID group (523 [10.85%] vs 4899 [14.16%]; odds ratio [OR] 0.74; P < .001), which remained significant after adjustment for demographics and comorbidities (OR 0.71; P < .001). Patients had normal cardiac troponin levels. AF was related to intensive care unit care, pressor support, and mechanical ventilation, and was associated with higher mortality (26.2% vs 10.21%; P < .001) and longer hospitalization (22.5 vs 15.1 days; P < .001) in the COVID+ group compared to the controls.

CONCLUSION Incident AF is lower in COVID+ compared to non-COVID pneumonia/ARDS patients and seems to be related to severity of illness rather cardiac injury. AF was associated with higher mortality and prolonged hospitalization.

KEYWORDS Atrial fibrillation; Coronavirus disease 2019 (COVID-19); Lung disease

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Introduction

Atrial fibrillation (AF) is the most common cardiac rhythm disorder and is associated with significant morbidity and mortality.¹ The development and sustainment of AF are multifactorial, with greater risk given increasing age and comorbidities such as hypertension, coronary artery disease, cerebrovascular disease, and diabetes.¹ Increased sympathetic tone and circulating inflammatory factors also are associated with the development of AF.²,³

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has resulted in a worldwide during the first year of the pandemic affecting more than 500 million people worldwide and 80 million people in the United States.⁴ Infec-

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We sought to measure the incidence of new-onset AF in patients with COVID-19 and directly compare it to the incidence in a cohort of subjects with non-COVID pneumonia and ARDS in order to assess whether COVID-19 is a risk factor for the development of AF. We hypothesize that the high rates of AF seen in COVID-19 patients is attributable to severe respiratory illness and not COVID-19 itself; therefore, we expect to see similar rates of incident AF in a non-COVID pneumonia cohort having a similar pulmonary disease process.

**Methods**

This was a multicenter retrospective cohort study utilizing the University of California COVID Research Data Set (CORDS). This database includes all patients tested for SARS-CoV-2 and treated at any of the 17 University of California (UC) Health hospitals across 5 academic medical centers (Davis, Irvine, Los Angeles, San Diego, San Francisco). Data were extracted for the period from March 2020 to December 2021.

Subjects were included if they were admitted to an inpatient facility and had a diagnosis of pneumonia or ARDS associated with their admission, determined using the *International Statistical Classification of Diseases, Tenth Revision* (ICD-10) codes in the patient electronic health record (EHR). If patients had multiple hospital admissions, only data from the first admission were included. Subjects were excluded if they had a previous diagnosis of AF.

Subjects were then divided into 2 cohorts based on their SARS-CoV-2 test results. Patients were placed in the COVID pneumonia cohort (COVID+) if they had a positive polymerase chain reaction COVID test confirmation within 10 days or during an inpatient admission. Patients without such a positive COVID test were placed in the non-COVID pneumonia cohort (non-COVID). All patients included in the database had an associated COVID test.

Patient characteristics, including race/ethnicity, sex, comorbidities, inpatient medications, and clinical outcomes, were collected. Ages were estimated from patient birth years because birth dates were removed from the database for deidentification. Self-identified race/ethnicity was categorized into Asian, White, Hispanic/Latino, Black/African American, American Indian or Alaska Native (AIAN), Native Hawaiian or Other Pacific Islander (NHPI), Other, and Unknown. The following comorbidities (using ICD-10 classification obtained from patient EHRs) were identified: hypertension, diabetes mellitus, coronary artery disease, previous history of coronary artery bypass graft, history of prosthetic heart valve, peripheral vascular disease, congestive heart failure, obstructive sleep apnea, chronic obstructive pulmonary disease, end-stage renal disease, cirrhosis, and thyroid disease. Comorbidities were considered present if the subject had a documented history of that condition before admission. Medications given during the hospitalization were queried from the EHR and grouped by general class of medication, including vasopressor drugs and

**KEY FINDINGS**

- The incidence of new-onset atrial fibrillation (AF) in patients hospitalized for coronavirus disease 2019 (COVID-19) pneumonia was approximately 10%.
- Compared to patients with non-COVID pneumonia and acute respiratory distress syndrome, the incidence of new-onset atrial fibrillation is less in patients with COVID pneumonia.
- AF is not directly associated with COVID-19, but development of incident AF is a poor prognostic factor, associated with higher mortality and longer hospitalization.

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antiarrhythmic drugs. Laboratory values represent the first laboratory value drawn during the subject’s admission.

These Health Insurance Portability and Accountability Act of 1996 (HIPAA)-limited data were determined to be exempt from human subject protection and patient consent by UC Davis IRB under protocol 1879428-1. The research reported in this paper adhered to Helsinki Declaration guidelines.

Statistical analysis

Values are given as number (%) and continuous variables as median [interquartile range]. Baseline characteristics are given for patients diagnosed with new-onset AF, comparing those with COVID pneumonia to those with non-COVID pneumonias. P values were calculated, using the χ² test for categorical variables and the Wilcoxon rank test for continuous variables.

Univariate analysis was performed first to identify the significant variables associated with development of AF. Multivariate logistic regression analysis then was performed to identify significant predictors. Candidate variables for model inclusion were those that were statistically and clinically relevant variables associated with AF and those with P < .05 on univariate analysis.

Results

A total of 45,047 subjects were included based on diagnosis of pneumonia or ARDS. Of these patients, 5632 (12.5%) were excluded because of previous AF history. Of the 39,415 remaining subjects, 4820 (12.23%) had an associated positive COVID test and were placed in the COVID+ cohort, compared to 34,595 (87.77%) with negative COVID test who were placed in the non-COVID cohort (Figure 1). A total of 1558 subjects (3.95%) had ARDS in addition to pneumonia. Patients in the COVID+ cohort were more likely to be <60 years old (49.1% vs 41.2%; P < .001), male (58.1% vs 55.1%; P = .001), and non-White (78.2% vs 59.5%; P < .001), and to have hypertension (39.6% vs 35.8%; P < .001) and diabetes (42.1% vs 35.9%; P < .001) (Table 1). COVID+ patients were more likely to require mechanical ventilation but required less hemodynamic support or intensive care unit care (Table 1).

Incident AF

A total of 5422 subjects developed new-onset AF, particularly male patients (61.6%) and older (>60 years) patients (81.3%), with a lower incidence of 523 (10.85%) in the COVID+ cohort vs 4899 (14.16%) in the non-COVID cohort (OR 0.738; P < .001) (Figure 2). Patients with incident AF in the COVID+ cohort were significantly more likely to have diabetes and hypertension than those without COVID-19 (Table 2).

Significant predictors of development of new-onset AF in COVID+ patients included male sex (OR 1.33; P < .001), age greater than 60 years, hypertension, diabetes, and male sex (Tables 2 and 3).

Table 1   Baseline characteristics of COVID patients compared to non-COVID patients with respiratory illness

| Characteristic                        | COVID+ (n = 4820) | Non-COVID (n = 34,595) | P value |
|---------------------------------------|-------------------|------------------------|---------|
| Female                                | 2022 (41.95)      | 15,535 (44.91)         | .001    |
| Age group (y)                         |                   |                        | <.001   |
| 18–29                                 | 275 (5.71)        | 2134 (6.17)            |         |
| 30–39                                 | 463 (9.61)        | 2842 (8.22)            |         |
| 41–49                                 | 625 (12.97)       | 3329 (9.62)            |         |
| 51–59                                 | 1001 (20.77)      | 5942(17.18)            |         |
| 61–69                                 | 1050 (21.78)      | 8532 (24.66)           |         |
| 71–78                                 | 685 (14.21)       | 6311 (18.24)           |         |
| 78+                                   | 721 (14.96)       | 5505 (15.91)           |         |
| Race                                  |                   |                        | <.001   |
| Asian                                 | 559 (11.60)       | 4247 (12.28)           |         |
| Black or AA                           | 384 (7.97)        | 2854 (8.25)            |         |
| White                                 | 1051 (21.80)      | 14,019 (40.52)         |         |
| Hispanic or Latino                    | 929 (19.27)       | 4569 (13.21)           |         |
| AIAN                                   | 14 (.29)          | 132 (.38)              |         |
| NHPI                                   | 50 (1.04)         | 208 (.60)              |         |
| Other                                  | 1135 (23.55)      | 5074 (14.67)           |         |
| Unknown                                | 698 (14.48)       | 3492 (10.09)           |         |
| Comorbidity                           |                   |                        |         |
| Hypertension                          | 1910 (39.63)      | 12,392 (35.82)         | <.001   |
| DM                                     | 2031 (42.14)      | 12,425 (35.92)         | <.001   |
| Coronary artery disease               | 836 (17.34)       | 6264 (18.11)           | .197    |
| Previous CABG                         | 112 (2.32)        | 799 (2.31)             | .951    |
| Peripheral vascular disease           | 338 (7.01)        | 2600 (7.52)            | .21    |
| Heart failure                         | 491 (10.19)       | 3660 (10.58)           | .405    |
| Sleep apnea                           | 425 (8.82)        | 2917 (8.43)            | .368    |
| COPD                                  | 297 (6.16)        | 2521 (7.29)            | .004    |
| ESRD                                  | 385 (7.99)        | 1940 (5.61)            | <.001   |
| Cirrhosis                             | 154 (3.20)        | 1790 (5.17)            | <.001   |
| Thyroid disease                       | 460 (9.54)        | 3587 (10.37)           | .077    |
| Hospital course                       |                   |                        |         |
| ICU                                   | 1615 (33.51)      | 13,288 (38.41)         | <.001   |
| Pressor use                           | 934 (19.38)       | 10,519 (30.41)         | <.001   |
| Mechanical ventilation                | 637 (13.22)       | 2576 (7.45)            | <.001   |
| Outcome                               |                   |                        |         |
| Death                                 | 400 (8.22)        | 1679 (4.85)            | <.001   |
| Length of stay (d)                    | 8 [4–16]          | 6 [3–12]               | <.001   |

Values are given as n (%) or median [interquartile range] unless otherwise indicated.

AA = African American; AIAN = American Indian or Alaska Native; CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; COVID = coronavirus disease; DM = diabetes mellitus; ESRD = end-stage renal disease; ICU = intensive care unit; NHPI = Native Hawaiian or other Pacific Islander.

Figure 2   Incidence of new-onset atrial fibrillation in coronavirus disease 2019 (COVID)+ and non-COVID patients.
Table 2  Characteristics of patients with new-onset AF during hospitalization for pneumonia, comparing COVID+ to non-COVID patients

| Characteristic       | COVID+ (n = 523) | Non-COVID (n = 4899) | P value |
|----------------------|------------------|----------------------|---------|
| Female               | 178 (34.03)      | 1905 (39.52)         | .03     |
| Age group (y)        |                  |                      | .029    |
| 18–29                | 7 (1.34)         | 40 (.82)             |         |
| 30–39                | 11 (2.10)        | 91 (1.86)            |         |
| 41–49                | 25 (4.78)        | 196 (4.00)           |         |
| 51–59                | 74 (14.15)       | 569 (11.61)          |         |
| 61–69                | 117 (22.37)      | 1234 (25.19)         |         |
| 71–78                | 108 (20.65)      | 1270 (25.92)         |         |
| 78+                  | 181 (34.61)      | 1499 (30.60)         |         |
| Race                 |                  |                      |         |
| Asian                | 90 (17.21)       | 698 (14.25)          |         |
| Black or AA          | 25 (4.78)        | 286 (5.84)           |         |
| White                | 153 (29.25)      | 2348 (47.93)         |         |
| Hispanic or Latino   | 83 (15.90)       | 476 (9.71)           |         |
| AJAN                 | 3 (.57)          | 18 (.37)             |         |
| NHPI                 | 5 (.96)          | 52 (1.10)            |         |
| Other                | 106 (20.27)      | 590 (12.04)          |         |
| Unknown              | 58 (11.09)       | 429 (8.79)           |         |
| Comorbidity          |                  |                      |         |
| Hypertension         | 199 (38.05)      | 1425 (29.09)         | <.001   |
| DM                   | 192 (36.71)      | 1151 (23.49)         | <.001   |
| Coronary artery disease | 89 (17.02)   | 913 (18.64)          | .364    |
| Previous CABG        | 14 (2.68)        | 120 (2.45)           | .750    |
| Prosthetic valve     | 4 (.76)          | 81 (1.65)            | .088    |
| Peripheral vascular disease | 40 (7.65) | 228 (4.65) | .003 |
| Heart failure        | 55 (10.52)       | 542 (11.06)          | .704    |
| Sleep apnea          | 35 (6.69)        | 297 (6.06)           | .568    |
| COPD                 | 32 (6.12)        | 280 (5.72)           | .707    |
| ESRD                 | 39 (7.46)        | 244 (4.98)           | .016    |
| Cirrhosis            | 10 (1.91)        | 158 (3.23)           | .099    |
| Hospital course      |                  |                      |         |
| ICU                  | 324 (61.95)      | 2854 (58.26)         | .103    |
| Antiarrhythmic drug use | 315 (60.23)   | 3066 (62.58)         | .291    |
| Pressor use          | 259 (49.52)      | 2365 (48.09)         | .534    |
| Mechanical ventilation | 133 (25.43) | 754 (15.39) | <.001 |
| Outcome              |                  |                      |         |
| Death                | 137 (26.20)      | 500 (10.21)          | <.001   |
| Length of stay (d)   | 15 [7–30]        | 9 [5–18]             | <.001   |

Values are given as n (%) or median [interquartile range] unless otherwise indicated.

AF = atrial fibrillation; other abbreviations as in Table 1.

Table 3  Univariate logistic regression analysis of predictors of incident AF in COVID+ patients

| OR (95% CI) | P value |
|-------------|---------|
| Male        | 1.33 (1.25–1.42) | <.001 |
| Comorbidity |          |         |
| Hypertension| 0.93 (0.77–1.12) | .435 |
| DM          | 2.02 (1.88–2.17) | <.001 |
| Coronary artery disease | 1.04 (0.96–1.12) | .335 |
| Previous CABG | 1.08 (0.90–1.30) | .398 |
| Prosthetic valve | 0.97 (0.34–2.73) | .949 |
| Peripheral vascular disease | 1.11 (0.79–1.57) | .547 |
| Heart failure | 1.04 (0.77–1.40) | .792 |
| Sleep apnea | 0.72 (0.50–1.03) | .071 |
| COPD        | 0.99 (0.70–1.45) | .965 |
| ESRD        | 0.92 (0.65–1.30) | .636 |
| Cirrhosis   | 0.56 (0.29–1.07) | .081 |
| Thyroid disease | 1.03 (0.76–1.40) | .864 |
| Hospital course | | |
| ICU         | 3.79 (3.14–4.58) | <.001 |
| Pressor use | 5.26 (4.35–6.37) | <.001 |
| Mechanical ventilation | 2.57 (2.06–3.19) | <.001 |

AF = atrial fibrillation; CI = confidence interval; OR = odds ratio; other abbreviations as in Table 1.

Mann-Whitney and t test) and COVID patients who did not develop AF (median 7 days; mean 12.19 days; P < .001 by Mann-Whitney and t test). Use of antiarrhythmic drugs for treatment of new-onset AF was similar in the 2 cohorts: 60.23% in COVID+ patients and 62.58% in non-COVID patients. Other characteristics of the patients who developed incident AF are listed in Table 2.

Laboratory values

Median values of troponin I, troponin T, brain natriuretic peptide (BNP), N-terminal pro–brain natriuretic peptide (NT-pro BNP), erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) are listed in Table 4. Overall, the values were in the normal range with no difference between the 2 groups. More patients who developed AF had troponin data available compared to those who did not develop AF (41.8% vs 27.8%, respectively). There was no significant elevation in troponin I or T level in those with incident AF (Table 5).

Table 4  Comparison of median laboratory values for the 2 cohorts

|                  | COVID+ Median [interquartile range] | Non-COVID Median [interquartile range] | P value |
|------------------|------------------------------------|---------------------------------------|---------|
| Troponin I       | .04 [0.04–0.04]                     | 1.451 [0.04–1.12]                     | 7106 .561 |
| Troponin T       | 19 [8–49.9]                        | 433 [34.5–104]                       | 2720 .623 |
| BNP              | 76.5 [37–196.5]                     | 1500 [197–7067]                      | 6471 .666 |
| NT-proBNP        | 330 [87–1417]                      | 331 [1009–2344917]                   | 1603 .641 |
| ESR              | 60 [37–89]                         | 896 [22–89]                          | 961 .441 |
| CRP              | 9.9 [5–16.73]                       | 1994 [4.9–118.138]                   | 2635 .364 |

BNP = brain natriuretic peptide; COVID = coronavirus disease; CRP = C-reactive protein; ESR = erythrocyte sedimentation rate; NT-proBNP = N-terminal pro–brain natriuretic peptide.
Mortality
The COVID+ cohort had significantly higher in-hospital mortality compared to the non-COVID cohort (8.22% vs 4.85%; \( P < .001 \)) (Figure 3). Incident AF was associated with significantly higher in-hospital mortality in both cohorts (COVID+: OR 5.53; 95% CI 4.39–6.98; \( P < .001 \); non-COVID: OR 2.75; 95% CI 2.46–3.07; \( P < .001 \)).

Discussion
In our analysis of 39,415 diverse subjects across the state of California, there was less incident AF in COVID+ subjects compared to the non-COVID pneumonia comparison group. Several surrogates of severe illness were associated with the development of AF, including vasopressor use, mechanical ventilation, admission to the intensive care unit, and longer length of stay. The lack of significant elevation in troponin T and I levels in either cohort among AF patients favors severity of illness and lung injury as an association with AF rather than myocardial injury. However, cardiac biomarkers were ordered for only a subset of patients, likely those with pre-existing cardiovascular disease, so these data are inherently biased.

Similar to previous studies, we demonstrated that patients with COVID-19 infection requiring hospitalization have high rates of cardiovascular comorbidities, are older, more frequently are male, and are disproportionately of non-White race.11-13 Our findings of incident AF are largely consistent with the few existing studies that have measured rates of 13%–21% for historical or new AF and 5.4%–11.5% for new-onset AF in COVID-19 patients.14-18 Similar rates of new-onset AF in patients with non-COVID ARDS have been reported.19

Few studies have sought to determine whether this high rate of AF is the result of direct cardiovascular involvement or simply is associated with severity of illness. One study demonstrated similar rates of incident AF in patients with COVID-19 compared to those with influenza, correlating to markers of inflammation and disease severity.16 To the best of our knowledge, our study is the first to compare COVID vs non-COVID pneumonia/ARDS patients in a large diverse population. Our findings are consistent with previous studies demonstrating increased mortality in COVID-19 patients who develop AF, and likely to be a marker of severe illness driving mortality.14,15

Several hypotheses exist for the mechanism of AF in COVID-19, including systemic inflammation, myocardial injury, increased sympathetic tone, and oxidative stress.20 Hypoxia and hypotension likely play a causal role in the development of the mechanistic triggers for the development of AF. The implications of incident AF during hospitalization for a severe COVID-19 infection are unknown, and long-term follow-up is needed to determine the risk of recurrent AF and cardioembolic stroke in these patients.

Unique strengths of this study include its extremely large and diverse sample size and comparison to a non-COVID pneumonia cohort. The CORDS database from which this study was derived includes all adult patients tested for COVID-19 across the entire UC Health system, which provides care to 1.8 million unique patients annually across California or approximately 4.6% of the state population.21,22

Table 5
Comparison of median laboratory values for patients who developed AF

|                    | COVID+                  | Non-COVID               |
|--------------------|-------------------------|-------------------------|
|                    | Median [interquartile range] | n | Median [interquartile range] | n | \( P \) value |
| Troponin I         | .041 [.04–.17]          | 169 | .05 [.04–.26]          | 1449 | .0412 |
| Troponin T         | 52.5 [18.75–145.25]     | 71 | 52 [25–149.1]          | 576 | .508 |

AF = atrial fibrillation; COVID = coronavirus disease.

Figure 3
Comparison of outcomes of mortality (B) and length of stay (LOS) (A) in patients with coronavirus disease 2019 (COVID) pneumonia vs non-COVID pneumonia.
Study limitations
The large sample size allowed for a diverse and representative population; however, individual chart review and long-term follow-up beyond index hospitalization were not available. In addition, the hospital day on which subjects developed AF is not known, making hazard proportion analysis unavailable. The COVID+ cohort had significantly longer length of stay, which can be an indicator of more severe disease. However, this increased disease severity should increase the risk of development of AF and promote the null hypothesis that AF is not associated with COVID-19 infection. This study included only patients with COVID-19 infection severe enough to warrant inpatient hospital admission and cannot be extrapolated to individuals with mild infection who likely are younger and healthier.

Conclusion
Incident AF is lower in COVID compared to non-COVID hospitalized patients with pneumonia/ARDS. AF seems to be associated with severity of illness and higher mortality rather than myocardial injury, as indicated by normal troponin levels in our study cohort of diverse California patients.

Acknowledgment: The authors have no conflicts to disclose.

Authorship: All authors attest they meet the current ICMJE criteria for authorship.

Patient Consent: These HIPAA-limited data were determined to be exempt from human subject protection and patient consent by UC Davis IRB under protocol 1879428-1.

Ethics Statement: The research reported in this paper adhered to Helsinki Declaration guidelines.

Disclaimer: Given her role as Section Editor, Uma N. Srivatsa had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Editors Julia Heisler Indik and Jeanne E. Poole.

References
1. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. Circulation 2014;130:2071–2104.
2. Wasmund SL, Li JM, Page RL, et al. Effect of atrial fibrillation and an irregular ventricular response on sympathetic nerve activity in human subjects. Circulation 2003;107:2011–2015.
3. Wu N, Xu B, Xiang Y. Association of inflammatory factors with occurrence and recurrence of atrial fibrillation: a meta-analysis. Int J Cardiol 2013;169:62–72.
4. Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). COVID-19 Dashboard. May 18, 2022. https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b88e9ecf6. Accessed May 18, 2022.
5. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 2020;395:507–513.
6. Tian W, Jiang W, Yao J. Predictors of mortality in hospitalized COVID-19 patients: a systematic review and meta-analysis. J Med Virol 2020;92:1875–1883.
7. Chang WT, Toh HS, Liao CT, Yu WL. Cardiac involvement of COVID-19: a comprehensive review. Am J Med Sci 2021;361:14–22.
8. Shi S, Qin M, Shen B, et al. Association of cardiac injury with mortality in hospitalized patients with COVID-19 in Wuhan, China. JAMA Cardiol 2020;5:802–810.
9. Bhatia A, Mayer MM, Adusumalli S. COVID-19 and cardiac arrhythmias. Heart Rhythm 2020;17:1439–1444.
10. Ip RJ, Ali A, Baloch ZQ, et al. Atrial fibrillation as a predictor of mortality in high-risk COVID-19 Patients: a multicentre study of 171 patients. Heart Lung Circ 2021;30:1151–1156.
11. Pijls BG, Jolani S, Atherley A, et al. Demographic risk factors for COVID-19 infection, severity, ICU admission and death: a meta-analysis of 59 studies. BMJ Open 2021;11:e044640.
12. Mackey K, Ayers CK, Kondo KK, et al. Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: a systematic review. Ann Intern Med 2021;174:362–373.
13. Gao Y, Ding M, Dong X, et al. Risk factors for severe and critically ill COVID-19 patients: a review. Allergy 2020;76:428–436.
14. Spinoni EG, Mennuni M, Rognoni A, et al. Contribution of atrial fibrillation to in-hospital mortality in patients with COVID-19. Circ Arrhythm Electrophysiol 2021;14:e009375.
15. Rosenblatt AG, Ayers CR, Rao A, et al. New-onset atrial fibrillation in patients hospitalized with COVID-19: results from the American Heart Association COVID-19 Cardiovascular Registry. Circ Arrhythm Electrophysiol 2022;15:e010666.
16. Handshardono D, Ng R, Chen X, et al. The association between atrial fibrillation and hospitalization with COVID-19: a comprehensive review. Am J Med 2021;361:1444.
17. Colon MM, Barrios JG, Chiles JW. Atrial arrhythmias in COVID-19 patients. JACC Clin Electrophysiol 2020;6:1156–1159.
18. Mountantonakis SE, Saleh M, Fishein J, et al. Northwell COVID-19 Research Consortium. Atrial fibrillation is an independent predictor for in-hospital mortality in patients admitted with SARS-CoV-2 infection. Heart Rhythm 2021;18:501–507.
19. Ambrus DB, Benjamin EJ, Bajwa EK, Hibbert KA, Walkey AJ. Risk factors and outcomes associated with new-onset atrial fibrillation during acute respiratory distress syndrome. J Crit Care 2015;30:994–997.
20. Gawalko M, Kaplan-Cieslicka A, Hohl M, Dobrev D. Linte D. COVID-19 associated atrial fibrillation: incidence, putative mechanisms and potential clinical implications. Int J Cardiol Heart Vasc 2020;30:100631.
21. https://accountability.universityofcalifornia.edu/2020/documents/pdfs/acct-2020-0-ch-11.pdf. Accessed October 31, 2019.
22. US Census Bureau QuickFacts. California. https://www.census.gov/quickfacts/CA. Accessed May 18, 2022.