Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Race affects adverse outcomes of deep vein thrombosis, pulmonary embolism, and acute kidney injury in coronavirus disease 2019 hospitalized patients

Young Erben, MD,[a] Christopher P. Marquez, MD,[b] Mercedes Prudencio, PhD,[c] Susana Fortich, MD,[a] Tania Gendron, PhD,[c] Devang Sanghavi, MD,[d] LaTonya Hickson, MD,[e] Yupeng Li, PhD,[f] Michael A. Edwards, MD,[g] Charles Ritchie, MD,[h] Pablo Moreno Franco, MD,[d] Leonard Petrucelli, PhD,[c] *and* James F. Meschia, MD,[i] *Jacksonville, FL; and Glassboro, NJ*

ABSTRACT

Objective: The purpose of the present study was to explore the racial disparities in the incidence of deep vein thrombosis (DVT), pulmonary embolism (PE), and acute kidney injury (AKI) in hospitalized patients with coronavirus disease 2019 (COVID-19).

Methods: A retrospective analysis was performed of prospectively collected data of consecutive COVID-19 patients hospitalized from March 11, 2020 to May 27, 2021. The primary outcome measures were the incidence of DVT/PE and mortality. The secondary outcome measures included differences in the length of hospitalization, need for intensive care unit care, readmission, and AKI. Multivariable regression models were used to assess for independent predictors of the primary and secondary outcome measures.

Results: The present study included 876 hospitalized patients with COVID-19. The mean age was 64.4 ± 16.2 years, and 355 were women (40.5%). Of the 876 patients, 694 (79.2%) had identified as White, 111 (12.7%) as Black/African American, 48 (5.5%) as Asian, and 23 (2.6%) as other. The overall incidence of DVT/PE was 8.7%. The DVT/PE incidence rates differed across the race groups and was highest for Black/African American patients (n = 18; 16.2%), followed by Asian patients (n = 5; 10.4%), White patients (n = 52; 7.5%), and other (n = 1; 4.4%; $P = .03$). All but one of the hospitalization outcomes examined demonstrated no differences according to race, including the hospitalization stay ($P = .33$), need for intensive care unit care ($P = .20$), readmission rates ($P = .52$), and hospital all-cause mortality ($P = .29$). The AKI incidence differed among races, affecting a higher proportion of Black/African American patients ($P = .003$). On multivariable regression analysis, Black/African American race (odds ratio [OR], 2.0; 95% confidence interval [CI], 1.0-4.0; $P = .04$) and higher D-dimer levels (OR, 1.1; 95% CI, 1.1-1.2; $P < .0001$) were predictors of DVT/PE. In addition, Black/African American race (OR, 2.3; 95% CI, 1.4-3.7; $P = .001$), lower hemoglobin levels (OR, 0.84; 95% CI, 0.8-0.9; $P \leq .0001$), male sex (OR, 1.7; 95% CI, 1.2-2.4; $P = .005$), hypertension (OR, 2.1; 95% CI, 1.4-3.1; $P = .0005$), and older age (OR, 1.02; 95% CI, 1.006-1.03; $P = .003$) were predictors of AKI.

Conclusions: In our single-center case series, we found a higher incidence of DVT/PE and AKI among Black/African American patients with COVID-19. Black/African American race and D-dimer levels were independent predictors of DVT/PE, and Black/African American race, hemoglobin, and D-dimer levels were independent predictors of AKI. (J Vasc Surg Venous Lymphat Disord 2022;■:1-6.)

Keywords: COVID-19; Deep vein thrombosis; Pulmonary embolism; Racial disparities; Venous thromboembolism

Coagulopathy is one of the most common complications in patients with coronavirus disease 2019 (COVID-19) infection.[1-3] A paucity of data is available that has specifically examined racial disparities in terms of the incidence of venous thromboembolism (VTE) among hospitalized patients with COVID-19.[4] However, a

From the Division of Vascular and Endovascular Surgery,[a] Department of Laboratory Medicine and Pathology,[b] Department of Neuroscience and Mayo Clinic Graduate School of Biomedical Sciences,[c] Department of Critical Care,[d] and Division of Nephrology and Hypertension,[e] Mayo Clinic, Jacksonville; the Department of Political Science and Economics, Rowan University, Glassboro[f]; the Department of General Surgery,[g] Department of Radiology,[h] and Department of Neurology,[i] Mayo Clinic, Jacksonville.

This work was supported by NIH grants RF1 NS120992 (to M.P.), R35 NS097273 (to L.P.), P01 NS084974 (to L.P.), P01 NS099114 (L.P.), U01 NS080168 (to J.F.M.), and U19 NS115388 (to J.F.M.); The Earl and Nyda Swanson Neurosciences Research Fund (to J.F.M.); The Harley N. and Rebecca N. Hotchkiss Endowed Fund in Neuroscience Research; Honoring Ken and Marietta (to J.F.M.); The Donald G. and Jodi P Heeringa Family (to L.P.); the Association of Frontotemporal Dementia (AFTD) (to L.P.).

Author conflict of interest: none.

Additional material for this article may be found online at www.jvsvenous.org.

Correspondence: Young Erben, MD, Division of Vascular and Endovascular Surgery, Mayo Clinic Florida, 4500 San Pablo Rd, Jacksonville, FL 32224 (e-mail: erben.young@mayo.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2213-333X

https://doi.org/10.1016/j.jvsv.2022.05.019

correlation has been found between VTE, COVID-19 infection, and poorer clinical outcomes.[5] We investigated whether racial disparities were present in the incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) in a cohort of hospitalized patients with COVID-19 infection. Our secondary outcomes included differences in hospitalization outcomes, including acute kidney injury (AKI). Analyzing the outcomes pertaining to AKI were of interest because evidence has suggested that AKI can predispose patients to VTE in the presence of both acute and chronic kidney disease.[6,7]

ARTICLE HIGHLIGHTS

- **Type of Research:** A retrospective analysis of prospectively collected data
- **Key Findings:** The incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) in hospitalized patients with COVID-19 (coronavirus disease 2019) was 8.7%. We found significant differences ($P = .03$) in the DVT and PE rates between Black/African American patients (16.2%), Asian patients (10.4%), White patients (7.5%), and patients of other races (4.4%). We found no racial differences in all-cause or venous thromboembolism-related mortality.
- **Take Home Message:** Among hospitalized patients with COVID-19, Black/African American patients were the most vulnerable to DVT/PE but had had no significant increase in venous thromboembolism-related mortality.

METHODS

Patient selection. The MC NEWS study [Mayo Clinic neurological, vascular and neurovascular events with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) study; institutional review board No. 20-003457] was a retrospective analysis of prospectively collected data for all patients affected by the COVID-19 pandemic identified within our campus. We used our electronic medical record system (Epic, Verona, WI) to identify all patients from March 11, 2020 to May 27, 2021 with a positive result for SARS-CoV-2 through polymerase chain reaction testing. Our cohort included 57.8% White, 12.4% Black/African American, and 6% Asian patients, representative of the national racial ecosystem. We used self-reported race data entered at the time of patient registration for care. To ensure accuracy in the data collection and validity of the cohort, we cross-checked the patients' unique identifiers and their inpatient status after March 11, 2020 using a natural language processing method (Mayo Data Explorer) developed by the Mayo Clinic. Furthermore, each of our patient's hospital medical records were manually accessed and reviewed by a physician investigator to ensure that the hospitalization had been linked to the SARS-CoV-2 infection. Race as reported by the patient and available in the patient's medical records was validated at patient admission to the hospital by one of the admission officers. The institution's institutional review board and the COVID-19 task force reviewed and approved the study protocol and waived the requirement for patient informed consent owing to the minimal risk to the patients.

Calculation of incidence of DVT and PE. We reviewed each patient's hospitalization records, including documentation of venous duplex ultrasound of either the upper or lower extremities, obtained at the discretion of the treating physician. Data regarding the presence or absence of acute DVT was abstracted. Additionally, we reviewed the records for documentation of computed tomography angiography (CTA) of the chest and recorded the presence or absence of acute PE. The rate of DVT/PE per racial group was calculated using the total number of hospitalized COVID-19 patients in each racial category as self-reported by the patients at registration as the denominator. The potential bias in obtaining duplex ultrasound scans was assessed by comparing the percent use of duplex ultrasound and CTA according to race.

Outcomes assessment among COVID-19 patients with DVT and PE. We collected demographic data, including self-reported race, pertinent medical history, and vital signs at admission or registration, laboratory values at admission and when first measured during hospitalization, and the hospital course data, including the requirement for intensive care unit (ICU) care, length of hospitalization, all-cause mortality, AKI, and hospital readmission (up to the end of data collection, August 15, 2021). AKI was defined in accordance with KDIGO (kidney disease improving global outcomes) criteria in 2012 as an acute increase in serum creatinine of 0.3 mg/dL within 48 hours, an increase in serum creatinine of $\geq$1.5 times the baseline within the previous 7 days, or a urine volume of $<$0.5 mL/kg/h for 6 hours.[8]

Statistical analysis. Tests of statistical significance for univariate comparisons of the demographics and baseline patient risk factors were conducted using the Pearson χ^2 test or Fisher exact test for categorical variables and the Kruskal-Wallis test for continuous variables. Descriptive statistics are presented as the median and interquartile range for continuous variables and frequencies and percentages for categorical variables. We used multivariable logistic regression analysis to examine the association of different factors (ie, race, age, sex, body mass index, hemoglobin, D-dimer level) with the outcomes, including DVT/PE and AKI. Differences were considered statistically significant at $P < .05$. All statistical analyses were performed using SAS statistical software, version 9.4 (SAS Institute, Cary, NC).

Table I. Patient demographic and clinical characteristics stratified by race

Characteristic	All patients (n = 876)	Race				*P* value
		White (n = 694)	Black/African American (n = 111)	Asian (n = 48)	Other (n = 23)	
Male sex	521 (59.5)	425 (61.2)	49 (44.1)	32 (66.7)	15 (65.2)	.004
Age, years	65.0 (53.0-77.0)	67.0 (56.0-78.0)	55.0 (43.5-5.0)	62.5 (45.8-70.5)	57.0 (48.0-68.5)	<.001
Hypertension	552 (63.0)	433 (62.4)	78 (70.3)	32 (66.7)	9 (39.1)	.04
Coronary artery disease	217 (24.8)	181 (26.1)	20 (18.0)	13 (27.1)	3 (13.0)	.16
Myocardial infarction	79 (9.0)	63 (9.1)	10 (9.0)	4 (8.3)	2 (8.7)	1.00
Diabetes mellitus	220 (25.1)	167 (24.1)	35 (31.5)	9 (18.8)	9 (39.1)	.10
Peripheral vascular disease	51 (5.8)	45 (6.5)	4 (3.6)	0 (0)	2 (8.7)	.14
Ischemic stroke	55 (6.3)	42 (6.1)	11 (9.9)	1 (2.1)	1 (4.4)	.28
Transient ischemic attack	49 (5.6)	42 (6.1)	5 (4.5)	2 (4.1)	0 (0)	.76
Intracerebral hemorrhage	13 (1.5)	10 (1.4)	2 (1.8)	1 (2.1)	0 (0)	.72
Atrial fibrillation	157 (17.9)	139 (20.0)	11 (9.9)	5 (10.4)	2 (8.7)	.02
Hyperlipidemia	445 (50.8)	363 (52.3)	51 (45.9)	23 (47.9)	8 (34.8)	.24
Antihypertensive medication	471 (53.8)	372 (53.7)	69 (62.2)	22 (45.8)	8 (34.8)	.05
Lipid-lowering medication	393 (44.9)	319 (46.0)	49 (44.1)	19 (39.6)	6 (26.1)	.24
Antiplatelet medication	322 (36.8)	259 (37.3)	39 (35.1)	17 (35.4)	7 (30.4)	.88
Endotracheal mechanical ventilation	59 (6.7)	44 (6.3)	6 (5.4)	8 (16.7)	1 (4.4)	.07
History of DVT/PE	99 (11.3)	84 (12.7)	10 (9.6)	4 (8.3)	1 (4.8)	.612
Diagnosis of thrombophilia	9 (1.0)	8 (1.2)	1 (0.9)	0 (0)	0 (0)	1.00
Active history of cancer	110 (12.6)	95 (13.7)	12 (10.8)	3 (6.3)	0 (0)	.10
Body mass index, kg/m^2	29.2 (24.9-34.3)	29.3 (24.9-33.6)	32.3 (26.3-38.3)	26.6 (23.6-29.7)	28.4 (25.8-32.2)	.002
White blood cell count,[a] 10^9/L	6.8 (4.9-9.7)	6.80 (4.90-9.80)	6.30 (4.50-9.40)	6.70 (5.05-8.00)	9.20 (5.15-10.8)	.389
Hemoglobin, g/dL	13.0 (11.4-14.4)	13.1 (11.5-14.5)	12.3 (10.1-13.4)	13.4 (12.0-14.9)	12.6 (10.9-13.6)	<.001
Hematocrit, %	39.3 (34.9-43.2)	39.4 (35.4-43.2)	38.2 (32.3-41.9)	41.0 (37.4-45.4)	38.6 (32.8-41.40)	.007
Platelets,[b] 10^9/L	194 (146-250)	190 (143-248)	209 (158-257)	206 (164-252)	200 (146-280)	.15
Albumin, g/dL	3.6 (3.3-3.9)	3.60 (3.30-3.90)	3.60 (3.25-3.80)	3.70 (3.40-3.90)	3.60 (3.15-3.90)	.50
Prothrombin time, seconds	13.2 (12.2-14.5)	13.3 (12.3-14.8)	13.2 (12.1-14.3)	12.9 (12.0-13.8)	12.9 (12.1-14.2)	.15
International normalized ratio	1.2 (1.1-1.3)	1.20 (1.10-1.30)	1.20 (1.10-1.30)	1.10 (1.10-1.20)	1.15 (1.10-1.30)	.23
D-dimer,[c] ng/mL						
All patients	811 (524-1453)	796 (513-1413)	1031 (579-1988)	722 (479-1030)	895 (527-1794)	.03
Patients without DVT/PE	787 (505-1331)	782 (495-1322)	838 (554-1399)	638 (448-1001)	844 (516-1630)	.22
C-reactive protein, mg/L	58.8 (23.9-112.i)	59.9 (21.7-110)	52.5 (26.6-114)	76.0 (35.0-119)	46.3 (29.7-118)	.861
Pro-brain natriuretic peptide, pg/mL	374.5 (105-1403)	391 (116-1326)	249 (45.0-1914)	216 (65.0-491)	1242 (166-7430)	.132
Interleukin-6, pg/mL	21 (9.3-46.3)	22.0 (10.0-48.2)	20.0 (5.80-33.0)	18.0 (9.38-47.8)	10.8 (6.45-30.0)	.341
Procalcitonin, ng/mL	0.14 (0.09-0.3)	0.13 (0.09-0.29)	0.15 (0.08-0.40)	0.18 (0.11-0.28)	0.19 (0.13-0.44)	.168
Interval from admission to diagnosis of DVT/PE, days	5.9 ± 10.2	5.9 ± 10.6	6.6 ± 10.5	1.0 ± 1.7	15	.573

DVT, Deep vein thrombosis; *PE*, pulmonary embolism.
Data presented as number (%), median (interquartile range), or mean ± standard deviation.
[a]Normal range: 3.4-9.6 × 10^9/L.
[b]Normal range: 135-317 × 10^9/L.
[c]Normal range: ≤500 mg/mL.

RESULTS

From March 11, 2020 to May 27, 2021, a total of 876 patients had required hospitalization at the Jacksonville campus of the Mayo Clinic because of COVID-19 infection. The mean age of this cohort was 64.4 ± 16.2 years, and 355 were women (40.5%). Of the 876 patients, 694 (79.2%) had self-identified as White, 111 (12.7%) as Black/African American, 48 (5.5%) as Asian, and 23 (2.6%) as other. The Black/African American patients had had a greater prevalence of hypertension (70.3%; *P* = .04), a

Table II. Hospitalization outcomes stratified by race

Outcome	White (n = 694)	Black/African American (n = 111)	Asian (n = 48)	Other (n = 23)	*P* value
Length of hospitalization, days	5.0 (4.0-8.75)	6.0 (4.0-9.5)	6.0 (4.0-10.0)	5.0 (4.0-8.75)	.33
Need for ICU care	98 (14.1)	18 (16.2)	12 (25.0)	2 (8.7)	.20
Readmission	32 (4.6)	2 (1.8)	1 (2.1)	1 (4.4)	.52
Mortality	41 (6.4)	3 (3.1)	1 (2.2)	2 (11.1)	.29
AKI	151 (21.8)	40 (36.0)	7 (14.6)	7 (30.4)	.003
DVT/PE	52 (7.5)	18 (16.2)	5 (10.4)	1 (4.4)	.03

AKI, Acute kidney injury; *DVT,* deep vein thrombosis; *ICU,* intensive care unit; *PE,* pulmonary embolism.
Data presented as median (interquartile range) or number (%).

higher body mass index (median, 32.3 kg/m^2; $P = .002$), higher D-dimer levels (median, 1031 mg/mL; $P = .03$), and lower hemoglobin levels (median, 12.3 g/dL; $P < .001$). The D-dimer level for the patients without DVT/PE did not differ among the races. The prevalence of atrial fibrillation was higher for the Asian patients (20%; $P = .02$). The time from admission to diagnosis of DVT/PE was not different among the races. The average interval was 5.9 ± 10.2 days (Table I).

The overall incidence of DVT/PE was 8.7% and differed among the races ($P = .03$). The DVT/PE incidence was highest for the Black/African American patients (n = 18; 16.2%), followed by Asian patients (n = 5; 10.4%), White patients (n = 52; 7.5%), and other patients (n = 1; 4.4%). To ensure no bias was present for the tested patients, we also tabulated the number of duplex ultrasound and CTA imaging studies obtained, which demonstrated no significance among the racial groups (Supplementary Table I, online only).

The location of DVT and extent of PE was not different among the races (Supplementary Table II, online only). The hospitalization outcomes also did not differ according to race, including the length of hospitalization ($P = .33$), need for ICU care ($P = .20$), readmission rate ($P = .52$), and mortality ($P = .29$). The only statistically significant difference among the races was the incidence of AKI for Black/African American patients ($P = .003$; Table II). The typical risk factors resulting in a higher risk of DVT/PE were assessed and included a history of DVT/PE, thrombophilia, and an active diagnosis of cancer, and these were not different among the racial groups (Table I). On multivariable regression analysis, the odds of DVT/PE were higher for Black/African American patients (odds ratio [OR], 2.0; 95% confidence interval [CI], 1.0-3.8; $P = .03$), as were the odds of higher D-dimer levels (OR, 1.1; 95% CI, 1.1-1.2; $P < .0001$). Black/African American race (OR, 2.3; 95% CI, 1.4-3.7; $P = .001$), lower hemoglobin levels (OR, 0.84; 95% CI, 0.8-0.9; $P < .0001$), hypertension (OR, 2.1; 95% CI, 1.4-3.1; $P = .0005$), male sex (OR, 1.7; 95% CI, 1.2-2.4; $P = .005$), and older age (OR, 1.02; 95% CI, 1.006-1.03; $P = .003$) conferred higher odds for the development of AKI (Table III).

DISCUSSION

In the present analysis of 876 patients admitted to our healthcare system because of COVID-19 infection, we found that the incidence of DVT/PE was 8.7%. Our results showed racial differences in the incidence of DVT/PE, with Black/African American patients the most affected. Although our Black/African American patients had had a higher risk of DVT/PE, most clinical outcomes, including mortality, the need for ICU care, and readmission to the hospital were not significantly different compared with the other races. However, our Black/African American patients had had a significantly higher risk of AKI.

The rate of DVT/PE has remained consistent across our network of hospitals and locally.[9] The higher rate of DVT/PE reported in the present study is in contrast to the findings from our recent systematic review and meta-analysis, in which no racial disparities in DVT/PE were found.[4] The limitations of the studies included in the systematic review and meta-analyses could account for the differences in the findings. These limitations included a retrospective study design and a lack of standardization and uniformity in the reporting of racial demographics and the diagnosis of DVT/PE. These differences added significant heterogeneity to our meta-analysis, limiting its generalizability.

We believe that the patient pool in the present study resembles the national demographic of the United States,[10] and, therefore, the findings are reflective of the true incidence of DVT/PE among racial groups. Before the COVID-19 pandemic, the incidence of DVT/PE had been reported to be higher for Black/African American patients, which had been attributed to the greater prevalence of comorbidities, a higher body mass index, poor educational level, and low socioeconomic status, among others.[11-13] However, we also noted within our cohort that the D-dimer levels were higher in our Black/African American patients, a finding that had also been reported before the COVID-19 pandemic.[9] Ongoing questions that our team are investigating are related to developing strategies to decrease the rate of DVT/PE in our COVID-19 hospitalized patients and understanding the procoagulant factors responsible for the hypercoagulability state

Table III. Multivariate regression analysis for deep vein thrombosis/pulmonary embolism (DVT/PE) and acute kidney injury (AKI)

Variable	Pr > χ^2	OR	95% CI
DVT/PE			
Race			
Asian vs White	0.5	1.5	0.45-3.94
Black/African American vs White	0.04	2.0	1.0-4.0
Other vs White	0.7	0.6	0.03-3.2
BMI (continuous)	0.2	0.98	0.95-1.0
AKI (yes vs no)	0.2	1.4	0.78-2.4
Hemoglobin (continuous)	0.6	0.97	0.88-1.1
D-dimer (continuous)	<0.0001	1.1	1.1-1.2
Sex (male vs female)	0.6	0.8	0.5-1.5
Age (continuous)	0.8	1.0	0.98-1.0
AKI			
Race			
Asian vs White	0.2	0.6	0.2-1.3
Black/African American vs White	0.001	2.3	1.4-3.7
Other vs White	0.2	1.9	0.7-4.8
BMI (continuous)	0.3	1.0	0.97-1.0
Hemoglobin (continuous)	<0.0001	0.84	0.8-0.9
D-dimer	0.07	1.03	1.0-1.1
Sex (male vs female)	0.005	1.7	1.2-2.4
Age (continuous)	0.003	1.02	1.006-1.03
Hypertension (yes vs no)	0.0005	2.1	1.4-3.1
Atrial fibrillation (yes vs no)	0.1	1.4	0.9-2.2

BMI, Body mass index; *CI*, confidence interval; *OR*, odds ratio.

that might predispose racially diverse patient groups to an increased risk of DVT/PE.

Differences in the metrics of the hospitalization outcomes overall were not statistically significant, except for the rate of patients developing AKI. This finding is in alignment with the current understanding of COVID-19 infection as a systemic endothelial microvascular thrombotic process.[14] In several postmortem studies, extensive acute tubular necrosis, interstitial fibrosis, fibrin deposits, tubular–interstitial inflammation, and peritubular thrombi were recognized within the kidney biopsies.[15,16]

Several limitations in our study are inherent to the retrospective nature of our review. Our electronic medical records do not include the socioeconomic status of each patient, which could have played a role in the incidence of DVT/PE, as reported in prepandemic studies. The testing for DVT and PE was not performed systematically for all patients hospitalized for COVID-19. Such testing was only performed for those patients with a clinical suspicion for DVT/PE, as determined by the treating clinician at hospitalization. The ultrasound studies for DVT were screening diagnostic studies, limiting the in-depth examination of each individual leg vein. Thus, only those with extensive DVT were captured owing to the symptomatic presentation of these patients. In addition, this limited the number of patients with only calf DVTs, because these patients might not have been clinically symptomatic and thus would not have undergone ultrasound of the extremities. Finally, we relied on the self-reported demographic data collected at admission to our hospital system. Therefore, more granular data regarding specific ethnic groups are lacking, such as individuals from Latin American countries, which represent a mixture of larger racial groups. Finally, a propensity matched analysis might have accounted for other possible confounders. However, at the data analysis, we did not have a large enough sample size for a propensity matched analysis. In addition, because our sample size was relatively small, we could not rule out that a type II error could have influenced the lack of a mortality difference among the races, although we would like to believe that this had resulted from the excellent patient care provided to our COVID-19 hospitalized patients.

CONCLUSIONS

In our single-center retrospective review of prospectively collected data, we found racial disparities in the incidence of DVT/PE and AKI in hospitalized patients with COVID-19 infection, with a higher incidence in Black/African American patients. Otherwise, the hospitalization outcomes were not significantly different among the races.

We thank Dr Aaron Spaulding for his unconditional support and constant careful review of our report.

AUTHOR CONTRIBUTIONS

Conception and design: YE, CM, MP, TG, DS, LH, ME, CR, PF, LP, JM
Analysis and interpretation: YL
Data collection: SF
Writing the article: YE, SF, JM
Critical revision of the article: YE, CM, MP, TG, DS, LH, YL, ME, CR, PF, LP, JM
Final approval of the article: YE, CM, MP, SF, TG, DS, LH, YL, ME, CR, PF, LP, JM
Statistical analysis: Not applicable
Obtained funding: Not applicable
Overall responsibility: SF

REFERENCES

1. Iba T, Levy JH, Levi M, Thachil J. Coagulopathy in COVID-19. J Thromb Haemost 2020;18:2103-9.
2. Ashraf O, Young M, Malik KJ, Cheema T. Systemic complications of COVID-19. Crit Care Nurs Q 2020;43:390-9.
3. Han H, Yang L, Liu R, Liu F, Wu K-L, Li J, et al. Prominent changes in blood coagulation of patients with SARS-CoV-2 infection. Clin Chem Lab Med 2020;58:1116-20.
4. Bhakta S, Erben Y, Sanghavi D, Fortich S, Li Y, Hasan MM, et al. A systematic review and meta-analysis on racial disparities in the incidence of deep venous thrombosis and pulmonary embolism in

COVID-19 hospitalized patients. J Vasc Surg Venous Lymphat Disord 2022;10:939-44.e3.
5. Wu C, Chen X, Cai Y, Xia J, Zhou X, Xu S, et al. Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan, China. JAMA Intern Med 2020;180:934-43.
6. Goto S, Haas S, Ageno W, Goldhaber SZ, Turpie AGG, Weitz JI, et al. Assessment of outcomes among patients with venous thromboembolism with and without chronic kidney disease. JAMA Netw Open 2020;3:e2022886.
7. McMahon MJ, Collen JF, Chung KK, Stewart IJ, Al-Eid HM, Moores RLK, et al. Acute kidney injury during hospitalization increases the risk of VTE. Chest 2021;159:772-80.
8. KDIGO Clinical Practice Guideline for Acute Kidney Injury. Kidney Int Suppl 2012;2. Available at: https://kdigo.org/wp-content/uploads/2016/10/KDIGO-2012-AKI-Guideline-English.pdf. Accessed September 10, 2021.
9. Erben Y, Franco-Mesa C, Gloviczki P, Stone W, Quinones-Hinojoas A, Meltzer AJ, et al. Deep vein thrombosis and pulmonary embolism among hospitalized coronavirus disease 2019-positive patients predicted for higher mortality and prolonged intensive care unit and hospital stays in a multisite healthcare system. J Vasc Surg Venous Lymphat Disord 2021;9:1361-70.e1.
10. U.S. Census Bureau. Quick Facts. Available at: https://www.census.gov/quickfacts/fact/table/US/PST045219. Accessed September 10, 2021.
11. Folsom AR, Basu S, Hong CP, Heckbert SR, Lutsey PL, Rosamond WD, et al. Reasons for differences in the incidence of venous thromboembolism in black versus white Americans. Am J Med 2019;132:970-6.
12. White RH, Keenan CR. Effects of race and ethnicity on the incidence of venous thromboembolism. Thromb Res 2009;123(Suppl 4):S11-7.
13. Zakai NA, McClure LA, Judd SE, Safford MM, Folsom AR, Lutsey PL, et al. Racial and regional differences in venous thromboembolism in the United States in 3 cohorts. Circulation 2014;129:1502-9.
14. Levy JH, Iba T, Olson LB, Corey KM, Ghadimi K, Connors JM. COVID-19: thrombosis, thromboinflammation, and anticoagulation considerations. Int J Lab Hematol 2021;43(Suppl 1):29-35.
15. Falasca L, Nardacci R, Colombo D, Lalle E, Di Caro A, Nicastri E, et al. Postmortem findings in Italian patients with COVID-19: a descriptive full autopsy study of cases with and without comorbidities. J Infect Dis 2020;222:1807-15.
16. Volbeda M, Jou-Valencia D, van den Heuvel MC, Knoester M, Zwiers PJ, Pillay J, et al. Comparison of renal histopathology and gene expression profiles between severe COVID-19 and bacterial sepsis in critically ill patients. Crit Care 2021;25:202.

Submitted Sep 13, 2021; accepted May 12, 2022.

Additional material for this article may be found online at www.jvsvenous.org.

Appendix (online only)

Supplementary Table I (online only). Imaging studies for suspected deep vein thrombosis/pulmonary embolism (DVT/PE) stratified by race

Imaging study	White (n = 694)	Black/African American (n = 111)	Asian (n = 48)	Other (n = 23)	*P* value
Duplex ultrasound scans					
Upper extremity	276 (39.8)	39 (35.1)	22 (45.8)	8 (34.8)	.589
Lower extremity	345 (49.7)	57 (51.4)	25 (52.1)	13 (56.5)	.905
CTA of chest	269 (38.8)	45 (40.5)	21 (43.8)	8 (34.8)	.863

CTA, computed tomography angiography.
Data presented as number (%).

Supplementary Table II (online only). Specific location of DVT and PE in all patients evaluated

Pt. No.	Age, years	Gender	Race	D-dimer, ng/mL	Upper DVT	Lower DVT	DVT location[a]
DVT							
1	59	Female	White	1534	Yes	No	Brachial vein
2	69	Male	Black/African American	18,796	No	Yes	Popliteal vein
3	64	Male	White	787	No	Yes	Femoral vein
4	70	Male	White	42,000	No	Yes	Peroneal vein
5	50	Male	Black/African American	1250	No	Yes	Femoral vein
6	44	Male	White	14,052	No	Yes	Peroneal vein
7	88	Female	Black/African American	5299	Yes	No	Brachial vein
8	65	Male	Unknown	4340	No	Yes	Popliteal vein
9	95	Female	White	1077	No	Yes	Femoral vein
10	72	Male	White	21,997	No	Yes	Peroneal vein
11	75	Female	White	1561	No	Yes	Popliteal vein
12	78	Male	White	845	Yes	No	Subclavian vein
13	38	Female	White	2121	Yes	No	Jugular vein
14	34	Male	White	20,749	No	Yes	Femoral vein
15	73	Male	White	2392	Yes	No	Brachial vein
16	52	Female	White	2344	Yes	No	Axillary vein
17	40	Female	Black/African American	7233	No	Yes	Femoral vein
18	92	Female	White	11,937	No	Yes	Popliteal vein
19	63	Male	White	6758	Yes	No	Jugular vein
20	62	Male	Black/African American	42,000	No	Yes	Femoral vein
21	59	Male	White	1222	No	Yes	Femoral vein
22	65	Male	White	5533	No	Yes	Femoral vein
23	92	Female	White	553	No	Yes	Femoral vein
24	41	Female	Black/African American	2694	No	Yes	Popliteal vein
25	83	Male	White	349	Yes	No	Jugular vein
26	66	Male	Black/African American	3217	Yes	No	Brachial vein
27	51	Male	White	1767	No	Yes	Popliteal vein
28	74	Female	Black/African American	1972	Yes	No	Axillary vein
29	98	Female	White	4919	No	Yes	Femoral vein
30	33	Female	Black/African American	3920	Yes	No	Jugular vein

PE					Laterality	NA	PE location
1	23	Female	White	523	Right		Segmental LL
2	50	Male	Black/African American	15,022	Right		Segmental branches
3	74	Male	Black/African American	20,327	Bilateral		Segmental to subsegmental
4	44	Male	White	1405	Right		Subsegmental LL
5	84	Female	White	1039	Right		ML segmental and LL subsegmental
6	61	Female	Black/African American	5697	Left		Left main
7	73	Male	White	24,133	Right		ML
8	67	Male	White	5097	Left		Pulmonary artery
9	72	Male	White	21,997	Left		Segmental LL
10	79	Male	White	9218	Right		Anterior basal segmental
11	65	Female	White	390	Bilateral		Segmental and subsegmental
12	66	Male	White	357	Left		Interlobar
13	59	Male	White	600	Bilateral		Multiple
14	84	Female	White	4064	Right		Subsegmental LL
15	70	Female	Asian	746	Right		Subsegmental LL

Supplementary Table II (online only). Continued.

PE					Laterality	NA	PE location
16	61	Male	Asian	42,000	Bilateral		Segmental to subsegmental
17	62	Male	Black/African American	42,000	Right		Segmental to subsegmental LL
18	50	Male	White	5120	Right		Segmental LL
19	52	Female	White	943	Right		Subsegmental UL and LL
20	62	Female	White	6303	Right		Segmental to subsegmental LL
21	87	Male	White	2243	Bilateral		Subsegmental
22	65	Female	White	6892	Right		LL pulmonary branches
23	67	Male	White	1541	Right		Main pulmonary
24	87	Female	White		Right		Segmental to subsegmental LL
25	92	Male	White	11,937	Right		Segmental to subsegmental UL and LL
26	78	Male	Asian	886	Right		LL
27	63	Male	White	6758	Left		Segmental UL
28	75	Male	White	527	Bilateral		Segmental and subsegmental
29	80	Male	White	299	Left		Segmental and subsegmental LL
30	48	Male	Black/African American	4649	Bilateral		Extensive
31	48	Female	White	1074	Left		LL
32	71	Male	White	2378	Right		UL
33	78	Male	White	1388	Left		UL and LL
34	75	Male	White	996	Right		Segmental LL
35	80	Female	White	27,846	Bilateral		Extensive
36	59	Male	White	1222	Right		Subsegmental LL
37	51	Male	Asian	2234	Right		Segmental and subsegmental UL
38	65	Male	White	5533	Right		Multiple
39	83	Male	White	678	Bilateral		Segmental and subsegmental
40	60	Female	White	12,992	Left		Segmental and subsegmental
41	94	Female	White	1256	Bilateral		Segmental and subsegmental
42	60	Female	Black/African American	1260	Bilateral		Segmental
43	71	Male	White	42,000	Bilateral		Segmental
44	92	Female	White	5818	Right		Segmental ML and subsegmental LL
45	48	Female	Black/African American	14,560	Right		Segmental and subsegmental UL and LL
46	87	Male	White	18,517	Bilateral		Multiple
47	46	Male	White	537	Left		Subsegmental UL
48	52	Female	Black/African American	4571	Left		Segmental and Subsegmental LL and lingula
49	65	Female	White	917	Bilateral		UL
50	84	Male	White	757	Right		Subsegmental LL
51	70	Male	White	1767	Right		UL, MD, LL
52	20	Male	Asian	1564	Right		Multiple, most central in ILA
53	67	Male	Black/African American		Bilateral		Multiple
54	51	Male	Black/African American	5943	Right		Segmental ML and LL

DVT, Deep vein thrombosis; *ILA*, interlobar artery; *LL*, lower lobe; *ML*, middle lobe; *NA*, not applicable; *PE*, pulmonary embolism; *Pt. No.*, patient number; *UL*, upper lobe.
[a]Location of most proximal area affected with greatest DVT burden.