Clinical profile and outcomes of COVID-19-associated pulmonary thromboembolism in critically ill patients

A single-center cross-sectional study in Colombia

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Abstract

Introduction: severe COVID-19 is associated with a hypercoagulable state and endothelial dysfunction that increases the risk of thromboembolic events like pulmonary embolism (PE), especially in critically ill patients in intensive care units (ICUs). The objective of this study was to describe the clinical, sociodemographic, and paraclinical characteristics of adult patients with PE and confirmed COVID-19, as well as to identify factors associated with mortality.

Methods: a cross-sectional descriptive study was conducted in the ICU of a quaternary care hospital in Bogotá, Colombia, from March 2020 to December 2021. Adult patients with SARS-CoV-2 infection (confirmed by RT-PCR) and PE (diagnosed by thoracic computed tomography angiography) were included. Clinical, laboratory and imaging variables were analyzed through descriptive statistics and bivariate analysis.

Results: 100 patients were included, with an average age of 59.3 ± 13.2 years; 70% were male. The most frequent comorbidities were hypertension (31%), diabetes mellitus (25%), and chronic obstructive pulmonary disease (13%). The overall mortality was 23% and was highest in patients with hypertension, diabetes, hemoptysis, the need for invasive mechanical ventilation and McConnell's sign. In addition, elevated lactate dehydrogenase, creatinine, lactate and ultrasensitive troponin were associated with greater mortality.

Conclusions: patients with severe COVID-19 and PE had a high mortality rate, especially those with cardiovascular comorbidities and right ventricular dysfunction. Identifying clinical and paraclinical predictors can improve risk stratification and guide treatment decisions in critically ill patients. **(Acta Med Colomb 2026; 51. DOI: https://doi.org/10.36104/amc.2026.4731).**

Keywords: *SARS-CoV-2, COVID-19, pulmonary embolism, intensive care unit, mortality, right ventricular dysfunction*.

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Introduction

In December 2019, a new coronavirus was identified as the etiological agent responsible for an outbreak of pneumonia in Wuhan, Hubei Province (China), an event that subsequently triggered a global pandemic (1). The World Health Organization formally named the disease caused by this virus "COVID-19" in February 2020 (2). The impact of COVID-19 through mortality and related complications like pulmonary thromboembolism (PTE) has been seen throughout the world, including Colombia (3, 4).

An association has been found between COVID-19 infection and a hypercoagulable state characterized by endothelial damage, venous stasis, and acute inflammatory changes, which increase the risk of thrombosis and foster thromboembolic disease (5–7). Critically ill patients, especially those admitted to intensive care units (ICUs), are particularly susceptible to venous thromboembolism (VTE), with reported prevalence rates ranging from 25 to 43%, even after receiving prophylactic anticoagulation (3, 8, 9). In contrast, the prevalence of VTE in patients hospitalized in general wards is lower, with values ranging from 3 to 15% (10, 11).

The suspicion of, approach to, and management of PTE in patients with COVID-19 is a clinical challenge due to symptom overlap with other acute respiratory infections and limitations in the availability of imaging studies for all cases. Given the high frequency of these events, as well as

the presence of additional VTE risk factors in some patients, diagnostic suspicion should be maintained in critically ill patients with these conditions. In addition, proper data gathering and characterization help identify the clinical and paraclinical profile as well as factors associated with mortality in this group of patients.

Therefore, the objective of this study was to describe the clinical, sociodemographic, and paraclinical characteristics of adult patients with acute pulmonary thromboembolism (confirmed by thoracic computed tomography angiography) and SARS-CoV-2 infection who were admitted to the ICU of a quaternary care clinic in Bogotá, Colombia, between March 2020 and December 2021. Variables associated with mortality in patients with these conditions were also sought.

Method

This was a cross-sectional, quantitative, descriptive observational study. It was carried out in the ICU of a quaternary care hospital in Bogotá, Colombia, from March 2020 to December 2021. The study population consisted of patients with SARS-CoV-2 infection confirmed by reverse transcription polymerase chain reaction (RT-PCR) who were admitted to the ICU and developed PTE confirmed by thoracic computed tomography angiography.

Patients over the age of 18 who were diagnosed with acute PTE and SARS-CoV-2 infection, confirmed by RT-PCR and treated in the ICU, were included. Patients with incomplete medical records and those who were referred to another institution with no possibility of follow-up were excluded.

During the study period, 4,200 patients were treated in the ICU, 1,981 of whom were diagnosed with COVID-19. Within this group, 110 patients developed PTE confirmed by thoracic computed tomography angiography. After excluding 10 patients due to incomplete information, the final sample included 100 patients. Sampling was consecutive, not probabilistic, for convenience.

The following variables were analyzed: age, sex, body mass index, time elapsed between the onset of symptoms and ICU admission, signs and symptoms of PTE, average ICU stay, and comorbidities. Relevant paraclinical variables were also evaluated, including hemoglobin, platelet count, lymphocyte count, D-dimer levels, lactate, ferritin, lactate dehydrogenase, C-reactive protein (CRP), ultrasensitive troponin, creatinine, and the ratio of the partial pressure of arterial oxygen to the fraction of inspired oxygen (PaO_2/FiO_2).

Data collection began in April 2022, after approval by the institutional review board and ethics committee. The data were obtained from the radiology service's databases that included thoracic computed tomography angiography studies performed during the established period. In PTE-positive cases, SARS-CoV-2 infection and ICU admission were confirmed through a clinical chart review. The information was recorded on a form previously designed by the researchers and was entered by trained associates.

The data were systematized in a Microsoft Excel version 16.73 spreadsheet, and a comprehensive review was conducted to ensure the consistency and quality of the information. Subsequently, a descriptive analysis of the sample's general characteristics was performed. Qualitative variables were expressed as absolute and relative frequencies, and quantitative variables were expressed as measures of central tendency and dispersion. The prevalence of PTE in patients with severe COVID-19 during the study period was also calculated.

The normality of continuous variables was evaluated using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Normally distributed variables were summarized using mean and standard deviation, while those with a non-normal distribution were described using median and interquartile range. A bivariate analysis was run to identify factors associated with hospital mortality. Continuous variables were analyzed using Student's t-test or the Mann-Whitney nonparametric test, as applicable, and categorical variables were analyzed using chi-square or Fisher's exact test when the expected values were less than five.

The associated clinical and paraclinical factors were expressed as odds ratios (ORs) with their respective 95% confidence intervals. The statistical analysis was done using SPSS® version 25.0 and STATA version 15.0 programs (12, 13).

Results

Demographic and clinical characteristics

A total of 100 patients were included in the cohort. The average age was 59.3 ± 13.2 years (median: 60 years), with a range of 28 to 85 years. Most of the patients were male. The average body mass index (BMI) was 28.3 ± 3.8 kg/m^2, with overweight being the most frequent category, and 31.0% of the patients were classified as obese (Table 1).

The most frequent symptoms among patients admitted to the ICU with COVID-19 and PTE were dyspnea, cough, and chest pain (Table 2).

Table 1. *Sociodemographic and clinical characteristics of patients with severe COVID-19 and acute PTE in the ICU.*

Sociodemographic variables		%
Sex	Male	70.0
	Female	30.0
Age range (years)	<50	20.0
	50-59.9	28.0
	60-69.9	27.0
	>= 70	25.0
BMI	Normal	14.0
	Overweight	55.0
	Class I obesity	24.0
	Class II obesity	7.0

BMI: body mass index, ICU: Intensive Care Unit.

Table 2. *Frequency of symptoms associated with pulmonary embolism (PE) and severe COVID-19 in the ICU.*

Clinical symptoms	Number of patients	%
Dyspnea	97	97.0
Chest pain	32	32.0
Cough	64	64.0
Hemoptysis	5	5.0
Syncope	6	6.0

The most frequent comorbidities were hypertension, diabetes mellitus, and chronic obstructive pulmonary disease (COPD). None of the patients were diagnosed with antiphospholipid syndrome or any other type of thrombophilia, and only 4% had a history of venous thromboembolic disease (Table 3).

Within the radiological findings, 6% of the patients had a saddle thrombus. Multilobar involvement was found in 75% of the cases during the initial assessment of the pulmonary parenchyma, a finding often associated with SARS-CoV-2 infection in patients requiring ICU care. Right ventricular dysfunction, defined as a right ventricular to left ventricular diameter ratio greater than one, was found on transthoracic echocardiography in 56% of the patients. McConnell's sign (hypo- or akinesia of the mid-right ventricular free wall with preserved apical contraction) was found in 2% of cases, with an average TAPSE of 22.25 ± 2.4 mm.

Among the paraclinical anomalies, 65% of the patients had evidence of acute myocardial injury, indicated by troponin levels > 99th percentile, with a mean of 64.3±120. The most relevant laboratory tests are shown in Table 4.

The prevalence of acute PTE and COVID-19 in the ICU at Clínica Universitaria Colombia during the stated period was 5.6%, with a mean ICU stay of eight days (range, 2-29 days). As far as the PTE risk classification, 55% were classified as having low risk, while 34% had intermediate risk. Furthermore, 11% of the patients were hemodynamically unstable and were classified as having high-risk PTE. Pharmacological thrombolysis was performed with intravenous alteplase in 12% of cases, and thromboaspiration was performed by the hemodynamics service in 1%.

Out of the 100 patients included, 60% required invasive mechanical ventilation, with an average duration of 5-8 days. The mortality rate associated with PTE and SARS-CoV-2 infection was 23%. There was a significant association between mortality and a history of hypertension and diabetes mellitus, the presence of hemoptysis as a clinical manifestation, and the need for invasive mechanical ventilation. In addition, there was an association approaching statistical significance with the presence of McConnell›s sign on echocardiography (Table 5).

Likewise, significant differences were found between mortality and higher levels of lactate dehydrogenase (LDH)

Table 3. *Prevalence of comorbidities associated with severe COVID-19 and acute PTE in the ICU.*

Comorbidities	Number of patients	%
Hypertension	31	31.0
Diabetes mellitus	25	25.0
Cancer	8	8.0
Cardiovascular disease	13	13.0
COPD	13	13.0
Asthma	2	2.0
Chronic kidney disease	5	5.0
Transplant	1	1.0
Immunosuppression	2	2.0
History of venous thromboembolic disease	4	4.0

COPD: chronic obstructive pulmonary disease

Table 4. *Associated paraclinical findings in patients with severe COVID-19 and acute PTE in the ICU.*

Laboratory test	Mean	Standard deviation	Median
Hemoglobin (g/dL)	14.0	2.1	14.1
Leukocytes (cells/µl)	16,358.2	28,734.2	11,873.5
Lymphocytes (cells/ µl)	892.9	611.7	765.0
Platelets (cells/ µl)	270,870.1	101,208.8	271,000.0
D-dimer (ng/mL)	15,017.2	22,122.6	6,992.5
Lactate (mmol/L)	2.5	1.5	2.1
Ferritin (ng/mL)	1,434.5	1,336.3	1,215.0
LDH (U/L)	539.8	445.2	460.0
CRP (mg/L)	163.2	95.8	158.0
Creatinine (mg/dL)	1.0	0.6	0.9
High-sensitivity troponin (peak) (ng/mL)	64.3	120.0	20.0
PAFI hypoxemia (mmHg)	108.98	59.15	91.50

DL: deciliter; g: gram; L: liter; LDH: lactate dehydrogenase; µl: microliter; mL: milliliter; mmHg: millimeters of mercury; ng: nanograms; PAFI: PaO_2/FIO_2 ratio; CRP: C-reactive protein; U: unit.

Table 5. *Risk factors associated with mortality in COVID-19 and acute PTE.*

Risk factors	RP, 95% CI, and p value of significance
Hypertension	2.04 95% CI: 1.013 – 4.108, p= 0.047
Diabetes mellitus	2.8 95% CI: 1.391 – 5.436, p= 0.006
Hemoptysis	4.0 95% CI: 2.2 – 7.2, p= 0.010
Invasive mechanical ventilation	4.4 95% CI: 1.4 - 13.9, p= 0.002
McConnell's sign	4.6 95% CI: 3.1 - 6.8, p= 0.051

IQR: interquartile range; CI: confidence interval.

($p = 0.033$), creatinine ($p < 0.001$), lactate ($p = 0.001$), and ultrasensitive troponin ($p = 0.006$) (Table 6).

Table 6. *Measures of central tendency and dispersion of the laboratory tests associated with mortality for COVID-19 and acute PTE in the ICU.*

	Mortality	
	+	-
Laboratory tests	**Median**	**Median**
Hemoglobin	14.2	14.0
Leukocytes	15,300.0	11,300.0
Lymphocytes	780.0	750.0
Platelets	230,500.0	277,000.0
D-dimer	5,760.0	7,269.0
Lactate	2.7	2.0
Ferritin	1,200.0	1,220.0
LDH	551.0	424.0
CRP	172.0	150.0
Creatinine	1.1	0.9
Peak ultrasensitive troponin	46.6	18.0

LDH: lactate dehydrogenase; µl: microliter; ml: milliliter; CRP: C-reactive protein.

Discussion

The importance of this study lies in the gathering of variables from critically ill patients using a comprehensive characterization and assessment of SARS-CoV-2 infection and its association with PTE in Colombia, thus contributing to a better understanding of this condition and the severity of the concomitant presentation of both diseases. Our findings align with other studies reported in the literature that have evaluated critically ill patients with COVID-19 and PTE. Previous studies have indicated that factors like initial hypoxemia, high SOFA scores, and a higher prevalence of complications – including acute respiratory distress syndrome, acute kidney failure, shock, arrhythmias, and respiratory infections – contribute to increased mortality in this group of patients (14, 15), consistent with our findings.

The authors of a study in Peru found similar comorbidities in the patients they evaluated, like obesity, diabetes mellitus, and hypertension. They also reported a 49.59% mortality rate and highlighted the relationship between lower oxygen saturation levels and higher mortality (16). On the other hand, a study in Mexico City reported a lower average age, with a significant proportion of patients being healthcare staff. In this cohort, obesity was highly prevalent, and a high BMI was associated with a higher respiratory rate and lower oxygen saturation levels. Furthermore, the study highlighted the need for ICU admission, especially in patients with diabetes mellitus, and reported a mortality rate of 3.57% (17).

These differences between studies can be explained by variations in the severity of the cases included, the demographic characteristics, and the comorbidities of the study populations, as well as the heterogeneity of the clinical management protocols, availability of hospital resources, and the epidemiological moment at which each study was carried out. Factors like the circulating viral variants and unequal access to specific therapies and ventilatory support should also be considered.

Our study identified other factors associated with mortality that coincide with what is described in the literature, like hypertension, diabetes mellitus, hemoptysis, and the need for invasive mechanical ventilation (18, 19). We also found McConnell's sign, characterized by hypo- or akinesia of the mid-right ventricular free wall with preserved apical contractility. This echocardiographic finding reflects acute right ventricular dysfunction secondary to a sudden rise in afterload caused by obstructed flow in the pulmonary circulation. From a pathophysiological perspective, this regional pattern is explained by unequal distribution of parietal stress and myocardial perfusion: while the mid-right ventricular free wall experiences overload and subendocardial ischemia, the apex preserves its mobility due to traction from the ventricular septum and the moderator band. In the context of PTE, the presence of McConnell's sign generally indicates significant right ventricular dysfunction and is associated with hemodynamic abnormalities or obstructive shock (20).

Regarding laboratory findings, elevated D-dimer and troponin levels have previously been identified as risk factors. Elevated troponin on admission has been associated with a worse prognosis in patients with PTE and occurs in 30-60% of cases; however, it has low specificity and limited positive predictive value for estimating early mortality (21). Our study also showed that abnormal LDH, creatinine, and lactate levels were significantly related to increased mortality.

As far as the treatment instated, thrombolytic drugs were used in 12% of cases at our institution, a higher percentage than reported in other VTE studies, in which fibrinolytics were used in approximately 5.7% (22). On the other hand, the need for invasive mechanical ventilation was lower in our cohort (60%) compared to the 88% requirement reported by Grasselli et al. This study also reported a 26% mortality rate in the ICU, which was comparable to the mortality found in our population (23).

This study has several limitations to be considered. First, its retrospective design limits longitudinal follow-up of the patients and the evaluation of long-term outcomes. Second, access to the medical records was a challenge, as not all had updated ICD-10 classifications, which may have led to errors or incomplete data. Third, the sample was not probabilistic, which limits the ability to make inferences for the general population; however, consecutive sampling was used to reduce selection bias. All pulmonary computed tomography angiographies performed during the study period were reviewed, and then, using the clinical charts, patients with a confirmed COVID-19 diagnosis and need for ICU care were identified. Although the final analysis included 100 patients, the potential population consisted of more

than 1,900 patients with a COVID-19 diagnosis admitted to intensive care.

Conclusions

This study characterized a cohort of patients in Colombia with severe COVID-19 and PTE, finding that a history of hypertension, a history of diabetes mellitus, hemoptysis as a clinical manifestation, the need for invasive mechanical ventilation, and the presence of McConnell's sign on echocardiography were factors associated with higher mortality. A significant association was also found between mortality and elevated levels of LDH, creatinine, lactate, and high-sensitivity troponin.

These findings help to better understand the clinical behavior of this condition and can potentially optimize risk stratification and clinical decision-making for critically ill patients. Ongoing research in this field is essential to improve care and clinical outcomes in treating this complex condition.

References

1. **Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al.** Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. *N Engl J Med*. 2020;382(13):1199–207.
2. **World Health Organization.** WHO director-general's opening remarks at the media briefing on COVID-19 - 24 February 2020. 2025; Disponible en: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—24-february-2020.
3. **Middeldorp S, Coppens M, van Haaps TF, Foppen M, Vlaar AP, Müller MCA, et al.** Incidence of venous thromboembolism in hospitalized patients with COVID□19. *J Thromb Haemost*. 2020;18(8):1995–2002.
4. **López Fontalvo J, Martínez Fontalvo A, Guerrero Caicedo L, Acosta Alvear D, Cuello García C, Rojas Romero R, et al.** Incidencia de eventos tromboembólicos venosos en pacientes hospitalizados con COVID-19. *Acta Colomb Cuid Intensivo*. 2022;22(Suppl 1):S11–8.
5. **Teuwen LA, Geldhof V, Pasut A, Carmeliet P.** COVID-19: the vasculature unleashed. *Nat Rev Immunol*. 2020;20(7):389–91.
6. **Lowenstein CJ, Solomon SD.** Severe COVID-19 is a microvascular disease. *Circulation*. 2020;142(17):1609–11.
7. **Libby P, Lüscher T.** COVID-19 is, in the end, an endothelial disease. *Eur Heart J*. 2020;41(32):3038–44.
8. **Martínez Chamorro E, Revilla Ostolaza TY, Arrieta Arbizu I, Gómez Fernández M, García Tejada J, Muñoz Burillo F, et al.** Tromboembolismo pulmonar en pacientes con COVID-19: estudio de prevalencia en un hospital terciario. *Radiología*. 2021;63(1):13–21.
9. **Cui S, Chen S, Li X, Liu S, Wang F.** Prevalence of venous thromboembolism in patients with severe novel coronavirus pneumonia. *J Thromb Haemost*. 2020;18(6):1421–4.
10. **Hill JB, Garcia D, Crowther M, Savage B, Perdomo C, Chang K, et al.** Frequency of venous thromboembolism in 6513 patients with COVID-19: a retrospective study. *Blood Adv*. 2020;4(21):5373–7.
11. **Fauvel C, Weizman O, Trimaille A, Mika D, Pommier T, Pace N, et al.** Pulmonary embolism in COVID-19 patients: a French multicentre cohort study. *Eur Heart J*. 2020;41(32):3058–68.
12. **IBM Corp.** IBM SPSS Statistics para Windows, versión 25.0. *Armonk, NY*: IBM Corp; 2017.
13. **StataCorp.** Stata statistical software: release 15. *College Station, TX: StataCorp LLC*; 2017.
14. **Ferrando C, Mellado-Artigas R, Gea A, Arruti E, Aldecoa C, Bordell A, et al.** Características, evolución clínica y factores asociados a la mortalidad en UCI de los pacientes críticos infectados por SARS-CoV-2 en España: estudio prospectivo, de cohorte y multicéntrico. *Rev Esp Anestesiol Reanim*. 2020;67(8):425–37.
15. **Bhatraju PK, Ghassemieh BJ, Nichols M, Kim R, Jerome KR, Nalla AK, et al.** Covid-19 in critically ill patients in the Seattle region—case series. *N Engl J Med*. 2020;382(21):2012–22.
16. **Mejía F, Medina C, Cornejo E, Morello E, Vásquez S, Alave J, et al.** Características clínicas y factores asociados a mortalidad en pacientes adultos hospitalizados por COVID-19 en un hospital público de Lima, Perú. *SciELO Preprints*. 2020.
17. **Ortiz-Brizuela E, Villanueva-Reza M, González-Lara MF, Tamez-Torres KM, Román-Montes CM, Díaz-Mejía BA, et al.** Clinical and epidemiological characteristics of patients diagnosed with COVID-19 in a tertiary care center in Mexico City: a prospective cohort study. *Rev Invest Clin*. 2020;72(4):165–77.
18. **Fu Z, Zhang Y, Wang J, Ye H, Zhang Y, Han P, et al.** Risk factors and mortality of pulmonary embolism in COVID-19 patients: evidence based on fifty observational studies. *Medicine (Baltimore)*. 2022;101(45):e29895.
19. Gong X, Yuan B, Yuan Y, Xu H, Wang J, Yang M, et al. Incidence and prognostic value of pulmonary embolism in COVID-19: a systematic review and meta-analysis. *PLoS One*. 2022;17(3):e0263580. doi:10.1371/journal.pone.0263580
20. **McConnell MV, Solomon SD, Rayan ME, Come PC, Goldhaber SZ, Lee RT.** Regional right ventricular dysfunction detected by echocardiography in acute pulmonary embolism. *Am J Cardiol*. 1996;78(4):469–73.
21. **Sociedad Europea de Cardiología.** Guía ESC 2019 para el diagnóstico y tratamiento de la embolia pulmonar aguda. *Rev Esp Cardiol*. 2020;73(6):497.e1–58.
22. **Ambra N, Suresh S, Jayaram R, Raghavan V, Balachandran M, Shanker R, et al.** Venous thromboembolism among hospitalized patients: incidence and adequacy of thromboprophylaxis – a retrospective study. *Vasc Health Risk Manag*. 2022;18:575–87.
23. **Grasselli G, Zangrillo A, Zanella A, Antonelli M, Cabrini L, Castelli A, et al.** Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy. *JAMA*. 2020;323(16):1574–81.

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