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# Clinical Characteristics and Outcomes of Patients with Severe COVID-19 and Chronic Obstructive Pulmonary Disease (COPD)

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**Background:** The rapid worldwide spread of the coronavirus disease 2019 (COVID-19) epidemic has placed patients with pre-existing conditions at risk of severe morbidity and mortality. The present study investigated the clinical characteristics and outcomes of patients with severe COVID-19 and chronic obstructive pulmonary disease (COPD).





**Material/Methods:** This study enrolled 336 consecutive patients with confirmed severe COVID-19, including 28 diagnosed with COPD, from January 20, 2020, to April 1, 2020. Demographic data, symptoms, laboratory values, comorbidities, and clinical results were measured and compared in survivors and non-survivors.

**Results:** Patients with severe COVID-19 and COPD were older than those without COPD. The proportions of men, of patients admitted to the intensive care unit (ICU) and of those requiring invasive ventilation were significantly higher in patients with than without COPD. Leukocyte and neutrophil counts, as well as the concentrations of NT-proBNP, hemoglobin, D-dimer, hsCRP, ferritin, IL-2R, TNF- $\alpha$  and procalcitonin were higher, whereas lymphocyte and monocyte counts were lower, in patients with than without COPD. Of the 28 patients with COPD, 22 (78.6%) died, a rate significantly higher than in patients without COPD (36.0%). A comparison of surviving and non-surviving patients with severe COVID-19 and COPD showed that those who died had a longer history of COPD, more fatigue, and a higher ICU occupancy rate, but a shorter average hospital stay, than those who survived.

**Conclusions:** COPD increases the risks of death and negative outcomes in patients with severe COVID-19.

**MeSH Keywords:** **COVID-19 • Outcome Assessment (Health Care) • Pulmonary Disease, Chronic Obstructive**

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## Background

Since December 2019, the sudden outbreak of coronavirus disease 2019 (COVID-19) has become a prominent public health emergency worldwide, with severe negative effects, including high death rates and major economic disruptions [1]. As of May 1, 2020, 215 countries and regions had reported cases of viral infection, with over 3.2 million confirmed cases and over 234 000 deaths due to COVID-19 worldwide [2]. Factors associated with the risks of severe disease and death include older age, male sex, smoking, and comorbidities [3].

Chronic obstructive pulmonary disease (COPD) is common in China, estimated in 2020 to affect 13.7% of individuals aged >40 years [4]. Most patients affected by this disease are elderly men who have smoked for a long time. COPD is often associated with other systemic diseases and can lead to disordered pulmonary ventilation and even ventilation dysfunction. COPD can therefore increase the risk of infection and further complicate the treatment of patients with severe pulmonary infections. These findings suggested that COPD may increase the risks of severe COVID-19 infection and death.

The most common comorbidities associated with poor prognosis in patients with COVID-19 include hypertension, diabetes, heart disease, respiratory disease, pregnancy, kidney disease, and malignancy [5]. To date, however, less is known about the relationship between clinical presentation and prognosis in patients with severe COVID-19 and COPD [6]. The present study therefore analyzed the clinical characteristics of patients with severe COVID-19 and COPD and determined the relationship between COPD and the prognosis of patients with severe COVID-19.

## Material and Methods

### Ethics statement

The study was carried out in strict compliance with the provisions of the Declaration of Helsinki and was approved by the Tongji Medical College Ethics Committee at Tongji Hospital and the Huazhong University of Science and Technology Committee. All the patients provided oral informed consent.

### Study design and population

This study included all patients hospitalized with severe COVID-19 at Tongji Hospital, Wuhan, China, from January 20, 2020, to April 10, 2020. Severe COVID-19 was defined as positivity for SARS-CoV-2 nucleic acid by real-time PCR or positivity for SARS-CoV-2-specific IgM and IgG antibodies and at least one of the following manifestations: respiratory rate (RR)

≥30/min, oxygen saturation ≤93% in a resting state, PaO<sub>2</sub>/FiO<sub>2</sub> ≤300 mmHg, pulmonary imaging (CT/DR) showing significant progression >50% within 24 to 48 hours, respiratory failure requiring mechanical ventilation, shock, or admission to the Intensive Care Unit (ICU) for failure of other organs [7]. Patients with a previous history of COPD were defined as those with a long history of smoking, a diagnosis of COPD at our hospital, and treatment with inhaled drugs.

### Data collection

Data collected from the medical records of each patient included age, sex, duration of COPD, treatment for COPD, comorbidities, and symptoms that included fever, sputum, dyspnea, cough, fatigue, chest pain, nausea, vomiting, and diarrhea. Laboratory parameters included routine blood tests; tests of liver, renal, and blood coagulation function; and concentrations of brain natriuretic peptide, troponin I, interleukin 2 receptor, C-reactive protein, procalcitonin, interleukin 6, interleukin 8, interleukin 10, and tumor necrosis factor-α. Also recorded were sepsis-related organ failure assessment (SOFA) score [8], patient outcomes, and length of stay in the hospital.

### Statistical analysis

Because the incidence and prevalence of COVID-19 in COPD patients were unknown, sample size could not be calculated prior to the study. Normally distributed continuous variables were reported as the mean±SEM and compared by independent *t*-tests. Non-normally distributed continuous variables were reported as median (first and third quartiles) and compared by Mann-Whitney U-tests. Categorical variables were reported as number (%) and compared by chi-square tests. The relationships of clinical factors to death from severe COVID-19 were assessed using a Cox proportional hazards regression model. Hazard ratios (HRs) and 95% confidence intervals (95% CI) were analyzed. All statistical analyses were performed using SPSS 20 software, with *P*<0.05 defined as statistically significant.

## Results

This study enrolled 336 consecutively hospitalized patients with severe COVID-19, including 28 with COPD. The overall median age was 65 (50-77) years but was significantly higher in patients with than without COPD (71 [63-79] years vs. 62 [43-73] years, *P*<0.001). The proportion of men was also significantly higher in patients with than without COPD (*P*=0.004). Hypertension was the most common comorbidity in these patients (38.1%), followed by diabetes (23.2%), coronary heart disease (17.6%), cerebrovascular disease (4.5%), cancer (4.1%), chronic kidney disease (2.4%), autoimmune disease (1.2%), and chronic liver disease (0.9%). COPD ranked as

the fourth most common comorbidity in these patients with severe COVID-19, at 8.3% (Table 1).

The most common symptoms of severe COVID-19 were fever (88.7%), cough (76.0%), dyspnea (60.4%), fatigue (47.9%), and expectoration (28.9%). Cough, expectoration, dyspnea, and fatigue were more common in patients with COPD than in those without COPD. Other symptoms, including diarrhea (27.7%), nausea (5.7%), vomiting (3.6%), and chest pain (2.4%), as well as SOFA scores, did not differ significantly in these 2 groups. Of the 28 patients with severe COVID-19 and COPD, 19 (67.9%) were admitted to the ICU, a rate significantly higher than in patients without COPD (45.4%). All patients with COPD used glucocorticoids, compared with only 54.5% of those without COPD. Similarly, the utilization rates of invasive ventilation were higher in patients with (67.9%) COPD than in those without (38.0%) COPD. In addition, median hospital stay (11 [6–14] days vs. 14 [10–21] days) and mortality rate (78.6% vs. 36.0%) were higher in patients with than without COPD (Table 1).

At admission, COPD patients had higher leukocyte ( $8.24 \times 10^9/L$  vs.  $5.72 \times 10^9/L$ ) and neutrophil ( $6.78 \times 10^9/L$  vs.  $3.54 \times 10^9/L$ ) counts and higher hemoglobin (13.2 vs. 11.3 g/L), NT-proBNP (729 vs. 422 pg/L), D-dimer (4.1 vs. 1.9 mg/L), hsCRP (79.6 vs. 49.1 mg/L), ferritin (1315 vs. 701 mg/L), IL-2R (962 vs. 576 U/mL), TNF- $\alpha$  (14.5 vs. 9.6 ng/L), and PCT (0.21 vs. 0.09 ng/mL) concentrations than the patients without COPD. In contrast, lymphocyte ( $0.46 \times 10^9/L$  vs.  $0.71 \times 10^9/L$ ) and monocyte ( $0.29 \times 10^9/L$  vs.  $0.41 \times 10^9/L$ ) counts were lower in the COPD group. Other laboratory indicators, such as platelet counts, prothrombin times, APTT, liver and kidney function tests, and CK, LDH, IL-6, IL-8 and IL-10 concentrations, did not differ in these 2 groups (Table 2).

Of the 336 patients with severe COVID-19, 133 (39.6%) died. Compared with survivors, non-survivors were older (69 [57–80] vs. 48 [36–69] years), had a larger proportion of men (59.8% vs. 40.2%), and were more likely to have other diseases, including hypertension (45.9% vs. 33%), diabetes (32.3% vs. 17.2%), cardiovascular disease (27.1% vs. 11.3%), and COPD (16.5% vs. 3.0%) (Table 3). The ICU admission rate (78.9% vs. 26.1%), the use of glucocorticoids (91.0% vs. 37.0%), SOFA scores (<0.001), and the need for mechanical ventilation support (92.5% vs. 6.4%) were higher in patients who died, whereas the average length of hospital stay (10 [5–14] days vs. 16 [12–24] days) was significantly shorter (Table 3).

Of the 28 patients with severe COVID-19 and COPD, 22 (78.6%) died. Kaplan-Meier analysis showed that the overall survival rate was worse in severe COVID-19 patients with than without COPD (HR 4.87; 95% CI 1.03 to 9.14,  $P < 0.01$ ; Figure 1). Cox proportional hazard regression analysis showed that the overall survival rate remained worse in severe COVID-19 patients

with than without COPD after adjusting for age and sex (HR 2.75; 95% CI 1.01 to 5.67,  $P = 0.018$ ) and after adjusting for hypertension and cardio-cerebrovascular disease (HR 1.98; 95% CI 0.59 to 3.44,  $P = 0.037$ ).

A comparison of survivors and non-survivors in the group with severe COVID-19 and COPD showed that those who died were significantly more likely to be men ( $P < 0.001$ ); to have a longer history of COPD ( $P = 0.032$ ), a higher SOFA score ( $P < 0.001$ ), and a higher likelihood of fatigue (81.8% vs. 33.3%) and to be admitted to the ICU. However, the median length of hospital stay was significantly shorter in patients who died than in those who survived (8 [5–13] days vs. 15 [11–19] days) (Table 4). Moreover, a comparison of survivors and non-survivors in this group showed that leukocyte ( $9.76 \times 10^9/L$  vs.  $6.32 \times 10^9/L$ ) and neutrophil ( $9.01 \times 10^9/L$  vs.  $4.66 \times 10^9/L$ ) counts were higher in non-survivors, as were blood urea nitrogen (9.2 vs. 5.4 mmol/L), creatinine (92 vs. 69  $\mu\text{mol/L}$ ), CK (168 vs. 92 U/L), LDH (519 vs. 316 U/L), NT-proBNP (889 vs. 398 pg/L), D-dimer (7.96 vs. 2.56 mg/L), hsCRP (89.1 vs. 44.3 mg/L), ferritin (1569 vs. 536 mg/L), IL-2R (1024 vs. 712 U/mL), TNF- $\alpha$  (12.6 vs. 6.4 ng/L), and PCT (0.47 vs. 0.14 ng/mL) concentrations. In contrast, lymphocyte ( $0.44 \times 10^9/L$  vs.  $0.87 \times 10^9/L$ ) and monocyte ( $0.31 \times 10^9/L$  vs.  $0.52 \times 10^9/L$ ) counts and albumin levels (25 vs. 33 g/L) were significantly lower in non-survivors (Table 5).

## Discussion

Despite the widespread COVID-19 pandemic and the large numbers of infected patients, relatively little is known about the clinical course in patients with severe COVID-19 and COPD [9]. Of the 336 patients with severe COVID-19 included in this study, only 28 (8.3%) had COPD. These patients were older, had more severe inflammation, and were more prone to bacterial infection than patients with severe COVID-19 without COPD. Furthermore, Kaplan-Meier analysis demonstrated that overall survival was significantly lower in severe COVID-19 patients with COPD than in those without COPD. Our results showed that COPD was strongly associated with poor prognosis and with adverse clinical outcomes such as ICU admission, glucocorticoid use, invasive mechanical ventilation, and death. Comparisons of survivors and non-survivors with severe COVID-19 and COPD showed that non-survivors were older, were more likely to be men and were more likely to be admitted to the ICU than survivors.

Most COPD patients in China are men with a long history of smoking. In addition, more COVID-19 patients are male, as SARS-CoV-2 infection is through the ACE2 receptor, which is expressed at almost 3-fold higher levels in men than in women [10–12]. Long-term exposure to smoke damages the airway intima and induces the proliferation of airway smooth muscle

**Table 1.** Clinical features of severe COVID-19 patients with and without COPD.

	Total (n=336)		COPD (n=28)		Non-COPD (n=308)		P value
	Number	(%)	Number	(%)	Number	(%)	
<b>Age*</b>	65	(50–77)	71	(63–79)	62	(43–73)	<b>&lt;0.001</b>
<b>Sex</b>							
Male	201	(59.8)	24	(85.7)	177	(57.5)	<b>0.004</b>
Female	135	(40.2)	4	(14.3)	131	(42.5)	
<b>Comorbidities</b>							
Essential hypertension	128	(38.1)	9	(32.1)	119	(39.3)	0.458
Diabetes	78	(23.2)	5	(17.9)	73	(23.7)	0.483
Cardiovascular disease	59	(17.6)	10	(35.7)	49	(15.9)	<b>0.008</b>
Cerebrovascular disease	15	(4.5)	4	(14.3)	11	(3.6)	<b>0.009</b>
Chronic kidney disease	8	(2.4)	2	(7.1)	6	(1.9)	0.089
Chronic liver disease	3	(0.9)	0	(0)	3	(1.0)	0.597
Malignancy	14	(4.1)	2	(7.1)	12	(3.9)	0.423
Autoimmune disease	4	(1.2)	0	(0)	4	(1.3)	0.541
<b>Symptoms</b>							
Fever	298	(88.7)	24	(85.7)	274	(89.0)	0.426
Cough	255	(76.0)	28	(100)	227	(73.7)	<b>0.003</b>
Expectoration	97	(28.9)	28	(100)	69	(22.8)	<b>&lt;0.001</b>
Dyspnea	203	(60.4)	28	(100)	175	(56.8)	<b>&lt;0.001</b>
Fatigue	161	(47.9)	20	(71.4)	141	(46.5)	0.012
Pectoralgia	21	(2.4)	1	(3.6)	20	(6.6)	0.5292
Diarrhea	93	(27.7)	7	(25.0)	86	(28.4)	0.7031
Nausea	19	(5.7)	2	(7.1)	17	(5.6)	0.7388
Vomiting	12	(3.6)	2	(7.1)	10	(3.3)	0.2980
<b>SOFA score</b>	1.98±1.06		2.04±1.15		1.87±0.94		0.0792
<b>ICU patients</b>	158	(47.0)	19	(67.9)	139	(45.4)	<b>0.0228</b>
<b>Glucocorticoid treatment</b>	196	(58.3)	28	(100)	168	(54.5)	<b>&lt;0.001</b>
<b>Mechanical ventilation**</b>	136	(40.5)	19	(67.9)	117	(38.0)	<b>&lt;0.001</b>
<b>Length of hospital stay***</b>	14	(8–19)	11	(6–14)	14	(10–21)	<b>0.001</b>
<b>Mortality</b>	133	(39.6)	22	(78.6)	111	(36.0)	<b>&lt;0.001</b>

\* Data reported as median interquartile range (IQR) years; \*\* invasive mechanical ventilation only; \*\*\* data reported displayed as IQR: days. ICU – Intensive Care Unit; SOFA score – Sepsis-related Organ Failure Assessment score. *P*<0.05 was defined as statistically significant.

**Table 2.** Laboratory results of severe COVID-19 patients with and without COPD.

	Normal range	COPD (n=28)		Non-COPD (n=308)		P value
		Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
<b>Blood routine</b>						
Leukocyte count, ×10 <sup>9</sup> /L	3.5–9.5	8.24 (5.23–13.67)	5.72 (4.21–9.18)			<b>0.001</b>
Neutrophil count, ×10 <sup>9</sup> /L	1.8–6.3	6.78 (3.92–10.96)	3.54 (2.38–7.66)			<b>0.001</b>
Lymphocyte count, ×10 <sup>9</sup> /L	1.1–3.2	0.46 (0.31–0.97)	0.71 (0.51–1.27)			<b>0.012</b>
Monocyte count, ×10 <sup>9</sup> /L	0.1–0.6	0.29 (0.21–0.47)	0.41 (0.27–0.57)			<b>0.006</b>
Hemoglobin, g/L	115–150	132 (117–146)	113 (98–134)			<b>0.026</b>
Platelet count, ×10 <sup>9</sup> /L	125–350	171 (125–224)	178 (128–237)			0.585
<b>Blood biochemistry</b>						
ALT, U/L	≤33	26 (15–45)	23 (14–41)			0.748
AST, U/L	≤32	36 (22–57)	32 (19–55)			0.637
Albumin, g/L	35–52	31 (24–45)	33 (26–48)			0.463
UN, mmol/L	3.1–8.8	7.1 (4.8–9.7)	6.7 (4.0–9.1)			0.379
Cr, μmol/L	45–104	76 (51–109)	71 (42–101)			0.281
CK, U/L	≤170	128 (64–282)	113 (56–276)			0.326
LDH, U/L	135–214	427 (342–619)	459 (354–651)			0.194
NT-proBNP, pg/L	<285	729 (253–2421)	422 (153–1028)			<b>0.001</b>
<b>Blood coagulation</b>						
PT, s	9–13	12.4 (11.5–16.8)	13.1 (12.2–17.9)			0.871
APTT, s	25–31.3	32.4 (24.7–36.5)	28.1 (21.4–30.8)			0.415
D-dimer, mg/L	0–0.55	4.1 (1.3–16.4)	1.9 (0.9–11.3)			<b>0.001</b>
<b>Inflammatory markers</b>						
hsCRP, mg/L	<1	79.6 (43.5–121.4)	49.1 (32.8–93.2)			<b>0.001</b>
ESR, mm/H	0–20	29.0 (14.0–55.6)	33.2 (19.2–61.3)			0.712
Ferritin, μg/L	15–150	1315 (564–2507)	701 (278–1980)			<b>0.001</b>
IL-2R, U/mL	223–710	962 (541–1237)	576 (489–989)			<b>0.003</b>
IL-6, ng/L	<7	37.8 (10.1–112.8)	32.1 (6.5–97.3)			0.312
IL-8, ng/L	<62	29.4 (12.1–60.5)	34.1 (14.6–68.2)			0.295
IL-10, ng/L	<9.10	11.2 (4.1–15.8)	13.5 (5.3–17.6)			0.631
TNF-α, ng/L	<8.1	14.5 (7.9–22.8)	9.6 (5.1–13.1)			<b>0.001</b>
<b>Bacterial infection marker</b>						
PCT, ng/mL	0.02–0.05	0.21 (0.10–1.15)	0.09 (0.05–0.18)			<b>0.001</b>

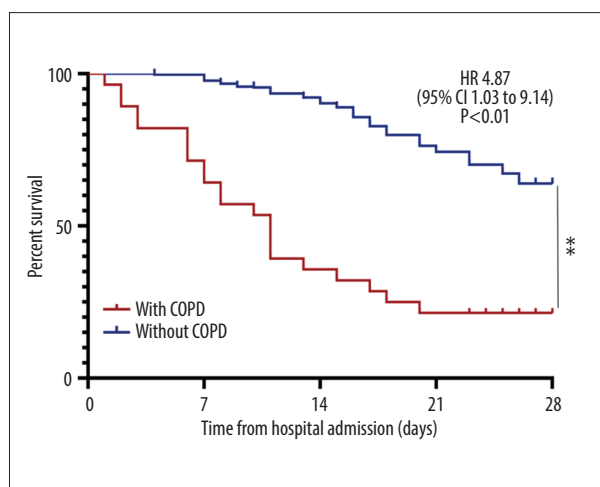
ALT – alanine aminotransferase; AST – aspartate aminotransferase; UN – urea nitrogen; Cr – creatinine; CK – creatine kinase; LDH – lactic dehydrogenase; PT – prothrombin time; APTT – activated partial thromboplastin time; hsCRP – high sensitive C-reactive protein; IL – interleukin; NT-proBNP – N-terminal pro-brain natriuretic peptide; TNF-α – tumor necrosis factor-α; PCT – procalcitonin; ESR – erythrocyte sedimentation rate. *P*<0.05 was defined as statistically significant.



**Table 3.** Baseline characteristics of survivors and non-survivors with severe COVID-19 patients.

	Total (n=336)		Survivors (n=203)		Non-survivors (n=133)		P value
	Number	(%)	Number	(%)	Number	(%)	
<b>Age*</b>	65	(50–77)	48	(36–69)	69	(57–80)	<b>&lt;0.001</b>
<b>Sex</b>							
Male	201	(59.8)	100	(49.3)	101	(75.9)	<b>&lt;0.001</b>
Female	135	(40.2)	103	(50.7)	32	(24.1)	
<b>Comorbidities</b>							
COPD	28	(8.3)	6	(3.0)	22	(16.5)	<b>&lt;0.001</b>
Essential hypertension	128	(38.1)	67	(33.0)	61	(45.9)	<b>0.018</b>
Diabetes	78	(23.2)	35	(17.2)	43	(32.3)	<b>0.001</b>
Cardiovascular disease	59	(17.6)	23	(11.3)	36	(27.1)	<b>&lt;0.001</b>
Cerebrovascular disease	15	(4.5)	7	(3.4)	8	(6.0)	0.265
Chronic kidney disease	8	(2.4)	5	(2.5)	3	(2.3)	0.903
Chronic liver disease	3	(0.9)	2	(1.0)	1	(0.8)	0.824
Malignancy	14	(4.1)	8	(3.9)	6	(4.5)	0.798
Autoimmune disease	4	(1.2)	3	(1.5)	1	(0.8)	0.549
<b>SOFA score</b>	1.98±1.06		1.02±0.93		2.46±1.23		<b>&lt;0.001</b>
<b>ICU patients</b>	158	(47.0)	53	(26.1)	105	(78.9)	<b>&lt;0.001</b>
<b>Glucocorticoid treatment</b>	196	(58.3)	75	(37.0)	121	(91.0)	<b>&lt;0.001</b>
<b>Mechanical ventilation**</b>	136	(40.5)	13	(6.4)	123	(92.5)	<b>&lt;0.001</b>
<b>Length of hospital stay***</b>	14	(8–19)	16	(12–24)	10	(5–14)	<b>&lt;0.001</b>

\* Data reported as IQR, years; \*\* invasive mechanical ventilation only; \*\*\* data reported as IQR, days. ICU – Intensive Care Unit; SOFA score – Sepsis-related Organ Failure Assessment score.  $P < 0.05$  was defined as statistically significant.



**Figure 1.** Kaplan-Meier survival curves comparing patients with severe COVID-19 with and without COPD (\*\*  $P < 0.01$ ).

cells, airway remodeling, disordered pulmonary function, and even ventilation disorders [13]. SARS-CoV-2 infection exacerbates previous lung function injury, significantly increasing the rates of ventilator use and ICU admission. Glucocorticoids are widely used to relieve airway inflammation, especially in severely ill patients [14]. However, anatomically small airways are chronically damaged in COPD patients. Because this damage is usually combined with bronchiectasis and obstruction of airway sputum removal, the small airways are more likely to be infected with bacteria, even with extensively drug-resistant bacteria, exacerbating the original severe pulmonary infection [15]. Together, these factors contribute to a high risk of adverse outcomes in patients with severe COVID-19 and COPD.

Cardiovascular and cerebrovascular diseases are more likely to be present in severe COVID-19 patients with than without COPD. These conditions may be due to long-term hypoxia, chronic inflammation, and other factors leading to vascular endothelial

**Table 4.** Clinical features of survivors and non-survivors with severe COVID-19 and COPD.

	Total (n=28)	Survivors (n=6)	Non-survivors (n=22)	P value
	Number (%)	Number (%)	Number (%)	
<b>Age<sup>#</sup></b>	70.5±10.6	67.8±8.7	72.3±11.4	0.379
<b>Sex</b>				
Male	24 (85.7)	4 (66.7)	20 (90.9)	<b>&lt;0.001</b>
Female	4 (14.3)	2 (33.3)	2 (9.1)	
<b>COPD duration*</b>	5 (3–8)	3.5 (2–5.5)	5 (3–8)	<b>0.0320</b>
<b>COPD treatment</b>				
None	7 (25.0)	3 (50.0)	4 (18.2)	0.111
LAMA/LABA	10 (35.7)	2 (33.3)	8 (36.4)	0.891
ICS+LAMA/LABA	6 (21.4)	1 (16.7)	5 (22.7)	0.748
Oxygen therapy	3 (10.7)	0 (0.0)	3 (13.6)	0.338
Ventilatory(NIV) support	2 (7.2)	0 (0.0)	2 (9.1)	0.443
<b>Comorbidities</b>				
Essential hypertension	9 (32.1)	2 (33.3)	7 (31.8)	0.944
Diabetes	5 (17.9)	2 (33.3)	3 (13.6)	0.264
Cardiovascular disease	10 (35.7)	3 (50.0)	7 (31.8)	0.410
Cerebrovascular disease	4 (14.3)	1 (16.7)	3 (13.6)	0.851
Chronic kidney disease	2 (7.1)	2 (33.3)	0 (0.0)	<b>0.005</b>
Chronic liver disease	0 (0.0)	0 (0.0)	0 (0.0)	–
Malignancy	2 (7.1)	0 (0.0)	2 (9.1)	0.443
Autoimmune disease	0 (0.0)	0 (0.0)	0 (0.0)	–
<b>Symptoms</b>				
Fever	24 (85.7)	4 (66.7)	20 (90.9)	0.133
Cough	28 (100)	6 (100)	22 (100)	–
Expectoration	28 (100)	6 (100)	22 (100)	–
Dyspnea	28 (100)	6 (100)	22 (100)	–
Fatigue	20 (71.4)	2 (33.3)	18 (81.8)	<b>0.020</b>
Pectoralgia	1 (3.6)	0 (0.0)	1 (4.5)	0.595
Diarrhea	7 (25.0)	2 (33.3)	5 (22.7)	0.595
Nausea	2 (7.1)	1 (16.7)	1 (4.5)	0.307
Vomiting	2 (7.1)	0 (0.0)	2 (9.1)	0.443
<b>SOFA score</b>	2.04±1.15	1.49±1.12	3.39±1.47	<0.001
<b>ICU patients</b>	19 (67.9)	2 (33.3)	17 (77.3)	<b>0.041</b>
<b>Glucocorticoid treatment</b>	28 (100)	6 (100)	22 (100)	–
<b>Mechanical ventilation**</b>	19 (67.9)	3 (50.0)	16 (72.7)	0.291
<b>Length of hospital stay*** 11 (6–14)</b>		15 (11–19)	8 (5–13)	<b>0.003</b>

<sup>#</sup> Mean±SD, years; \* data reported as IQR, years; \*\* invasive mechanical ventilation only; \*\*\* data reported as IQR, days. ICU – Intensive Care Unit; SOFA score – Sepsis-related Organ Failure Assessment score. *P*<0.05 was defined as statistically significant.

**Table 5.** Laboratory findings of survivors and non-survivors with severe COVID-19 and COPD.

	Normal range	Survivors (n=6)		Non-survivors (n=22)		P value
		Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
<b>Blood routine</b>						
Leukocyte count, ×10 <sup>9</sup> /L	3.5–9.5	6.32 (3.78–8.14)	9.76 (4.91–14.54)			<b>0.003</b>
Neutrophil count, ×10 <sup>9</sup> /L	1.8–6.3	4.66 (3.02–6.45)	9.01 (5.27–13.16)			<b>0.001</b>
Lymphocyte count, ×10 <sup>9</sup> /L	1.1–3.2	0.87 (0.49–1.67)	0.44 (0.31–0.67)			<b>0.001</b>
Monocyte count, ×10 <sup>9</sup> /L	0.1–0.6	0.52 (0.34–0.77)	0.31 (0.18–0.55)			<b>0.016</b>
Hemoglobin, g/L	115–150	135 (107–166)	141 (114–175)			0.486
Platelet count, ×10 <sup>9</sup> /L	125–350	173 (120–226)	182 (134–245)			0.279
<b>Blood biochemistry</b>						
ALT, U/L	≤33	21 (14–37)	24 (18–46)			0.136
AST, U/L	≤32	34 (21–49)	35 (22–52)			0.572
Albumin, g/L	35–52	33 (21–43)	25 (19–31)			<b>0.001</b>
BUN, mmol/L	3.1–8.8	5.4 (3.8–7.5)	9.2 (6.4–13.6)			<b>0.001</b>
Cr, μmol/L	45–104	69 (42–93)	92 (57–121)			<b>0.012</b>
CK, U/L	≤170	92 (45–129)	168 (86–296)			<b>0.029</b>
LDH, U/L	135–214	316 (219–427)	519 (324–755)			<b>0.001</b>
NT-BNP, pg/L	<285	398 (149–998)	889 (354–2410)			<b>0.001</b>
<b>Blood coagulation</b>						
PT, s	9–13	11.9 (9.5–15.8)	14.2 (10.2–18.5)			0.061
APTT, s	25–31.3	31.8 (23.5–34.8)	33.4 (24.9–36.1)			0.215
D-dimer, mg/L	0–0.55	2.56 (0.8–6.4)	7.96 (2.9–14.2)			<b>0.001</b>
<b>Inflammatory markers</b>						
hsCRP, mg/L	<1	44.3 (29.5–87.4)	89.1 (35.6–129.2)			<b>0.001</b>
ESR, mm/H	0–20	31.2 (17.0–46.0)	33.5 (18.1–55.6)			0.538
Ferritin, μg/L	15–150	536 (249–1645)	1569 (579–2598)			<b>0.001</b>
IL-2R, U/mL	223–710	712 (558–915)	1024 (796–1357)			<b>0.003</b>
IL-6, ng/L	<7	34.2 (8.8–78.5)	35.9 (9.6–96.7)			0.479
IL-8 >62 ng/L	<62	31.5 (13.3–56.5)	35.2 (15.6–69.8)			0.172
IL-10 >9.1 ng/L	<9.10	12.4 (5.2–14.6)	14.9 (6.3–15.7)			0.324
TNF-α >8.1 ng/L	<8.1	6.4 (4.9–11.8)	12.6 (6.7–17.5)			<b>0.001</b>
<b>Bacterial infection marker</b>						
PCT, ng/mL	0.02–0.05	0.14 (0.09–0.28)	0.47 (0.13–0.58)			<b>0.001</b>

ALT – alanine aminotransferase; AST – aspartate aminotransferase; UN – urea nitrogen; Cr – creatinine; CK – creatine kinase; LDH – lactic dehydrogenase; PT – prothrombin time; APTT – activated partial thromboplastin time; hsCRP – high sensitive C-reactive protein; ESR – erythrocyte sedimentation rate; IL – interleukin; NT-proBNP – N-terminal pro-brain natriuretic peptide; TNF-α – tumor necrosis factor-α; PCT – procalcitonin. Data expressed as median interquartile range (IQR). P values in the 2 groups compared by the χ<sup>2</sup> test, Fisher’s exact test, or the Mann-Whitney U test, as appropriate. P<0.05 was defined as statistically significant.



injury [16]. Although the clinical features of the 2 groups in the present study were generally similar, cough, expectoration, dyspnea, and fatigue occurred more frequently in patients with than without COPD. However, because of the small sample size, the differences were not statistically significant.

Laboratory test results showed that lymphocyte and monocyte counts were significantly lower, whereas leukocyte and neutrophil counts, as well as hemoglobin and procalcitonin (PCT) levels, were significantly higher, in patients with than without COPD. These results suggested that bacterial infection may have occurred after viral infection. However, the higher hemoglobin concentration in patients with COPD may have been due to a lack of oxygen. In addition, we found that markers of inflammation, such as hsCRP, ferritin, IL-2R, and TNF- $\alpha$ , were higher in patients with than without COPD, as were the rates of coagulation disorders and myocardial injuries. A comparison of surviving and non-surviving patients with severe COVID-19 and COPD found that leukocyte counts, neutrophil counts, and procalcitonin levels were higher, whereas lymphocyte and monocyte counts were lower, in non-survivors. Moreover, there was greater damage to myocardial, hepatic, and renal functions in non-survivors than in survivors. These results indicate that the degree of inflammation is greater in severe COVID-19 patients with than without COPD and that the degree of inflammation is closely related to patient prognosis.

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## Conclusions

These results indicate that severe COVID-19 patients with COPD have a higher prevalence of cardiovascular and cerebrovascular diseases, are more likely to receive mechanical ventilation and to be treated in the ICU, and have a higher mortality rate than severe COVID-19 patients without COPD. These results also suggest that, in severe COVID-19 patients, COPD is a high risk factor for poor prognosis. Therefore, COPD patients should be more vigilant to prevent infection with COVID-19. Larger studies with longer follow-up durations are needed to confirm these findings.