Hospitalization and Critical Care of 109 Decedents with COVID-19 Pneumonia in Wuhan, China

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Abstract

Rationale: The current outbreak of COVID-19 pneumonia caused by SARS-CoV-2 in Wuhan, China, spreads across national and international borders. The overall death rate of COVID-19 pneumonia in Chinese population was 4%.

Objectives: To describe process of hospitalization and critical care of decedents with COVID-19 pneumonia.

Methods: This was a multi-center observational study of 109 decedents with COVID-19 pneumonia from three hospitals in Wuhan. Demographic, clinical, laboratory, and treatment data were collected and analyzed, and final date of follow-up was February 24, 2020.

Results: The mean age of 109 decedents with COVID-19 pneumonia was 70.7 years, and 35 (32.1%) patients were female. 85 (78.0%) patients suffered from one or more underlying comorbidities. Multiple organ failure, especially respiratory failure and heart failure, appeared in all patients even at early stage of disease. Overall, from onset of symptom to death, the mean time was 22.3 days. All 109 hospitalized patients needed ICU admission, however, only 51 (46.8%) had such a chance because of limited availability. The period of hospitalization to death in ICU group and non-ICU group was 15.9 days (SD, 8.8 days) and 12.5 days (8.6 days, P = 0.044), respectively.

Conclusions: Mortality due to COVID-19 pneumonia was concentrated in old people whose age was always above 65 years, especially those with major comorbidities. Patients admitted to ICU lived longer than those who did not gain admission to ICU. Our findings should aid in the recognition and clinical management of such infections, especially ICU resource allocation.

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The ongoing pandemic of COVID-19 caused by the novel coronavirus SARS-CoV-2 is an emerging, rapidly evolving situation. As of March 30, 2020, a total of 735,560 confirmed cases and 34,830 deaths have been reported in at least 174 countries, indicating that the overall death rate of COVID-19 pneumonia was 4.7% (1). In the first cohort of 41 patients with COVID-19 pneumonia from Wuhan, China, 13 (31.7%) patients were admitted to an ICU and 6 (14.6%) died (2); when the cohort size expanded to 99 cases, 11 (11.1%) worsened in a short period of time and died of multiple organ failure (3). Recent studies have demonstrated that older age, higher sequential organ failure assessment (SOFA) score, and elevated D-dimer were risk factors for death of patients with COVID-19 pneumonia (4-6), and that high fever (≥ 39 °C) was associated with lower likelihood of death (6); however, these studies have not reported the issues faced around the world of the rapid increase in cases potentially overwhelming healthcare resources. Between December 25, 2019 and February 15, 2020, a total of 1017 patients with confirmed COVID-19 pneumonia were admitted to one special hospital for infectious diseases and two general hospitals in Wuhan. As of February 24, 2020, 114 patients died in the hospitals and 109 of them were available for collecting the required data. This report describes the clinical course and critical care of 109 decedents from the initial Wuhan experience to address the issues concerning intensive care clinician resources.

Methods

Patients

In response to a pandemic of COVIA-19 pneumonia, all hospitals in Wuhan initiated active

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

surveillance for the disease on December 31, 2019 at the requirement of Wuhan Health Commission. Between December 25, 2019 and February 15, 2020, the numbers of COVID-19 pneumonia patients admitted to Wuhan Pulmonary Hospital (Pulmonary Hospital), Tianyou Hospital Affiliated to Wuhan University of Science and Technology (Tianyou Hospital), and Central Hospital of Wuhan (Central Hospital), were 273, 301, and 443, respectively. The confirmed diagnosis of COVID-19 pneumonia was established according to the case definition established by WHO interim guidance with positive SARS-CoV-2 test results in throat-swab specimens (7).

Data Collection

We retrospectively collected the demographics, clinical symptoms or signs, laboratory findings on admission and during hospitalization, treatment, and date of death from electronic medical records of the decedents. Data were entered into a computerized database and cross-checked. Ethics approval was exempted from institutional review boards of the hospitals since we collected and analyzed all data from the patients according to the policy for public health outbreak investigation of emerging infectious diseases issued by the National Health Commission of the People's Republic of China. Two researchers independently reviewed the data collection forms to double check the collected data.

Statistical Analysis

Descriptive data are presented as frequencies (percentages) for discrete variables and as means (standard deviations [SDs]) or medians (interquartile ranges [IQRs]) for continuous variables.

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

Comparisons were determined by Student's *t* test or Mann-Whitney U test for continuous variables as appropriate and by the use of the χ^2 test for categorical variables. The statistical significance level was set at 0.05 (two-tailed). All analyses were conducted with MedCalc and SPSS version 23.0 statistical software.

Results

Characteristics of Study Patients

In Wuhan city, a total of 48 hospitals (35 in urban districts and 13 in suburban areas) were designated as "COVID-19 hospitals" by local government. Pulmonary Hospital is one of two special hospitals for infectious diseases in Wuhan, and the other one is Wuhan Jinyintan Hospital. It was local policy that those critical ill patients with COVID pneumonia were transferred to the special hospitals for treatment from general hospitals, including Tianyou Hospital and Central Hospital. During the study period 1017 patients with confirmed COVID-19 pneumonia were admitted to our three study hospitals. As of February 24, 2020, the numbers (percentages) of dead cases in Pulmonary Hospital, Tianyou Hospital, and Central Hospital were 45 (16.5%), 29 (9.6%), and 40 (9.0%), respectively. In Central Hospital, 40 non-survivors were distributed in different wards, 5 of them died within a few hours after they had been admitted to the hospital who could not provide the required data, and only 35 cases were included in the present study. Therefore, study population of this multi-center observational study consisted of 109 decedents.

Among 109 decedents, throat-swab specimens showed positive SARS-CoV-2 test results.

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

Pulmonary involvement was seen on computed tomography of all patients, and the most frequent computed tomographic findings were bilateral extensive ground-glass opacification and/or consolidation.

The mean age of decedents with COVID-19 pneumonia was 70.7 years (SD, 10.9 years; range, 43–99 years), and 35 (32.1%) patients were female (Table 1). Three (2.8%) patients were younger than 50 years old, while 76.1% above 65 years old. 85 (78.0%) patients suffered from one or more underlying comorbidities, and the most three common comorbidities included hypertension, cardiovascular or cerebrovascular diseases, and diabetes (Table 1).

At onset of illness, fever, fatigue, and dry cough were the three most common symptoms reported in the overall populations (2, 8). We noted that dyspnea took place of fatigue, becoming one of the top three symptoms of decedents, followed by fatigue, sputum production, and diarrhea, etc. (Table 1). On admission to hospital, all patients were critical ill, and the most frequent and the most significant symptom was rapid progressive dyspnea. As shown in Table 1, the medians of acute physiology and chronic health evaluation (APACHE) II score and SOFA score were 22.0 and 3.0, respectively, indicating that more severe condition even multiple organ injury was common.

The numbers of ICU beds provided for COVID-19 patients were 21, 10, and 12 in Pulmonary Hospital, Tianyou Hospital, and Central Hospital, respectively. All 109 hospitalized patients needed ICU admission, however, only 51 (46.8%) had such a chance because of very limited availability. As a matter of fact, only after someone in ICU had died and the next one could then be admitted to occupy that ICU bed during this study period. When comparing the demographic and clinical characteristics of patients who were admitted to ICU with those who

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were not, we noted that most characteristics, including APACHE) II score and SOFA score, were similar, except that younger age, less underlying chronic respiratory disease, less fatigue symptom, and faster heart rate were seen in ICU group (Table 1).

Laboratory Findings

White blood cell numbers in 55.0% of decedents with COVID pneumonia were not outside the normal range, 31.2% above upper boundary of normal ranges, while around a half had increased neutrophilic granulocytosis (Table 2). Lymphopenia is always a leading feature of viral pneumonia. Like the findings from the overall population of COVID-19 pneumonia patients throughout China (9), a majority (82.6%) of decedents in our study demonstrated a remarkable lymphopenia, only one (0.9%) had lymphocyte numbers above the upper boundary of normal range. In addition, anemia and thrombocytopenia were also common (Table 2). As shown in Appendix Figure 1, leukocytosis, neutrophilic granulocytosis, lymphopenia, and anemia occurred right after hospitalization and lasted till at least two weeks or till death.

All decedents were severely hypoxemic, indicated by a remarkable decrease in arterial partial pressure of oxygen (PaO_2), arterial oxygen saturation (SaO_2), and ratio of PaO_2:F_IO_2 at hospital admission (Table 2 and Appendix Figure 2). They underwent more frequent and more severe heart injury, as an elevation in all laboratory parameters reflecting heart injury, including cardiac troponin I, creatine kinase MB, myoglobin, NT-pro-brain natriuretic peptide, was seen in a high proportion of the decedents (Table 2). Furthermore, they kept such high concentrations above the upper boundaries of normal ranges for at least first two weeks (Appendix Figure 3). In some patients, the concentrations of alanine aminotransferase, aspartate aminotransferase,

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

urea nitrogen, and creatinine were increased, especially in the late stage of illness (Table 2 and Appendix Figure 4), indicating that they were also susceptible to hepatic or renal insufficiency. Multiple organ failure was further manifested by coagulation disorders, as D-dimer concentration was elevated, and prothrombin time and activated partial thromboplastin time were prolonged, and these abnormalities were long-lasting (Table 2 and Appendix 5).

The comparison of laboratory findings between ICU group and non-ICU group demonstrated some statistical differences in anemia, hypoproteinemia, creatinine, D-dimer, and prothrombin time (Table 2), such differences did not show any clinical significance.

Treatment

Totally, the mean period for COVID-19 pneumonia patients waiting for a hospital bed was 9.7 days (SD, 5.3 days). One day (percentage, 0–4 days) after hospitalization, 51 patients had an opportunity to be transferred from a non-ICU setting to the ICU. After ICU admission, these patients stayed in there for 11.8 days (SD, 8.8 days) before death. Overall, from onset of symptom to death, the mean time was 22.3 days (SD, 9.2 days) (Table 3). As shown in Figure 1, 66.1% (72/109) of patients died in the first half month after hospitalization, and 70.6 % (36/51) died in the first half month after ICU admission. As expected, ICU group lived longer than non-ICU group did (Table 3). Given that the surge in patients requiring ICU admission was overwhelming and that there was no a specific decision rule risk score or criteria used to decide who got ICU admission in China, our physicians made the decision at sole discretion.

As shown in Table 3, all patients (100%) were administered with antibiotics to prevent or to treat co-existing or secondary bacterial infection and almost all patients in either ICU group

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

(96.1%) or non-ICU group (93.1%) were administered with antivirus drugs (oseltamivir or peramivir) to treat possible influenza. 20 (39.2%) patients in ICU group, but none in non-ICU group were administered with antifungal drugs. However, actual lung bacterial or fungal infection were documented in only 42 (38.5%) patients.

Hoping to alleviate severe inflammatory response, glucocorticoids were given to 83 (76.1%) patients; hoping to enhance immunocompetence, intravenous immune globulin was given to 66 (60.6%) (Table 3). Indicated by the elevation of D-dimer and extension of prothrombin time and/or activated partial thromboplastin time, anticoagulant therapy was given to 42 (38.5%) patients. In addition, more patients in ICU group received immune globulin and anticoagulant therapy than those in non-ICU group did (Table 3).

Due to rapid progressive hypoxemia, oxygen therapy was provided for all patients, including high-flow nasal cannula oxygen therapy (39.4%), noninvasive mechanical ventilation (58.7%), and invasive ventilation (30.3%). In addition, 12 (11.0%) patients received continuous renal-replacement therapy, and 7 (6.4%) received extracorporeal membrane oxygenation (Table 3). In our settings, invasive ventilation and extracorporeal membrane oxygenation could only be performed in ICU. All 51 patients admitted to ICU needed invasive mechanical ventilation, unfortunately, only 33 (64.7%) of them did so due to a lack of ventilators.

Discussion

This multi-center observational study of 109 decedents indicated that mortality due to COVID-19 pneumonia was concentrated in old people whose age was always above 65 years, especially

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

those with major comorbidities, and that 51 patients admitted to ICU lived longer than 58 patients who did not gain admission to ICU. It must be an important issue how a healthcare system to allocate the ICU resource, when facing overwhelming numbers of critical ill patients. There were a total of 1379 beds in our three designated COVID-19 hospitals, however, only 43 ICU beds were available for patients with severe COVID-19 pneumonia. All 51 patients admitted to ICU died in there, none had a chance to be transferred to a general ward because of rapid progressive disease. Given that the numbers of critical ill patients with COVID-19 pneumonia far exceeded the numbers of ICU beds, and that no specific decision rule risk scores or criteria were available for judging who got ICU admission, our physicians made the decision at sole discretion. Usually, only after someone in ICU had died, and next one in waiting could then be transferred into ICU during the study period. Occasionally if any, the physicians tended to allocate the ICU care to the younger patients since they seemed to have higher possibilities to survive.

It is not surprising that there were approximately twice as many men as women among the non-survivors with COVID-19 pneumonia, as in most infectious diseases and related conditions such as sepsis and septic shock, men always represent a larger proportion of cases and have a higher mortality (10, 11). In one single-center retrospective study, 32 non-survivors were older and were more likely to have per-existing chronic medical illness (12). In the present study, we noted that only 3 (2.8%) of decedents was younger than 50 years old, while 83 (76.1%) were above 65 years old. We also noted that most patients suffered from underlying comorbidities, and their most common comorbidities included hypertension, cardiovascular or cerebrovascular diseases, diabetes, chronic digestive disorders. In contrast, severe disease and

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

mortality of 2009 influenza A (H1N1) infection is concentrated in relatively healthy adolescents and adults between the ages of 10 and 60 years without major comorbidities (13-15).

Pathological study of a patient who died from COVID-19 pneumonia reveals bilateral diffuse alveolar damage with cellular fibromyxoid exudates, interstitial lymphocyte infiltrates, and multinucleated syncytial cells in the intraalveolar spaces (16). Consistent with these extensive pathological abnormalities, widespread bilateral ground-glass opacification and/or consolidation on pulmonary computed tomography were present in all decedents with COVID-19 pneumonia, accounting for that dyspnea was a remarkable symptom. Unfortunately, because of very severe disease, no one had a chance to take second computed tomography. These patients experienced symptoms for a median of around 10 days prior to hospitalization, but rapidly worsened and required care in the ICU within a short time. Some severe patients died right after their arrival to the hospital, some died in general wards before ICU admission in Tianyou Hospital and Central Hospital, or before being transferred to Pulmonary Hospital or Wuhan Jinyintan Hospital for critical care. Although 45 patients in Pulmonary Hospital had an opportunity to receive advanced ventilatory support and rescue therapies for profound hypoxemic respiratory failure, including noninvasive ventilation, invasive ventilation, high-frequency oscillatory ventilation, and extracorporeal membrane oxygenation, they did not survive because of rapid progressive multiple organ failure, especially respiratory failure and heart failure.

None of antiviral drug, antibiotic, antifungal drug, corticosteroid treatment, or immune globulin is routinely recommended to be administered for COVID-19 pneumonia (7), a combination of two or more of these drugs was given to all patients included. Antiviral drugs

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

were prescribed because a diagnosis of influenza had been suspected or could not be excluded before SARS-CoV-2 test result was available. Empirical broad-spectrum antibacterial agents and/or antifungal regimens were initiated because of the suspicion of community-acquired bacterial pneumonia and/or secondary bacterial and fungal infection. However, actual lung bacterial or fungal infection were documented only in 42 (38.5%) patients at late stage of disease. Corticosteroids were believed to be able to alleviate inflammatory response occurring in lungs, and were therefore given to most patients.

As above mentioned, patients admitted to ICU lived longer than those did not gain admission to ICU, because the ICU group received more active therapies, including mechanical ventilation, continuous renal-replacement therapy, and extracorporeal membrane oxygenation. Unfortunately, all 51 patients admitted to ICU eventually died in there, none had a chance to be transferred to a general ward because of rapid progressive disease. Possibly, some deceased patients should have survived if they had earlier ICU care, especially earlier incubation and invasive ventilation.

This study has a major strength. It represents the largest and detailed series of non-survivors of severe COVID-19 pneumonia yet described. These observations of typical clinical features, laboratory findings, and response to therapy should aid in the recognition and clinical management of such infections, especially ICU resource allocation. This study also has major limitations. One is that we did not provide the comparisons of non-survivors and survivors in the present observational study. Another major limitation is that only decedents from three designated COVID-19 hospitals were included in the present study. Actually, there were 35 such hospitals in the urban districts of Wuhan.

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

In conclusion, our analysis of a multi-center cohort of decedents with COVID-19 pneumonia reveals that death is concentrated in an older patient group, especially those with one or more underlying diseases. Since multiple organ failure, especially respiratory failure and heart failure, occurred rapidly after hospital admission, ICU care should be provided as soon as possible for severe patients with COVID-19 pneumonia. A social distancing policy should be proposed to slow the rate of cases and prevent health care systems from being overwhelmed by cases for whom they cannot provide ICU care.

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

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Figure Legend

Figure 1. Distribution of Death Time After Hospitalization (A, n=109) and After ICU Admission (B, n=51) among Decedents with COVID-19 Pneumonia.

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

Table 1. Demography and Clinical Presentation in 109 Decedents with COVID-19 Pneumonia

Characteristic	Total (n=109)	ICU (n=51)	Non-ICU (n=58)	*P* value
Age, years				
Mean±SD, years	70.7±10.9	68.4±9.7	72.7±11.6	0.038
Subgroup, No. (%)				0.005
≤ 49 years	3 (2.8)	3 (5.9)	0 (0)	
50–64 years	23 (21.1)	10 (19.6)	13 (22.4)	
65–74 years	45 (41.3)	27 (52.9)	18 (31.0)	
≥ 75 years	38 (34.8)	11 (21.6)	27 (46.6)	
Female sex, No. (%)	35 (32.1)	15 (29.4)	20 (34.5)	0.572
Underlying diseases, No. (%)				
Hypertension	65 (59.6)	29 (56.9)	36 (62.1)	0.580
Cardiovascular or cerebrovascular diseases	37 (33.9)	15 (29.4)	22 (37.9)	0.349
Diabetes	34 (31.2)	18 (35.3)	16 (27.6)	0.386
Chronic respiratory disease	17 (15.6)	4 (7.8)	13 (22.4)	0.036
Chronic digestive disorders	16 (14.7)	6 (11.8)	10 (17.2)	0.420
Chronic renal insufficiency	8 (7.3)	1 (2.0)	7 (12.1)	0.099
Peripheral vascular disease	8 (7.3)	2 (3.9)	6 (10.3)	0.360
Malignancy	8 (7.3)	2 (3.9)	6 (10.3)	0.360
Chronic hepatic insufficiency	2 (1.8)	0 (0)	2 (3.4)	0.497
Autoimmune diseases	1 (0.9)	1 (2.0)	0 (0)	0.468
Symptoms at onset of illness, No. (%)				
Fever	99 (90.8)	49 (96.1)	50 (86.2)	0.147
Cough	77 (70.6)	36 (70.6)	41 (70.7)	0.991
Dyspnea	75 (68.8)	38 (74.5)	37 (63.8)	0.228
Fatigue	58 (53.2)	22 (43.1)	36 (62.1)	0.048
Sputum production	47 (43.1)	21 (41.2)	26 (44.8)	0.701
Diarrhea	29 (26.6)	15 (29.4)	14 (24.1)	0.534
Myalgia	19 (17.4)	12 (23.5)	7 (12.1)	0.116
Headache	8 (7.3)	4 (7.8)	4 (6.9)	1.000
Hemoptysis	8 (7.3)	6 (11.8)	2 (3.4)	0.196
Vital signs on admission				
Temperature				
Median (IQR), °C	36.6 (36.4–	36.6 (36.5–	36.6 (36.4–	0.367

ANNALSATS Articles in Press. Published April 07, 2020 as 10.1513/AnnalsATS.202003-225OC

	37.2)	37.3)	37.2)	
Subgroup, No. (%)				0.184
< 37.3 °C	83 (76.1)	38 (74.5)	45 (77.6)	
37.3–38.0 °C	17 (15.6)	7 (13.7)	10 (17.2)	
38. 1–39.0 °C	6 (5.5)	3 (5.9)	3 (5.2)	
> 39.0 °C	3 (2.8)	3 (5.9)	0 (0)	
Systolic blood pressure, mmHg	132±22	131±23	133±22	0.713
Diastolic blood pressure, mmHg	75±12	73±11	76±13	0.326
Respiratory rate				
Median (IQR), breath/min	20 (20–26)	21 (20–28)	20 (20–25)	0.387
> 24 breath/min, No. (%)	32 (29.4)	17 (33.3)	15 (25.9)	0.393
Heart rate				
Mean±SD, breath/min	88.5±18.5	92.3±19.6	85.2±16.9	0.043
> 100 beat/min, No. (%)	29 (26.6)	17 (33.3)	12 (20.7)	0.136
APACHE II score	22.0 (16.0–34.8)	26.5 (17.0–35.3)	21.0 (14.8–33.5)	0.163
SOFA score	3.0 (2.0–6.0)	3.0 (2.0–7.0)	3.0 (2.0–6.0)	0.880

Comparisons were determined by Student's **t** test, Mann-Whitney U test, or χ^2 test as appropriate.

Abbreviations: APACHE II, Acute Physiology and Chronic Health Evaluation II; IQR, interquartile range; SD, standard difference; SOFA, Sequential Organ Failure Assessment.

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Table 2. Blood Analysis in 109 Decedents with COVID-19 Pneumonia

Parameter	Total (n=109)	ICU (n=51)	Non-ICU (n=58)	*P* value
White blood cells				
Mean± SD, $\times 10^9$/L	8.7±4.8	9.6±5.5	7.9±4.1	0.067
Subgroup, No. (%)				0.897
< 4 $\times 10^9$/L	15 (13.8)	7 (13.7)	8 (13.8)	
4–10 $\times 10^9$/L	60 (55.0)	27 (52.9)	33 (56.9)	
> 10 $\times 10^9$/L	34 (31.2)	17 (33.3)	17 (29.3)	
Neutrophils				
Mean±SD,$\times 10^9$/L	7.5±4.6	8.3±5.2	6.9±4.1	0.101
Subgroup, No. (%)				0.033
< 1.8 × 10^9/L	4 (3.7)	0 (0)	4 (6.9)	
1.8–6.3 × 10^9/L	50 (45.9)	21 (41.2)	29 (50.0)	
> 6.3 × 10^9/L	55 (50.5)	30 (58.8)	25 (43.1)	
Lymphocytes				
Median (IQR), $\times 10^9$/L	0.6 (0.4–0.9)	0.6 (0.4–0.9)	0.6 (0.5–0.8)	0.817
Subgroup, No. (%)				0.696
< 1.1 × 10^9/L	90 (82.6)	41 (80.4)	49 (84.5)	
1.1–3.2 × 10^9/L	18 (16.5)	9 (17.6)	9 (15.5)	
> 3.2 × 10^9/L	1 (0.9)	1 (2.0)	0 (0)	
Red blood cells				
Mean± SD, $\times 10^{12}$/L	4.2±0.7	4.3±0.6	4.0±0.8	0.022
Subgroup, No. (%)				0.051
< 4.3 × 10^{12}/L	62 (56.9)	24 (47.1)	38 (65.5)	
4.3–5.8 × 10^{12}/L	46 (42.2)	27 (52.9)	19 (32.8)	
> 5.8 × 10^{12}/L	1 (0.9)	0 (0)	1 (1.7)	
Hemoglobulin				
Mean±SD, g/L	125.8±21.2	131.2±17.3	121.0±23.2	0.010
< 110 g/L, No. (%)	19 (17.4)	4 (7.8)	15 (25.9)	0.013
Platelets				
Mean±SD, × 10^9/L	169.4±78.4	169.2±72.5	169.5±83.9	0.983
< 100 × 10^9/L, No. (%)	16 (14.7)	7 (13.7)	9 (15.5)	0.792
C-response protein				
Mean± SD, mg/L	85.7±57.3	87.1±63.0	84.5±52.3	0.815
≥ 10 mg/L, No. (%)	104 (95.4)	48 (94.1)	56 (96.6)	0.883

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Procalcitonin				
Median (IQR), μg/L	0.1 (0.1–0.3)	0.1 (0.1–0.4)	0.1 (0.0–0.3)	0.395
≥ 0.5 μg/L, No. (%)	20 (18.3)	10 (19.6)	10 (17.2)	0.750
PaO_2				
Mean±SD, mmHg	62.3±25.4	63.6±27.4	61.1±23.6	0.617
< 80 mmHg, No. (%)	91 (83.5)	42 (82.4)	49 (84.5)	0.765
SaO_2				
Median (IQR),%	90.0 (80.5–94.0)	90.0 (80.0–95.0)	90.0 (81.5–93.3)	0.803
< 95%, No. (%)	84 (77.1)	38 (74.5)	46 (79.3)	0.552
PaO_2:F_IO_2				
Median (IQR), mmHg	124 (90–186)	121 (90–158)	133 (90–230)	0.143
< 200 mmHg, No. (%)	84 (77.1)	43 (84.3)	41 (70.7)	0.091
Cardiac troponin I				
Median (IQR), μg/L	0.0(0.0–0.1)	0.0(0.0–0.1)	0.0 (0.0–0.1)	0.543
≥ 0.05 μg/L, No. (%)	52 (47.7)	25 (49.0)	27 (46.6)	0.797
Creatine kinase MB				
Median (IQR), μg/L	3.0(1.7–9.5)	2.7(1.4–7.0)	3.9 (1.7–10.7)	0.182
> 5μg/L, No. (%)	39 (35.8)	15 (29.4)	24 (41.4)	0.193
Myoglobin				
Median (IQR), μg/L	68.3(36.6–141.1)	71.4(37.3–153.9)	68.1 (35.5–133.7)	0.491
> 100 μg/L, No. (%)	42 (38.5)	23 (45.1)	19 (32.8)	0.187
NT-pro-Brain natriuretic peptide*				
Median (IQR), ng/L	582.0 (307.0–1097.5)	480.0 (164.0–1046.5)	722.0(498.5–1335.0)	0.134
> 300 ng/L, No. (%)	34/45 (75.6)	18/28 (64.3)	16/17 (94.1)	0.057
Albumin				
Median (IQR), g/L	34.2(31.6–37.0)	33.2(30.7–35.2)	35.6 (32.0–38.9)	0.011
< 40 g/L, No. %	92(84.4)	47 (92.2)	45 (77.6)	0.036
Alanine aminotransferase				
Median (IQR), U/L	24.0(19.0–	27.0(21.0–	21.6 (16.8–	0.103

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	39.0)	45.0)	36.5)	
> 50 U/L, No. (%)	18 (16.5)	10 (19.6)	8 (13.8)	0.415
Aspartate aminotransferase				
Median (IQR), U/L	37.0(25.7–50.0)	40.0(27.0–56.0)	32.0 (24.8–47.0)	0.216
> 40 U/L, No. (%)	50 (45.9)	25 (49.0)	25 (43.1)	0.536
Urea nitrogen				
Median (IQR), mmol/L	7.3(5.7–10.1)	7.3(5.4–8.7)	7.7(5.7–12.4)	0.101
> 8 mmol/L, No. (%)	43 (39.4)	16 (31.4)	27 (46.6)	0.106
Creatinine				
Median (IQR), μmol/L	76.0 (62.3–96.0)	71.0 (58.0–86.0)	85.8 (70.0–110.3)	0.002
> 133 μmol/L, No. (%)	12 (11.0)	2 (3.9)	10 (17.2)	0.027
D-dimer, mg/L				
Median (IQR), mg/L	1.4 (0.6–4.8)	2.3 (0.9–7.5)	1.0 (0.4–4.2)	0.011
> 0.5 mg/L, No. (%)	85 (78.0)	44 (86.3)	41 (70.7)	0.050
Prothrombin time				
Median (IQR), seconds	12.9 (11.6–15.4)	13.6(12.1–16.0)	12.3 (11.3–14.4)	0.007
Subgroup, No. (%)				0.023
< 11.0 seconds	13 (11.9)	3 (5.9)	10 (17.2)	
11.0–13.0 seconds	44 (40.4)	17 (33.3)	27 (46.6)	
> 13.0 seconds	52 (47.7)	31 (60.8)	21 (36.2)	
Activated partial thromboplastin time				
Median (IQR), seconds	34.3±10.7	35.0±11.9	33.8±9.6	0.546
Subgroup, No. (%)				0.545
< 21.0 seconds	7 (6.4)	2 (3.9)	5 (8.6)	
21.0–34.0 seconds	54 (49.5)	27 (52.9)	27 (46.6)	
> 34.0 seconds	48 (44.1)	22 (43.2)	26 (44.8)	
Potassium				
Mean± SD, mmol/L	4.1±0.6	4.0±0.7	4.1±0.6	0.650
Subgroup, No. (%)				0.700
< 3.5 mmol/L	16 (14.7)	9 (17.7)	7 (12.1)	
3.5–5.5 mmol/L	89 (81.7)	40 (78.4)	49 (84.5)	
> 5.5 mmol/L	4 (3.7)	2 (3.9)	2 (3.4)	

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Sodium				
Mean± SD, mmol/L	138.8±5.3	139.2±4.8	138.5±5.7	0.508
Subgroup, No. (%)				0.753
< 135 mmol/L	24 (22.0)	10 (19.6)	14 (24.1)	
135–145 mmol/L	73 (67.0)	36 (70.6)	37 (63.8)	
> 145 mmol/L	12 (11.0)	5 (9.8)	7 (12.1)	

*Data from 45 patients in Wuhan Pulmonary Hospital. Comparisons were determined by Student's *t* test, Mann-Whitney U test, or χ^2 test as appropriate.

Abbreviations: F_IO_2, fraction of inspired oxygen; IQR, interquartile range; PaO_2, arterial partial pressure of oxygen; SaO_2, arterial oxygen saturation; SD, standard difference.

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Table 3. Treatment in 109 Decedents with COVID-19 Pneumonia

Treatment	Total (n=109)	ICU (n=51)	Non-ICU (n=58)	*P* Value
Onset of symptom to, Mean± SD, days				
Hospitalization*	9.7±5.3	10.5±4.9	9.0±5.5	0.128
ICU admission	14.0±7.6	14.0±7.6	–	–
Death	22.3±9.2	24.8±9.4	20.1±8.5	0.007
Period of Hospitalization, Mean± SD, days	14.1±8.8	15.9±8.8	12.5±8.6	0.044
ICU admission				
No. (%)	51 (46.8)	51 (100)	–	–
Period, days	11.8±8.8	11.8±8.8	–	–
Period of hospitalization to ICU, days	1.0 (0–4.0)	1.0 (0–4.0)	–	–
Antibiotics, No. (%)	109 (100)	51 (100)	58 (100)	–
Antivirus drugs, No. (%)	103 (94.5)	49 (96.1)	54 (93.1)	0.796
Antifungal drugs, No. (%)	20 (18.3)	20 (39.2)	0 (0)	< 0.001
Glucocorticoids, No. (%)	83 (76.1)	34 (66.7)	49 (84.5)	0.029
Intravenous immune globulin, No. (%)	66 (60.6)	41 (80.4)	25 (43.1)	< 0.001
Anticoagulant therapy, No. (%)	42 (38.5)	26 (51.0)	16 (27.6)	0.012
Oxygen therapy				
High-flow nasal cannula oxygen therapy, No. (%)	43 (39.4)	21 (41.2)	22 (37.9)	0.729
Mechanical ventilation, No. (%)				
Noninvasive	64 (58.7)	39 (76.5)	25 (43.1)	< 0.001
Invasive	33 (30.3)	33 (64.7)	0 (0)	< 0.001
Continuous renal-replacement therapy, No. (%)	12 (11.0)	10 (19.6)	2 (3.4)	0.007
Extracorporeal membrane oxygenation, No. (%)	7 (6.4)	7 (13.7)	0 (0)	0.012

*Data are reported from 107 patients, as 2 patients were hospitalized because of other diseases; n = 50 in ICU group and n = 57 in non-ICU group. Comparisons were determined by Student's **t** test or χ^2 test as appropriate.

Abbreviations: SD, standard difference.

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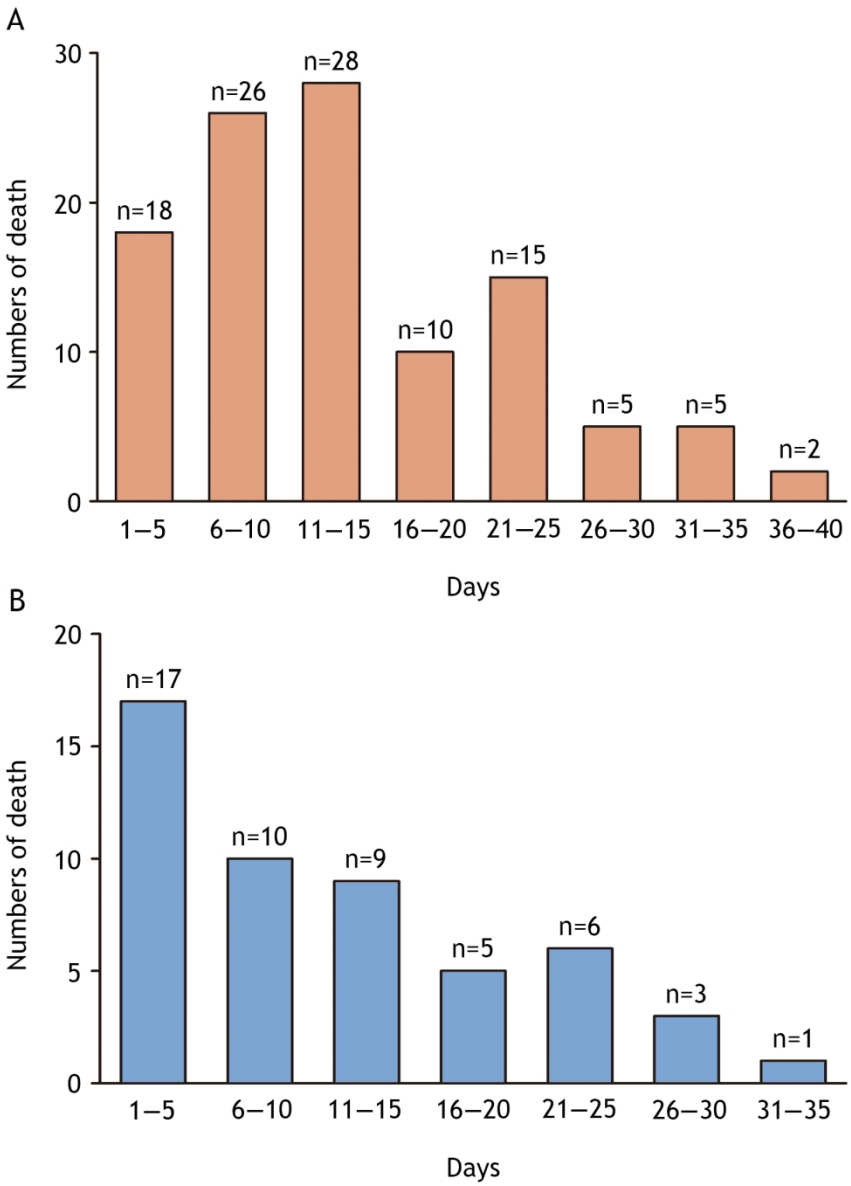

Figure 1. Distribution of Death Time After Hospitalization (A, n=109) and After ICU Admission (B, n=51) among Decedents with COVID-19 Pneumonia.

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Online Data Supplement

Hospitalization and Critical Care of 109 Decedents with COVID-19 Pneumonia in Wuhan, China

Rong-Hui Du, Li-Min Liu, Wen Yin, Wen Wang, Lu-Lu Guan, Ming-Li Yuan, Yu-Lei Li, Yi Hu, Xu-Yan Li, Bing Sun, Peng Peng, Huan-Zhong Shi

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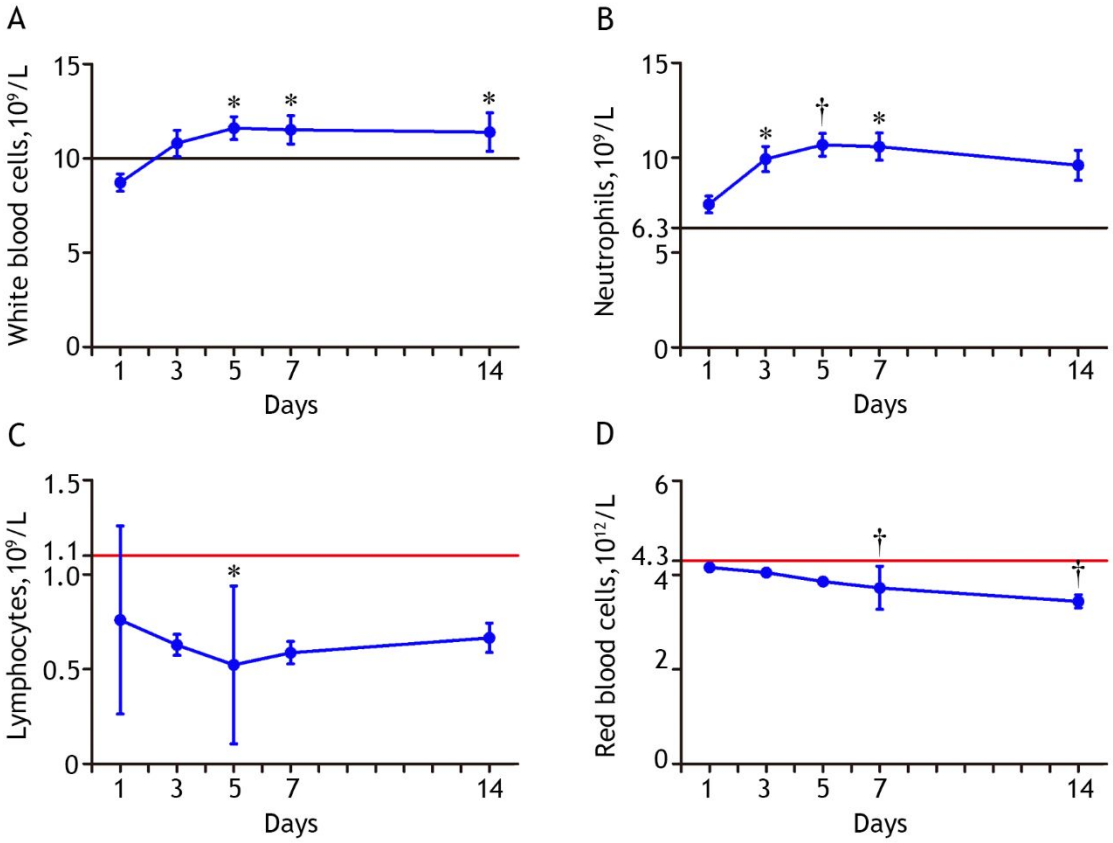

Appendix Figure 1. Dynamic Profile of Blood Cell Counts in Deceased Patients with COVID-19 Pneumonia. The changes in numbers of white blood cells (A), neutrophils (B), lymphocytes (C), and red blood cells (D) on the day 1 (n=109), 3 (n=76), 5 (n=72), 7 (n=72), and 14 (n=46) after hospitalization are presented. The lines in black show the upper normal limit of each parameter, and the lines in red show the lower normal limit. *$P < 0.05$, † $P < 0.01$ compared with day 1 determined by Student's t test (A, B and D) or Mann-Whitney U test (C).

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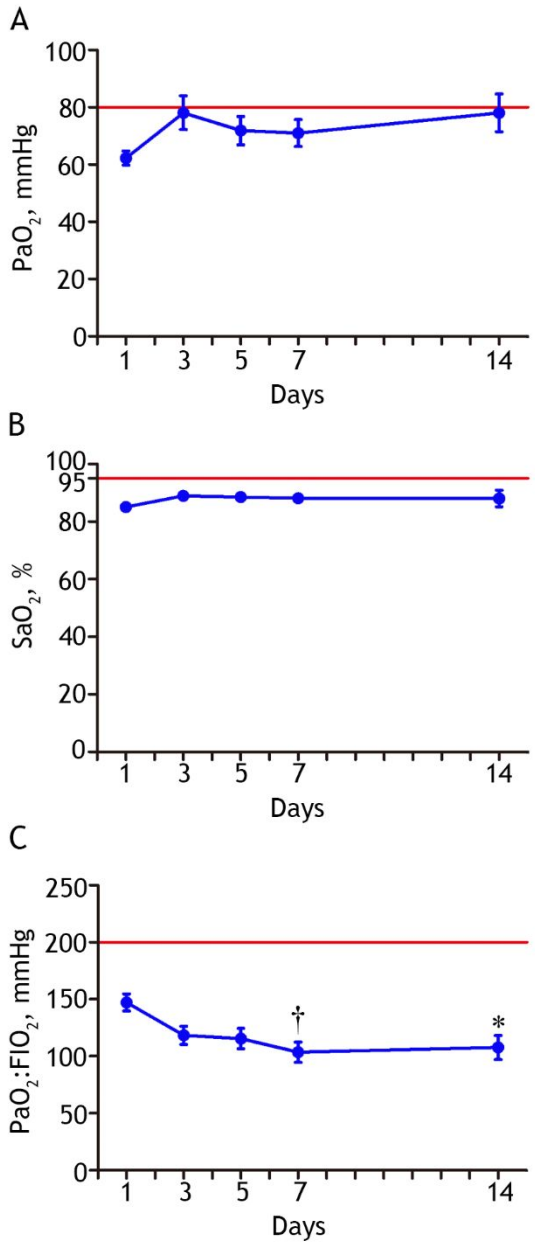

Appendix Figure 2. Dynamic Profile of Arterial Partial Pressure of Oxygen (PaO_2), Arterial Oxygen Saturation (SaO_2), and Fraction of Inspired Oxygen (PaO_2:F_IO_2) in Deceased Patients with COVID-19 Pneumonia. The changes in PaO_2 (A), SaO_2 (B), and PaO_2:F_IO_2 (C) on the day 1 (n=109), 3 (n=62), 5 (n=57), 7 (n=52), and 14 (n=32) after hospitalization are presented. The lines in red show the lower normal limit of each parameter. *$P < 0.05$, † $P < 0.01$ compared with day 1 determined by Student's t test (A) or Mann-Whitney U test (B and C).

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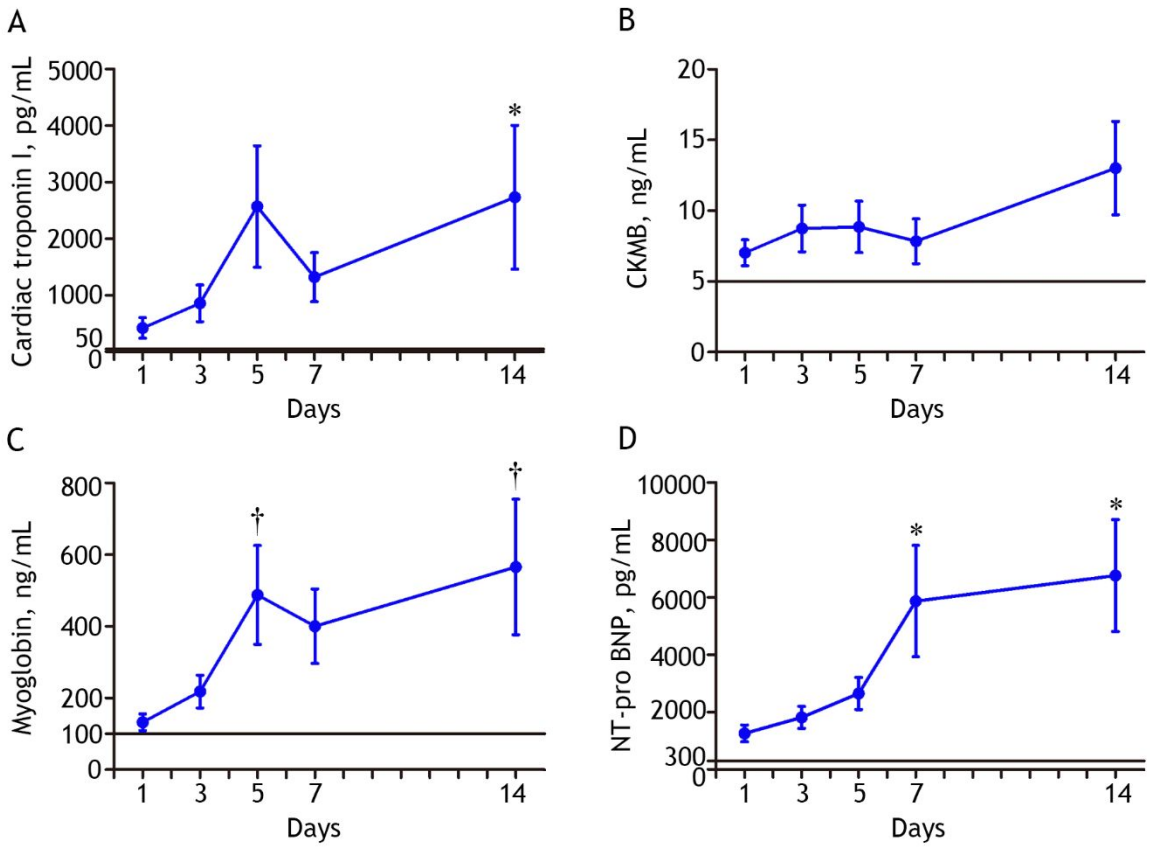

Appendix Figure 3. Dynamic Profile of Heart Function in Deceased Patients with COVID-19 Pneumonia. The changes in concentrations of cardiac troponin I (A), creatine kinase MB (CKMB) (B), myoglobin (C), and NT-pro-brain natriuretic peptide (BNP) on the day 1 (n=109), 3 (n=57), 5 (n=53), 7 (n=54), and 14 (n=43) after hospitalization are presented. The lines in black show the upper normal limit of each parameter. *$P < 0.05$, † $P < 0.01$ compared with day 1 determined by Mann-Whitney U test.

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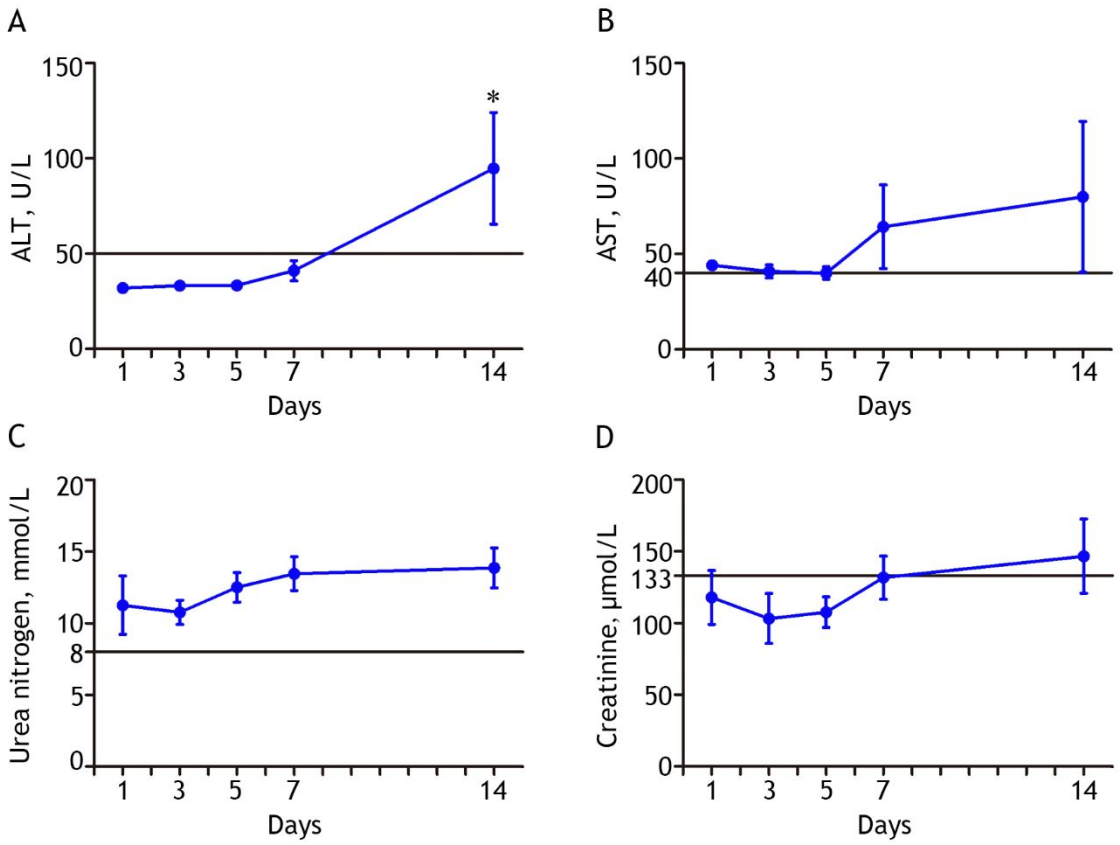

Appendix Figure 4. Dynamic Profile of Hepatic and Renal Function in Deceased Patients with COVID-19 Pneumonia. The changes in concentrations of alanine aminotransferase (A), aspartate aminotransferase (B), urea nitrogen (C), and creatinine on the day 1 (n=109), 3 (n=65), 5 (n=60), 7 (n=68), and 14 (n=38) after hospitalization are presented. The lines in black show the upper normal limit of each parameter. * $P < 0.01$ compared with day 1 determined by Mann-Whitney U test.

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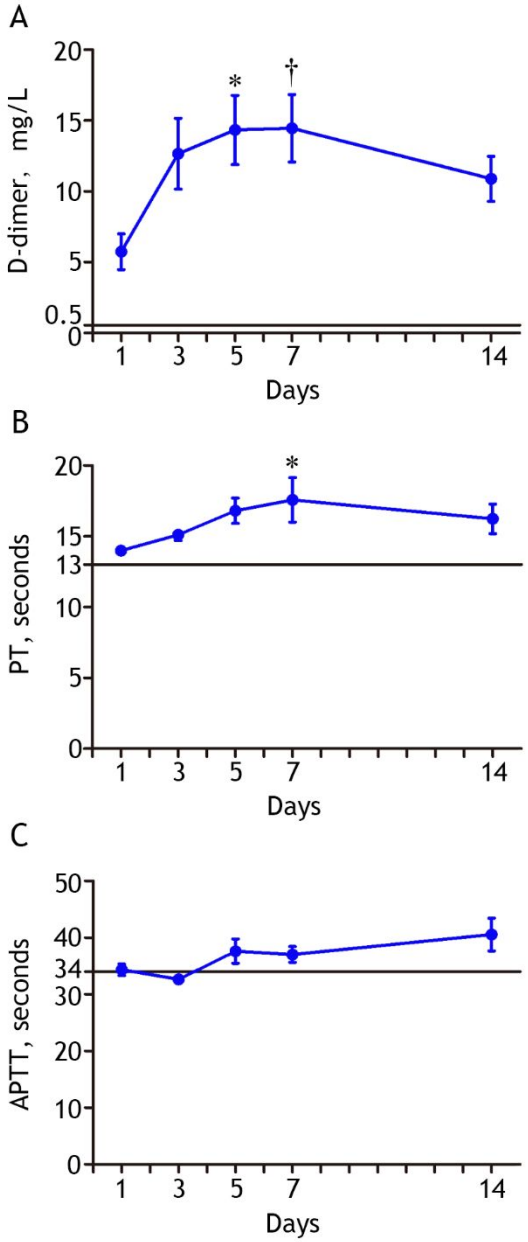

Appendix Figure 5. Dynamic Profile of Coagulation Function in Deceased Patients with COVID-19 Pneumonia. The changes in concentrations of D-dimer (A), prothrombin time (B), and activated partial thromboplastin time (C) on the day 1 (n=109), 3 (n=61), 5 (n=54), 7 (n=57), and 14 (n=34) after hospitalization are presented. The lines in black show the upper normal limit of each parameter. *$P < 0.05$, † $P < 0.01$ compared with day 1 determined by Mann-Whitney U test (figure A and B) or Student's t test (figure C).

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