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Association Between Clinical Manifestations and Prognosis in Patients with COVID-19

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\textbf{ABSTRACT}

\textbf{Purpose:} The purpose of this study was to determine the risk factors associated with pneumonia, acute respiratory distress syndrome (ARDS), and clinical outcome among patients with novel coronavirus disease 2019 (COVID-19).

\textbf{Methods:} This was a cross-sectional multicenter clinical study. A total of 95 patients infected with COVID-19 were enrolled. The COVID-19 diagnostic standard was polymerase chain reaction detection of target genes of 2019 novel coronavirus (2019-nCoV). Clinical, laboratory, and radiologic results, as well as treatment outcome data, were obtained. ARDS was defined as an oxygenation index (arterial partial pressure of oxygen/fraction of inspired oxygen) $\leq 300$ mm Hg.

\textbf{Findings:} Multivariate analysis showed that older age (odds ratio [OR], 1.078; $p = 0.008$) and high body mass index (OR, 1.327; $p = 0.024$) were independent risk factors associated with pneumonia. For patients with ARDS, multivariate analysis showed that only high systolic blood pressure (OR, 1.046; $p = 0.025$) and high lactate dehydrogenase level (OR, 1.010; $p = 0.021$) were independent risk factors associated with ARDS. A total of 70 patients underwent CT imaging repeatedly after treatment. Patients were divided in a disease exacerbation group ($n = 19$) and a disease relief group ($n = 51$). High body mass index (OR, 1.285; $p = 0.017$) and tobacco smoking (OR, 16.13; $p = 0.032$) were independent risk factors associated with disease exacerbation after treatment.

\textbf{Implications:} These study results help in the risk stratification of patients with 2019-nCoV infection. Patients with risk factors should be given timely intervention to avoid disease progression. (\textit{Clin Ther}. 2020;42:964–972) © 2020 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

\textbf{Key words:} 2019-nCoV, Acute respiratory distress syndrome, COVID-19, Pneumonia, Risk factors.

\textbf{INTRODUCTION}

Since December 2019, several cases of pneumonia of unknown etiology have been reported in Wuhan, Hubei Province, of China.\textsuperscript{1} Those cases have been confirmed as acute respiratory infections caused by a novel coronavirus infection. To date, confirmed cases have been found in many countries worldwide.\textsuperscript{2,3} Until now, however, the source of the virus and the pathogenesis of the disease are unknown. Early detection, quarantine, and timely treatment are the keys to better controlling the epidemic and reducing the spread of the disease.

\textsuperscript{1} These authors contributed equally to this work.
Coronaviruses are RNA viruses and can be divided into 4 genera according to the genomic characteristics: α, β, γ, and δ. Among these, Middle East respiratory syndrome coronavirus and severe acute respiratory syndrome coronavirus are known coronaviruses. The new virus recently discovered in China is now recognized to be a novel coronavirus named 2019-nCoV. The coronavirus isolated from patients with this novel pneumonia in Wuhan is a coronavirus of genus β.

This sudden infectious disease mainly manifests as fever, fatigue, and cough. Upper respiratory symptoms such as nasal congestion and runny nose are rare. About one half of the patients develop dyspnea after 1 week. In severe cases, patients progress rapidly to acute respiratory distress syndrome (ARDS), sepsis, and coagulopathy. Some patients have mild symptoms with no fever or without pneumonia and usually recover after 1 week. However, some patients may suddenly worsen and develop ARDS. At present, how to stratify high-risk and low-risk patients is an important but unresolved issue.

In the present study, the clinical manifestations and clinical outcomes of patients with 2019 novel coronavirus disease (COVID-19) were evaluated. The purpose of this study was to identify the risk factors associated with pneumonia, ARDS, and clinical outcomes.

**PATIENTS AND METHODS**

**Patients**

This cross-sectional multicenter clinical study was approved by the institutional ethics board of the Nanfang Hospital, Southern Medical University. All consecutive patients with confirmed 2019-nCoV infections who were diagnosed in the Dongguan People’s Hospital and Nanfang Hospital, Southern Medical University, from January 2020 to February 2020 were enrolled. The study population comprised hospitalized patients. Because COVID-19 is an infectious disease, all outpatients were required to be

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**Table I. Demographic and clinical characteristics in patients with coronavirus disease 2019 (COVID-19) with or without pneumonia. Values are given as mean (SD) unless otherwise indicated.**

| Characteristic              | Patients With COVID-19 | P     |
|-----------------------------|------------------------|-------|
|                             | With Pneumonia         | Without Pneumonia |
| Sample size, n              | 73                     | 22    |       |
| Male sex                    | 39 (53.4%)             | 14 (63.6%) | 0.398 |
| Age, y                      | 42.66 (17.93)          | 23.86 (13.88) | <0.001 |
| SBP, mm Hg                  | 126.41 (16.01)         | 120.95 (14.90) | 0.175 |
| DBP, mm Hg                  | 83.69 (10.26)          | 79.90 (8.60)  | 0.138 |
| BMI, kg/m²                  | 23.71 (3.41)           | 20.78 (3.15)  | 0.001 |
| Serum lactate acid, mmol/L  | 1.51 (0.71)            | 1.61 (0.59)   | 0.608 |
| Neutrophil count, × 10⁹     | 3.32 (1.52)            | 3.33 (1.29)   | 0.972 |
| Lymphocyte count, × 10⁹     | 1.25 (0.94)            | 1.81 (0.87)   | 0.014 |
| Hemoglobin, g/L             | 139.07 (18.07)         | 143.41 (13.01)| 0.298 |
| Platelet count, × 10⁹       | 196.27 (56.67)         | 251.50 (77.46)| <0.001 |
| Serum creatinine, μmol/L    | 68.60 (41.11)          | 60.95 (17.97)| 0.400 |
| ALT, U/L                    | 21.33 (12.00)          | 22.77 (24.75)| 0.718 |
| AST, U/L                    | 23.97 (10.48)          | 18.75 (7.72)  | 0.041 |
| LDH, IU/L                   | 204.04 (67.44)         | 154.32 (34.88)| 0.003 |
| Tobacco smoking             | 5 (6.8%)               | 3 (13.6%)     | 0.315 |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; SBP = systolic blood pressure.
quarantined in the hospital if infection with 2019-nCoV was confirmed. The 2019-nCoV infection diagnostic standard was polymerase chain reaction detection of 2 target genes of 2019-nCoV, open reading frame 1 ab (ORF1ab) and nucleocapsid protein. A positive result was determined to be 2019-nCoV infection.

Ethics, Consent, and Permissions
The Institutional Review Board of Nanfang Hospital, Southern Medical University, approved this study. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the 1975 Declaration of Helsinki as revised in 2008. Oral consent was obtained from patients.

Data Collection
All patients' clinical, laboratory, and radiologic characteristics, as well as treatment outcome data, were obtained through medical record extraction. Data were reviewed by a team of trained physicians. The recorded information included demographic data, medical history, contact history, potential comorbidities, symptoms, laboratory test results, and chest computed tomography (CT) scans. ARDS was defined as an acute-onset oxygenation index (arterial partial pressure of oxygen/fraction of inspired oxygen) ≤ 300 mm Hg and a chest radiograph showing patchy shadows.10

Real-Time Polymerase Chain Reaction Assay for 2019-nCoV
All patients had pharyngeal swab samples collected to detect 2019-nCoV. The specific steps were as follows: The throat swab was placed into a collection tube containing 150 μL of virus preservation solution, and a respiratory sample RNA isolation kit (Zhongzhi, Wuhan, China) was used to extract total RNA within 2 h. Forty microliters of cell lysate were transferred to a collection tube and vortexed for 10 s. It was centrifuged after incubation at room temperature for 10 min. Real-time polymerase chain reaction was then performed, and 2 target genes (ORF1ab and nucleocapsid protein) were detected. Target 1 (ORF1ab): forward primer

### Table II. Factors associated with pneumonia in patients with coronavirus disease 2019.

| Variable                  | Univariate Analysis | Multivariate Analysis |
|---------------------------|---------------------|-----------------------|
|                           | OR  95% CI          | P         | OR  95% CI          | P         |
| Sex                       | 0.655 0.245–1.751   | 0.400     | 1.078 1.020–1.140   | 0.008     |
| Age                       | 1.073 1.034–1.112   | <0.001    | 1.327 1.038–1.697   | 0.024     |
| SBP                       | 1.023 0.990–1.057   | 0.176     |                      |          |
| DBP                       | 1.040 0.987–1.095   | 0.141     |                      |          |
| BMI                       | 1.298 1.103–1.527   | 0.002     |                      |          |
| Serum lactic acid         | 0.815 0.376–1.765   | 0.603     |                      |          |
| Neutrophil count          | 0.994 0.717–1.378   | 0.972     |                      |          |
| Lymphocyte count          | 0.548 0.305–0.986   | 0.045     |                      |          |
| Hemoglobin                | 0.986 0.959–1.013   | 0.301     |                      |          |
| Platelet count            | 0.987 0.979–0.995   | 0.002     |                      |          |
| Serum creatinine          | 1.011 0.986–1.036   | 0.387     |                      |          |
| ALT                       | 0.994 0.965–1.025   | 0.716     |                      |          |
| AST                       | 1.080 1.001–1.165   | 0.048     |                      |          |
| LDH                       | 1.023 1.007–1.039   | 0.004     |                      |          |
| Tobacco smoking           | 0.466 0.102–2.127   | 0.324     |                      |          |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; OR = odds ratio; SBP = systolic blood pressure.
CCTGGTGGGTTTTACACTTAA; reverse primer ACGATTGTGCATCAGCTGA; probe 5'-VIC-CCGTCTGCAGTATGTGGAAAGTTATGG-BHQ1-3'. Target 2 (N protein): forward primer GGGGAACTTCTCCTGCTAGAAT; reverse primer CAGACATTGTCCTCAAGCTG; probe 5'-FAM- TTAGCTGCTGTGACAGATT-TAMRA-3'. The diagnostic criteria were based on the recommendations of the National Institute of Viral Disease Prevention and Control (http://ivdc.chinacdc.cn/kyjz/202001/t20200121_211337.html).

**Statistical Analysis**

Continuous data are reported as mean (SD), and categorical data are expressed as percentages. The significance of differences was tested by using either the Student's t test (for continuous variables) or the χ² test (for categorical variables). Univariable and multivariable regression analyses were performed by using logistic regression analysis, and the results are expressed as odds ratio (OR) and 95% CIs. All analyses were performed by using SPSS version 13.0 (IBM SPSS Statistics, IBM Corporation, Armonk, New York) with an alpha level of 0.05.

**RESULTS**

**Characteristics of Patients With COVID-19**

A total of 95 patients infected with 2019-nCoV were enrolled. Seventy-three had pneumonia based on the CT findings, and 22 did not have pneumonia. Demographic and clinical characteristics are shown in Table I. Patients with pneumonia were significantly older than the other patients (p < 0.001). The body mass index (BMI) (p = 0.001), aspartate aminotransferase levels (p = 0.041), and lactate dehydrogenase (LDH) levels (p = 0.003) were significantly higher in patients with pneumonia. However, lymphocyte count (p = 0.014) and platelet

| Characteristic                  | Patients With COVID-19 | P     |
|--------------------------------|-----------------------|-------|
|                                 | With ARDS             | Without ARDS |       |
| Sample size, n                  | 24                    | 71    | 0.772 |
| Male sex                        | 14 (58.3%)            | 39 (54.9%) | 0.772 |
| Age, y                          | 45.92 (18.44)         | 35.73 (13.32) | 0.021 |
| SBP, mm Hg                      | 130.96 (14.62)        | 123.15 (15.87) | 0.038 |
| DBP, mm Hg                      | 84.92 (10.42)         | 82.12 (9.93)  | 0.245 |
| BMI, kg/m²                      | 24.26 (3.32)          | 22.64 (3.55)  | 0.053 |
| Serum lactic acid, mmol/L       | 1.49 (0.51)           | 1.55 (0.74)  | 0.703 |
| Neutrophil count, × 10⁹         | 3.21 (1.34)           | 3.36 (1.51)  | 0.656 |
| Lymphocyte count, × 10⁹         | 1.05 (0.48)           | 1.49 (1.04)  | 0.046 |
| Hemoglobin, g/L                 | 141.46 (12.47)        | 139.61 (18.41) | 0.648 |
| Platelet count, × 10⁹           | 193.67 (67.23)        | 214.27 (65.15) | 0.187 |
| Serum creatinine, μmol/L        | 81.42 (65.91)         | 61.90 (18.02) | 0.025 |
| ALT, U/L                        | 23.83 (14.07)         | 20.91 (16.05) | 0.439 |
| AST, U/L                        | 25.49 (11.68)         | 21.92 (9.48)  | 0.146 |
| LDH, IU/L                       | 228.86 (80.21)        | 181.79 (55.17) | 0.003 |
| Tobacco smoking                 | 1 (4.2%)              | 7 (9.9%)  | 0.385 |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; SBP = systolic blood pressure.
count \((p < 0.001)\) were significantly lower in patients with pneumonia.

**Univariate and Multivariate Analyses of Factors Associated With Pneumonia**

Univariate and multivariate analyses were conducted to analyze the risk factors associated with 2019-nCoV–infected patients developing pneumonia. Univariate results showed that older age, high BMI, low lymphocyte count, low platelet count, high aspartate aminotransferase level, and high LDH level were risk factors associated with patients developing pneumonia. However, multivariate analysis showed that only older age (OR, 1.078; \(p = 0.008\)) and high BMI (OR, 1.327; \(p = 0.024\)) were independent risk factors associated with patients developing pneumonia (Table II).

**Differences in Characteristics Between the ARDS Group and the Non-ARDS Group**

Using the ARDS definition, patients were divided into an ARDS group \((n = 24)\) and a non-ARDS group \((n = 71)\) (Table III). Patients with ARDS were older than those without ARDS \((p = 0.021)\). Moreover, systolic blood pressure (SBP) \((p = 0.038)\), serum creatinine \((p = 0.025)\), and LDH \((p = 0.003)\) levels were significantly higher in patients with ARDS. However, lymphocyte counts were lower in patients with ARDS than in others \((p = 0.046)\).

**Univariate and Multivariate Analyses of Factors Associated With ARDS**

Logistic regression was used to identify factors that were significantly associated with ARDS in patients with COVID-19. In multivariate analysis, high SBP level (OR, 1.046; \(p = 0.025\)) and high LDH level (OR, 1.010; \(p = 0.021\)) were found to be independent risk factors associated with ARDS among patients with COVID-19 (Table IV).

**Differences in Characteristics Between Patients With Pneumonia Exacerbation and Relief**

A total of 70 patients underwent CT scanning repeatedly after 1 week of treatment. Based on the findings obtained after comparison with the first CT scan, differences in characteristics were identified between patients with pneumonia exacerbation and relief.

### Table IV. Factors associated with acute respiratory distress syndrome in patients with coronavirus disease 2019.

| Variable               | Univariate Analysis | Multivariate Analysis |
|------------------------|---------------------|-----------------------|
|                        | OR      | 95% CI    | \(P\)     | OR      | 95% CI    | \(P\)     |
| Sex                    | 1.149   | 0.450–2.930 | 0.772     | 1.046   | 1.006–1.089 | 0.025     |
| Age                    | 1.031   | 1.004–1.058 | 0.025     |         |           |           |
| SBP                    | 1.033   | 1.001–1.066 | 0.042     |         |           |           |
| DBP                    | 1.029   | 0.981–1.079 | 0.244     |         |           |           |
| BMI                    | 1.147   | 0.996–1.320 | 0.057     |         |           |           |
| Serum lactic acid      | 0.865   | 0.416–1.801 | 0.699     |         |           |           |
| Neutrophil count       | 0.927   | 0.665–1.292 | 0.652     |         |           |           |
| Lymphocyte count       | 0.359   | 0.141–0.918 | 0.032     |         |           |           |
| Hemoglobin             | 1.006   | 0.980–1.034 | 0.645     |         |           |           |
| Platelet count         | 0.995   | 0.987–1.003 | 0.188     |         |           |           |
| Serum creatinine       | 1.021   | 0.995–1.048 | 0.116     |         |           |           |
| ALT                    | 1.011   | 0.983–1.040 | 0.443     |         |           |           |
| AST                    | 1.033   | 0.988–1.080 | 0.154     |         |           |           |
| LDH                    | 1.011   | 1.003–1.018 | 0.007     | 1.010   | 1.001–1.019 | 0.021     |
| Tobacco smoker         | 0.398   | 0.046–3.408 | 0.400     |         |           |           |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; OR = odds ratio; SBP = systolic blood pressure.
scan, patients were divided into the pneumonia exacerbation group \( (n = 19) \) and the pneumonia relief group \( (n = 51) \). The characteristics were compared, and the results showed that patients with pneumonia exacerbation were significantly older \( (p = 0.021) \), with a higher BMI \( (p = 0.003) \) and a higher proportion of tobacco smokers \( (p = 0.006) \) (Table V).

### Univariate and Multivariate Analyses of Factors Associated With Pneumonia Exacerbation

Logistic regression was used to identify factors that were associated with pneumonia exacerbation in patients with COVID-19. Multivariate analysis showed that a high BMI (OR, 1.285; \( p = 0.017 \)) and tobacco smoking (OR, 16.13; \( p = 0.032 \)) were independent risk factors associated with 2019-nCoV-infected patients with pneumonia exacerbation after treatment (Table VI).

### DISCUSSION

The present study found that older age and high BMI were independent risk factors associated with patients with pneumonia. Furthermore, high SBP level and high LDH level were independent risk factors associated with ARDS among patients with COVID-19. High BMI and tobacco smoking were independent risk factors associated with pneumonia exacerbation after treatment in patients with COVID-19. These results help in the risk stratification of patients with COVID-19. Timely intervention should be initiated in patients with risk factors to avoid disease progression. In addition, the results of this study may have implications for the pathogenesis of COVID-19.

Most patients with COVID-19 will develop pneumonia.\(^{11}\) However, a small proportion of patients have negative radiographic findings. The largest study sample to date showed that among the 3665 confirmed cases, 95.5\% \( (n = 3498) \) of patients were diagnosed with pneumonia.\(^{12}\) According to the

| Characteristic | Patients with COVID-19 | \( P \) |
|----------------|------------------------|------|
| Sample size, n | 19                     | 51   |      |
| Male sex       | 11 (57.9\%)            | 24 (47.1\%) | 0.420 |
| Age, y         | 49.58 (22.16)          | 38.37 (15.80) | 0.021 |
| SBP, mm Hg     | 127.63 (13.11)         | 125.39 (17.43) | 0.614 |
| DBP, mm Hg     | 81.26 (10.95)          | 84.14 (10.58) | 0.322 |
| BMI, kg/m\(^2\) | 25.38 (2.49)           | 22.95 (3.61) | 0.003 |
| Serum lactic acid, mmol/L | 1.53 (0.75) | 1.56 (0.72) | 0.896 |
| Neutrophil count, \( \times 10^9 \) | 3.47 (1.62) | 3.29 (1.58) | 0.679 |
| Lymphocyte count, \( \times 10^9 \) | 1.13 (0.58) | 1.31 (1.05) | 0.481 |
| Hemoglobin, g/L | 139.68 (13.46)         | 137.92 (19.83) | 0.722 |
| Platelet count, \( \times 10^9 \) | 184.95 (50.78) | 207.19 (60.51) | 0.159 |
| Serum creatinine, \( \mu \text{mol/L} \) | 81.74 (73.92) | 61.76 (17.34) | 0.073 |
| ALT, U/L       | 19.38 (11.03)          | 21.78 (12.55) | 0.477 |
| AST, U/L       | 23.26 (12.71)          | 23.80 (10.05) | 0.856 |
| LDH, IU/L      | 201.16 (80.15)         | 200.40 (64.92) | 0.968 |
| Tobacco smoking | 4 (21.1\%)            | 1 (2.0\%) | 0.006 |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; SBP = systolic blood pressure.
Diagnosis and Treatment Program of 2019 New Coronavirus Pneumonia recommended by The National Health Commission of China, these patients only exhibited low fever and mild fatigue with no pneumonia manifestations, and they usually recovered after 1 week. Our study confirmed these results. We found that some patients had negative CT scan results, although the throat swabs confirmed infection with 2019-nCoV. Most previous studies were conducted in Wuhan Province with patients enrolled from Wuhan, and the symptoms of those first-generation patients were relatively severe. The patients enrolled in the present study were from Guangdong Province, which is not the first generation of infected patients. In our study, the patients’ symptoms were relatively mild, which is in line with the results of patients from Zhejiang Province.13 Symptoms of patients outside Hubei Province are relatively mild.

Some 2019-nCoV–infected patients will rapidly become critically ill.9,14 Previous research reported that the mortality rate of 2019-nCoV–infected patients is 4%–15%.7,9 In our study, only one patient aged 75 years (BMI, 29.37 kg/m²) died (mortality rate, 1.05%). Therefore, early detection of this population is very important. However, this subpopulation of patients who have severe disease may have moderate to low fever in the development of the disease. It is still difficult to screen out these patients. Our research may provide a sign. According to the results of our study, the 2019-nCoV–infected patients who developed ARDS were older and had higher SBP, serum creatinine, and LDH levels. This group of people also had lower lymphocyte counts. However, multivariate analysis suggested that only high SBP level and high LDH level were independent risk factors associated with ARDS among patients with COVID-19.

Previous research implied that some patients’ conditions will change dramatically in ~1 week.9 In our study, we performed repeated CT examinations on 70 patients after 1 week of treatment and found that those with imaging findings suggesting exacerbations had clinical baseline data significantly different from patients with reduced disease. Tobacco smoking has been confirmed to be associated with many diseases.13,16 In our study, multivariate analysis

| Table VI. Factors associated with pneumonia exacerbation in patients with coronavirus disease 2019. |
| Variable | Univariate Analysis | Multivariate Analysis |
|----------|-------------------|---------------------|
|          | OR | 95% CI   | P   | OR  | 95% CI   | P   |
| Sex      | 1.547 | 0.534–4.482 | 0.422 | 1.285 | 1.045–1.581 | 0.017 |
| Age      | 1.037 | 1.004–1.071 | 0.026 |         |           | 0.608 |
| SBP      | 1.009 | 0.976–1.042 | 0.608 |         |           | 0.319 |
| DBP      | 0.974 | 0.926–1.025 | 0.319 |         |           | 0.013 |
| BMI      | 1.253 | 1.049–1.497 | 0.013 |         |           | 0.894 |
| Serum lactic acid | 0.949 | 0.440–2.047 | 0.894 |         |           | 0.674 |
| Neutrophil count | 1.072 | 0.774–1.485 | 0.674 |         |           | 0.490 |
| Lymphocyte count | 0.746 | 0.325–1.714 | 0.490 |         |           | 0.718 |
| Hemoglobin | 1.005 | 0.977–1.034 | 0.718 |         |           | 0.161 |
| Platelet count | 0.993 | 0.983–1.003 | 0.161 |         |           | 0.244 |
| Serum creatinine | 1.014 | 0.990–1.039 | 0.244 |         |           | 0.472 |
| ALT      | 0.982 | 0.936–1.031 | 0.472 |         |           | 0.854 |
| AST      | 0.995 | 0.945–1.048 | 0.854 |         |           | 0.967 |
| LDH      | 1.000 | 0.992–1.008 | 0.967 |         |           | 0.032 |
| Tobacco smoking | 6.667 | 1.110–40.04 | 0.038 |         |           | 16.13 |

ALT = alanine aminotransferase; AST = aspartate aminotransferase; BMI = body mass index; DBP = diastolic blood pressure; LDH = lactate dehydrogenase; OR = odds ratio; SBP = systolic blood pressure.
suggests that high BMI and tobacco smoking were independent risk factors associated with disease exacerbation in 2019-nCoV–infected patients after treatment.

Until now, there have been no antiviral drugs specifically approved for treating 2019-nCoV–infected patients. Although reports have suggested the potential antiviral effects of lopinavir/ritonavir, it remains controversial. Remdesivir has shown strong potential antiviral effects in previous reports but has not yet been approved by the US Food and Drug Administration, and large clinical research results are lacking to support its application. Finding an effective treatment plan is a particularly important clinical problem.

The present study discusses the evolution of CT findings for patients with COVID-19. However, CT scans are not frequently used for assessment of patients with complicated pneumonia or ARDS. CT scan findings cannot completely identify exacerbation or relief of the disease. The CT scan results can only reflect some aspects in the development of the disease. The findings from our study may not have clinical relevance across different parts of the world.

This study has limitations. First, it involved a cross-sectional investigation. Second, the relative sample size was limited. The potential limitations of the present report could be overcome in future studies by enrolling more patients. In our study, there was no control group, and there was no comparator virus-infected group. Most of these findings are the same as would be seen with influenza, respiratory syncytial virus, and human metapneumovirus. The results from our study may imply that high-risk patients are at high risk of complications because of who they are (their specific characteristics), and not because of the specific nature of the individual pathogen. The airway inflammation coupled with their clinical factors is the real issue. In addition, prognostic outcomes were assessed. In the present study, all patients diagnosed with ARDS were admitted to the intensive care unit to continue further treatment. However, other prognostic outcomes, including length of stay data, in this study are missing because some patients are still in the hospital. Further study is needed to determine mortality and length of stay data.

CONCLUSIONS
Older age and high BMI were independent risk factors associated with pneumonia in patients with COVID-19. High SBP and LDH levels were independent risk factors associated with ARDS, whereas high BMI and tobacco smoking were independent risk factors associated with disease exacerbation after treatment. For such patients, stratification by using independent risk factors could help with the management of their disease.

DISCLOSURES
The authors have indicated that they have no conflicts of interest regarding the content of this article.

ACKNOWLEDGMENTS
This work was supported by grants from the Major Science and Technology Special Project of China (2017ZX09304016, 2017ZX10302201004008). The authors thank Jian Zhang for his helpful assistance in the study.

Drs. S. Cai, Yin, Xu, and Peng designed and guided the study; Drs. S. Cai and Yu wrote the main manuscript text; and Drs. Zheng, Liu, and X. Cai prepared all tables and data analysis. All authors reviewed the manuscript.

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