Retrospective analysis of clinical characteristics and laboratory results of COVID-19 patients

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Abstract
The positive detection of SARS-CoV-2 is the “gold standard” for diagnosing COVID-19. However, due to the low detection capacity of SARS-CoV-2 and the high false negative rate at the beginning of the epidemic, and the medical staff did not know much about the condition and treatment of COVID-19 patients. Therefore, our hospital paid more attention to the results of other laboratory indicators in the early stage of the epidemic of COVID-19. The aim of this study was to explore clinical characteristics and laboratory results of COVID-19 patients in Wuhan, China and provide evidence for the prevention and treatment of COVID-19. Retrospective study of 562 COVID-19 patients hospitalized in Wuhan Red Cross Hospital from January 28 to March 12, 2020 was performed. The patients were divided into 2 groups according to the severity of illness: Mild group (n = 436) and Severe group (n = 126). The general clinical characteristics of the patients were collected, including age, gender, past medical history, clinical symptoms, etc. All patients underwent blood routine test, biochemical indicators, blood gas analysis and other related laboratory examinations. The clinical data and laboratory results of the two groups were compared. Compared with the patients in the Mild group, the patients in Severe group were older and the proportion of patients suffering from underlying disease (61.11%) was higher (p < 0.05). In Severe group, WBC, NEUT, NLR, PCT, IL-6, ESR, CK, CK-MB, Mb, cTnI, D-D, Fib, and PaCO2 of patients had higher values, while the levels of LYMPH, HBG, PLT, PO2, and SaO2 were significantly reduced, and the differences were statistically significant (p < 0.05). Between Severe group and Mild group, there was no significant difference in other indexes such as ALT, Urea, and Cr (p > 0.05) or in the positive rate of influenza A, B virus, or other respiratory pathogens by pairwise comparison (p > 0.05). Viral infection and inflammation were more serious in elderly patients or patients with underlying diseases. They were more likely to progress to severely ill patients. Clinical manifestations and laboratory examinations were important basis for clinical classification and treatment. Therefore, Timely and accurate attention to these indicators is beneficial to prevent the deterioration of the disease.

Keywords
COVID-19, mild group, SARS-CoV-2, severe group

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Introduction
Coronavirus disease 2019 (COVID-19) is an acute respiratory disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection. It is contagious and passed from person to person, extensively in family settings.1–4
Clinical symptoms are mainly characterized by fever, dry cough, fatigue, etc. A small number of patients will have dyspnea, muscle soreness and other symptoms, and severe patients may progress to acute respiratory distress signs, sepsis, coagulation disorders and multiple organ failure, or even death.\textsuperscript{5,6} At present, the National Health Commission of China has included it in the management of statutory infectious diseases in Category B, and has adopted preventive and control measures for Category A infectious diseases.

The positive detection of SARS-CoV-2 is the “gold standard” for diagnosing COVID-19. However, due to the low detection capacity of SARS-CoV-2 and the high false negative rate at the beginning of the epidemic, and the medical staff did not know much about the condition and treatment of COVID-19 patients. Therefore, our hospital paid more attention to the results of other laboratory indicators in the early stage of the epidemic of COVID-19.

The aim of this study was to further understand the disease more to preventing deterioration of the patients by analyzing the clinical characteristics and laboratory indicators of 562 COVID-19 patients.

**Methods**

**Patients information**

We selected 562 COVID-19 patients with complete case information who were admitted to Wuhan Red Cross Hospital from January 28, 2020 to March 12, 2020 and confirmed by nucleic acid testing as the research objects. Among them, 322 were males and 240 were females, the age was 44.74 ± 15.3 years. The general clinical characteristics of the patients were collected, including age, gender, past medical history, clinical symptoms, etc. Diagnosis and clinical classification of patients based on diagnosis and treatment of novel coronavirus infected pneumonia (trial eighth edition).\textsuperscript{7} According to the research plan, they were divided into two groups: Mild group (including 280 cases of light type and 156 cases of common type) and Severe group (including 82 cases of severe type and 44 cases of critical type). All subjects’ informed consent has been obtained before the study and this study was approved by the Ethics Committee of Wuhan Red Cross Hospital.

Clinical classification of COVID-19 patients (trial eighth edition).\textsuperscript{7}

1. **Light type.**
   - The clinical symptoms are mild, and there is no evidence of pneumonia in imaging.

2. **Common type.**
   - With fever, respiratory symptoms, etc., pneumonia can be seen on imaging.

3. **Heavy type.**
   - Adults meet any of the following:
     1. Shortness of breath occurs, RR $\geq 30$ times/min;
     2. In the resting state, when inhaling air, the oxygen saturation is $\leq 93\%$;
     3. Arterial partial pressure of oxygen (PaO$_2$)/inhaled oxygen concentration (FiO$_2$) $\leq 300$ mmHg (1 mmHg $= 0.133$ kPa);
     4. The clinical symptoms are progressively worsening, and lung imaging shows that the lesions have progressed significantly $> 50\%$ within 24 to 48 h.

   In areas with high altitude (over 1000 meters above sea level), PaO$_2$/FiO$_2$ perform calibration: PaO$_2$/FiO$_2$ $\times [760/\text{atmospheric pressure (mmHg)}]$.

4. The clinical symptoms are progressively worsening, and lung imaging shows that the lesions have progressed significantly $> 50\%$ within 24 to 48 h.

   Children meet any of the following:

1. High fever lasts for more than 3 days;
2. Shortness of breath ($<$2 months old, RR $\geq 60$ beats/min; 2–12 months old, RR $\geq 50$ times/min; 1 to 5 years old, RR $\geq 40$ times/min; $>$5 years old, RR $\geq 30$ times/min), except the influence of external fever and crying;
3. In the resting state, when inhaling air, the oxygen saturation is $\leq 93\%$;
4. Assisted breathing (nostril flapping, three concave signs);
5. Drowsiness, convulsions;
6. Anti-feeding or feeding difficulties, with signs of dehydration.

(4) Critical type.
Meet one of the following conditions:

1. Respiratory failure occurs and mechanical ventilation is required;
2. Shock;
3. Combination of other organ failures requires ICU monitoring and treatment.

Inclusion criteria: All patients with laboratory-identified SARS-CoV-2 infection by real-time PCR.

Exclusion criteria: (1) Suspected COVID-19 patients who have not been confirmed by nucleic acid. (2) Covid-19 patients with incomplete information.

**Laboratory examinations**

Retrospective study of 562 COVID-19 patients hospitalized in Wuhan Red Cross Hospital. All patients underwent blood routine test, biochemical indicators, blood gas analysis and other related laboratory examinations including white blood cell (WBC), neutrophils (NEUT), lymphocytes (LYMPH), neutrophil to lymphocyte ratio (NLR), hemoglobin (HGB), Platelet (PLT), C-reactive protein (CRP), procalcitonin (PCT), interleukin 6 (IL-6), erythrocyte sedimentation rate (ESR), alanine aminotransferase (ALT), Urea, Creatinine (Cr), D-dimer (D-D), fibrinogen (Fib), creatine kinase (CK), creatine kinase MB (CK-MB), myoglobin (Mb), cardiac troponin I (cTnI). Partial pressure of oxygen (PO2), oxygen saturation (SaO2), and partial pressure of carbon oxygen (PaCO2) were included in blood gas analysis. In addition, nasopharyngeal swabs and serum samples were collected to detect influenza A and B influenza virus antigens and respiratory tract nine-test antibodies.

**Statistical analysis**

Statistical software SPSS 23.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis, measurement data of normal distribution was expressed as mean ± SD (x ± s), and independent sample t test was used for comparison between groups; count data was expressed by rate n (%), and Pearson χ² test or Fisher’s exact test was used, p < 0.05 was considered statistically significant.

**Results**

**Information on 562 COVID-19 patients and characteristics of combined basic diseases**

Compared with Mild group, COVID-19 patients in Severe group were significantly older, and had a significantly higher ratio of underlying diseases such as renal function impairment, liver function damage, chronic respiratory disease, coronary heart disease, hypertension, diabetes and malignant diseases, the differences were statistically significant (p < 0.05). There was no significant difference between the two groups in the gender composition ratio of men and women (p > 0.05), Table 1.

**Comparison of blood cells and reactive indexes between two groups of COVID-19 patients**

Compared with Mild group, patients in Severe group had lower levels of LYMPH, HGB, and PLT,
while the levels of WBC, NEUT, and NLR were higher, the differences were statistically significant ($p < 0.05$). The results of CRP, IL-6, PCT, and ESR in Severe group were significantly increased, and the differences were statistically significant ($p < 0.05$), Table 2.

**Comparison of blood biochemical and blood gas index results between two groups of COVID-19 patients**

This study showed that the results of CK, CK-MB, Mb, cTnI, D-D, Fib, and PaCO$_2$ in Severe group were increased compared with COVID-19 patients in Mild group, and the level of PO$_2$ and SaO$_2$% of the severe COVID-19 patients were lower, the differences were statistically significant by pairwise comparison ($p < 0.05$). The results of ALT, Urea and Cr between the two groups were compared, and the differences were not statistically significant ($p > 0.05$), Table 3.

**Comparison of positive rates of COVID-19 patients with other respiratory pathogens**

Some of the 562 COVID-19 patients were infected with other respiratory pathogens. The positive rate of Severe group of patients with influenza A, B, or other respiratory pathogens was not statistically different from that of Mild group ($p > 0.05$) Table 4.

**Discussion**

COVID-19 is an infectious disease caused by SARS-CoV-2. SARS-CoV-2 is the seventh known β-CoV coronavirus that can infect humans, and its natural host may be bats, which is highly infectious. Studies showed that the infectivity of SARS-CoV-2 is higher than SARS-CoV. SARS-CoV-2 is mainly transmitted through respiratory droplets and contact, and may be transmitted through aerosols, digestive tract, etc. under certain conditions. The population is generally susceptible, and patients are the main source of infection.
This study found that in Mild group the results of WBC were normal or decreased, LYMPH were decreased, while NLR was increased. In Severe group, the levels of WBC, NEUT, and NLR of patients were increased significantly, while LYMPH, HGB, and PLT were more significantly decreased. The differences were statistically significant after pairwise comparison (\( p < 0.05 \)). Lymphocytes are white blood cells that play an important role in the immune system. Lymphocyte reduction in patients with COVID-19 indicated that the patient's immune system was heavily attacked by SARS-CoV-2. NLR is a sensitive indicator that reflects the immune status and inflammation of the body. When the disease progresses and the immune response is severe, the NLR increases. Compared with NEUT and LYMPH, NLR can better reflect the systemic inflammation state. Therefore, NLR can be used as a screening indicator for the diagnosis of COVID-19.

This study showed that the PCT value of patients in Mild group was basically normal, and CRP, Urea, and Cr were not statistically significant (\( p > 0.05 \)), indicating that SARS-CoV-2 might have little effect on the three indicators of ALT, Urea, and Cr in COVID-19 patients. It was slightly different from previous research results. The reason might be that the patient population with underlying diseases (such as liver damage, chronic renal insufficiency, renal failure, etc.) in this study were different from other studies.

This study showed that only a few cases of COVID-19 patients in Mild group have increased CK, CK-MB, Mb, or cTnI, but the magnitude was small and the recovery was fast. However, CK, CK-MB, Mb, and cTnI of some patients in the severe group significantly increased, and the differences were statistically significant by pairwise comparison (\( p < 0.05 \)). This is consistent with the findings of the study conducted by Shi et al. The results indicated that myocardial injury were more common in Severe group, and it might be related to respiratory system damage, hypoxoxygenation, myocardial ischemia and inflammation in critically ill patients. In addition, D-D and Fib of some patients with COVID-19 increased, and the increase in Severe group was more obvious. The differences between the two groups were

| Test items                                | Mild group (n = 436) | Severe group (n = 126) | \( \chi^2 \) | p-Value |
|-------------------------------------------|----------------------|------------------------|-------------|---------|
| Influenza A virus antigen                  | 6 (1.38%)            | 3 (2.38%)              | 0.15        | 0.698   |
| Influenza B virus antigen                  | 4 (0.92%)            | 2 (1.59%)              | ...        | 0.621   |
| Influenza A virus antibody                 | 7 (1.61%)            | 2 (1.59%)              | 0.00        | 1.000   |
| Influenza B virus antibody                 | 12 (2.75%)           | 5 (3.97%)              | 0.17        | 0.684   |
| Parainfluenza virus antibody               | 8 (1.83%)            | 2 (1.59%)              | 0.00        | 1.000   |
| Respiratory syncytovirus antibody          | 1 (0.00%)            | 0 (0.00%)              | ...        | 0.621   |
| Adenovirus antibody                        | 2 (0.46%)            | 0 (0.00%)              | ...        | 1.000   |
| Legionella pneumophila serotype I          | 18 (4.13%)           | 6 (4.76%)              | 0.10        | 0.757   |
| Mycoplasma pneumoniae antibody             | 26 (5.96%)           | 6 (8.73%)              | 1.22        | 0.270   |
| Chlamydia pneumoniae antibody              | 3 (0.69%)            | 0 (0.00%)              | ...        | 0.000   |
| Q fever rickettsia antibody                | 2 (0.46%)            | 0 (0.00%)              | ...        | 1.000   |

*Fisher’s exact test.
statistically significant ($p < 0.05$). The results were consistent with previous study.\textsuperscript{19,20} This indicates that patients with SARS-CoV-2 infection have damaged the vascular endothelial system and the patient’s blood is in a hypercoagulable state. Therefore, we should pay more attention to early monitoring and timely preventive anticoagulation therapy in these patients. Compared with patients in Mild group, as the disease worsened, the $\text{PO}_2$ and $\text{SaO}_2\%$ of the severe COVID-19 patients decreased significantly, while the $\text{PaCO}_2$ increased, the differences were statistically significant ($p < 0.05$). This study found that some patients in Severe group have difficulty breathing, respiratory failure, even death. This showed that COVID-19 patients were progressing rapidly, and hypoxemia was a risk factor for severely ill patients with new coronary pneumonia.

This study showed that some of the 562 COVID-19 patients were infected with other respiratory pathogens, and the positive rates of Severe group patients with influenza A, B or other respiratory pathogen infections were not statistically different from that of Mild group. The differences were not statistically significant ($p > 0.05$). The results showed that the infection of other respiratory pathogens in mild patients was not an independent factor in progression to severe patients, but these interfering factors must be excluded during the clinical diagnosis process, and attention should be paid to distinguish SARS-CoV-2 from other respiratory pathogens to avoid misdiagnosis.

As a designated hospital for COVID-19 patients, Wuhan Red Cross Hospital is also a hospital for severe patients with COVID-19. Most patients were elderly or suffering from underlying diseases. Once such patients were infected with COVID-19, they progressed very quickly and their condition is relatively more serious. Therefore, more attention should be paid to these patients, and their laboratory indicators should be monitored accurately and timely to prevent the disease from getting worse.

Our research had some limitations. First, those patients whose nucleic acid tests were negative weren’t included in this study, although their clinical manifestations and imaging studies were similar to COVID-19 patients. Second, we ruled out clinically diagnosed COVID-19 cases with incomplete information. This might result in a small population in this study, which might lead to bias. Third, the high proportion of patients in Severe group with underlying diseases might cause greater bias in the results of certain laboratory indicators. Last, this is a single-center study. Since COVID-19 is a new disease, there are few studies on the impact of SARS-CoV-2 on patient’s laboratory indicators and the expected results are unknown. Therefore, this study can only collect as many cases in our hospital as possible. In addition, our research lacks a dynamic monitoring process for patients’ clinical manifestations and laboratory indicators. Therefore, multi-center cooperation is needed to conduct more studies to further clarify these issues.

**Conclusion**

Viral infection and inflammation were more serious in elderly patients or patients with underlying diseases. They were more likely to progress to severely ill patients. Clinical manifestations and laboratory examinations were important basis for clinical classification and treatment. Therefore, Timely and accurate attention to these indicators is beneficial to prevent the deterioration of the disease.

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**Authors’ contributions**

Pu Chen and Liying Zhang performed the major research. The manuscript was written mainly with the efforts of Pu Chen, Liying Zhang and Qiao Zheng, Yusheng Peng provided the statistical analysis. Lanbin Jiang and Shijie Tang have given approval to the final version of the manuscript.

**Declaration of conflicting interests**

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**Ethical approval**

Ethical approval for this study was obtained from Wuhan Red Cross Hospital of Ethics Committee (2020-011).

**Informed consent**

Verbal informed consent was obtained from legally authorized representatives before the study. Written informed
consent retrospectively was obtained from legally authorized representatives.

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