Clinical characteristics of 78 cases of patients infected with coronavirus disease 2019 in Wuhan, China

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Received June 13, 2020; Accepted September 22, 2020

DOI: 10.3892/etm.2020.9439

Abstract. Coronavirus disease 2019 (COVID-19) emerged in Wuhan and rapidly spread throughout the world in December 2019. The present study aimed to describe the clinical characteristics and laboratory findings of 78 patients with COVID-19 in order to enhance the understanding of the disease. Medical records and data of 78 patients with COVID-19, including demographics, clinical features, laboratory findings and radiological characteristics, were collected and analyzed. Of the 78 hospitalized patients with COVID-19, the median age was 66.5 years and 48.7% of patients were male. Hypertension and diabetes were the most common chronic underlying diseases, and the most common symptoms were a cough and a fever. Furthermore, the most common findings on the chest CT were extensive ground-glass opacity and bilateral shadowing. Anemia and lymphocytopenia were the most common abnormalities identified during routine blood tests. COVID-19 caused early liver renal damage, with 52.9% of patients displaying elevated D-dimer levels, 98.7% of patients displaying elevated IL-6 levels and 80.8% of patients displaying a reduced level of low-density lipoprotein cholesterol (LDL-C). In the present single-center case study of 78 patients with COVID-19 in Wuhan, China, the patients displayed abnormal routine blood tests, liver function, renal function and levels of D-dimer, LDL-C and IL-6. Therefore, the development of drugs and vaccines that can be used to prevent and treat infections of COVID-19 is urgently required.

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Key words: clinical characteristics, coronavirus disease 2019

Introduction

In December 2019, in Wuhan, Hubei, China, a number of patients with pneumonia of an unknown cause were confirmed to be infected with a novel coronavirus, which had not been detected in humans or animals previously (1). On January 7th 2020, researchers rapidly isolated a novel coronavirus from patients with confirmed infectious pneumonia (2). The pathogen was named SARS-Cov-2 due to its similarity to the coronavirus that causes severe acute respiratory syndrome (SARS-CoV). These infections share ≥79% of the sequence of the subgenus *Sarbecovirus* (β-CoV lineage B). SARS-Cov-2 shares only 50% homology with the coronavirus responsible for Middle East respiratory syndrome (MERS-CoV), which is a member of the *Merbecovirus* subgenus (3).

The World Health Organization recently assessed that coronavirus disease 2019 (COVID-19) can be classified as a pandemic (4). As of April 25th 2020, a total of 2,719,896 laboratory-confirmed cases had been reported globally (5), but these figures are increasing every day. The spread of COVID-19 among people has been demonstrated to occur via droplets, aerosols, feces and mouth mucus membranes (1). According to recent studies, the most common symptoms were fever, cough, expectoration, myalgia or fatigue, nausea or vomiting and diarrhea. The most common radiologic finding in chest CT was ground-glass opacity (3,6).

The aim of the present study was to describe the clinical characteristics and laboratory findings of patients with COVID-19 admitted to the Z13 Unit of Union Hospital Affiliated to Tongji Medical College of Huazhong University of Science and Technology to improve the understanding of COVID-19 globally.

Materials and methods

Patients. Patients with confirmed cases of COVID-19 were enrolled from Z13 Unit of Union Hospital Affiliated to Tongji Medical College of Huazhong University of Science and Technology between February 14th 2020 and March 14th 2020. Only laboratory-confirmed cases were enrolled in the present study, which were previously diagnosed by a positive result from a reverse transcription-quantitative PCR (RT-qPCR) of nasal and pharyngeal swab specimens. All patients enrolled in

the present study were non-severe. COVID-19 and the degree of severity was diagnosed on the basis of the latest version of the guidelines of Diagnosis and Treatment of Pneumonitis Caused by the novel coronavirus, including the fourth, fifth, and sixth versions, which were issued by the National Health Commission of China (7).

Data collection. The medical records and data of patients were extracted on admission from electronic medical records, and included demographics, clinical features, laboratory findings and characteristics of the chest CT. The aforementioned data were collected and reviewed by the doctors who had been treating the patients with COVID-19, and were then entered into a computerized database and crosschecked. As the cohort of patients enrolled in the present study and the laboratory tests conducted were not derived from random selection, the statistics of the present study are descriptive only. The normal ranges of laboratory findings are presented in Table I.

Statistical analysis. For categorical variables, the percentage of patients in each category was calculated. Continuous variables were appropriately represented as the median with interquartile or simple ranges. There are no estimates of the missing data. Medians and interquartile ranges (IQRs) were calculated using SPSS software (version 22.0; IBM Corp.).

Results

General information of patients with COVID-19. Up to March 14th 2020, a total of 78 patients with COVID-19 had been admitted to the Z13 Unit of Union Hospital Affiliated to Tongji Medical College of Huazhong University of Science and Technology, including 40 female patients and 38 male patients. The median age of the patients was 66.5 years (interquartile range, 53.75-70), with 5 (6.4%) patients aged 15-40 years, 27 (34.6%) patients aged 41-65 years and 46 (59%) patients aged >65 years. Coexisting conditions were observed in 50% of patients, including hypertension, diabetes, cerebral infarction, malignant tumor and chronic renal failure. Hypertension and diabetes were the most common chronic underlying diseases in the cohort (Table II).

Symptoms. On admission, the majority of the patients presented with a fever (65.4%) or cough (75.6%) and 50% of patients reported fatigue. Other symptoms included sputum production, shortness of breath, myalgia or arthralgia, diarrhea and nausea. Out of the 78 patients, only 4 (5.1%) patients did not display any symptoms (data not shown).

CT findings. All patients enrolled in the present study displayed CT abnormalities. The most common chest CT findings of patients with COVID-19 on admission were ground-glass opacity (53.8%) and consolidation shadowing (28.2%) (Table II).

Routine blood examination. The hemoglobin levels and blood cell count of 77 patients (one patient did not receive a routine blood examination) on admission, including white cell, neutrophil, lymphocyte, platelet and eosinophil counts, are presented in Table III. Anemia was identified in 47.4% of male patients and 41% of female patients. Moreover, 14 (18.2%) patients displayed leucopenia and 3 (3.9%)

Table I. The normal reference ranges of laboratory findings.

Parameters	Reference ranges
Hemoglobin (male, g/l)	130-175
Hemoglobin (female, g/l)	115-150
White-cell count, x10 per mm^3	4-10
Neutrophil count, x10 per mm^3	1.8-6.3
Lymphocytes count, x10 per mm^3	1.1-3.2
Platelet count, x10 per mm^3	125-350
Eosinophilia count, x10 per mm^3	0.02-0.52
Total bilirubin, μmol/l	5.1-19.0
Direct bilirubin, μmol/l	1.7-6.8
Total protein, g/l	64-83
Albumin, g/l	35-55
Globulin, g/l	20-30
Alanine aminotransferase, IU/l	8-40
Aspartate aminotransferase, IU/l	5-35
Alkaline phosphatase, IU/l	40-150
γ-Glutamyltranspeptidase, IU/l	7-32
Blood urea nitrogen, mmol/l	2.9-8.2
Creatinine, μmol/l	44-106
Uric acid, μmol/l	155-357
Cystatin C, mg/l	≤1.0
Total carbon dioxide, mmol/l	21-30
Prothrombin time, sec	11-16
International normalized ratio	0.8-1.31
Fibrinogen degradation products, μg/ml	≤5.0
D-dimer, μg/l	≤0.5
C-reactive Protein, mg/l	≤5.0
Procalcitonin, mg/l	≤0.5
Erythrocyte sedimentation rate, mm/H	≤15
Ferritin, μg/l	≤4.6
$CD3^+$ total T-lymphocytes, %	58.17-84.22
$CD4^+$ T-lymphocyte, %	25.34-51.37
$CD8^+$ T-lymphocyte, %	14.23-38.95
$CD4^+/CD8^+$	0.41-2.72
IL-6, pg/ml	≤2.9
TNF-α, pg/ml	≤23
IL-4, pg/ml	≤3.2
IL-2, pg/ml	≤4.1
IL-10, pg/ml	≤5.0
IFN-γ, pg/ml	≤18
LDH, U/l	109-245
CK, U/l	26-140
CK-MB, U/l	≤6.6
cTnI, ng/l	≤26.2
BNP, μg/ml	≤100
TG, mmol/l	≤1.7
LDL-c, mmol/l	2.7-3.1

LDH, lactic dehydrogenase; CK, creatine kinase; CK-MB, CK isoenzyme-the Muscle Brain isoenzyme; cTnI, hypersensitive troponin I; BNP, brain natriuretic peptide; TG, triglyceride; IQR, interquartile range; LDL-c, low density lipoprotein cholesterol.

Table II. General information of patients with COVID-19.

Characteristics	All patients, n=78
Median (interquartile) age (years)	66.5 (53.75-70)
Age groups (years)	
15-40	5 (6.4)
41-65	27 (34.6)
>65	46 (59)
Sex (%)	
Male	38 (48.7)
Female	40 (51.3)
Coexisting conditions (%)	
Any	39 (50)
Hypertension	24 (30.8)
Diabetes	16 (20.5)
Cerebral infarction	1 (1.3)
Malignant tumor	3 (3.8)
Chronic renal failure	3 (3.8)
Symptoms (%)	
Fever	51 (65.4)
Cough	59 (75.6)
Sputum production	24 (30.8)
Shortness of breath	12 (15.4)
Fatigue	39 (50)
Myalgia or arthralgia	19 (24.4)
Diarrhea	13 (16.7)
Nausea	14 (17.9)
Headache	0 (0)
Nausea or vomiting	0 (0)
Abnormalities on chest CT (%)	
Ground-glass opacity	42 (53.8)
Bilateral patchy shadowing	20 (25.6)
Thread net shadowing	14 (17.9)
Linear shadowing	13 (16.7)
Consolidation shadowing	22 (28.2)

COVID-19, coronavirus disease 2019.

Table III. Routine blood examination.

Parameter	Patient no.
Hemoglobin (Male, g/l)	
Median (IQR)	131 (122-138.25)
<130 (%)	18/38 (47.4)
>175 (%)	0/38 (0)
Hemoglobin (Female, g/l)	
Median (IQR)	118 (111-123)
<115 (%)	16/39 (41)
>150 (%)	0/39 (0)
White-cell count, x10 per mm^3	
Median (IQR)	5.51 (4.40-7.34)
<4 (%)	14/77 (18.2)
>10 (%)	3/77 (3.9)
Neutrophil count, x10 per mm^3	
Median (IQR)	3.37 (2.56-5.28)
<1.8 (%)	3/77 (3.9)
>6.3 (%)	8/77 (10.4)
Lymphocytes count, x10 per mm^3	
Median (IQR)	1.29 (0.91-1.68)
<1.1 (%)	28/77 (36.4)
>3.2 (%)	2/77 (2.6)
Platelet count, x10 per mm^3	
Median (IQR)	216 (159.5-271)
<125 (%)	8/77 (10.4)
>350 (%)	5/77 (6.5)
Eosinophilia count, x10 per mm^3	
Median (IQR)	0.07 (0.03-0.12)
<0.02	12/77 (15.6)
>0.52	0/77 (0)

IQR, interquartile range.

patients displayed leukocytosis. Lymphocytopenia was present in 28 (36.4%) patients and thrombocytopenia was identified in 8 (10.4%) patients. Twelve patients displayed lower eosinophilia counts than the lower limit of the reference range.

Assessment of liver function. Among the 78 patients, 14 (17.9%) patients displayed elevated levels of total bilirubin, whereas elevated direct bilirubin was observed in 7 (9%) patients. The incidence rates of elevated alanine aminotransferase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP) and γ-glutamyl transferase (γ-GGT) were 17.9, 37.2, 1.3 and 43.6%, respectively. Moreover, 36 patients displayed lower total protein counts than the lower limit of the reference range. Levels of albumin were decreased in 27 (34.6%) the patients. In addition, 55 (70.5%) patients displayed normal serum levels of globulin (Table IV).

Assessment of renal function. The levels of blood urea nitrogen, creatinine, uric acid, cystatin C and total carbon dioxide are presented in Table V. Among the 77 patients, 64 (83.1%) patients displayed normal blood urea nitrogen levels. Total creatinine levels <44 μmol/l were observed in 2 (2.6%) patients, whereas 4 (5.2%) patients displayed total creatinine levels >106 μmol/l. Moreover, 5 (6.6%) patients out of 76 patients displayed a lower uric acid count than the lower limit of the reference range, whereas 11 (14.5%) patients displayed a higher uric acid count (one patient missed the blood examination of uric acid and cystatin C). Elevated cystatin C levels were observed in 64.5% of patients.

Assessment of coagulation function. The results of the assessment of coagulation function are presented in Table VI. Among the 51 D-dimer tests performed, 52.9% identified elevated D-dimer levels (median, 0.6 μg/l; interquartile range, 0.2-1.56 μg/l).

Level of infection-related biomarkers. C-reactive protein levels were increased in 34 (47.2%) patients. Only one patient displayed a procalcitonin level >0.5 mg/l. Among

Table IV. Assessment of liver function.

Parameter	Patient no.
Total bilirubin, umol/l	
Median (IQR)	12.95 (10.27-16.92)
<5.1 (%)	1/78 (1.3)
>19.0 (%)	14/78 (17.9)
Direct bilirubin, μmol/l	
Median (IQR)	4.0 (3.3-5.0)
<1.7 (%)	0/78 (0)
>6.8 (%)	7/78 (9.0)
Total protein, g/l	
Median (IQR)	64.9 (61.82-67.32)
<64 (%)	36/78 (46.2)
>83(%)	0/78 (0)
Albumin, g/l	
Median (IQR)	36.75 (33.08-40.25)
<35 (%)	27/78 (34.6)
>55 (%)	0/78 (0)
Globulin, g/l	
Median (IQR)	27.3 (24.98-30.43)
<20 (%)	2/78 (2.6)
>30 (%)	21/78 (26.9)
Alanine aminotransferase, IU/l	
Median (IQR)	27 (20-37.25)
<8 (%)	0/78 (0)
>40 (%)	14/78 (17.9)
Aspartate aminotransferase, IU/l	
Median (IQR)	25.5 (17.75-48)
<5 (%)	0/78 (0)
>35 (%)	29/78 (37.2)
Alkaline phosphatase, IU/l	
Median (IQR)	78 (67-99.25)
<40 (%)	0/78 (0)
>150 (%)	1/78 (1.3)
γ-Glutamyltranspeptidase, IU/l	
Median (IQR)	28.5 (19-48.5)
<7 (%)	0/78 (0)
>32 (%)	34/78 (43.6)

IQR, interquartile range.

Table V. Assessment of renal function.

Parameter	Patient no.
Blood urea nitrogen, mmol/l	
Median (IQR)	4.2 (3.22-5.05)
<2.9 (%)	10/77 (13)
>8.2 (%)	3/77 (3.9)
Creatinine, μmol/l	
Median (IQR)	75 (66.25-87.5)
<44 (%)	2/77 (2.6)
>106 (%)	4/77 (5.2)
Uric acid, μmol/l	
Median (IQR)	277 (215.25-328.25)
<155 (%)	5/76 (6.6)
>357 (%)	11/76 (14.5)
Cystatin C, mg/l	
Median (IQR)	1.08 (0.94-1.28)
>1.0 (%)	49/76 (64.5)
Total carbon dioxide, mmol/l	
Median (IQR)	23.6 (20.45-26.7)
<21	20/77 (26)
>30	2/77 (2.6)

IQR, interquartile range.

Table VI. Assessment of coagulation function.

Parameter	Patient no.
Prothrombin time, sec	
Median (IQR)	12.95 (10.27-16.92)
<11 (%)	0/70 (0)
>16 (%)	2/7 (2.9)
International normalized ratio	
Median (IQR)	1.04 (0.99-1.10)
<0.8 (%)	0/70 (0)
>1.31 (%)	2/70 (2.9)
Fibrinogen degradation products, μg/ml	
Median (IQR)	2.2 (1.3-4.7)
>5 (%)	12/51 (23.5)
D-dimer, μg/l	
Median (IQR)	0.6 (0.21-1.56)
>0.5 (%)	27/51 (52.9)

IQR, interquartile range.

the 45 erythrocyte sedimentation rate (ESR) examinations performed, levels of ESR were increased in 36 (80%) patients. Only 24 patients received ferritin tests, with 16 patients displaying ferritin levels >204 μg/l (Table VII).

Measurement of T-lymphocyte subsets. The numbers of total T-lymphocytes were lower than the reference range in 13 (16.7%) patients, but higher in 18 patients (23.1%). Among the 78 patients, 6 (7.7%) patients displayed declined $CD4^+$ T-lymphocyte counts and 25 (32.1%) patients displayed elevated counts. Moreover, $CD8^+$ T-lymphocyte counts were elevated in 9 (11.5%) patients and decreased in 9 (11.5%) patients. The ratio of $CD4^+$ T-lymphocytes to $CD8^+$ T-lymphocytes was increased in 25 (32.1%) patients (Table VIII).

Cytokine detection. A total of 77 out of the 78 patients received cytokine detection. The majority of patients displayed elevated levels of IL-6 (98.7%). The incidence rates of elevated IL-2, IL-4, IL-10 and TNF-α were 32.5, 53.2, 33.8 and 9.1%, respectively. IFN-γ levels were within the normal range (Table IX).

Table VII. Level of infection-related biomarkers.

Parameter	Patient no.
C-reactive protein, mg/l	
>5 (%)	34/72 (47.2)
Procalcitonin, mg/l	
>0.5 (%)	1/71(1.4)
Erythrocyte sedimentation rate, mm/H	
>15 (%)	36/45 (80)
Ferritin, μg/l	
Median(IQR)	248.8 (132.3-492.95)
>4.6 (%)	0/24 (0)

IQR, interquartile range.

Table VIII. Measurement of T-lymphocyte subsets.

Parameter	Patient no.
$CD3^+$ total T-lymphocytes, %	
Median (IQR)	78.28 (67.34-83.98)
<58.17 (%)	13/78 (16.7)
>84.22 (%)	18/78 (23.1)
$CD4^+$ T-lymphocyte, %	
Median (IQR)	46.74 (36.30-54.33)
<25.34 (%)	6/78 (7.7)
>51.37 (%)	25/78 (32.1)
$CD8^+$ T-lymphocyte, %	
Median (IQR)	23.67 (17.95-31.39)
<14.23 (%)	9/78 (11.5)
>38.95 (%)	9/78 (11.5)
$CD4^+/CD8^+$	
Median (IQR)	1.79 (1.41-2.81)
<0.41 (%)	2/78 (2.6)
>2.72 (%)	25/78 (32.1)

IQR, interquartile range; CD, cluster of differentiation.

Levels of lactate dehydrogenase (LDH), creatine kinase (CK), creatine kinase-MB, hypersensitive troponin I (cTnI) and brain natriuretic peptide (BNP). The levels of LDH, CK, CK-MB, cTnI and BNP in blood are presented in Table X. The results indicated that 35.9, 18.2, 1.4, 6.7 and 11.8% of patients displayed elevated levels of LDH, CK, CK-MB, cTn and BNP peptide, respectively.

Level of triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C). Elevated levels of TG were observed in 31.5% of patients, whereas 59 (80.8%) of the 73 patients displayed reduced levels of LDL-C (Table XI).

Discussion

In the present study, a total of 78 patients with COVID-19 were recruited. The majority of patients were elderly individuals (median age, 66.5 years), including 40 female patients and 38 male patients. Similarty to MERSCOV (8), hypertension and diabetes were the most common chronic underlying diseases, which was consistent with the results reported by

Table IX. Cytokine detection.

Parameter	Patient no.
IL-6, pg/ml	
Median (IQR)	11.23 (6.16-22.78)
>2.9 (%)	76/77 (98.7)
TNF-α, pg/ml	
Median (IQR)	5.39 (3.53-11.07)
>23 (%)	7/77 (9.1)
IL-4, pg/ml	
Median (IQR)	3.34 (2.52-4.11)
>3.2 (%)	41/77 (53.2)
IL-2, pg/ml	
Median (IQR)	3.77 (3.00-4.19)
>4.1 (%)	25/77 (32.5)
IL-10, pg/ml	
Median (IQR)	4.6 (3.88-5.29)
>5 (%)	26/77 (33.8)
IFN-γ, pg/ml	
Median (IQR)	3.29 (2.56-3.69)
>18 (%)	0/77 (0)

IQR, interquartile range; IL, interleukin; TNF, tumor necrosis factors; IFN, interferon.

Table X. Level of LDH, CK, CK-MB, cTnI and BNP.

Parameter	Patient no.
LDH, U/l	
Median (IQR)	210 (170.25-272.5)
<109 (%)	1/78 (1.3)
>245 (%)	28/78 (35.9)
CK, U/l	
Median (IQR)	65 (49.5-126)
<26 (%)	1/77 (1.3)
>140 (%)	14/77 (18.2)
CK-MB, U/l	
Median (IQR)	0.6 (0.4-1.0)
>6.6 (%)	1/73 (1.4)
cTnI, ng/l	
Median (IQR)	2.7 (1.5-6.1)
>26.2 (%)	5/75 (6.7)
BNP, μg/ml	
>100 (%)	6/51 (11.8)

IQR, interquartile range; LDH, lactic dehydrogenase; CK, creatine kinase; CK-MB, CK isoenzyme-the Muscle Brain isoenzyme; cTnI, hypersensitive troponin I; BNP, brain natriuretic peptide.

Table XI. Level of TG and LDL-C.

Parameter	Patient no.
TG, mmol/l	
Median (IQR)	1.28 (0.9-1.86)
>1.7 (%)	23/73 (31.5)
LDL-c, mmol/l	
Median (IQR)	2.21 (1.89-2.61)
<2.7 (%)	59/73 (80.8)
>3.1 (%)	7/73 (9.6)

TG, triglyceride; IQR, interquartile range; LDL-c, low density lipoprotein cholesterol.

Chen *et al* (9), and was potentially an outcome of the weaker immune functions of these patients. Common symptoms upon admission were cough, fever, fatigue, expectoration, myalgia, anepithymia and diarrhea, which were absent in four patients. Consistent with recent studies, future studies should examine asymptomatic patients who come into contact with patients with COVID-19. In the present study, the rate of acute respiratory distress syndrome (ARDS), shock and other serious complications was much lower compared with the rates in early reports (3,6). The low incidence may be associated with the fact that the majority of the cohort consisted of non-severe cases. Furthermore, cases in the previous study were from the early epidemic stage (3,6). Pathogens tend to decrease their virulence to maximize their between-host transmission (6), a phenomenon that occurred in the transmission of MERS-CoV. The global case mortality of MERS-CoV was ~40%, but was ~20% in the second generation (3).

As for the chest CT, the most common findings in the present study were extensive ground-glass opacity and bilateral patchy shadowing. All of the patients enrolled in the present study displayed CT abnormalities. However, Guan *et al* (6) reported that 17.9% of patients with non-severe disease and 2.9% of patients with severe disease displayed normal chest radiographic or CT upon admission. Yang *et al* (10) reported that 11.4% cases did not display abnormalities in the chest CT upon admission and 12 remained normal 10 days later. The aforementioned studies and the results of the present study suggested that a normal chest CT scan cannot rule out the diagnosis of COVID-19.

In terms of routine blood tests, anemia and lymphocytopenia were the most common abnormalities in the present study, which was consistent with the results of a descriptive study of 99 cases of 2019 novel coronavirus pneumonia in Wuhan (9). Guan *et al* (6) reported a median lymphocyte count of 1,000 per mm^3 in 926 non-severe patients, but a median lymphocyte count of 800 per mm^3 in severe patients. Ding *et al* (11) reported that lymphocytopenia was present during the admission and progression stages. Lymphocytes increase gradually during the remission stage and this may be associated with cellular immune deficiency, which suggests that the absolute value of lymphocytes correlates with the severity of new coronavirus infection, indicating that lymphocyte count may serve as a reference index in the clinical diagnosis of COVID-19 infection. Anemia in patients with COVID-19 has been rarely reported. Moreover, the underlying mechanism of action behind the development of anemia is not completely understood. As such, it was speculated that it may be associated with disease consumption.

In the present study, patients with COVID-19 displayed elevated markers of liver function injury, such as ALT and AST. Elevated ALT and AST levels have been previously reported, with an incidence of 14-53% (6,12,13). In the present study, the incidence rates of elevated ALT and AST were 17.9 and 37.2%, respectively. However, the occurrence of increased γ-GGT was the highest in all patients on admission in the present study, which may be associated with bile duct cells. A previous study reported that bile duct epithelial cells can express novel coronavirus receptor, angiotensin converting enzyme 2 (ACE2). Therefore, it was hypothesized that the compensatory proliferation of hepatic parenchymal cells derived from bile duct cells leads to upregulated overall expression of ACE2 in liver tissue, which may serve as a potential mechanism underlying COVID-19 infection-mediated liver tissue injury (14). More than a quarter of patients displayed decreased albumin and increased globulin in the present study, which were associated with disease progression and the involvement of humoral immunity. Chen *et al* (9) reported that severe and critically ill patients can experience a decrease in serum albumin levels to 26.3-30.9 g/l. In the present study, the albumin levels were lower, which might be due to insufficient consumption and nutrition, but could also be associated with alterations in vascular permeability leading to protein leakage into the tissue gap.

In the present study, on admission, elevated levels of cystatin C were observed in >50% of patients. To the best of our knowledge, there have been no similar reports previously. All nucleated cells can produce cystatin C, which is released constitutively to the bloodstream. Serum cystatin C is less influenced by demographic characteristics and health status compared with creatinine as a direct measurement of glomerular filtration rate (GFR) (15). Cystatin C displays stronger association than estimated GFR with cardiovascular disease, heart failure, hypertension, infection risk, frailty and mortality (15-18). The results of the present study suggested that COVID-19 may cause early renal damage, particularly by altering glomerular filtration ability.

Furthermore, >50% of patients displayed elevated levels of D-dimer, which was similar to the results reported by Chen *et al* (9). Dolhnikoff *et al* (19) observed a variable number of small fibrinous thrombi in small pulmonary arterioles in areas of damaged and more preserved lung parenchyma in 8 out of 10 cases of COVID-19. The results of the present study support the current concept of hypercoagulative status in patients with COVID-19.

In the present study, cytokine levels were measured in 77 patients with COVID-19. IL-6, IL-2, IL-4, IL-10 and TNF-α levels were demonstrated to be increased, among which increased levels of IL-6, IL-4, IL-10 and IL-2 were the most common. Cytokine storms (CSs) are defined as the excessive and uncontrolled release of proinflammatory cytokines, presenting as systemic inflammation, high inflammatory parameters and multiple organ failure. In coronavirus pneumonia, for example in SARS and MERS, massive

inflammatory cell infiltration and CSs can lead to acute lung injury, and even ARDS and mortality with rapid virus replication (20-22). Huang *et al* (12) reported that IL-2, IL-7, IL-10, monocyte chemoattractant protein-1, macrophage inflammatory protein 1A, granulocyte colony-stimulating factor, interferon γ-induced protein 10 and TNFα levels were higher in patients with severe infection, but IL-6 levels were not significantly different in intensive care unit (ICU) and non-ICU patients. A multicentre cohort study reported significantly higher levels of IL-6 in the non-survival group of patients with COVID-19 compared with the survival group (23). A number of other studies have also reported an increase in IL-6 within patients with severe COVID-19 (9,24,25). In the present study, 76 out of the 77 patients with non-severe COVID-19 displayed elevated levels of IL-6. To date, IL-6 has been used in clinical trials as a therapeutic target for critically ill patients (tocilizumab) and has also been used as an indicator of disease severity (26,27).

In a previous study, 78 patients were analyzed for lymphocyte subsets and cytokines (28). The reduction rate of $CD8^+$ T cells was 28.43% in the mild group and 61.9% in the severe group (28). The number of $CD4^+$ and $CD8^+$ T cells of deceased patients was significantly reduced, but in the state of overactivation, the proportion of highly positive $CCR6^+$ Th17 in $CD4^+$ T cells was increased, and the cytotoxic particles, such as perforin and granolysin, were highly expressed in $CD8^+$ T cells (28). In the present study, increased and decreased $CD8^+$ T cell counts were equal, and the elevated level of $CD4^+$ T cells was more common, which may be associated with the fact that the majority of patients enrolled in the present study displayed a mild infection.

In the present study, patients with COVID-19 displayed decreased serum LDL-C levels upon admission, which was consistent with the results of a study conducted by Wei *et al* (29). COVID-19-mediated reductions in LDL-C biosynthesis may be associated with its damage to liver function. COVID-19 may also alter lipid metabolism by inducing acute inflammation. It has been previously reported that proinflammatory cytokines can alter liver function, and reduce cholesterol efflux and transport, thus modulating lipid metabolism (30). COVID-19 may elevate the level of free radicals, which can degrade lipids (31). Furthermore, COVID-19 may alter vascular permeability, leading to cholesterol molecules leaking into the tissue (29).

The sample size of the present study was small, which may have influenced the statistical results. Additionally, a number of patients with typical clinical symptoms or positive chest CT findings displayed negative RT-qPCR results; however, only CDC-confirmed cases were included in the present study. COVID-19 has spread rapidly worldwide. Therefore, developing drugs and vaccines against COVID-19 is of vital importance.

Acknowledgements

Not applicable.

Funding

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

FC, RH and LL made substantial contributions to the conception and design of the study. FC, RH, LL, CZ, SR and HL performed the data acquisition, data analysis and interpretation. LL and CZ drafted the article or critical revision for important intellectual content. All authors read and approved the final manuscript.

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of Union Hospital of Fujian Medical University (the reference number: 2020XGFKY006) and approved to exempt patients from written informed consent.

Patient consent for publication

Not applicable.

Competing interest

The authors declare that they have no competing interests.

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