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Kidney manifestations of mild, moderate and severe coronavirus disease 2019: a retrospective cohort study

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ABSTRACT

Background. Coronavirus disease 2019 (COVID-19) is a pandemic that has affected more than 3 million patients globally. Previous data from Wuhan city showed that acute kidney injury (AKI), proteinuria and hematuria occurred frequently in patients with severe COVID-19. However, the prevalence of kidney injury in milder cases remains unclear.

Methods. This retrospective study included two major consecutive cohorts of COVID-19 patients in Sichuan Province. Baseline characteristics, laboratory data including renal function, proteinuria and dipstick hematuria, and other laboratory parameters were collected. A subgroup of patients was followed up for 2–4 weeks to evaluate the short-term outcome of renal impairment.

Results. Overall, 168 COVID-19-positive patients were included in the study. The majority of patients (79.7%) were diagnosed with mild or moderate disease. Half of patients presented with fever; however, in The Tibetan cohort, fever only occurred in 13.4% of patients. On hospital admission, proteinuria and dipstick hematuria were noted in 18.4% and 17.4% of patients, respectively, while AKI only occurred in one patient. Further analysis showed that severe or critical COVID-19 was associated with higher risk of proteinuria [relative risk (RR) 7.37, 95% confidence interval (CI) 2.45–22.18, $P = 3.8 \times 10^{-4}$] and dipstick hematuria (RR 8.30, 95% CI 2.69–25.56, $P = 2.3 \times 10^{-4}$). Proteinuria, dipstick hematuria, or the combination of proteinuria and hematuria could significantly predict severe or critical severe COVID-19.

Conclusions. Proteinuria and dipstick hematuria are not uncommon in patients with COVID-19 infection, especially in severe or critical cases.

Keywords: acute kidney injury, COVID-19

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INTRODUCTION

The coronavirus disease 2019 (COVID-19), which was first reported in Wuhan [1, 2], China, in December 2019, has now become pandemic and affected more than 3 million patients globally [3]. A novel beta coronavirus was identified by high-throughput sequencing and is currently named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is associated with increased mortality [2].

The clinical features of COVID-19 vary from mild flu-like illness to severe pneumonia. The current literature shows that patients with coronary heart disease, hypertension, diabetes or chronic kidney disease (CKD) are more likely to develop into severe cases after being infected with SARS-CoV-2 [1, 4–8]. SARS-CoV-2 can be associated with multiple organ dysfunction syndrome, involving the liver, heart and kidney [1, 4–9]. This is probably due to viremia, as positive SARS-CoV-2 detected by real-time polymerase chain reaction in plasma samples was found in 15% of COVID-19 patients [1].

Acute kidney injury (AKI) can occur in COVID-19 but its clinical epidemiological features remain unclear. Up to now there have been many mild or asymptomatic patients in most parts of the world, who have not been detected, so the data were unable to reflect the real situation after SARS-CoV-2 infection. Since thorough screening has been carried out outside Hubei Province, almost all the infected people have been identified, so these data can better reflect the real situation of infected patients. This study aimed to assess the incidence, risk factors and clinical outcomes of AKI in COVID-19 patients.

MATERIALS AND METHODS

Subjects and data collection

Sichuan province is located in the southwest of China, >700 km away from Wuhan, with 83 million population. All confirmed COVID-19 patients (SARS-CoV-2 RNA positive) were admitted to different hospitals in Sichuan Province. In this study, two hospitals (the Public Health Clinical Center of Chengdu, Chengdu cohort, and Daofu People's Hospital, Daofu cohort) with the largest number of patients were included. The study retrospectively assessed COVID-19 patients who were admitted to these two hospitals from 16 January to 13 March 2020, using their electronic health records. All patients with COVID-19 admitted to the two hospitals were included in the study, accounting for 31.2% (168/539) of all patients in Sichuan.

The average altitude of Daofu County is 3245 m, and the main residents are Tibetans. It is the only concentrated area of high altitude COVID-19 patients in the epidemic in China.

In Sichuan, individuals with suspected contact history, recent travel history to Hubei province or suspected clinical manifestations, as well as most patients who had fever, were tested for SARS-CoV-2 RNA by reverse transcription–polymerase chain reaction. All patients who were enrolled in this study were diagnosed as COVID-19 according to the Guideline for Diagnosis and Treatment of the Novel Coronavirus Pneumonia (Seventh Edition) released by the Chinese National Health Commission on 4 March 2020 [10]. All patients were SARS-CoV-2 RNA positive detected by one or more throat swabs or sputum tests. The admission and discharge criteria of COVID-19 patients were the same in all hospitals: admission criteria, every patient who had positive virus RNA was admitted to the hospital for treatment regardless of symptoms; discharge criteria, clinical symptoms

of the patients were relieved, and two consecutive virus RNA tests were negative.

A subgroup of patients was followed up until discharge. A total of 26 cases were followed-up for mean \pm standard deviation (SD) 21.7 ± 7.0 days. The clinical outcomes were monitored up to 13 March 2020.

The epidemiological and clinical characteristics, as well as laboratory data, were extracted from the two cohorts. Laboratory data included complete blood count, liver and renal function, high-sensitivity C-reactive protein, procalcitonin, erythrocyte sedimentation rate, lactate dehydrogenase, creatine kinase, B-type natriuretic peptides (BNP) and high-sensitivity cardiac troponin T (hs-cTnT). The proteinuria and dipstick hematuria were assessed by dipstick test.

Definitions

Based on the current Chinese guideline, the COVID-19 patients were divided into four categories: mild, common, severe and critical types [10]. A mild case was defined as mild clinical symptoms without radiographic evidence of pneumonia by chest CT scan. A moderate type was defined as clinical symptoms of fever and cough, with radiographic evidence of pneumonia. A severe case was defined as one of the following: (i) respiratory rate >30 /min, (ii) oxygen saturation $\leq 93\%$, (iii) $\text{PaO}_2/\text{FiO}_2$ ratio ≤ 300 mmHg or (iv) radiographic evidence of progression of pulmonary infiltration $>50\%$ in 24–48 h. A critical case was defined as when one of the following conditions occurred: respiratory failure requiring mechanical ventilation, shock or evidence of multiple organ failure requiring management in intensive care units.

AKI was defined as an increase in serum creatinine (SCr) by 0.3 mg/dL within 48 h or a 50% increase in SCr from the baseline within 7 days. It was divided into three stages based on the change of SCr according to the Kidney Disease: Improving Global Outcomes guideline [11]. SCr values at admission were used as a baseline SCr level.

Statistical analysis

Categorical variables were summarized as percentages, and continuous variables were expressed as the mean \pm SD or median with interquartile range. Two-sample t-tests or Wilcoxon rank-sum tests were used for continuous variables, and chi-square tests or Fisher's exact tests were used for categorical variables as appropriate. Univariate logistic regression was used to estimate relative risk (RR). Statistical analyses were performed using SPSS software (version 21.0). P-value <0.05 was considered as statistical significance.

Ethics approval and consent to Participate

This study used the data from electronic health records, which was approved by the institutional review board at Sichuan Provincial People's Hospital (2020-113). Informed consent was waived in light of the urgent need for this study.

RESULTS

Baseline data and demographic characteristics of the two cohorts

The study identified a total of 168 COVID-19 patients diagnosed in Sichuan province, including 101 patients from the Public

Health Clinical Center of Chengdu (the Chengdu cohort), and 67 patients from the Daofu People's Hospital (the Daofu cohort). The average age of the population was 47 years and 54.2% were males. Among them, only four cases occurred in children.

The majority of patients (79.7%) had mild or moderate disease. Only 49.4% of patients presented with fever. In the Chengdu cohort, the percentages of fever and cough as an initial presentation were 74.3% and 54.5%, respectively; in the Daofu cohort, only 11.9% and 17.9% presented with fever and cough, respectively (Table 1). There were 75 cases (74.3%) with fever in the Chengdu cohort but 41 of them had normal temperature at admission. There were eight cases with fever in Daofu cohort and four of them had normal temperature at admission. In total, only 42 patients (25.0%) had temperature $>37.3^{\circ}\text{C}$ at admission. The majority of patients (87.8%) who had CT evidence of pneumonia did not have clinical fever.

The following comorbidities occurred in these two cohorts: diabetes (8.3%), hypertension (17.3%), coronary heart disease (3.6%), CKD [estimated glomerular filtration rate (eGFR) $<60\text{ mL/min/1.73 m}^2$] (2.4%), and history of tuberculosis (4.8%). The proportion of history of tuberculosis in the Daofu cohort was much higher than in the Chengdu cohort (10.4% versus 0.99%, $P=0.0062$). However, there were no significant differences in the proportion of diabetes, hypertension, coronary heart disease and CKD between these two cohorts.

Laboratory results

No lymphopenia was noted in these two cohorts, although the mean level of plasma lymphocyte counts was at the lower end of the normal range at $1.39 \times 10^9/\text{L}$. There was no significant difference in lymphocyte counts between the two cohorts. The leukocytes counts were also within the normal range ($6.02 \times 10^9/\text{L}$) (Table 2).

Elevated serum procalcitonin levels (normal range $<0.5\text{ ng/mL}$) were noted in 73.6% cases, which all occurred

in the Chengdu cohort (Chengdu 95.0% versus Daofu 0%, $P=1.8 \times 10^{-23}$). The proportion of high-sensitive C-reactive protein (normal range $<5\text{ mg/L}$) was 61.0% and 37.5% ($P=3.3 \times 10^{-3}$) in the Chengdu and Daofu cohorts, respectively. Heart failure and acute coronary syndrome were not common in COVID-19 patients in these two cohorts. Only 24.8% of cases had increased BNP and 6.7% had increased hs-cTnT (Table 2).

Comparison of AKI in the two cohorts

The baseline SCr level was not significantly different in the two cohorts [median 65.00 (52.82–73.50) versus 67.78 (54.00–76.70) $\mu\text{mol/L}$, $P=0.35$]. Only one patient developed AKI in the Chengdu cohort and none in the Daofu cohort. One-hundred and three patients (74 in the Chengdu and 29 in the Daofu cohort) completed a urine dipstick test. There were 17 cases (23.0%) with proteinuria and 18 cases (24.3%) with dipstick hematuria in the Chengdu cohort, while only 2 cases (6.9%) had proteinuria and no dipstick hematuria noted in the Daofu cohort (Table 2). The serum sodium level was higher in Chengdu than in Daofu (139.67 ± 12.55 versus $136.25 \pm 2.81\text{ mmol/L}$, $P=0.032$). Among the 21 patients with the severe or critical type of COVID-19 in the Chengdu cohort who completed a urine dipstick test, 10 of them (47.6%) were positive for proteinuria and 11 of them (52.4%) were positive for dipstick hematuria (Figure 1). On the contrary, 10 cases with proteinuria (58.8%) and 10 cases with dipstick hematuria (55.6%) had severe or critical type of COVID-19 (Figure 2). The patients with severe or critical COVID-19 were associated with an increased risk of proteinuria [RR 7.37, 95% confidence interval (CI) 2.45–22.18, $P=3.8 \times 10^{-4}$] and dipstick hematuria (RR 8.30, 95% CI 2.69–25.56, $P=2.3 \times 10^{-4}$). The proteinuria (RR 6.85, 95% CI 2.31–20.33, $P=5.2 \times 10^{-4}$), dipstick hematuria (RR 4.93, 95% CI 1.79–13.59, $P=2.05 \times 10^{-3}$), or the combination of proteinuria and hematuria (RR 7.22, 95% CI 2.56–20.28, $P=1.8 \times 10^{-4}$) could significantly predict severe or critical severe COVID-19.

Table 1. Baseline and demographic characteristics of patients with COVID-19 at admission

Variables	All patients	Chengdu cohort (n = 101)	Daofu cohort (n = 67)	P-values
Age, years	46.7 \pm 17.7	48.4 \pm 18.0	41.1 \pm 16.8	0.12
Male patients, %	92 (54.2)	49 (48.5)	42 (62.7)	0.071
Fever, %	83 (49.4)	75 (74.3)	8 (11.9)	2.6×10^{-15}
Cough, %	67 (39.9)	55 (54.5)	12 (17.9)	2.0×10^{-6}
Heart rate, bpm	87.7 \pm 14.2	88.8 \pm 14.9	86.0 \pm 13.1	0.22
Systolic blood pressure, mmHg	128.3 \pm 18.1	125.7 \pm 16.1	132.0 \pm 20.1	0.027
Diastolic blood pressure, mmHg	81.3 \pm 12.2	77.8 \pm 9.8	86.5 \pm 13.3	1.2×10^{-5}
SaO ₂ , %	95.1 \pm 4.2	96.9 \pm 3.5	92.3 \pm 3.6	1.4×10^{-13}
Diabetes mellitus, %	14 (8.3)	12 (11.8)	2 (3.0)	0.041
Hypertension, %	29 (17.3)	18 (17.6)	11 (16.4)	0.81
Coronary heart disease, %	6 (3.6)	5 (4.9)	1 (1.5)	0.45
Chronic kidney disease (eGFR $<60\text{ mL/min/1.73 m}^2$), %	4 (2.4)	4 (4.0)	0	0.26
CVVH	6 (3.6)	6 (5.9)	0	0.11
History of tuberculosis	8 (4.8)	1 (0.99)	7 (10.4)	6.2×10^{-3}
Severity classification				
Mild	33 (19.6)	23 (22.5)	10 (14.9)	3.5×10^{-4}
Moderate	101 (60.1)	50 (49.0)	51 (76.1)	
Severe	24 (14.3)	18 (17.8)	6 (9.0)	
Critical severe	10 (6.0)	10 (9.9)	0	
AKI, %	1 (0.6)	1 (1.0)	0	1.0
In-hospital death, %	3 (1.8)	3 (3.0)	0	0.41

Data are presented as number/total (percentage), mean \pm SD or median (interquartile range). The severity was staged based on the guidelines for diagnosis and treatment of COVID-19 (trial Seventh Edition) published by the Chinese National Health Commission on 4 March 2020.

bpm, beats per minute; SaO₂, arterial oxygen saturation.

Table 2. Baseline laboratory data of patients with COVID-19 at admission

Variables	All patients	Chengdu cohort (n = 101)	Daofu cohort (n = 67)	P-values
Leukocyte, $\times 10^9/L$	6.02 \pm 2.27	6.04 \pm 2.52	5.98 \pm 1.84	0.88
Lymphocyte, $\times 10^9/L$	1.39 \pm 1.12	1.35 \pm 1.07	1.45 \pm 1.19	0.56
Platelet, $\times 10^9/L$	172.59 \pm 78.44	188.76 \pm 81.30	147.48 \pm 67.00	8.1×10^{-4}
Procalcitonin > 0.1 ng/mL, %	95/129 (73.6)	95/100 (95.0)	0/29 (0)	1.8×10^{-23}
hs-CRP >5 mg/L, %	85/164 (51.8)	61/100 (61.0)	24/64 (37.5)	3.3×10^{-3}
Erythrocyte sedimentation rate >15 mm/h, %	37/50 (74.0)	30/37 (81.1)	7/13 (53.8)	0.12
Glucose, mmol/L	6.52 \pm 3.07	7.12 \pm 3.48	5.62 \pm 2.03	5.8×10^{-4}
Alanine aminotransferase, U/L	37.3 \pm 29.8	28.49 \pm 20.42	50.51 \pm 36.23	1.8×10^{-5}
Aspartate aminotransferase, U/L	32.7 \pm 15.9	29.12 \pm 11.84	38.13 \pm 19.35	9.3×10^{-4}
Lactose dehydrogenase, U/L	255.07 \pm 93.53	239.97 \pm 86.08	278.29 \pm 100.24	9.7×10^{-3}
Creatinine kinase, U/L	72 (50, 120)	74 (50, 125)	69 (52, 109)	0.75
Prealbumin, mg/L	186.82 \pm 67.76	162.70 \pm 64.42	216.31 \pm 59.99	1.0×10^{-6}
BNP >100 pg/mL	33/133 (24.8)	25/97 (25.8)	8/36 (22.2)	0.67
hs-cTnT >15 pg/mL	10/150 (6.7)	10/101 (9.9)	0/49 (0)	0.053
Sodium, mmol/L	138.33 \pm 10.07	139.67 \pm 12.55	136.25 \pm 2.81	0.032
Potassium, mmol/L	3.94 \pm 0.54	3.91 \pm 0.55	3.98 \pm 0.53	0.37
Blood urea nitrogen, mmol/L	4.30 \pm 2.86	4.58 \pm 3.53	3.88 \pm 1.20	0.071
SCr, $\mu\text{mol/L}$	65.00 (53.48–75.00)	65.00 (52.82–73.50)	67.78 (54.00–76.70)	0.35
Uric acid, $\mu\text{mol/L}$	282.02 \pm 92.03	282.02 \pm 92.03	–	–
Proteinuria, %				
Negative	57/103 (55.3)	57/74 (77.0)	27/29 (93.1)	0.031
1+	10/103 (9.7)	8/74 (10.8)	2/29 (6.9)	
2+ to 3+	9/103 (8.7)	9/74 (12.2)	0/29 (0)	
Dipstick hematuria, %				
Negative	56/103 (54.4)	56/74 (75.7)	29/29 (100)	1.3×10^{-3}
1+	12/103 (11.6)	12/74 (16.2)	0/29 (0)	
2+ to 3+	6/103 (5.8)	6/74 (8.1)	0/29 (0)	

Data are presented as number/total (percentage), mean \pm SD or median (interquartile range). None of the patients had the procalcitonin >0.5 ng/mL. hs-CRP, high-sensitivity C-reactive protein.

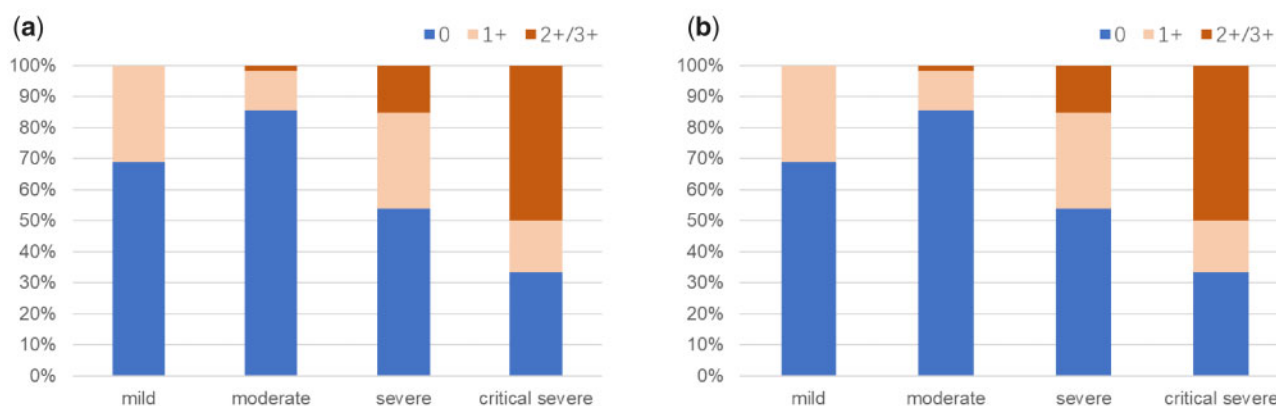


FIGURE 1: Distribution of urine protein and dipstick hematuria in patients according to the severity of COVID-19. (a) Proteinuria; (b) dipstick hematuria.

There were four patients with decreased GFR and three of them were on maintenance hemodialysis (MHD) before admission (Table 1). A total of six patients had received continuous veno-venous hemofiltration (CVVH), including the three uremic patients with MHD and one patient with CKD Stage G5. The other two patients received CVVH due to AKI; one of them had AKI at admission and the other one developed AKI during hospitalization. One of the AKI patients had diabetes and proteinuria of 2+ at admission. Three patients in the Chengdu cohort died: one MHD patient had anuria, and the other two patients had proteinuria at admission.

Comparison of baseline and follow-up data

A total of 29 patients in the Chengdu cohort were followed up after discharge from the hospital for 21.2 ± 7.0 days (14–34 days). Eight patients (27.6%) became SARS-CoV-2 RNA positive in the throat swab again after recovery.

There were no significant changes in plasma lymphocyte counts between the baseline and follow-up cohorts. The serum albumin level increased significantly in the follow-up data (42.24 ± 5.26 g/L versus 46.79 ± 2.86 g/L, $P = 6.0 \times 10^{-6}$), while lactose dehydrogenase (232.31 ± 85.94 U/L versus 152.79 ± 71.17 U/L, $P = 5.2 \times 10^{-5}$) and BNP level [31.70 (11.83–61.35) versus 14.30 (0–55.15), $P = 0.002$] decreased significantly. There were no

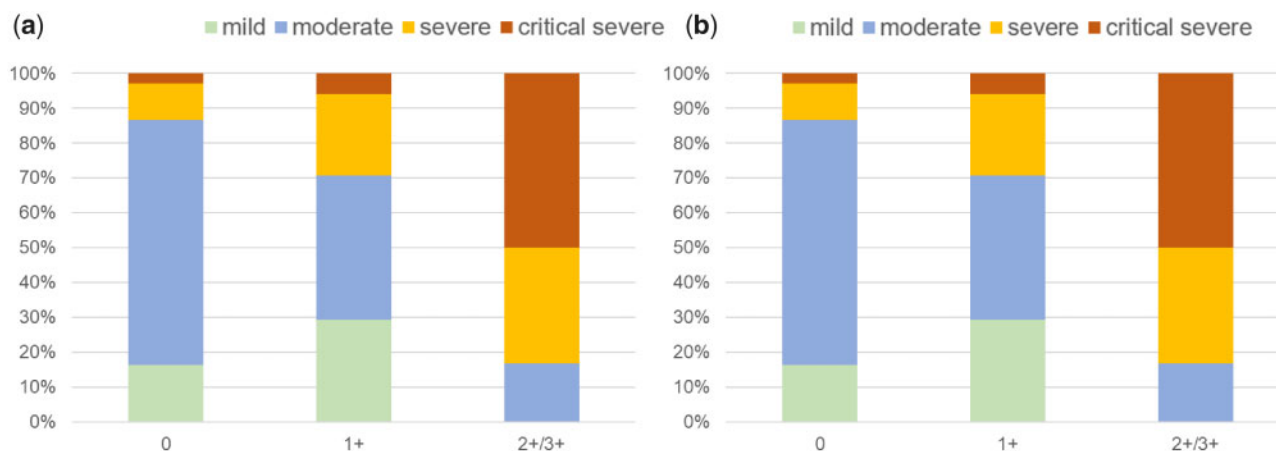


FIGURE 2: The severity category of COVID-19 according to the urinalysis. (a) Proteinuria; (b) dipstick hematuria.

Table 3. Comparison of baseline and follow-up data of 29 patients with COVID-19

Variables	Baseline	Follow-up	P-values
Gender, male, %	15 (51.7%)	–	
Age, years	43.9 ± 16.5	–	
Severity	10/12/5/2	–	
Length of follow-up, days	–	21.2 ± 7.0	
Leukocyte, ×10 ⁹ /L	6.24 ± 2.65	6.67 ± 2.22	0.28
Lymphocyte, ×10 ⁹ /L	1.37 ± 0.87	1.55 ± 0.58	0.33
Platelet, ×10 ⁹ /L	195.60 ± 77.75	198.67 ± 65.41	0.80
Albumin, g/L	42.24 ± 5.26	46.79 ± 2.86	6.0 × 10 ⁻⁶
Lactose dehydrogenase, U/L	232.31 ± 85.94	152.79 ± 71.17	5.2 × 10 ⁻⁵
BNP, pg/mL	31.70 (11.83–61.35)	14.30 (0–55.15)	0.002
Proteinuria ^a	15/1/2	–	
Hematuria ^a	11/5/2	–	
Blood urea nitrogen, mmol/L	3.82 ± 1.63	3.89 ± 1.42	0.66
SCr, μmol/L	61.92 ± 16.42	60.31 ± 14.36	0.83

Data are presented as number/total (percentage), mean ± SD or median (interquartile range). The severity categories included mild (10 cases), moderate (12 cases), severe (5 cases) and critical severe (2 cases).

^aThe urinalysis categories included 0, 1+, 2+/3+. The length of follow-up was this counted from discharge of the patients.

significant differences in SCr and urea nitrogen level between the baseline and follow-up data (Table 3), but the SCr of two patients with increased baseline SCr recovered. Unfortunately, these patients did not have repeated tests for proteinuria and dipstick hematuria.

DISCUSSION

This retrospective cohort study assessed all confirmed 168 COVID-19 cases in two cohorts in Sichuan province and showed low incidence of AKI in this population. However, the incidence of proteinuria and hematuria was much higher than the general adult population in China [12].

Previous studies showed that the prevalence of AKI in severe acute respiratory syndrome (SARS) was 6.7% and the mortality rate was up to 91.7% in SARS patients complicated by AKI [11]. The reported incidence of AKI in COVID-19 patients was lower in a number of studies [1, 4–6]. For example, a recent study investigated 710 hospitalized patients with COVID-19 disease and demonstrated that an increase in SCr and blood urea nitrogen was seen 15.5% and 14.1% of patients, respectively, while AKI only occurred in 3.2% patients [13]. However, AKI was an independent risk factor for COVID-19 patients' in-

hospital mortality [13]. Except for CKD patients, there were two patients with increased SCr (including one AKI patient). We noticed that the patients in the Wuhan group were more seriously ill: 89 of 710 patients died, and 35.5% of them were severe and critical [13].

The exact mechanism of development of AKI in COVID-19 patients remains unclear. The postulated mechanisms include cytokine storm syndrome induced by sepsis and direct cellular injury to the kidneys from coronavirus infection [8]. As recently demonstrated, angiotensin-converting enzyme (ACE2, the receptors of SARS-CoV-2 virus) [14, 15] and dipeptidyl peptidase-4 (receptor of MERS-CoV) [16] are highly expressed in the kidneys. In addition, coronavirus was also isolated from the blood [1] and urine sample of COVID-19 patients [8]. When SARS-CoV-2 viremia occurred, coronavirus was able to reach the kidneys through the blood circulation, and subsequently attached to the ACE2 receptor causing renal impairment. Although the positive rate of viral RNA in urine was low (4/58; 6.9%), the clearance of viral RNA in patients' stools and urine was delayed compared with that in oropharyngeal swabs in rehabilitation patients [17].

Acute tubular necrosis was shown as the most common histopathological feature of AKI in SARS patients, with no evidence

of glomerular pathology [18]. According to the pathological results of autopsy of COVID-19 patients [10], the kidney involvement was prominent and serious; proteinaceous exudates were seen in the glomerular Bowman's capsule, along with degeneration of the epithelium of the renal tubules and exfoliation of tubular luminal hyaline casts. Intratubular pigmented casts have been reported in a previous histological study [19]. There was also interstitial congestion with microthrombi and focal fibrosis [10].

The recent Wuhan study confirmed that elevated SCr, elevated urea nitrogen, AKI, proteinuria and dipstick hematuria were independent risk factors for in-hospital death after adjusting for multiple confounding factors [13]. Our data also showed that the COVID-19 patients with proteinuria or dipstick hematuria were more likely to be severe or critical cases, and about half of severe or critical patients have dipstick hematuria or albuminuria. Do these patients have more viral load and are more likely to have virus binding to receptors in the kidney? Further evidence is needed.

Our limited follow-up data showed resolution of renal function and cardiac biomarkers including lactate dehydrogenase and BNP, suggesting good prognosis of renal and cardiac outcomes in COVID-19 patients.

Our study reported clinical epidemiological features and renal outcomes in COVID-19 patients in a local province that shed a light on further assessment of the association of epidemiological features and renal outcomes in COVID-19. However, our study has several limitations. First of all, we were unable to obtain the pre-admission urine analysis results, and therefore, unable to confirm whether or not proteinuria and dipstick hematuria were present prior to the admission. Second, we only used dipstick to test the hematuria and could not differentiate true hematuria from hemoglobinuria or myoglobinuria. Third, the follow-up data were of small sample size and short duration, and there were no follow-up data for proteinuria or dipstick hematuria. Fourth, the prevalence of proteinuria and dipstick hematuria in patients in our study was much higher than the 15.1% seen in the general population in Sichuan [12], but the patients with COVID-19 in our two cohorts were older than the population average. Finally, the RR was estimated by univariate analysis; it could not eliminate the influence of confounding factors.

CONCLUSIONS

Proteinuria and dipstick hematuria are not uncommon in patients with COVID-19 infection, especially in severe or critical cases. Larger samples are needed to clarify the relationship between COVID-19 and renal damage, and long-term follow-up for COVID-19 patients should be conducted to explore its impact on renal outcome.

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AUTHORS' CONTRIBUTIONS

G.L. and D.H. designed the study. L.L., D.H. and Y.L. collected and analyzed the data. X.S. and Y.H. collected the data. L.L. followed up the patients. A.Y.W., J.W.Z., Y.T. and G.L. drafted the manuscript. A.Y.W. completed critical review of the article. E.W., G.L. and L.W. conceived the project, and supervised and coordinated all the work.

CONFLICT OF INTEREST STATEMENT

None declared.

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