Clinical characteristics and short-term mortality of 102 hospitalized hemodialysis patients infected with SARS-CoV-2 omicron BA.2.2.1 variant in Shanghai, China

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Abstract

Background: The aim of this study was to analyze clinical features and short-term mortality in hemodialysis (HD) patients infected with severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) omicron BA.2.2.1 variant.

Methods: In a retrospective single-center case series, 102 consecutive hospitalized HD patients infected with the coronavirus omicron variant were assessed at Pudong Hospital in Shanghai, China, from April 6 to April 18, 2022; the final date of follow-up was May 16, 2022. Clinical, laboratory, chest CT, and treatment data were collected and analyzed. The association between these factors and all-cause mortality was studied using univariate and multivariate analyses. The relationship between lymphocyte count and short-term mortality was based on receiver operating characteristic (ROC) curve analysis. Kaplan–Meier analysis was used to assess overall survival.

Results: In total, 102 patients were included in this study. The patients were divided into two groups: HD patients with pneumonia (N = 46) and without pneumonia (N = 56). Of the 102 patients, 12 (11.8%) died. Multivariate regression analysis revealed that all-cause mortality was correlated with lymphocyte counts and type B natriuretic peptide (BNP), C-reactive protein (CRP), and D-dimer levels (P < 0.05). The cut-off value of lymphocyte counts was 0.61 × 10⁹/L for all-cause mortality. The overall survival rate was significantly different between HD patients with and without pneumonia (P < 0.05).

Conclusions: Lymphocyte counts are important for the prediction of short-term mortality in HD patients with SARS-CoV-2 infection. HD patients with lung involvement have poorer survival rates than those without lung involvement.

Keywords: All-cause mortality, hemodialysis (HD), lymphocyte, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2)

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I. Introduction

Since early March 2022, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has rapidly swept across all areas of Shanghai, China. According to news released by the Shanghai government at the beginning of May 2022, the number of infected individuals increased to more than 600,000. The SARS-CoV-2 genome indicated that all new viral variants in Shanghai were the omicron BA.2.2.1 sub-lineage [1]. Novel coronavirus infection is highly likely to occur in hemodialysis (HD) patients because of their low immune function and co-existing diseases. It is important to recognize patients on HD who are SARS-CoV-2 nucleic acid-positive at an early stage so that they can be isolated earlier in order to avoid transmission of the virus to other HD patients. The incidence of SARS-CoV-2 positivity in patients on HD varies greatly. In an early retrospective multicenter study in Wuhan, China, the prevalence of SARS-CoV-2 infection was 9.6% (99/1027) [2]. Data from the US Renal Data...
System indicate that 5.5% of patients on HD (438/7948) developed SARS-CoV-2 infection [3]. During the new coronavirus disease outbreak in 2020, the rate of in-hospital deaths was high, over 20% within 28 days [4,5]. A meta-analysis of 396,062 HD patients indicated that the incidence of SARS-CoV-2 infection was 7.7%, and in 29 studies with 3261 confirmed SARS-CoV-2 patients, the overall mortality was 22.4% [6]. In the two years following the initial outbreak, SARS-CoV-2 changed continuously, from alpha, beta, and delta to omicron BA.1 and BA.2. A recent study showed that all omicron sub-lineages, including BA.2, were comparably neutralized by omicron patient sera, indicating that booster vaccines were important for protection against all omicron variants [7]. Previous studies and meta-analyses showed that fever, dyspnea, cough, abnormal platelet and leukocyte counts, lymphocyte percentage, and procalcitonin and C-reactive protein (CRP) levels are strongly associated with in-hospital mortality in HD patients [4,5,8]. It is unknown whether SARS-CoV-2 variants and sub-lineages lead to different clinical features and mortality in the HD population. The aim of this study was to describe the clinical features and 28-day outcomes of hospitalized HD patients infected with the omicron BA.2.2.1 sub-lineage in Shanghai Pudong Hospital, China, in order to provide information for other doctors to treat similar patients so as to reduce mortality in the future.

2. Methods

2.1. Study patients

The study included all HD patients with the new SARS-CoV-2 variant who were admitted to Shanghai Pudong Hospital (Fudan University Pudong Medical Center, Shanghai, China) from April 6 to April 18, 2022. This retrospective study was approved by the ethics committee of Shanghai Pudong Hospital (No. WZ-11). This hospital was designated by the government to treat new coronavirus-positive patients. The hemodialysis center of Pudong Hospital is also one of the largest hemodialysis centers in Shanghai.

2.2. Data collection

The medical history (duration of HD and history of hypertension, diabetes, or coronary heart disease (CHD)), symptoms, signs, laboratory data (white blood cell (WBC), lymphocyte, and platelet counts and C-reactive protein (CRP), procalcitonin (PCT), type B natriuretic peptide (BNP), albumin, hemoglobin, potassium, calcium, phosphorus, and D-dimer levels), chest CT scans, treatment regimens, and all-cause death data were collected during hospitalization from days 1 to 28.

**TABLE 1. Baseline characteristics of HD patients with SARS-CoV-2 omicron BA.2.2**

| Total (N = 102) | HD with pneumonia (n = 46) | HD without pneumonia (n = 56) |
|----------------|---------------------------|-------------------------------|
| Age (year)     | 63.32 ± 12.21             | 63.67 ± 13.98                 |
| BPI (kg/m²)    | 22.03 ± 3.5               | 22.06 ± 4.0                   |
| Sex            | Female 37 (36.3)           | 14 (30.4)                     |
|                | Male 65 (63.7)             | 32 (69.6)                     |
| Comorbidities  | Hypertensions 88 (86.3)    | 42 (91.3)                     |
|                | Diabetes 34 (33.3)         | 17 (37.0)                     |
|                | CHD 13 (12.7)              | 6 (13.0)                      |
|                | HBV 3 (2.9)                | 0 (0)                         |
|                | HCV 1 (1.0)                | 0 (0)                         |
|                | Syphilis 1 (1.0)           | 1 (2.2)                       |
| Signs and symptoms | Fever ≥37.3°C (43.1)  | 26 (59.1)                     |
|                | Dry cough 56 (54.9)        | 31 (67.4)                     |
|                | Expectoration 27 (26.5)    | 15 (32.6)                     |
|                | Pharyngalgia 18 (17.6)     | 11 (23.9)                     |
|                | Diarrhea 5 (4.9)           | 1 (2.2)                       |
|                | Chest tightness 31 (30.4)  | 20 (43.5)                     |
|                | Length of no 3 (1-4)       | 3 (1-4)                       |

BPI, body mass index; CHD, Coronary heart disease; HD, hemodialysis; Length of no HD, days without hemodialysis before hospitalization. Continuous variables were shown as Median (IQR) or Mean ± SD or No. (%) at the C level. The Categorical variables were expressed as number of patients (percentage). The level of significance was set at P < 0.05 (HD with pneumonia vs HD without pneumonia).

Diagnosis of SARS-CoV-2 pneumonia: Patients whose specimens collected from the upper respiratory tract were positive for SARS-CoV-2 nucleic acid were diagnosed with SARS-CoV-2-associated pneumonia if their lung CT showed typical manifestations such as bilateral and peripheral ground-glass opacities in the early stage of the disease, or an irregular-shaped paving pattern at later stages [9–11].

2.3. Study endpoint

The endpoint was short-term all-cause mortality from day 1 to day 28 of hospitalization.

2.4. Statistical analysis

Statistical analysis was performed using the Stata 14.0 statistical software (Stata). Continuous variables are expressed as the mean ± standard deviation (SD), median, and interquartile range (25th and 75th percentiles). Categorical variables are expressed in terms of the number of patients (percentage). If the data followed a normal distribution, they were analyzed using an unpaired T-test; otherwise, they were analyzed using Wilcoxon’s signed rank test or chi-square test. The relationships between variables and all-cause mortality were examined using univariate and multivariate regression analyses. The Kaplan–Meier survival curve was used to analyze the overall
Most common symptoms of patients were fever (44 (43.1%)), dry cough (31 (67.4%) vs. 25 (44.6%)), and chest tightness (20 (43.5%) vs. 11 (19.6%)) (P < 0.05) compared to HD patients without pneumonia.

Each patient underwent chest CT examination on admission, and body temperature, vital signs, and symptoms were closely monitored in the hospital. Patients were divided into 2 groups: HD patients with pneumonia (N = 46) and HD patients without pneumonia (N = 56). HD patients with pneumonia were more likely to report symptoms of fever (26 (59.1%) vs. 18 (40.9%)), dry cough (31 (67.4%) vs. 25 (44.6%)), and chest tightness (31 (30.4%), some of them had a sore throat (18 (17.6%)), and 5 patients had diarrhea (4.9%).

As shown in Table 2, most of the data were similar between HD patients with and without pneumonia. Higher CRP levels occurred more frequently in the pneumonia group than in the non-pneumonia group. Patients with pneumonia were more likely to have hypoxemia (P < 0.01).

3. Results

3.1. SARS-CoV-2 omicron variant

The SARS-CoV-2 outbreak in Shanghai during spring 2022 was verified in the laboratory as being caused by the omicron BA.2.2.1 variant [1].

Baseline clinical characteristics in HD patients infected with SARS-CoV-2 omicron BA.2.2.1 variant [1].

The study population included 102 hospitalized HD patients with nucleic acid confirmed SARS-CoV-2 infection. As shown in Table 1, there were 65 men (63.7%) and 37 women (36.3%). The average age was 63.32 ± 12.21 years. The average body mass index (BMI) was 22.03 ± 3.5. The medical course of most patients was complicated by basic diseases such as hypertension, diabetes, and cardiovascular disease. We found that the most common symptoms of patients were fever (44 (43.1%)), dry cough (56 (54.9%)), sputum (27 (26.5%)), and chest tightness (31 (30.4%)), some of them had a sore throat (18 (17.6%)), and 5 patients had diarrhea (4.9%).

As shown in Table 2, most of the data were similar between HD patients with and without pneumonia. Higher CRP levels occurred more frequently in the pneumonia group than in the non-pneumonia group. Patients with pneumonia were more likely to have hypoxemia (P < 0.01).

3.2. Chest CT findings

A chest computed tomography (CT) scan was obtained on admission. Of the 102 patients, 35 (34.3%) had bilateral involvement and 9 (8.8%) had focal involvement; 2 (2.0%) had pulmonary edema and bilateral involvement, and 56 (54.9%) had clear involvement. Ground-glass opacities were noted on the CT scans of all HD patients with pneumonia (N = 46). The CT findings of bilateral and focal involvement included ground-glass opacities with or without other findings (lung nodules, interlobular septal thickening, and air bronchogram).

### Table 2. Laboratory findings of HD patients with SARS-CoV-2 omicron BA.2.2 on admission to hospital

| Laboratory Parameter | Median (IQR) or Mean ± SD or No. (%) | Normal range | Total (N = 102) | HD with pneumonia (n = 46) | HD without pneumonia (n = 56) | P |
|----------------------|--------------------------------------|--------------|----------------|--------------------------|-----------------------------|---|
| WBC (×10^9/L)        | 3.5~9.5                              | 4.65 (3.5~7.54) | 5.06 (3.45~7.68) | 4.65 (3.44~6.12) | 0.129 |
| Lym (×10^9/L)        | 1.1~3.2                              | 0.89 (0.6~1.37) | 0.86 (0.56~1.21) | 0.93 (0.65~1.43) | 0.090 |
| Hemoglobin (g/L)     | 130~175                              | 102 (93.75~144.75) | 100 (94.25~108.75) | 109 (92.25~120.75) | 0.549 |
| Platelets (×10^9/L)  | 125~350                              | 142.5 (106.75~201.25) | 134 (90.25~202) | 156.5 (112.75~205.5) | 0.654 |
| CRP (mg/L)           | < 10                                 | 5.71 (3.69~28.67) | 9.38 (4.75~30.36) | 2.077 (4.02~8.23) | 0.041 |
| PCT (ng/ml)          | 0~0.5                                | 0.5 (0.39~1.6) | 0.75 (0.4~1.73) | 0.43 (0.37~1.3) | 0.140 |
| D-dimer (mg/L)       | < 0.55                               | 0.86 (0.39~1.42) | 1.13 (0.53~1.45) | 0.56 (0.31~1.46) | 0.142 |
| Alb (g/L)            | 63~82                                | 37.29 ± 4.99 | 36.92 ± 4.75 | 37.66 ± 5.25 | 0.712 |
| AST (IU/L)           | 17~59                                | 23 (17.75~28) | 25 (17~29.75) | 22 (18.75~24) | 0.243 |
| ALT (IU/L)           | 21~72                                | 19 (15.75~25) | 20.5 (15.25~25) | 18 (15.75~24.25) | 0.417 |
| CK (IU/L)            | 55~170                               | 843.5 (52.75~181) | 137 (66.25~266.5) | 58.5 (45.75~95) | 0.081 |
| LDH (IU/L)           | 120~246                              | 191 (158.25~226.75) | 199 (169.75~247.5) | 175.5 (148.25~199.75) | 0.158 |
| BNP (pg/ml)          | 0~100                                | 384.09 (130.77~830.57) | 386.14 (125.43~1613.28) | 376.15 (135.99~702.15) | 0.397 |
| Potassium (mEq/L)    | 3.5~3.5                              | 5.03 (4.24~5.58) | 4.37 (4.02~5.09) | 5.14 (4.96~6.37) | 0.158 |
| Calcium (mEq/L)      | 2.1~2.55                             | 2.16 ± 0.26 | 2.17 ± 0.29 | 2.13 ± 0.23 | 0.197 |
| Phosphorus (mEq/L)   | 0.81~1.45                            | 2.16 (1.76~2.65) | 2.12 (1.8~2.4) | 2.33 (1.69~2.84) | 0.907 |
| Hypokalemia          | 20 (19.6)                            | 9 (19.6) | 11 (19.6) | 0.992 |
| Chest CT             |                                     |              |                |                           |     |
| Bilateral involvement| 35 (34.3)                            | 35 (76.1) | 0 (0) | < 0.001 |
| Focal involvement    | 9 (8.8)                              | 9 (19.6) | 0 (0) | 0.001 |
| Pulmonary Edema and bilateral involvement | 2 (2.0) | 2 (4.3) | 0 (0) | 0.115 |
| Clear                | 56 (54.9)                            | 56 (100) | 0 (0) | < 0.001 |
| Hypoxemia            | 11 (10.8)                            | 11 (23.9) | 0 (0) | < 0.001 |

Data presented as mean ± SD, median and interquartile range (25 and 75th percentiles) or numbers (percentage). IQR, interquartile range.
TABLE 3. Treatment and Outcome of HD patients with SARS-CoV-2 omicron BA.2.2 on admission to hospital

|                | Median (IQR) or No. (%) |
|----------------|-------------------------|
|                | Total (N = 102) | HD with pneumonia (n = 46) | HD without pneumonia (n = 56) | P      |
| **Antihypertensive drugs** |             |                          |                           |        |
| ACEI/ARB       | 21 (20.6)     | 9 (19.6)                 | 12 (21.4)                 | 0.860  |
| β blockers     | 3 (2.9)       | 0 (0)                    | 3 (5.4)                   | 0.115  |
| α blockers     | 14 (13.7)     | 8 (17.4)                 | 6 (10.7)                  | 0.307  |
| **Hypoglycemic agents** |         |                          |                           |        |
| Subcutaneous insulin injection | 25 (24.5) | 12 (26.1)             | 13 (23.2)                 | 0.737  |
| Oral hypoglycemic drugs | 6 (5.9)   | 2 (4.3)                  | 4 (7.1)                   | 0.551  |
| **Antibiotic** |             |                          |                           |        |
| Carbapenems    | 22 (21.6)     | 21 (45.7)                | 1 (1.8)                   | <      |
| Quinolones     | 13 (12.7)     | 10 (21.7)                | 3 (5.4)                   | 0.014  |
| β-lactams      | 11 (10.8)     | 10 (21.7)                | 1 (1.8)                   | 0.001  |
| Oxoazolidinones| 3 (2.9)       | 3 (6.5)                  | 0 (0)                     | 0.052  |
| Glycylcyclines | 1 (1.0)       | 1 (2.2)                  | 0 (0)                     | 0.268  |
| Vinclozolinones| 1 (1.0)       | 1 (2.2)                  | 0 (0)                     | 0.268  |
| Glucocorticoids| 9 (8.8)       | 8 (17.4)                 | 1 (1.8)                   | 0.006  |
| Methylprednisolone | 3 (2.9) | 3 (6.5)                   | 0 (0)                     | 0.052  |
| **Immunomodulatory** |         |                          |                           |        |
| Thymosin       | 13 (12.7)     | 12 (26.1)                | 1 (1.8)                   | <      |
| Gamma globulin | 8 (7.8)       | 8 (17.4)                 | 0 (0)                     | 0.001  |
| Imaging findings | 8 (7.8)   | 8 (17.4)                 | 0 (0)                     | 0.001  |
| Chest CT       | 8 (7.8)       | 8 (17.4)                 | 0 (0)                     | 0.001  |
| Progress       |              |                          |                           |        |
| Outcomes       |              |                          |                           |        |
| CRRT           | 11 (10.8)     | 11 (23.9)                | 0 (0)                     | <      |
| Transfer to ICU| 3 (2.9)       | 3 (6.5)                  | 0 (0)                     | 0.052  |
| Discharged from hospital | 89 (87.3) | 36 (78.3)             | 53 (94.6)                 | 0.014  |
| Hospital stay  |              |                          |                           |        |
| (day)          | 15 (12-20.5) | 16 (11-24.25)           | 14 (12-19)                | 0.090  |
| Mortality      |              |                          |                           |        |
| 102            | 89 (87.3)     | 36 (78.3)                | 53 (94.6)                 | 0.014  |

CT: computed tomography; CCB: calcium channel blocker; ACEI: angiotensin-converting enzyme inhibitor; ARB: angiotensin II receptor antagonist; CRRT: continuous renal replacement therapy; ICU: intensive care unit; BMI: body mass index; BNP: type B natriuretic peptide; CHD: coronary heart disease; HD: hemodialysis; PCT: procalcitonin; CRP: C-reactive protein; WBC: white blood cell; Length of no HD: days without hemodialysis before hospitalization.

3.3. Treatments for and short-term outcomes of HD patients

The treatments for and outcomes of the 102 patients are shown in Table 3. There was no significant difference in the use of antihypertensive drugs and hypoglycemic agents between HD patients with and without pneumonia. There was a significant difference between the two groups in antibiotic use, especially carbapenems, quinolones, and β-lactams. Likewise, the use of dexamethasone and immunomodulatory drugs differed between the two groups.

Of the 102 patients, 11 (10.8%) received continuous renal replacement therapy (CRRT) and 3 (2.9%) were transferred to the intensive care unit (ICU). A total of 89 patients (87.3%) were discharged within 28 days, one patient stayed in the ICU for more than 28 days, and 12 patients (11.8%) died. During hospitalization, the condition of 8 patients (17.4%) in the pneumonia group was found to worsen after repeat chest CT scans. HD patients with pneumonia were more in need of CRRT and were discharged from the hospital significantly less frequently within 28 days compared to HD patients without pneumonia. In all, 46 patients received antibiotics in the pneumonia group, compared with 5 patients in the non-pneumonia group. Most common used antibiotics was carbapenems (21.6%), followed by quinolones (12.7%), β-lactams (10.8%), and oxazolidinones (2.9%). Our data show that the pneumonia group had a greater risk of death than those without pneumonia (9 vs. 3, 0.05).

3.4. Single factor correlation analysis and multiple linear regression analysis of all-cause mortality with clinical parameters

Univariate linear regression analysis (Table 4) showed that all-cause mortality was correlated with sex, duration of HD, albumin, type B natriuretic peptide (BNP), procalcitonin (PCT), CRP white blood cells (WBCs), lymphocytes, and D-dimer. Multivariate regression analysis showed that all-cause mortality was correlated with lymphocyte count and BNP, CRP, and D-dimer levels.

3.5. Predictive value of lymphocyte counts for mortality

Considering that the HD patients were infected with the new coronavirus, we focused on the relationship between...
lymphocyte counts and short-term outcomes. The analysis of lymphocyte counts based on the area under the ROC curve showed a value of 0.736, and a cut-off value of 0.61 × 10⁹/L provided a sensitivity of 72.73% and specificity of 71.95% for the prediction of all-cause mortality in HD patients infected with the new coronavirus (Fig. 1).

3.6. Survival outcome and subgroup analysis
By the completion of the study on May 16, 2022, 12 patients had died. Kaplan–Meier analysis showed that in HD patients with pneumonia, the survival probability was significantly lower compared to HD patients without pneumonia (P = 0.0258; Fig. 2).

Considering the confounding factors that affected the outcome, we further analyzed these factors. The relationship between pneumonia and all-cause mortality was evaluated and stratified according to age (<70 years or ≥70 years), sex, BMI (<18, 18-24, or >24 kg/m²), diabetes (yes or no), CHD (yes or no), hypertension (yes or no), and duration of hemodialysis (0.1-5, 6-9, or ≥10 years). After fully adjusting for other factors, the incidence of all-cause mortality was higher for HD patients than those without pneumonia in the male subgroup (HR = 4.50, 95% CI: 1.05–19.22). There were no significant interactions between the other subgroups and pneumonia in the incidence of all-cause mortality (Fig. 3).

3.7. Dynamic profile of patients’ laboratory values
During hospitalization, laboratory values (white blood cell count, lymphocyte count, platelet count, CRP level, PCT level, and D-dimer level) were tracked from days 1 to 28. The total blood white cell counts were higher and severe lymphopenia was observed more often in non-survivors than in survivors over time. CRP and PCT levels were higher in non-survivors than survivors. Elevated D-dimer levels and reduced platelet counts were associated with non-survivors, but the difference was not statistically significant (Fig. 4).

4. Discussion
This study describes the clinical characteristics and 28-day mortality of 102 HD patients infected with SARS-CoV-2.
omicron BA.2.2.1 variant in Shanghai, China. The risk factors for mortality in this patient population include lymphocyte count and CRP, D-dimer, and BNP levels. The lymphocyte count is especially important in predicting mortality in these patients, similar to previous reports of HD patients in London, UK, and the Bronx, New York [4,5]. A low lymphocyte count was strongly associated with poor survival in our HD patients, like the population without HD 2 years ago in Wuhan, China [12]. For our HD patients, the cut-off value calculated by the ROC curve was 0.61, indicating that a lymphocyte counts lower than this level will predict a high risk of mortality. This result can help clinicians become aware of the short-term prognosis.

In-hospital short-term mortality in our HD population was 10.78%, which was lower than the values reported in similar populations 2 years ago in the Bronx, New York, and London, UK (28 and 23%, respectively) [4,5]. The 28-day outcomes of patients with and without pneumonia were significantly different in this study. Survival analysis showed significantly more deaths of HD patients with pneumonia than those without (9/46 vs. 3/56). In the general population, it has been observed that few patients with SARS-CoV-2 infection without pneumonia become critical, require invasive mechanical ventilation, or die during hospitalization [13]. Viral pneumonia occurs in approximately 60% of children, and 15-30% of patients develop severe pneumonia [14,15]. The clinical presentation ranges from mild to severe pneumonitis, and chest CT scans show bilateral infiltrates, focal infiltrates, combined pulmonary edema and bilateral infiltrates, or pulmonary edema alone. Subgroup analysis showed that compared to the group without pneumonitis, only male sex was associated with increased mortality in the pneumonitis group, and other factors such as age, BMI, duration of dialysis, and coexisting hypertension, diabetes, or cardiovascular disease were not associated with increased mortality.

Currently, several small-molecule antiviral agents for the treatment of patients with SARS-CoV-2 infection have been reported to be effective in clinic trials [15,16]. However, most of those drugs are contraindicated in patients with renal dysfunction, mainly due to kidney excretion. Clinical management is very difficult in chronic kidney disease, especially in special HD patients. Corticosteroids have been proposed for use in patients with moderate or severe acute respiratory distress syndrome (ARDS). Several trials showed that 80-day and 180-day mortality rates were not reduced in patients with severe hypoxemia, whether high- or low-dose dexamethasone was administered [17–19]. In 2020, 44.9% of
patients with novel coronavirus-induced pneumonia in Wuhan, China, received glucocorticoid therapy [12]. A meta-analysis of 1703 patients indicated that corticosteroid administration was associated with lower 28-day all-cause mortality [20]. Another meta-analysis of pooled results from 18 RCTs showed that patients who received a longer course of corticosteroids (over 7 days) had a higher possibility of surviving than those who received a shorter course [21]. A new study of 1540 patients showed that corticosteroids were associated with reduced inhospital mortality among those with severe and critical SARS-CoV-2 infection [22]. In our study, 23.9% of hospital patients with pneumonia received steroid therapy, and most of them had severe pneumonia. Overall, the timing and duration of corticosteroid use may have an important influence on patient prognosis.

Antibiotic use has been a concern during the SARS-CoV-2 outbreak. International guidelines have strongly discouraged the use of antibiotics to treat COVID-19 patients with mild or moderate symptoms; however, antibiotics are frequently being used in some countries. According to a cross-sectional survey among physicians involved in treating SARS-CoV-2 patients during September–November 2021, 94.13% of physicians prescribed antibiotics irrespective of disease severity, and the most frequently prescribed antibiotics were meropenem, moxifloxacin, and azithromycin [23]. A retrospective observational cohort study using Symphony Health data (January–November 2020) showed that 19.70% of SARS-CoV-2 patients received an antibiotic; among them, about 37.01% were prescribed an antibiotic “appropriately”, 39.46% were prescribed a “potentially appropriate” antibiotic, and 22.64% received an “inappropriate” antibiotic [24]. In fact, the reported bacterial infection rate in SARS-CoV-2 patients was 10.5%, and the most frequently reported pathogenic bacteria were Staphylococcus aureus, followed by Pseudomonas aeruginosa, Escherichia coli, and Klebsiella pneumoniae [25]. In the studies on HD patients infected with SARS-CoV-2 in the Bronx, New York, and London, UK, the authors did not mention how many people were prescribed antibiotics [4,5]. In our study, antibiotic use was higher in HD patients with pneumonia than those without pneumonia, and it was probably inappropriate for some patients. Precise treatment of coexisting bacterial infections is the essence of the guidelines.

This study had several limitations. First, this was a retrospective analysis, involving a relatively small group of HD patients infected with SARS-CoV-2, which inevitably led to selection bias. Second, no well-matched HD patients who were SARS-CoV-2-negative served as the control group, because we could only accept HD patients who were SARS-CoV-2-positive during this period of the pandemic. Third, because the total sample size was relatively small, the number of deaths was low (12/102), which probably led to a low estimated risk of death. Fourth, inflammatory cytokines such as IL-1β, TNFα, and IL-6 were not measured during the special period, and if there was an unknown inflammatory storm in some patients, the appropriate time to use corticosteroids to suppress the storm would have been missed.

In conclusion, this retrospective analysis of 102 HD patients who were SARS-CoV-2-positive indicated that lymphocyte count and CRP, D-dimer, and BNP levels are strongly associated with short-term mortality. A lymphocyte counts lower than 0.61 predicted a high risk of mortality. The risk of death was higher for men with pneumonia than those without pneumonia (HR = 4.50, 95% CI 1.05-19.22).

Availability of data and materials

The dataset(s) supporting the conclusions of this article is (are) included within the article.

Competing interests

The authors declare that they have no competing interests.

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Declaration of competing interest

The authors declare that they have no competing interests.

CRediT authorship contribution statement

Wen Jing Bao: Methodology, Software, Data curation, Writing – original draft. Shun Kun Fu: Data curation, Writing – original draft. Hua Zhang: Data curation, Writing – original draft. Jun Li Zhao: Supervision. Hui Min Jin: Supervision, Writing – review and editing. Xiu Hong Yang: Supervision, Writing – review and editing.
