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Radiology, Laboratory, Clinical Course, and Outcomes of Covid-19 in Chronic Hemodialysis Patients: A Retrospective Case-Control Study

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ABSTRACT

Coronavirus disease 2019 causes higher mortality in chronic hemodialysis patients. Previous studies on this subject generally covered 30 days or a hospital stay. This study compares the 100-day mortality of chronic hemodialysis patients with patients without kidney disease with the same disease severity.

This retrospective case-control study is conducted in a single center, including 24 chronic hemodialysis in-patients and 48 control in-patients without renal disease, all diagnosed with coronavirus disease 2019.

According to the findings, the 100-day mortality rate of the hemodialysis group was significantly higher than that of the control group (odds ratio 4,53; %95 confidence interval 1.17-17.47). Multivariable regression analysis in Model A showed that chronic hemodialysis and critical illness were significantly associated with 100-day mortality, while cardiovascular disease comorbidity was a significant factor only in univariable analysis. The pneumonia severity index score was beneficial in predicting the in-hospital mortality of hemodialysis patients (odds ratio 1.07; %95 confidence interval 1.01-1.14). In addition, while all the patients in the control group were alive in the 90-day follow-up after discharge, three hemodialysis patients died at home due to sudden cardiac death.

Patients undergoing chronic hemodialysis are at a higher mortality risk than those without kidney disease, even with the same severity of coronavirus disease 2019. Monitoring deaths among chronic hemodialysis patients during their hospital stay and the first three months after discharge is crucial. Clinicians can predict in-hospital mortality and manage patients more effectively by evaluating the pneumonia severity index scores.

Keywords: 100-day Mortality, Chronic Hemodialysis, COVID-19, Disease Severity, Pneumonia Severity Index

Introduction

The coronavirus disease 2019 (COVID-19), which is induced by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), became a global pandemic (1). This disease poses a significant risk to all community members due to its high infectivity and pathogenicity. It severely affects older adults and those with underlying medical comorbidities, increasing hospitalisations and mortality rates (2). Common comorbidities heightening mortality in COVID-19 patients include cardiovascular disease, diabetes, chronic lung diseases, and renal diseases (3).

End-stage kidney disease (ESKD) patients face changes in their immune system due to chronic kidney dysfunction, increasing their susceptibility to infections. Cardiovascular diseases and infections account for approximately 70% of all ESKD patient deaths (4). COVID-19 initially causes acute respiratory illness with interstitial and alveolar pneumonia, affecting the lungs, kidneys, and other organs (5). Due to their regular interaction with healthcare facilities, ESKD patients, who typically have a weakened immune system, are more prone to contract COVID-19 (6). Furthermore, ESKD patients receiving hemodialysis (HD) several times a week struggle to adhere to isolation and social distancing rules, increasing their vulnerability to COVID-19 (7). As these patients often have other chronic conditions, the repercussions of COVID-19 tend to be more severe (8). Notably, higher mortality rates have been observed in chronic HD patients who develop COVID-19 pneumonia, as reported by various studies that typically cover 30 days or the duration of a hospital stay (9-13). There are limited studies evaluating long-term mortality post-discharge for HD patients with COVID-19 (7, 14-17). Therefore, our study aims to compare

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the 100-day mortality rate of chronic HD patients with a similar severity group without kidney disease. We also analyse the clinical, laboratory, and radiological characteristics, in-hospital mortality rates, and factors influencing mortality.

Materials and Methods

We conducted a retrospective case-control study that included hospitalized maintenance HD patients diagnosed with COVID-19 between April 1, 2020, and December 31, 2020, in the service and intensive care units of Van Yuzuncu Yil University's Dursun Odabaş Medical Center. The Yuzuncu Yil University Non-Interventional Clinical Research Ethics Committee approved the protocol (EPM; 2021/04-12).

The definitive diagnosis of COVID-19 was established by detecting SARS-CoV-2 positivity via real-time polymerase chain reaction (PCR) in nasopharyngeal or oropharyngeal clinical samples. Patients demonstrating clinical and radiological findings according to the criteria outlined by the Ministry of Health Turkish Scientific Committee COVID-19 and World Health Organization (WHO) guidelines were identified as possibly having COVID-19 (18, 19).

For our study, we classified hospitalized adult patients (over 18 years) diagnosed with COVID-19 into two groups: those with ESKD and those without (non-ESKD). We excluded renal transplant recipients, peritoneal dialysis patients, and HD patients with less than three months of treatment. We only included chronic HD patients receiving treatment for more than three months. Cases with positive PCR SARS-CoV-2 test or clinical and radiological findings consistent with COVID-19 were selected from this group for further analysis. The control group comprised non-ESKD patients who tested positive via PCR and did not have acute or chronic kidney disease. For each chronic HD patient, we included two non-kidney disease patients admitted subsequently to the same COVID-19 ward or intensive care unit in the control group. We categorized all patients according to the WHO COVID-19 disease severity classification (18). We excluded asymptomatic or mild patients, children under 18, pregnant patients, and those undergoing acute HD from the study.

We recorded the demographic data of all patients, oxygen saturations upon admission, details of the ward or intensive care unit, initial laboratory values, antiviral and other medications used, mechanical ventilation application, hospital stay duration, intensive care necessity, survival/death information during hospitalization, and survival/death information for 90 days post-discharge. Using an electronic database, we calculated the mortality rates of both patient groups in the first 90 days post-discharge and recorded the specific days of death. We evaluated chest computed tomography (CT) radiologically for lung involvement levels, and pneumonia severity index (PSI) scores were calculated for all patients (20, 21). We also recorded vascular access types, such as arteriovenous fistula or catheter use, and dialysis vintage.

Statistical Analysis: We statistically compared the demographic data, symptoms, disease severity, admission units, treatment, radiology and laboratory data, and mortality rates of the HD and control groups. We also conducted a statistical analysis of the data from HD patients who either survived or died during the 100-day follow-up. Data normality was evaluated with the Kolmogorov-Smirnov test. We used independent samples t-test or Mann-Whitney U test to compare quantitative data between groups. We applied the Chi-square test for categorical data comparison and analyzed multiple comparisons of the results with the Bonferroni-corrected Z test. We used binary logistic regression analysis to identify factors affecting 100-day mortality. In model A, we conducted univariable analyses of age, gender, HD group (indicator: control group), critical disease (indicator: moderate-severe disease), comorbidity, and symptoms, including variables with $p<0.10$ in the multivariable analysis. In model B, we used the PSI score for HD patients in a univariable analysis to estimate in-hospital and 100-day mortality. We presented the 100-day survival data of the HD and control groups using the Kaplan-Meier curve. A p-value of <0.05 was considered significant. We conducted data analysis using IBM SPSS Statistics for Windows, Version 23.0. (Armonk, NY: IBM Corp.).

Results

We examined 2,263 patients admitted to our tertiary hospital's COVID-19 intensive care and service units. Among them, 58 patients had ESKD. Figure 1 outlines the inclusion criteria and reasons for excluding both HD and control patients and identifies the number of cases included in the study analysis. Our study comprised 24 chronic HD patients and 48 control patients without kidney disease, all hospitalized

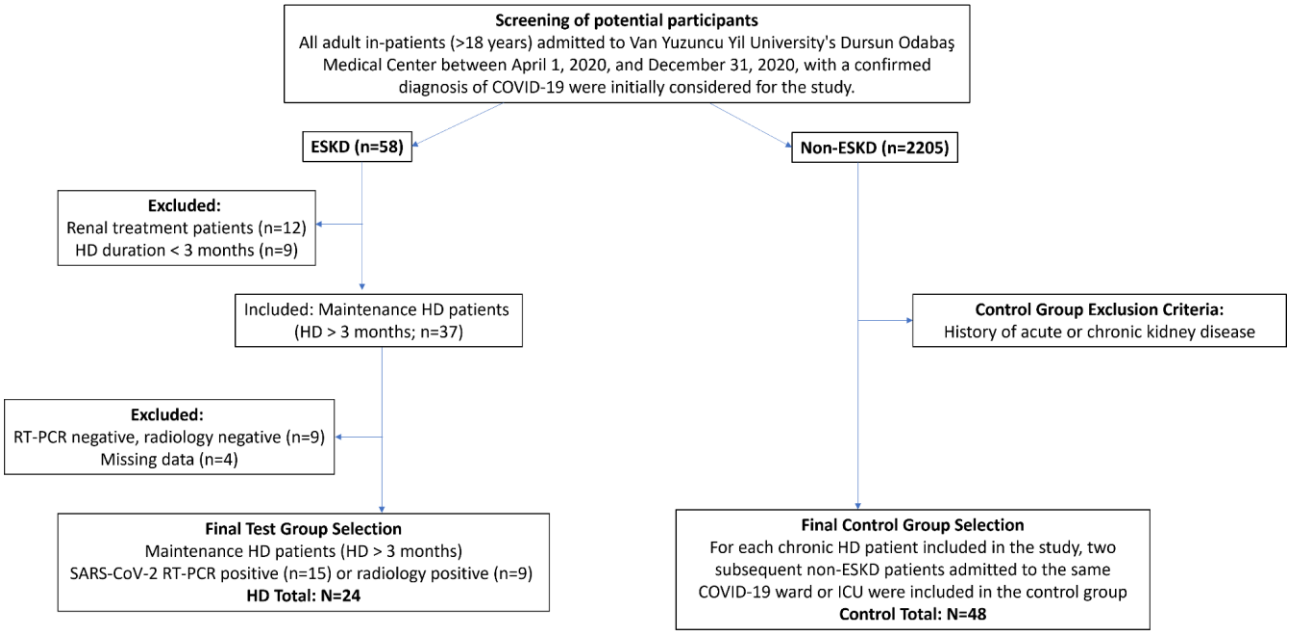

Fig. 1. Inclusion and exclusion criteria of HD and control group patients and the number of cases included in the analysis

Abbreviations: COVID-19, coronavirus disease 2019; ESKD, end-stage kidney disease; HD, hemodialysis; RT-PCR, reverse transcriptase polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome-coronavirus-2.

with a COVID-19 diagnosis. Fifteen of the 24 HD patients included in the study were diagnosed with a positive PCR test for SARS-CoV-2, while the other nine patients were diagnosed with clinical and radiological findings.

Table 1 presents the demographic and clinical data of the patients. The HD patients had a higher prevalence of cardiovascular disease and diabetes, but only the incidence of hypertension was significantly higher than the control group (p=0.004). Dyspnea was the most common symptom in both groups, followed by cough, fatigue, and fever. Both groups exhibited similar symptom frequencies. Upon chest CT evaluation, COVID-19-compatible lesions were found in 96% (n=23) of the HD group and 83% (n=40) of the control group. Pleural effusion was detected in two HD patients and one control patient.

Table 2 shows a statistical evaluation of the patients' laboratory values, treatments, and in-hospital and 100-day mortality rates in the HD and control groups. Table 3 compares the data of HD patients who either died or survived at 100 days of follow-up.

We used binary logistic regression analysis in two different models to analyze factors affecting 100-day mortality. Model A (Table 4) involved univariable analyses of age, gender, HD group (indicator: control group), critical disease (indicator: moderate-severe disease), comorbidity, and symptoms. Variables with $p<0.10$ were included in the multivariable analysis. Only the presence of cardiovascular disease comorbidity in the univariable analysis (odds ratio [OR] 4.250, 95% confidence interval [95% CI] 1.083–16.671; p=0.038) was significant. In the multivariable analysis, being a chronic HD patient (OR 6.878, 95% CI 1.131–41.829; p=0.036) and having a critical disease of COVID-19 (OR 19.525, 95% CI 3.192–119.433; p=0.001) were significantly associated with mortality. In Model B, the PSI score was significant for estimating in-hospital mortality in the HD patient group (OR 1.071, 95% CI 1.01–1.13; p=0.020) but not for estimating 100-day mortality (OR 1.029, 95% CI 0.997–1.063; p=0.073).

The Kaplan-Meier curve allowed us to compare the 100-day mortality rates of patients in the HD and control groups (p=0.022; Figure 2).

Table 1. Demographic and Clinical Data of The Participants at Admission

Demographic and Clinical Data	COVID-19 with HD (n=24)	COVID-19 Without Renal Disease (n=48)	Total (n=72)	Test Statistics	P-Value
Age (Year) ± SD	63.4 ± 12.2	61.4 ± 12.7	62.0 ± 12.5	0.635	0.527[t]
Sex, n (%)					
Female	15 (62.5)	20 (41.7)	35 (48.6)	2.780	0.095[p]
Male	9 (37.5)	28 (58.3)	37 (51.4)		
Dialysis					
Dialysis vintage, mean months (IQR)	72 (11-135)	0	NR	NR	NR
Dialysis three times a week, n (%)	22 (92)	0	NR	NR	NR
Dialysis twice a week, n (%)	2 (8)	0	NR	NR	NR
Arteriovenous fistula, n (%)	19 (79)	0	NR	NR	NR
Catheter, n (%)	5 (21)	0	NR	NR	NR
Comorbid Diseases n (%)					
Hypertension	19 (79.2)	21 (43.8)	40 (55.6)	8.128	0.004[p]
Cardiovascular disease	8 (33.3)	7 (14.6)	15 (20.8)	3.411	0.065[p]
Diabetes	13 (54.2)	17 (35.4)	30 (41.7)	2.314	0.128[p]
COPD	3 (12.5)	7 (14.6)	10 (13.9)	NR	1.000[f]
Any Tumor	1 (4.2)	1 (2.1)	2 (2.8)	NR	1.000[f]
Symptoms n (%)					
Fever >37.3 °C	5 (20.8)	10 (20.8)	15 (20.8)	0.000	1.000[p]
Cough	10 (41.7)	11 (22.9)	21 (29.2)	2.723	0.099[p]
Dyspnea	11 (45.8)	25 (52.1)	36 (50)	0.250	0.617[p]
Fatigue	8 (33.3)	12 (25)	20 (27.8)	0.554	0.457[p]
Vomiting	2 (8.3)	5 (10.4)	7 (9.7)	NR	1.000[f]
Joint pain	2 (8.3)	5 (10.4)	7 (9.7)	NR	1.000[f]
COVID-19 disease severity n (%)					
Moderate	6 (25)	15 (31.3)	21 (29.2)		
Severe	13 (54.2)	23 (47.9)	36 (50)	0.339	0.844[p]
Critical	5 (20.8)	10 (20.8)	15 (20.8)		
Chest CT, n (%)					
Bilateral involvement	19 (79.2)	35 (72.9)	54 (75)		
Unilateral involvement	4 (16.7)	5 (10.4)	9 (12.5)		
Atypical	-	2 (4.2)	2 (2.8)	4.333	0.363[p]
No lung involvement	-	5 (10.4)	5 (6.9)		
Missing data	1 (4.2)	1 (2.1)	2 (2.8)		
Admission unit n (%)					
Ward	19 (79.2)	38 (79.2)	57 (79.2)	0.000	1.000[p]
ICU	5 (20.8)	10 (20.8)	15 (20.8)		
Oxygen saturation (%)	89 (85-92)	89 (84-92)	89 (85-92)	-0.096	0.924[m]

[t] *Independent samples t-test*
[m] *Mann-Whitney U test*
[p] *Pearson chi-square test*
[f] *Fisher's Exact Test, mean ± SD, median (interquartile range), frequency (percentage)*
Abbreviations: COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; HD, hemodialysis; ICU, intensive care unit; IQR, interquartile range; SD, standard deviation; NR, no result

Table 2. Laboratory Values, Treatments, and In-Hospital and 100-Day Mortality Rates of the Patients in the HD and Control Groups

Analyte and Mortality	COVID-19 with HD (n=24)	Control Group (n=48)	Total (n=72)	Test Statistics	P-Value
White blood cells (/μL)	5710 (4745-9077)	5635 (4627-7135)	5695 (4690-8020)	-0.836	0.403[m]
Hemoglobin (g/dL)	10.57 ± 2.23	13.91 ± 2.01	12.80 ± 2.61	-6.418	<0.001[t]
Lymphocyte (/μL)	950 (565-1127)	1205 (870-1577)	1050 (763-1425)	-2.670	0.008[m]
NLR	4.67 (2.88-13.06)	3.79 (1.99-4.89)	3.99 (2.11-7.69)	-2.067	0.039[m]
Platelets (103/μL)	151 (116-226)	213 (168-257)	205 (154-248)	-2.264	0.024[m]
Creatine (mg/dL)	6.18 (5.23-7.81)	0.85 (0.74-1.05)	1.04 (0.80-5.50)	-6.595	<0.001[m]
Sodium (mmol/L)	137.5 (135-139)	137 (134.3-139.8)	137 (135-139)	-0.595	0,552[m]
Troponin I (μg/L) †	0.057 (0.028-0.280)	0.005 (0.002-0.011)	0.010 (0.004-0.050)	-4.888	<0.001[m]
C-reactive protein (mg/L)	55 (25-108)	52 (26-108)	53 (26-108)	-0.388	0.698[m]
Ferritin (ng/mL)	1918 (532-3179)	346 (180-583)	462 (262-1196)	-4.778	<0.001[m]
D-dimer (μg/mL)	1.90 (0,60-2.36)	0.61 (0.43-0.80)	0.69 (0.47-1.77)	-2.879	0.004[m]
AST (U/L)	24 (18-36)	33 (27-47)	31 (24-45)	-2.934	0.003[m]
LDH (U/L) ‡	294 (242-455)	344 (273-430)	323 (256-430)	-1.401	0.161[m]
Glucose (mg/dL)	119 (102-155)	114 (102-182)	116 (102-178)	-0.102	0.919[m]
Antiviral therapy, n (%)	23 (95.8)	46 (95.8)	69 (95.8)	NR	1,000[f]
Hydroxychloroquine (HQ), n (%)	2 (8.3)	2 (4.2)	4 (5.6)	NR	NR
Favipiravir (Fav), n (%)	17 (70.8)	39 (81.3)	56 (77.8)	NR	NR
HQ + Fav, n (%)	4 (16.7)	5 (10.4)	9 (12.5)	NR	NR
LMWH, n (%)	19 (79.2)	43 (89.6)	62 (86.1)	NR	0.285[f]
Standard heparin, n (%)	3 (12.5)	0	3 (4.2)	NR	0.034[f]
Antibiotic, n (%)	22 (91.7)	41 (85.4)	63 (87.5)	NR	0.708[f]
Corticosteroid, n (%)	6 (25)	28 (58.3)	34 (47.2)	7.133	0.008[p]
Methylprednisolone pulse therapy, n (%)	0	6 (12.5)	6 (8.3)	NR	0.169[f]
Convalescent plasma, n (%)	4 (16.7)	7 (14.6)	11 (15.3)	NR	1,000[f]
Tocilizumab, n (%)	3 (12.5)	5 (10.4)	8 (11.1)	NR	1,000[f]
NIMV, n (%)	7 (29.2)	13 (27.1)	20 (27.8)	0.035	0.852[p]
Mechanical ventilation,n (%)	4 (16.7)	3 (6.3)	7 (9.7)	NR	0.212[f]
LTOT§, n (%)	2 (10)	8 (18.2)	10 (15.6)	NR	0.486[f]
ICU admission, n (%)	10 (41.7)	13 (27.1)	23 (31.9)	1.565	0.211[p]
Pneumonia severity index	104 (91-136)	66 (56-88)	80 (60-103)	-5.155	<0.001[m]
Length of stay (days)	10 (6,3-12)	10 (7-12,8)	10 (7-12)	-0.126	0.900[m]
In-hospital mortality, n (%)	4 (16.7)	4 (8.3)	8 (11.1)	NR	0.427[f]
100-day mortality, n (%)	7 (29.2)	4 (8.3)	11 (15.3)	NR	0.034[f]

[t] Independent samples t-test, m Mann-Whitney U test
[p] Pearson chi-square test
[f] Fisher's Exact Test, mean ± SD, median (interquartile range), frequency (percentage)
†Missing data for Troponin I (HD group; 1/24, control group; 8/48
‡ Missing data for LDH (HD group; 1/24)
§ Exitus patients were excluded (HD group; n= 20, control group; n= 44)
Abbreviations: AST, aspartate aminotransferase; COVID-19, coronavirus disease 2019; HD, hemodialysis; ICU, intensive care unit; LDH, lactate dehydrogenase; LMWH, low molecular weight heparin; LTOT, long-term oxygen therapy; NIMV, non-invasive mechanical ventilation; NLR, neutrophil/lymphocyte ratio; NR, no result.

Table 3. Comparison of Demographic Data and Clinical and Laboratory Findings of HD Patients with Covid-19 Who Died or Survived at 100-Day Follow-Up

Demographic and Clinical Data	Non-survivors (n=7)	Survivors (n=17)	Test Statistics	P-Value
Age (year) (IQR)	63 (61-72)	66 (50-72)	-0.095	0.951[m]
Sex, n (%)				
Female	3 (43)	12 (70)	NR	0.356[f]
Male	4 (57)	5 (30)	NR	
Clinical Data				
Vintage dialysis, month	96 (18-108)	60 (9-142)	-0.318	0.757[m]
PCR positive, n (%)	4 (57)	11 (65)	NR	1.000[f]
Oxygen saturation SpO2 (%)	85 (75-87)	90 (88-93)	-2.908	0.003[m]
Hypertension, n (%)	5 (71)	14 (82)	NR	0.608[f]
Cardiovascular disease, n (%)	4 (57)	4 (24)	NR	0.167[f]
Diabetes, n (%)	5 (71)	8 (47)	NR	0.386[f]
COPD, n (%)	1 (14)	2 (12)	NR	1.000[f]
Fever, n (%)	1 (14)	4 (24)	NR	1.000[f]
Dyspnea, n (%)	4 (57)	7 (41)	NR	0.659[f]
Cough, n (%)	2 (29)	8 (47)	NR	0.653[f]
COVID-19 disease severity, n (%)				
Moderate	0	6 (35)		
Severe	4 (57)	9 (53)	4.788	0.091[p]
Critical	3 (43)	2 (12)		
ICU admission, n (%)	4 (57)	6 (35)	NR	0.393[f]
Mechanical ventilation, n (%)	4 (57)	0	NR	0.003[f]
NIMV, n (%)	2 (29)	5 (29)	NR	1.000[f]
PSI (IQR)	131 (103-165)	102 (89-115)	-1.747	0.087[m]
Laboratory Values, mean (range)				
Hemoglobin (g/dL)	10.7 (9.2-12.7)	10.1 (9.0-12.8)	-0.032	1.000[m]
White blood cells (/μL)	6470 (4610-11450)	5670 (4770-8670)	-0.286	0.804[m]
Lymphocyte (/μL)	750 (450-1090)	960 (570-1160)	-0.667	0.534[m]
NLR	12.08 (2.92-15.74)	4.62 (2.81-9.47)	-0.921	0.383[m]
Platelets (103/μL)	142 (107-225)	172 (117-258)	-1.048	0.318[m]
C-reactive protein(mg/L)	56 (14-87)	53 (26-123)	-0.413	0.710[m]
Troponin I † (μg/L)	0.165 (0.050-18.900	0.046 (0.023-0.266)	-1.537	0.135[m]
D-dimer (μg/mL)	2.10 (0.86-16.00)	1.79 (0.53-2.30)	-0.762	0.455[m]
Ferritin (ng/mL)	2000 (467-3246)	1597 (594-3170)	-0.445	0.664[m]
LDH ‡ (U/L)	322 (224-458)	282 (244-346)	-0.401	0.720[m]
AST (U/L)	24 (17-87)	22 (19-32)	-0.891	0.383[m]

[f] *Independent samples t-test*
[m] *Mann-Whitney U test*
[p] *Pearson chi-square test*
[f] *Fisher's Exact Test, mean ± SD, median (interquartile range), frequency (Percentage)*
†Missing data for Troponin I (survivor 1/17)
‡LDH missing data (survivor 1/17)
Abbreviations: AST, aspartate aminotransferase; COVID-19, coronavirus disease 2019; COPD, chronic obstructive pulmonary disease; HD, hemodialysis; ICU, intensive care unit; LDH, lactate dehydrogenase; NIMV, non-invasive mechanical ventilation; NLR, neutrophil/lymphocyte ratio; NR, no result; PCR, polymerase chain reaction; PSI, pneumonia severity index.

Table 4. Evaluation of Age, Gender, Symptoms, Comorbidities, and COVID-19 Disease Severity Variables Affecting 100-day Mortality by Binary Logistic Regression Analysis (Model A†)

Variables	Univariable		Multivariable†	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
Age	1.021 (0.968 - 1.077)	0.446	NR	NR
Sex				
Female	0.861 (0.237 – 3.124)	0.820	NR	NR
Male	1.161 (0.320 – 4213)			
Symptoms/Comorbidities				
Dyspnea	3.143 (0.760 -12.993)	0.114	NR	NR
Diabetes	2.891 (0.762 – 10.967)	0.119	NR	NR
Cardiovascular disease	4.250 (1.083 - 16.671)	0.038	3.720 (0.681 – 20.329)	0.130
Hemodialysis group	4.529 (1.174 - 17.471)	0.028	6.647 (1.113 – 39.677)	0.038
COVID-19 critical disease	11.594 (2.758 – 48.733)	0.001	19.568 (3.200 – 119.647)	0.001

† *In Model A, univariable analyses of age, gender, HD group (indicator: control group), critical disease (indicator: moderate-severe disease), comorbidity, and symptoms were performed, and variables with p<0.10 were included in the multivariable analysis.*
Abbreviations: COVID-19, coronavirus disease 2019; OR, odds ratio; 95% CI, 95% confidence interval

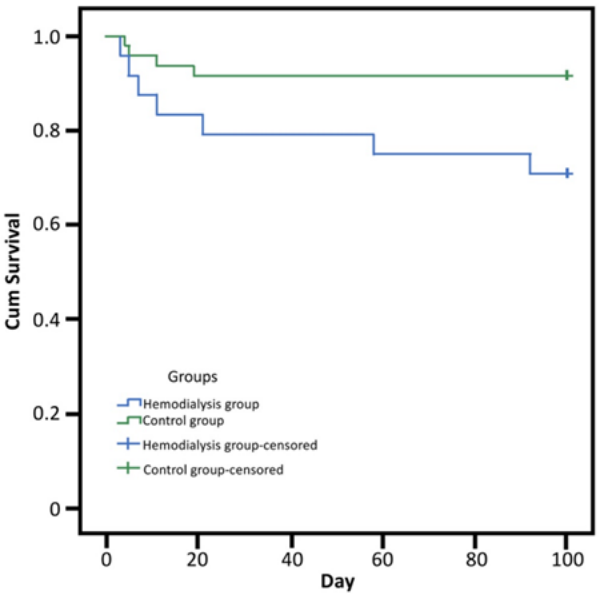

Fig. 2. Comparison of 100-day mortality rates of patients in the hemodialysis and control groups (p=0.022; Kaplan-Meier curve)

Discussion

This retrospective case-control study examined patients who were hospitalized for COVID-19 and followed up for 90 days after discharge. We found that the 100-day mortality rate, our primary endpoint, was considerably higher in patients undergoing chronic HD compared to the control group without kidney disease (29.2% vs. 8.3%, OR 4.53, 95% CI 1.17–17.47). Both groups showed equal moderate-severe (79.2%) and critical (20.8%) disease cases.

Our findings align with a previous study that reported a significantly higher one-year mortality rate from all causes in HD patients than in non-ESKD patients (40% vs. 24%, OR 2.13, 95% CI 1.16–3.91) (15). The in-hospital mortality rate in the HD group (27%) and the non-ESKD group (17%) in the earlier study were higher than the results of our research. We believe this difference may be due to the inclusion of patients from different ethnicities and a higher rate of cardiovascular comorbidity in their sample (15).

Several other studies have investigated long-term COVID-19-related mortality in chronic HD patients but did not include a non-ESKD comparison group. Two of these studies reported 90-day mortality rates of 25% (n=14 of 56) and 32% (n=95 of 296) (7, 14). Similarly, Salerno et al. found a 100-day mortality rate of approximately 26% among dialysis patients diagnosed with COVID-19 (16). We found that the 100-day mortality rate in our study was 29.2% among HD patients, which is consistent with these earlier results.

We observed that three HD patients (15%) died following hospital discharge, all from sudden cardiac death at home. In contrast, all patients in the control group (n=44) survived the 90-day

follow-up. Other research has compared in-hospital mortality between HD patients and patients without ESKD, but these studies did not focus on long-term follow-up post-discharge. Some of these studies found significantly higher in-hospital mortality among HD patients (11-13), while others did not find a significant difference (10, 15).

Chronic HD, critical COVID-19, and cardiovascular disease were significantly associated with 100-day mortality in both HD and non-ESKD patients. In particular, being an HD patient and having a severe illness were associated with higher in-hospital mortality (12).

In our sample of chronic HD patients, we noted significantly lower mean lymphocyte (p=0.008) and platelet counts (p=0.024) and a significantly higher neutrophil/lymphocyte ratio (p=0.039). Similarly, troponin I, ferritin, and D-dimer values were significantly higher in the HD group. These findings align with previous studies that have reported high ferritin, high D-dimer, low lymphocyte, and low platelet levels in HD patients with COVID-19 compared to the non-ESKD group (10, 12, 15).

The use of therapies such as antiviral treatment, antibiotics, low molecular weight heparin, methylprednisolone pulse, convalescent plasma therapy, and tocilizumab were similar between the HD and control groups. However, the use of methylprednisolone pulse therapy was unique to six patients in the control group.

Previous studies have reported that mortality in COVID-19 is associated with male gender (16, 22) and age (7, 12, 16, 22, 23). Although our study saw a higher mortality rate in males, this finding was not statistically significant (n=4 of 9 vs. n=3 of 15; p=0.356). The lack of statistical significance could be due to our patient group being younger on average than those in previous studies.

The relationship between frail clinical index (7, 17, 23), elevated C-reactive protein (CRP) (12, 14, 17), D-dimer levels (17, 24), and increased mortality among HD patients with COVID-19 has been documented in prior studies. In our study, patients with high frail clinical index were minimal. Consequently, we did not perform any score calculation and analysis on this variable. Although higher CRP and D-dimer levels were noted in our deceased HD patients, these findings were not statistically significant.

At admission, we found that oxygen saturation (SpO2) values were significantly lower for HD patients who died than surviving HD patients (SpO2 85% vs. 90%; p=0.003). Consistent with prior research (10, 11), our study found significantly higher use of mechanical ventilation among HD patients who died than survivors (57% vs. 0%; p=0.003).

Our study used the PSI to predict in-hospital mortality in COVID-19 pneumonia, similar to previous studies (25, 26). The PSI score was significant in predicting in-hospital mortality in our HD patients (OR 1.071, 95% CI 1.01–1.13; p=0.020). However, its predictive power for 100-day mortality in HD patients was not significant (OR 1.029, 95% CI 0.997–1.063, p=0.073).

Our study has several strengths. We used a control group with the same COVID-19 severity as the HD group and followed all patients for mortality 90 days post-discharge. We believe that including all non-ESKD patients in the control group could have skewed results due to a higher proportion of mild cases and younger individuals.

Our study had several limitations. First, the sample size was relatively small, which could reduce the power to detect statistically significant differences and associations. Additionally, our study was single-center retrospective design. This design may limit the generalizability of our findings, as it could introduce bias related to the specific patient population, treatment protocols, and practices of the single institution. Another limitation is the lack of a non-COVID-19 HD control group. This omission might affect our understanding of the outcomes in the HD group, as it restricts the comparability of COVID-19 outcomes in HD patients to those in a similar population without COVID-19. Finally, some data that may be important in understanding the prognosis and outcomes of COVID-19 patients, such as detailed comorbidity data, specifics of COVID-19 treatment, and follow-up information, might not have been fully captured or analyzed in this study due to its retrospective nature. These limitations should be considered when interpreting our study results and planning future research.

Our study found that patients undergoing chronic HD face a higher mortality risk from COVID-19, even when matched with patients of similar disease severity without kidney disease. Chronic HD and critical illness were significant predictors of 100-day mortality, whereas cardiovascular disease comorbidity was only significant in univariable analysis. Monitoring mortality among chronic HD patients during hospitalization and in the first three months post-discharge is paramount. Clinicians may predict in-hospital

mortality and manage patients more effectively by evaluating PSI scores.

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