Comparison of all renal replacement therapy modalities in terms of COVID-19 infection rate & mortality in the COVID-19 pandemic and importance of home therapies

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Abstract
Background: This study aimed to compare the infection rate and infection-related mortality among all renal replacement therapies during the COVID-19 pandemics.

Methods: One thousand three hundred thirty-six end-stage renal disease (ESRD) patients who had applied for renal replacement therapy between March 2020 and January 2021 were included in the study. COVID-19 infection and mortality rates were compared between patient groups.

Results: The COVID-19 infection rate in the whole study group was 13.12% (n: 178). The highest infection rate was in the center hemodialysis, 16.33% (n: 139). There was no COVID-19 infection in home hemodialysis (HHD). Mortality rate was 2.87% (n: 39) in the whole cohort and 3.87% (n: 33) in center hemodialysis (CHD), 1.47% (n:5) in kidney transplant (Tx), and 0.81% (n: 1) in the peritoneal dialysis (PD) group. COVID-19 infection rate of home replacement therapy (HRT) (n: 39) patients was significantly lower than CHD (n: 139) (p < 0.001).

Conclusion: The COVID-19 infection rate and mortality were significantly lower than those of CHD in all home-based modalities subgroups.

KEYWORDS
Covid-19, home-hemodialysis, mortality, renal replacement modality

1 | INTRODUCTION

Nowadays, the entire world is struggling with the SARS-CoV-2 (COVID-19) pandemic, which emerged at the end of 2019 and has affected all over the world in a short time. The well-defined risk factors for the infection were being over 65-years-old, diabetes mellitus (DM), renal failure, chronic diseases, cardiovascular disease (CVD), hypertension (HT), immune-compromised disease, respiratory diseases (RD), and cancer.1 Nephrology practitioners were familiar with many kidney disease patients with at least one mentioned risk factor. Various studies from different countries have reported that COVID-19 infection leads to 16% to 35% mortality in dialysis patients.2-4 Even in stage 3–5 renal failure patients with no history of dialysis, the mortality of COVID-19 infection reaches up to 28%.5 If we consider the 1.4% to 8% mortality rate of COVID-19 infection in the general population and 16% to 50% mortality rates in critically ill COVID-19 patients in the intensive care unit (ICU), the
renal failure patients have a morbidity and mortality risk as high as ICU patients at the beginning of the infection."

Patients treated in hemodialysis centers (CHD) have the highest risk of infection transmission among the renal replacement treatment (RRT) modalities. The possible explanation for this situation is the mandatory periodic medical center visits and long dialysis periods of CHD patients. In peritoneal dialysis (PD) and home hemodialysis (HHD), where dialysis is performed in an isolated home environment, the infection transmission rate is expected to be low. The follow-up of kidney transplant (Tx) patients in the home setting prevents community-acquired infection transmission. Although Tx patients’ immunosuppressive state is considered a handicap for effective immune response, it is speculated that immunosuppression may reduce the cytokine storm of COVID-19 infection, which was regarded as the leading cause of mortality. Due to advanced technology and the availability of telemedicine applications, it is feasible to monitor fragile patients remotely. These interventions markedly decreased the patients’ medical center visit requirements in the pandemic era.

A few studies compare the renal replacement therapy modalities, especially HHD, with regards to infection and mortality in the COVID-19 pandemic. This study aimed to compare all renal replacement therapies regarding the infection rate and infection-related mortality in the COVID-19 pandemic, including the comparison of home replacement therapy (HRT) and CHD.

2 MATERIALS AND METHODS

2.1 Study design

The study was designed as a multicenter, retrospective, and observational. Nine medical centers in the Bursa region, composed of eight CHD, two PD, two Tx, and two HHD units, were included in the study. Hemodialysis (HD) is applied 3 times a week for 4 h a day in study centers. Patient follow-up visits are done monthly with routine blood tests. Follow-up visits for PD patients are done bi-monthly after the patient has reached a metabolically stable state. General systemic examination findings, vital signs, weight, volume status, and residual renal functions were recorded, and blood samples for full blood count and biochemical tests were collected at each follow-up visit. In this patient group, Kt/V is evaluated every 3rd month. HHD patients received HDD > 20 h/week and ≥3 sessions/week during the study period. Follow-up visits and medical therapy modifications for HHD patients are done monthly in medical centers with vital signs, physical examinations, and routine blood tests. The Tx patients who are included in this study were transplanted at least 3 months prior to the study. Follow-up visits for Tx patients are done monthly in the first year, bi-monthly, and after the first year if stable.

We retrospectively investigated 10 months of medical records of RRT patients from March 2020, when the first case of COVID-19 infection was detected in the region, to January 2021. Neither vaccines against novel coronaviruses nor therapeutic agents were not commercially and legally available in our country at the period of the study. Any of the patients who were not vaccinated or treated with any therapeutic agent specific against COVID-19. Patients older than 18 years who are treated with RRT for at least 3 months, The CHD and HHD patients who had Kt/V > 1.7 and urea reduction ratio (URR) > %60 and the PD patients who had Kt/V > 1.7 were included in the study. The diagnosis of COVID-19 infection is based on the positive test results of the reverse transcriptase-polymerase chain reaction (PCR) test of the nasopharyngeal and/or oropharyngeal swab test against the SARS COV-2 virus. Patients with COVID-19 symptoms and radiologic findings that support COVID-19 infection were included in the study after confirmation of the presence of infection with a PCR test. Patients who do not have signs and symptoms of fever, cough, shortness of breath, sore throat, headache, muscle aches, loss of taste and smell, or diarrhea, which are considered COVID-19 symptoms, have not been tested. Patients with suspected contact with the COVID-19 case, who were tested and whose test results were negative were considered negative. The follow-up visits of Tx and HHD patients and blood sampling for routine laboratory tests were done in their residency by the medical staff who were deployed by medical authorities during the pandemic. The laboratory results were evaluated and therapy modifications were applied by their own medical centers. The follow-up visits of PD patients were done via phone call during the pandemic, except there is no need to visit the medical center.

2.2 Data collections

All the ESRD patients on any type of RRT who met the study criteria and were followed-up in study centers were enrolled in the study. The patients were grouped according to renal replacement therapy modalities: CHD (n: 851), PD (n: 123), HHD (n: 42), and Tx (n: 340). Demographic varies of the patients were collected from records. For laboratory evaluation of the patients who were COVID-19 negative; available last follow-up visit,
| TABLE 1  | The clinical and demographic characteristics of all the patients in groups |
|-----------|--------------------------------------------------------------------------|
| **(n)**   | **RRT type**                                                              |
| Age (year), median (range) | HHD (42) | PD (123) | Tx (340) | CHD (851) | HRT (505) | Sig. (2-tailed)* |
| 47/20–79 | 54/18–80 | 48/18–75 | 61/18–80 | 50/18–80 | 0.000     |
| Gender, Female, n(%) | 23/45,3 | 72/41 | 209/38,6 | 403/41 | 304/39,7 | >0.05     |
| RRT duration (month), median (range) | 43,7/4–97 | 43/5–200 | 32/2–107 | 48/7–360 | 32/2–200 | 0.011     |
| Current smoker (%) | 5/11,9 | 20/11,9 | 39/11,6 | 98/15 | 64/12,9 | >0.05     |
| BMI (median/range) | 23,80/17,3–46,7 | 27,26/13,4–41,7 | 26,12/12,9–43,4 | 24,58/10,9–67,1 | 26,07/12,9–46,7 | 0.001     |
| Primer kidney disease (n/%) | DN 13/30,9 | 21/17 | 54/16,4 | 289/34,9 | 88/17,8 | 0.000     |
|             | GN 3/7,1 | 11/8,9 | 31,9,4 | 6/0,7 | 45,9,1 | 0.000     |
|             | HT 1/20,4 | 21/17 | 14,4,2 | 32/5,9,3 | 52/10,5 | 0.000     |
|             | PKD 1/2,3 | 10/8,1 | 18,5,4 | 21/0,02 | 29,5,8 | 0.002     |
| Obs U.     | 1/2,3 | 3/2,4 | 16,4,8 | 8/0,9 | 20,4,1 | 0.001     |
| Coexisting disorders (n/%) | DM 14/33,3 | 31/25,4 | 97/28,5 | 310/37,7 | 14/2,8,1 | 0.000     |
|             | HT 27/64,2 | 102/83,6 | 287/84,6 | 539/65,6 | 416/82,7 | 0.000     |
|             | CVD 11/26,1 | 41/33,6 | 124/36,4 | 193/23,7 | 176/34,9 | 0.000     |
|             | RS 1/2,3 | 2/1,6 | 17/5,1 | 64/7,8 | 20/3,9 | 0.003     |
|             | Malignancy 10/23,8 | 185,3 | 12/1,4 | 28/5,5 | 0.000     |
| Obs U.     | 4/9,5 | 1/2,9 | 11/1,3 | 5/0,9 | 0.567     |
| Leukocyte (/mm$^3$) (median/range) | 6515/2990–13,570 | 7725/2910–16,220 | 6840/1058–29,950 | 6900/1610–31,600 | 7085/1058–29,950 | >0.05     |
| Platelet (x10$^3$/mm$^3$) (median/range) | 198/99–339 | 239/94–503 | 208/67–508 | 191/19–868 | 213/67–508 | 0.001     |
| Neutrophil (/mm$^3$) (median/range) | 3785/1530–9230 | 4945/539–14,800 | 5060/800–10,290 | 4640/570–25,260 | 4660/539–14,800 | 0.001     |
| Lymphocyte (/mm$^3$) (median/range) | 1515/310–2960 | 1660/460–3840 | 16,90/280–3870 | 1400/170–5700 | 1640/280–3870 | 0.001     |
| Hemoglobin (g/dl) (mean/std) | 10,98 ± 1,48 | 11,05 ± 1,89 | 11,84 ± 2,37 | 11,2 ± 1,53 | 11,58 ± 2,23 | 0.000     |
| BUN (mg/dl) (mean/std) | 45,88 ± 18,4 | 47,02 ± 13,4 | 27,03 ± 16,6 | 80,12 ± 42,0 | 33,39 ± 18,5 | 0.000     |
| Creatinine (mg/dl) (mean/std) | 7,12 ± 2,57 | 7,63 ± 2,85 | 1,78 ± 1,24 | 6,76 ± 2,08 | 3,63 ± 3,27 | 0.000     |
| Albumin (g/dl) (mean/std) | 3,82 ± 0,42 | 3,62 ± 0,48 | 3,73 ± 0,75 | 3,86 ± 0,43 | 3,70 ± 0,61 | 0.000     |
| Uric acid (mg/dl) (median/range) | 5,7/3,1–9,2 | 5,5/2,7–12 | 6,2/1,2–12,5 | 5,4/2,3–12,1 | 5,9/1,2–12,5 | 0.000     |
| Ferritin (ng/ml) (median/range) | 43,24–11,26 | 282/26–5783 | 378/1,2–9764 | 876,5/58–7125 | 357,5/1,2–9764 | 0.000     |
| CRP (median/range) | 1,6/0–14,2 | 2,3/3–11,2 | 0,25/1–9,9 | 1,3/0–38,5 | 1,4/0–14,2 | 0,199     |
| ALT (mg/dl) (median/range) | 10/1–30,5 | 13/1–254 | 16/1–119 | 10/1–174 | 13,5/1–254 | 0.000     |
| AST (mg/dl) (median/range) | NA | 12/1–116 | 15/6–176 | 22/5–225 | 15/1–176 | 0,008     |

Abbreviations: ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; BUN, Blood urea nitrogen; CHD, Center hemodialysis; CRP, C reactive protein; CVD, Cardiovascular disease; DM, Diabetes Mellitus; DN, Diabetic Nephropathy; GN, Glomerulonephritis; HHD, Home hemodialysis; HRT, Home renal replacement therapies; HT, Hypertension; LN, Lupus Nephritis; NA, Not applicable; Obs U., Obstructive uropathy; PD, Peritoneal dialysis; PKD, Polycystic kidney disease; RRT, Renal replacement therapy; RS, Respiratory system disease; Tx, Renal transplantation.

*Statistical evaluations were made between HRT and CHD.
laboratory values were used in the analysis. For COVID-19 positive patients, the laboratory values at the time of detected infection were collected. Besides demographic properties of the patients, available information about primary etiological causes; comorbidities (e.g., DM, HT, CVD, RD, and malignancies) were also recorded. For laboratory evaluation, available leucocyte, platelet, lymphocyte counts, serum hemoglobin, albumin, creatinine, C-reactive protein, uric acid, ferritin, and alanine aminotransferase levels were recorded. Presenting symptoms of COVID-19 positive patients were all recorded.

All RRT patient groups were compared in terms of infection morbidity and mortality rates. Besides that, these patients were grouped as a center and home RRT. The HRT group was composed of PD, HHD, and Tx patients; CHD was the only group in the center renal replacement therapy group. HRT patient groups (HHD, Tx, PD) were evaluated for infection and mortality among each other and also with the CHD patient group.

2.3 | Statistical analysis

The collected data were analyzed with the use of SPSS statistics for Windows 22.0 (IBM SPSS, Chicago, Illinois). The data is presented as mean ± standard deviation (SD) or median and range, as appropriate. Differences between groups were analyzed by parametric tests were applied to data with a normal distribution, whereas nonparametric tests were applied to data with a non-normal distribution. The chi-square test or Fisher’s exact tests were applied to categorical variables. A student t-test was applied to determine the difference between the groups for continuous variables. The relationships among the variables were evaluated using Pearson and Spearman rho correlation analysis. In order to do sub-group analysis, a one-way ANOVA test was used for continuous normally distributed data. The Bonferroni test was used for Post Hoc analysis between the groups. Results were expressed as mean ± SD and median (interquartile range), and a p < 0.05 was considered statistically significant.

3 | RESULTS

A total of 1356 patients who received renal replacement therapy from 9 centers were included in the study. The mean age was 54.7 ± 13.8 years, the mean RRT duration was 51 ± 47.4 months, and 40.42% of the patients were female, 14.14% of the patients were smokers. The etiology of chronic renal failure (CRF), the cause was unknown in 32.75% of the patients, while 28.58% had DM and the same rate of HT. The most common comorbid conditions in patients were HT 72.12%, followed by DM 34.11% and CVD 28.02%. Table 1 presents the patients’ clinical and demographic characteristics in groups.

COVID-19 infection rate was 13.12% (n: 178) in all RRT patients. The highest COVID-19 infection rate was

![Figure 1](image-url)
in the CHD group with 16.33% (n: 139) (p < 0.05). At the same time, the COVID-19 infection rate was 8.82% (n: 30) in the Tx group, 7.31% (n: 9) in the PD group, and no infection was detected in the HHD group (p > 0.05). In the HRT group, the COVID-19 infection rate was 7.72% (n: 39) (Figure 1). The primary etiology of CKD of patients with COVID-19, DM was the most common with 17.77% (n: 67), followed by HT with 13.06% (n: 49). In terms of comorbid conditions, in addition to CKD, COVID-19 infection was found in 34 (40.47%) of 84 patients with respiratory system disease, 76 (20.48%) of 371 patients with CVD, 81 (17.92%) of 452 patients with DM, and 125 (13.08%) of 955 patients with HT. The risk of getting an infection was found to be higher in patients with CKD accompanied by DM, CVD, and RD (p < 0.05) (Table 2).

The mortality rate calculated for the 10-month period was 2.87% (39/1356) in all patients who received RRT. The highest mortality rate was 3.87% (33/851) in the CHD group and it was statistically significant (p < 0.05). The mortality rate of the HRT group was found to be 1.18% (6/505) and was found to be 1.47% (5/340) in the Tx group, and 0.81% (1/123) in the PD group, and 0 (0/42) in HHD. There is no statistically significant difference in mortality among HRT subgroups (Tx, HHD, PD) (p > 0.05).

The mortality rates in patients with COVID-19 infection, 21.91% (39/178) in all subjects, 23.74% (33/139) in the CHD group, 11.11% (1/9) in the PD group, and 16.66% (5/30) in the Tx group (Figure 1). DM and HT were the most critical risk factors for primary and comorbid diseases. In addition to DM and age, the presence of CVD significantly increased the mortality risk in the COVID-19 patients (p < 0.05) (Table 2), (Figure 1).

The COVID-19 infection rate in the CHD group was significantly higher than the HRT group (16.33%: n: 139 vs. 7.72%: n: 39 in orderly, p < 0.001). Furthermore, a significant difference between the CHD and HRT groups was detected in mortality rates (3.87%: n: 33 vs. 1.18%: n: 6 in orderly, p = 0.002). The mortality rate in those who had the infection was 23.74% (33/139) in the CHD group vs. 15.38% (6/39) in HRT (p < 0.001) (Figure 1).

The most common presenting symptoms among the COVID-19 positive patients were fever (60.07%), fatigue (55.61%), and cough (51.23%). Besides that, serum hemoglobin, albumin, lymphocyte, and eosinophil levels of the COVID-19 patients were detected significantly lower than the COVID-19 negative patients (p < 0.01). Also, serum uric acid, ferritin, C-reactive protein, AST, and troponin levels of the COVID-19 positive patients were detected significantly higher than the COVID-19 negative patients (p < 0.01). The mean age of both COVID-19 positive patients and mortality detected patients was significantly higher than other groups (p < 0.01). There was no significant difference between the groups in terms of gender (Table 2).

4 | DISCUSSION

This study compared RRT patient groups (CHD, PD, Tx, and HHD) in terms of COVID-19 infection transmission and COVID-19 related mortality. According to the study, HRT patients had a significantly lower COVID-19 infection and mortality rate than CHD patients. The COVID-19 infection rates of PD and Tx patients were detected to be lower than 9%. Also, in the HHD group, no COVID-19 infection was detected. The mortality rate in the COVID-19 positive RRT patients was detected as high as 21.91%.

During the COVID-19 pandemic, health authorities and institutions faced increased health-work demand, especially at peak infection periods. In those periods, medical practitioners searched for ways to decrease ongoing chronic disease patient-related health work burden and protect high-risk patients from contaminated healthcare settings. Chronic kidney disease patients requiring close follow-up were at a high risk for COVID-19 infection.1 HRT patients have the ability to maintain RRT at their home without necessitating professional medical staff’s physical aid, except for mandatory situations. Unfortunately, the rate of patients using HRT is quite low.10 It was assumed that the infection and infection related mortality will be decreased inversely proportional with the increase in HRT rate. With a very low-cost infrastructure system that minimizes hospital visits, HRT patients can be monitored visually and audibly with telemedicine applications from afar.9,10 The home care practices used for Tx patients at our center have been very beneficial in reducing the risk of infection. There are small-scale studies that include one or two groups and evaluate the infection and mortality status of HRT in the pandemic, which support such advantages of HRT. In this study, all HRT applications and CHD treatments were compared.

This study detected no COVID-19 infection in the HHD group for 10 months. There are limited studies investigating HHD patients and the COVID-19 infection. COVID-19 infection rate of HHD patients (1.8%–3.6%) were reported to be significantly lower than CHD patients (3.8%–11.5%) from two different countries in Europe; France, and UK.1,12 On the contrary; in another study from Spain, the COVID-19 infection rate of HHD patients did not appear to be different from PD patients (HHD 13.7%, PD 15.7%), while the mortality rates were 22% in PD patients and 0% in HHD patients.13 The
| (n)                          | All patients          | COVID-19 positive | p value | COVID-19 positive | p value |
|-----------------------------|-----------------------|-------------------|---------|-------------------|---------|
|                             | COVID-19 negative (1178) | COVID-19 positive (178) |         | Alive (139) | Dead (39) | p value |
| Age (year), median/range    | 55/18–80              | 61/21–80          | 0.000   | 60/21–80        | 65/37–80 | 0.002   |
| Gender (Male), n (%)        | 610/60,3              | 97/54,8           | 0.162   | 81/57,9         | 18/46,2  | 0.113   |
| RRT duration (month), median/range | 40/2–360             | 48/7–120          | 0.121   | 36/7–120        | 78/48–96 | 0.108   |
| Current smoker n (%)        | 144/14,6              | 18/10,9           | 0.160   | 14/10,3         | 5/16,1   | 0.621   |
| Primer kidney disease n (%) | Diabetic Nephropathy  | 310/27            | 0.001   | 45/32,6         | 24/63,1  | <0.001  |
|                             | Glomerulonephritis    | 50/4,3            | 0.000   | 1/0,7           |          |         |
|                             | Hypertension          | 328/28,6          | 0.852   | 39/28,3         | 10/26,3  | 0.756   |
|                             | Polycystic kidney disease | 46/4              | 0.263   | 4/2,9           |          |         |
|                             | Lupus Nephritis       | 3/0,2             | 0.486   | 1/0,7           |          |         |
|                             | Obstructive uropathy  | 27/2,3            | 0.126   | 1/0,7           |          |         |
|                             | Others                | 381/33,2          | 0.276   | 47/34,1         | 4/10,5   | 0.004   |
| Coexisting disorders n (%)  | Diabetes Mellitus     | 371/32,3          | 0.001   | 57/40,4         | 26/66,6  | 0.008   |
|                             | Hypertension          | 830/72,4          | 0.543   | 102/72,3        | 25/64,1  | 0.231   |
|                             | Cardiovascular disease| 295/25,7          | 0.000   | 54/38,3         | 24/61,5  | 0.025   |
|                             | Respiratory disease   | 50/4,3            | 0.000   | 27/19,1         | 7/17,9   | 0.975   |
|                             | Obstructive nephropathy| 13/1,1           | 0.526   | 3/2,1           |          |         |
|                             | Fever n (%)           | 9/0,2             | 0.000   | 72/55,8         | 24/80    | 0.007   |
|                             | Cough n (%)           | 16/4,6            | 0.000   | 65/50,0         | 17/56,6  | 0.517   |
|                             | Sputum n (%)          | 8/2,3             | 0.000   | 17/13,1         | 9/30     | 0.068   |
|                             | Dyspnea n (%)         | 10/2,9            | 0.000   | 52/40           | 18/60    | 0.053   |
|                             | Tiredness n (%)       | 19/5,5            | 0.000   | 68/52,3         | 21/70    | 0.071   |
|                             | Lymphocyte (/mm\(^3\)) median/range | 1533/170–4480 | 0.000   | 1300/450–4020  | 1070/200–5700 | 0.347 |
|                             | Hemoglobin (g/dl) Mean ± SD | 11,4 ± 1.87  | 0.001   | 11,1 ± 1.86    | 10,65 ± 1.91 | 0.029 |
|                             | Platelet (10\(^9\)/mm\(^3\)) median/range | 200/19–868 | 0.286   | 199,5/70–644   | 195/58–465 | 0.770 |
|                             | Leukocyte (/mm\(^3\)) median/range | 7065/1290–21 980 | 0.147   | 5180/1900–25 260 | 84,8/49,1 | 0.005 |
|                             | BUN (mg/dl) Mean ± SD | 58,6/39,3         | 0.000   | 60,2/40,8      | 84,8/49,1 | 0.005 |
|                             | Creatinine (mg/dl) Mean ± SD | 5,60 ± 3,3     | 0.819   | 5,49 ± 2,88    | 5,62 ± 2,28 | 0.453 |
|                             | Albumin (g/dl) Mean ± SD | 3,84 ± 0,49     | 0.000   | 3,72 ± 0,44    | 3,48 ± 0,62 | 0.067 |
|                             | Uric acid (mg/dl) median/range | 5,6/1–12,5     | 0.033   | 5,85/3,00–10,4 | 6,2/2,9,8 | 0.202 |
|                             | Ferritin (ng/ml) median/range | 634/1,2–9764 | 0.000   | 118,5/8–7125  | 1390/6,9–2000 | 0.422 |
|                             | CRP median/range      | 1,0/0–32         | 0.000   | 2,2/1–38,5     | 10,9/2–34,1 | 0.005 |
|                             | ALT (mg/dl) median/range | 11/1–254     | 0.075   | 13/1–128       | 12/1–40  | 0.009   |
|                             | ASTa (mg/dl) median/range | 15/1–176     | 0.000   | 18/7–225       | 23,5/5–135 | 0.335 |
|                             | Troponin median/range | 2,8/0,0–514     | 0.010   | 39,3/0,0–665   | 204/0,1–1542 | 0.030 |

*Abbreviations: ALT, Alanine aminotransferase; AST, Aspartate aminotransferase; BUN, Blood urea nitrogen; CRP, C-reactive protein; RRT, Renal replacement therapy.*
possible explanatory reasons why we did not encounter any infection in our HHD patients. We think that the patients do not enter the hospital environment where the COVID-19 infection is intense and that they have the opportunity to communicate online with the center where they are followed with the help of telemedicine. The routine monthly laboratory and clinical follow-ups can be provided by health professionals in the home environment.

This study revealed a 7.31% COVID-19 infection rate in PD patients, resulting in 1 death in 10 months of the COVID-19 pandemic. In two different studies from China at an early stage of the COVID-19 pandemic, the reported COVID-19 infection and mortality among PD patients was 8 (1%) and 2 (0.25%) in orderly. An important point that emerged from the other studies is that the detected infection rates are similar to the general population in the same city, but the mortality rate is at the level of chronic kidney disease patients (25%). In a study conducted in the USA, 11 of 419 end-stage renal disease (ESRD) patients were hospitalized due to COVID-19. It was determined that two of them (18%) had PD and died in the hospital. Especially, the availability of remote monitoring capacity of some automated PD machines and telemedicine applications allows nearly full remote monitoring of the PD patient’s treatment, significantly reducing the need for patients to go to the hospital. In a recent prospective study from Brazil, they reported that COVID-19 infection was detected in 120 out of 522 patients. Eighty-six percent of COVID-19 positive patients had HD and resting 14% was in the PD group of patients. They also reported that the observed incidence, mortality, and fatality rates in both HD and PD groups exceed those observed in the general Brazilian population (incidence of 1026.7/10000 inhabitants, mortality of 28.6/10000 inhabitants, and lethality rate of 2.8%), confirming the high risk of poor outcomes in the population on maintenance dialysis. The importance of telemedicine application gains importance in terms of preventing COVID-19 infection contagion at this point. Especially the dialysis machine that enables frequent online monitoring and early detection and management of possible problems in patients with automated peritoneal dialysis (APD) further decreases the need to visit medical centers.

Although Tx is the most effective treatment for RRT. Compared to the previous year, the number of patients on the waiting list decreased by 9% to 41% during the COVID-19 pandemic. With the concern of the potential negative effect of immunosuppressive medications used in transplantation in COVID-19 infection-related morbidity and mortality of Tx patients, many Tx centers postponed or suspended transplantation programs in the pandemic. With the accumulation of knowledge about the natural course and related clinical manifestations of COVID-19 infection, the excessive immune response of the host has been identified as the prominent factor that aggravates the clinical picture. Therefore, it is thought that immunosuppressive drugs used in Tx patients will reduce the worsening of the disease.

In our study, the detected infection rate was 8.8% in the Tx group, and the mortality rate was 1.5% in 10 months. In a study conducted with hospitalized 20 COVID-19 positive patients in Italy at the beginning of the pandemic, all immunosuppressives were discontinued and followed up with steroids only. Four (20%) patients needed intensive care, and 5 (25%) died. In another study from Turkey, 17 (21%) of 81 Tx patients at the beginning of the pandemic required intensive care, and 9 (11%) of the patients resulted in death. The study from France, with a population of 1216 Tx patients, had a history of active contact for 8 weeks during the first wave of the pandemic. They reported the incidence of COVID-19 as 5% and the death rate as 1%. In a meta-analysis evaluating 1 year of the pandemic, Tx patients exhibited high hospitalization rates of 32% to 97% compared to the normal population; 7% to 32% of the patients had to be followed up in the ICU. Although there are differences between the reported studies, the reported mortality rates in those with COVID-19 infection are 13% to 32%. Our results according to literature did not support the positive effect of immunosuppressive agents among COVID related mortality. The differences among reported rates may vary depending on many factors, such as donor type, age, concomitant diseases, and drugs used.

According to this study, CHD patients were the highest risk group in terms of COVID-19 infection (16, 3%) and mortality (3, 9%). The mortality rate of COVID-19 infection in CHD patients was reported as 16.2% to 31% in different studies. This study showed that the calculated mortality rate of CHD patients was 23.7%. There are many reasons why patients with CHD have much higher rates of COVID-19 infection than other RRTs. The necessity of applying to a health institution is one of the important reasons. The fact that most of the patients use public transportation to get to the health care facility, wait for their sessions in waiting rooms, participate in bulk sessions, and have close contact with healthcare professionals increases the risk of transmission significantly. Studies on this subject revealed that the most important transmission source in CHD patients is dialysis centers (47.8%). In addition, advanced age, higher prevalence of comorbid diseases (e.g., DM, HT), and impaired immune system increase the mortality risk of patients compared to the normal population.
With the advanced age, COVID-19 related hospitalization, ICU requirement and mortality rate increases significantly. The deteriorating effect of age among COVID-19 infections markedly increases and becomes clinically significant in patients >65 years old. The speculated mechanisms and causes of increased COVID-19 related mortality and morbidity with aging are; deteriorated immune regulation, decreased immune response, decreased CD4 and CD8 T helper cell response and repertoire adaptation, high co-morbidity incidence and decreased compensatory capacity of host organ and systems. In the presented study, all the patient groups had <65 median age. Although the patient groups had statistically significant differences among age due to the reduced number of age groups of home-based dialysis modalities, it was ignored in statistical analysis. However, regardless of the dialysis modality, the mortality rate in patients receiving RRT is much higher than in the normal population. The mortality of ESRD patients with COVID-19 infection is as high as that of ICU patients with COVID-19 infection in the general population.

This study, which compares the CHD and HRT in terms of COVID-19 infection, clearly stated that HRT significantly decreases the infection rate (16.3% vs. 7.7% in orderly). CRF patients were prone to RD due to attenuation of both the natural and adaptive immune system, and frequent hospital admission. The presence of uremic toxins, nutritional deficiencies, and immune suppressive therapies further deteriorates the immune system, which leads to susceptibility to contagious infectious disease. The contagious infectious disease is the second leading cause of mortality after CVD in CRF patients. Home-based RRT allows getting away from crowded environments with a high risk of infection, as well as providing adequate ventilation of the treatment environment and reducing the transmission of infection. Also, HHD provides better clearance of uremic toxins as a result of longer dialysis per session and slows down the weakening of immunity. The majority of these patients were patients who were able to enter their own veins, had good self-confidence and self-care, and had a high intellectual level. Both the patient properties of HHD patients and being away from public/crowded health centers decreased the exposure risk of COVID-19 infection compared to CHD patients. As demonstrated in our study, there was no infection during the first year of the COVID-19 pandemic. Routine health care setting visits of CHD patients, bulk dialysis sessions, close contact with health care professionals, advanced age, male sex, ethnicity, inheritance and genetic factors, poor socio-economic condition, and the excess of accompanying comorbid conditions were possible explanations for the increased infection rate and mortality. From this point of view, developments in remote monitoring and treatment modalities should be considered in informing and determining treatment for ESRD patients who apply for RRT. In addition, the increased HRT application rate will reduce the risk of COVID-19 infection among RRT patients and the workload of healthcare professionals and hospitals.

In conclusion, this study revealed that all other HRT modalities have significantly lower COVID-19 infection and mortality rates compared to CHD. However, especially in the CHD group, the mortality rate is significantly higher in all COVID-19 positive RRT patients compared to the general population. Therefore, it would be a proper approach to review modifiable risk factors to reduce the risk of RRT patients being infected. In the upcoming period, directing patients who have applied for RRT to home treatments will become even safer with technological developments and telemedicine applications.

The limitations of the study: Although the main purpose of the study is to evaluate the superiority of home-based RRT modalities in terms of infection and mortality in the pandemic era, the limited number of cases and lack of detailed hospitalization follow-up, progression process of the infection, and retrospective study design were limitations of our study. Together with the other limitations, unfortunately the small size of sub-groups leads to ignoring the possible effect of aging on infection and mortality between the groups.

CONFLICTS OF INTEREST
All authors have no conflict of interests to declare.

DATA AVAILABILITY STATEMENT
All data are stored in an Excel file by Prof. Dr. Serdar KAHVECIOGLU personal archive.

CONSENT TO PARTICIPATE
Patient consent was obtained from the centers that entered data in the registry.

CONSENT FOR PUBLICATION
The informed consent form contained the following warning: “Your data will be used in a clinical trial without personal information.”

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