

# The reliability and success of peritoneal dialysis during the COVID-19 pandemic

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## Research Article

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# Abstract

**Aim:** This study aimed to evaluate the symptoms, changes in laboratory findings during the COVID-19 pandemic, and the effect of depression on symptoms associated with end-stage kidney disease in patients with peritoneal dialysis (PD).

**Methods:** This was an observational and cross-sectional study. The patients underwent three different PD modalities, including continuous ambulatory PD, automated peritoneal dialysis, and remote monitoring automated peritoneal dialysis (RM-APD). All patients were asked to complete the clinical assessment form and Beck depression and anxiety inventory. Additionally, the last two laboratory evaluations during this period were examined.

**Results:** A total of 123 patients undergoing PD were included. None of the patients were diagnosed with COVID-19 infection. Serum ferritin, creatinine, phosphorus, albumin and parathyroid hormone levels were significantly elevated in the total study population ( $p=0.03$ ,  $p=0.01$ ,  $p=0.02$ ,  $p=0.02$  and  $p=0.05$ , respectively). While calcium, phosphorus, and parathyroid hormone tended to increase in patients with APD or CAPD, they remained stable in patients performing RM-APD. Most of the patients did not experience dyspnea, pitting edema, difficulty in blood pressure control, palpitation, bone muscle pain, or peritonitis. Moderate to severe depression was associated with dyspnea, weight gain, fatigue, palpitation, and increased anxiety.

**Conclusion:** PD is a reliable and successful form of dialysis and can be safely administered even if hospital access is restricted. PD is a safe method of renal replacement therapy to protect patients from COVID-19 infection. Additionally, RM-APD may be a better choice because it provides more stable bone mineral metabolism. Moreover, evaluating depression and anxiety at phone visits may be necessary for accurate clinical assessment.

## Introduction

Novel coronavirus disease (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was accepted as a pandemic on 11 March 2020 by the World Health Organization (WHO)<sup>1</sup>. The disease, which primarily manifests as an acute upper and lower respiratory tract infection, could affect multiple organs and systems, including the heart, intestine, kidneys, blood, and nervous system<sup>1,2</sup>. The overall estimated frequency of severe cases and mortality were 25% (17.4-34.9) and 3.6% (1.1-7.2), respectively<sup>3</sup>.

The patient population with chronic disease was the most affected group by this pandemic. One of these frail groups consisted of patients with end-stage kidney disease (ESRD). Patients on maintenance dialysis are likely to have an increased risk of COVID-19 and its complications due to older age, multiple comorbid conditions, and a suppressed immune system<sup>1,2,4</sup>. Additionally, the need for travel thrice weekly

to the dialysis center, clustering of patients in dialysis units, and contact of dialysis staff members for more than one patient also restricts the physical isolation of hemodialysis patients, which is necessary for protection from the virus. Hereby, frequency and mortality are detected as 16% and 16.2%, respectively, in this patient population<sup>5</sup>.

On the other hand, peritoneal dialysis (PD) is the most frequent home-based dialysis treatment and could provide physical isolation of dialysis patients. The International Society of Peritoneal Dialysis (ISPD) provided practical guidelines that encourage clinicians to choose PD as a maintenance dialysis modality during this pandemic<sup>6</sup>. Technological advances, such as remote access modules in the PD field, made it easier to manage patients' dialysis prescriptions for physicians and provided increased patient treatment compliance<sup>7-9</sup>. However, it is known that there is a strong relationship between depression and non-compliance<sup>10</sup>. Patients were constantly at home during this pandemic, and this social isolation may lead to anxiety and depression<sup>11</sup>. Additionally, the anxiety that the disease has caused may affect dialysis treatment compliance.

However, there is no literature about how successful PD is as a maintenance dialysis treatment without regular clinic visits. Additionally, it is not known how often the patients experienced the important consequences of ESRD, including itching, weakness, palpitation, loss appetite, muscle-joint pain, hypervolemia and difficulty in blood pressure control, and how they solved the problem during the COVID-19 pandemic. In addition, the effect of anxiety and depression level on symptoms associated with ESRD is unknown.

The aim of this study was to evaluate the symptoms experienced by patients during this period. Additionally, changes in laboratory findings when they could not admit to hospital visits will be analyzed. In addition, the depression and anxiety levels of patients who underwent PD during the pandemic will be questioned, and the effects of depression on symptoms associated with ESRD will be examined.

## Methods

### *Study population*

This study was an observational and cross-sectional study investigating the effects of the COVID-19 pandemic on patients undergoing PD. The study was conducted in the peritoneal dialysis units of Gazi University, Ankara, and Diskapi education and research hospitals. All patients were asked about symptoms related to ESRD and problems specific to PD (e.g., catheter outlet problems and peritonitis), and patients were asked to complete the Beck depression and anxiety scale. The Health Ministry of Turkey Republic and the local Ethics Committee of Gazi University approved the study's design and procedures in agreement with the principles of the Declaration of Helsinki and ethical standards for human experimentation. Written informed consent was obtained from all participants. The inclusion criteria of the present study were as follows: treatment by maintenance PD for at least six months, age > 18 years, and patients who agreed to participate.

## ***PD modalities, clinical assessment, Beck depression, and anxiety scales***

The patients included in this study underwent three different PD modalities. Continuous ambulatory PD (CAPD) consisted of multiple exchanges (generally three or four) during the day by the patient or caregiver. Automated peritoneal dialysis (APD) uses a cycler device to perform multiple overnight exchanges with short dwells. Remote monitoring automated peritoneal dialysis (RM-APD) is working on the same principle as APD, additionally transmitting relevant dialysis session data including missing a treatment, lost connectivity, and bypass drain through to the PD center via cloud-based software. The same PD nurse checked the record of the patients with performing RM-APD included in the study on the ShareSource connectivity platform daily (Homechoice Claria, Baxter Healthcare Corporation, Deerfield, Illinois). Patients were contacted when a problem was detected.

On the other hand, all of the patients were evaluated by phone if they had any problems (e.g., constipation, discharge problem, abdominal pain, blurred dialysate, or high blood pressure), and the problem was solved without a hospital visit. If there is a problem that cannot be solved by phone, the patient was called to the clinic visit. In addition, all patients, regardless of the problem, were called by phone once a month for clinical evaluation.

After three months (between March and June 2020) of limited hospital access, patients who referred to routine clinic visits were asked to complete a "clinical evaluation form" (supplementary 1). This form was prepared mainly to investigate symptoms, evaluate problems specific to PD, and evaluate the effects of COVID-19. Additionally, patients were asked to complete Beck's depression and anxiety inventories. The Beck Depression Inventory is a widely used measure of depression and has been validated in the Turkish population<sup>12</sup>. The survey consisted of 21 items, and scores were in the range of 0-63. Higher scores indicated severe depression (0-13: minimal; 14-19: mild; 20-28: moderate; 29-63: severe). The Beck Anxiety Inventory with 21 items is a severity indicator of anxiety and has been validated in the Turkish population<sup>13</sup>. Scores are in the range of 0-63, and higher scores indicate severe anxiety (0-21: low, 22-35: moderate; and >36: concerning levels of anxiety)

## ***Clinical outcomes***

The hospital electronic medical records system was used for baseline information, such as sex, age, PD modality, education level, and laboratory parameters, including hemoglobin, ferritin, blood urea nitrogen, creatinine, total protein, albumin, calcium, phosphorus, and parathyroid hormone. Data were collected at the last clinical visit, and patient data, which were obtained three months ago, were also recorded. More than 100 ml of urine per day was considered residual renal function (RRF). The patients were asked to perform blood pressure measurements at home, with automatic calibrated regularly and validated automatic devices following the 10-minute rest period. Smoking, drinking tea, or coffee and exercise for at least 30 minutes were prohibited. We determined target blood pressure as <140/90 mm/hg for all patients. Dialysis interruption refers to skipping a session.

## ***Statistical Analysis***

Analyses were performed with SPSS 21.0.0.1 (SPSS, IBM, Armonk, NY) software for Windows. Data distribution was determined using the Kolmogorov-Smirnov test. The homogeneity of variables was determined using the one-way ANOVA homogeneity of variance test. Continuous variables are reported as the means and standard deviation or as median and minimum-maximum according to data distribution. Categorical variables are reported by percentages. We used the paired sample T-test or Wilcoxon test according to data distribution when we compared changes in laboratory parameters within groups. The chi-square test was used to compare categorical variables between two groups. When we compared more than two groups, the Kruskal Wallis test was used for numerical variables, and the Chi-square trend test was used for categorical variables. Post hoc analysis was used to determine the significant difference between more than two groups. A value of  $p \leq 0.05$  was considered statistically significant.

## Results

### *Demographic and laboratory evaluation*

We analyzed a total of 123 patients undergoing PD. Fifty-nine of the total patients (48%) were female, and the mean age of the study population was  $51 \pm 14$  years. The most common cause of CKD was hypertension (54/123, 44%). While the median dialysis vintage time was 41 (8-120) months, 80% (98/123) of patients had RRF. The distribution of demographic characteristics was similar between the three groups, except for education level. Twenty-five percent of patients who performed RM-APD were university graduates, and the difference was significantly higher than that of the groups performing CAPD and APD ( $p < 0.001$ ) (table 1).

The laboratory evaluation of the patients is shown in Table 2. The mean time between the last two laboratory evaluations during this period, when the patients had limited hospital access, was  $97 \pm 31$  days. In this time interval, we found that serum ferritin, creatinine, phosphorus, albumin, and parathyroid hormone levels were significantly elevated in the total study population ( $p = 0.03$ ,  $p = 0.01$ ,  $p = 0.02$ ,  $p = 0.02$ , and  $p = 0.05$ , respectively). The serum ferritin level of patients performing RM-APD was significantly elevated during this period (from  $387 \pm 208$  ng/mL to  $460 \pm 237$  ng/mL,  $p = 0.02$ ). On the other hand, there was no significant change in laboratory parameters in patients performing RM-APD. While serum creatinine was significantly elevated in patients with CAPD (from 8.42 mg/dL to  $9.09 \pm 3.05$  mg/dL,  $p = 0.03$ ), serum calcium, phosphorus, and parathyroid hormone levels tended to be significantly elevated during this time interval ( $p = 0.08$ ,  $p = 0.06$ , and  $p = 0.09$ , respectively). In the group of patients performing APD, serum phosphorus, albumin and parathyroid hormone levels were found to be significantly elevated [from  $4.66 \pm 1$  mg/dL to  $5.05 \pm 1.27$  mg/dL, from  $3.43 \pm 0.52$  g/dl to  $3.49 \pm 0.48$  g/dl and from 297 (7-1956) pg/mL to 398 (9-808) pg/mL;  $p = 0.001$ ,  $p = 0.04$  and  $p = 0.01$ , respectively].

When we compared the PD modalities, we found that serum BUN and albumin levels were significantly higher in patients with CAPD ( $p = 0.002$  and  $p = 0.007$ ) at baseline. Post hoc analysis revealed that CAPD and APD ( $p = 0.001$ ) caused a significant difference. During this period, while the serum albumin level difference between groups remained significant ( $p = 0.02$ ), the serum BUN level lost significance ( $p = 0.07$ ).

On the other hand, the serum calcium level was significantly higher in patients who underwent RM-APD ( $p=0.02$ ), and post hoc analysis showed that the difference was caused by RM-APD and APD ( $p=0.02$ ). However, the difference between the three groups lost its significance during this time interval ( $p=0.8$ ).

### ***Clinical assessment***

Table 3 is designed for the evaluation of the clinical assessment of patients with PD. While 67% (82/123) of total patients did not describe dyspnea, only 2% (3/123) of them had dyspnea at rest. Fifty-one percent (63/123) of patients did not experience pitting edema as evidence of hypervolemia. During this period, only ten patients (8%) did not measure blood pressure in any way, while 52% (64/123) of total patients measured blood pressure daily by following instructions. Although 69% (78/113) of patients had blood pressure within the target range, two (2%) of the patients had to refer to the E. R due to uncontrolled hypertension. While PD prescription changes were not required in most of the patients due to hypervolemia (109/123, 88%), PD prescription was changed more than once in 7% (2/30) of patients who underwent APD. While weakness was the most common complaint of patients, 32% of them complained of bone-muscle pain, 20% complained of loss appetite, and 19% complained of itching. The distribution of complaints was similar in patients performing all three PD modalities.

Table 4 shows the PD-related clinical assessment of patients. Eighty-three percent of the total patients did not experience any PD solution discharge problem during this period. More than half of the discharge problem has been solved by changing the position (12/21, 57%). PD nurses solved nine of the 21 discharge problems, and five episodes needed to add heparin to the PD solution. All of the PD solution discharge problems have been solved via phone calls. Twelve percent (15/123) of the total patients experienced redness at the catheter exit site, and most of the episodes had been treated by daily catheter care (11/15, 69%). Likely to the PD solution discharge problem, all of the catheter exit site problems have been solved via phone call. In general, problems related to PD and ESRD were solved without clinical visits via phone calls. However, twelve (10%) of the total patients had to be hospitalized during this period. Four of them (3%) had peritonitis, and two of them (2%) were hospitalized due to cardiovascular problems. None of the patients who needed hospitalization died during this period.

PD-related clinical assessment of patients was similar between the three PD modalities, except dialysis interruption. Ten patients interrupted their dialysis sessions more than once per month. Five of them (17%) were performing APD, and the frequency was significantly higher than patients with CAP and performing RM-APD [5 (17%) vs. 3 (6%) vs. 2 (5%),  $p=0.04$ ].

### ***Assessment of depression***

Eighty-five of the total patients were analyzed for depression evaluation (table 5). Twenty-two percent (19/85) of them had moderate to severe depression. Patients who had moderate to severe depression complained more dyspnea, weakness and palpitation than patients who had minimal to mild depression [11 (58%) vs. 20 (30%), 14 (74%) vs. 28 (42%) and 6 (32%) vs. 3 (5%);  $p=0.03$ ,  $p=0.01$  and  $p=0.003$ , respectively]. Additionally, the frequency of patients who gained more than 5 kg was significantly higher

in patients with moderate to severe depression than in those with minimal to mild depression [2(11%) vs. 0,  $p=0.008$ ]. None of the patients had concerning level anxiety in our study population. However, moderate degree anxiety was significantly higher in patients who also had moderate to severe depression [3 (16%) vs. 2 (3%),  $p= 0.03$ ]. When we asked patients whether COVID-19 affected their lives, 38% (47/123) of patients stated that they were affected (figure 1). The most common condition that patients complained about was the restriction of their activity (23/123, 49%). Additionally, 30% of the patients stated that they felt fear and panic, while 17% of them stated that the restriction of access to the hospital was the most important effect of the pandemic.

## Discussion

The COVID-19 pandemic is a global crisis that affects and changes the world order and causes hundreds of thousands of deaths. In this period, people's social lives have been restricted, and perhaps most importantly, there have been delays in the diagnosis and treatment of chronic diseases that need regular follow-up. Our results suggested that PD, which is a home-based dialysis modality, is a reliable and successful form of dialysis and can be safely administered even if hospital access is restricted. Most of the problems were solved without clinical visits via phone calls with patients. However, we found that depression and anxiety can mimic the symptoms, which could be seen in conditions such as renal anemia and dialysis insufficiency.

Direct person-to-person transmission is the primary method of transmission of COVID-19. It is well known that close-range contact contributes mainly via respiratory droplets, which spread while coughing, sneezing, or even talking <sup>14</sup>. Therefore, the primary way of preventing disease is social isolation and protection from droplets. However, this is a relatively difficult situation to follow for patients with chronic diseases, especially ESRD. Although outpatient hemodialysis facilities had taken the necessary precautions and tried to maintain the distance between patients, this could not be entirely achieved due to the need for travel thrice weekly to the dialysis center, clustering of patients, and contact of dialysis staff members. These limitations combined with older age, impaired immune system, and multiple comorbid conditions resulted in increased mortality. In the literature, the mortality rate of patients with maintenance center hemodialysis due to COVID-19 was reported to be between 16% and 30% <sup>4,5</sup>.

During the pandemic, home-based dialysis modalities such as PD become prominent, and it is recommended to be preferred as the first-line treatment option if possible by the ISPD <sup>6</sup>. There are limited data on the frequency and mortality of COVID-19 in patients performing PD. Ronco et al. reported that the frequency of COVID-19 is 0.7% (1/130) in Vicenza and 0.6% (3/497) in the Veneto region, and none of the patients died <sup>15</sup>. Their results also showed that PD provided a significantly lower rate of COVID-19 infection and all-cause hospitalization than HD. In our study population, we did not observe any PD patients with COVID-19 infection. Similarly, Valeri et al. conducted a study in the USA with 59 COVID-19-infected patients on maintenance dialysis. Only two of them performed PD, and they did not observe mortality in patients with PD <sup>16</sup>. The reason why the frequency of COVID-19 infection is lower in patients

with PD than in those with center hemodialysis may be that patients apply hygiene rules as well as isolation. These patients are regularly trained about hand hygiene and the correct way of wearing face masks by PD nurses to prevent peritonitis. Although there is limited study in the literature on the safety of PD during the COVID-19 pandemic, the data obtained support the reliability of PD based on decreasing the frequency of disease transmission and mortality.

Although PD is a safe way of maintaining dialysis during the pandemic, it is necessary to clarify several important points, including renal anemia, bone mineral disease, phosphorus balance, and compliance with dialysis treatment, to prove the success of PD. To the best of our knowledge, no previous studies have examined the clinical and laboratory assessment of patients with PD during limited access to the hospital.

In this study, we found that the mean hemoglobin value of patients remained stable during the average of three months. We think that the most critical contributor factor for remaining hemoglobin stable is RRF. It is well known that the decline of RRF contributes significantly to anemia and resistance to erythropoietin stimulating agents<sup>17,18</sup>. In our study population, 80% of them had RRF, and we observed that 90% of them preserved RRF without increased diuretic needs during this period. Peritoneal dialysis provides better long-term preservation of RRF compared to HD patients, and it makes PD more prominent and successful in this period<sup>19</sup>. Because we do not know when the pandemic comes to an end. It is important to note that it is necessary to be careful in the clinical evaluation of patients via phone calls without examining laboratory values. Based on our results, some findings, including fatigue, palpitation, and dyspnea, suggesting inadequate dialysis or deep anemia, may be misleading. In our study, moderate to severe depression was observed in 22% of patients, and it was also associated with increased anxiety. It is known that fatigue and increased appetite are well described symptoms of depression, and increased anxiety could lead to dyspnea and palpitation<sup>20</sup>.

The other points to consider when evaluating the success of PD in this period are bone mineral disease and hypervolemia. Based on our results, 80% of the total patients complained of little or no peripheral edema as a hypervolemia finding. Additionally, the fact that more than 90% of patients did not have serious adverse events due to increased blood pressure and 80% of them could control blood pressure within normal limits also supported our results. On the other hand, it was found that patients were adversely affected in terms of bone mineral metabolism. At the end of three months, serum calcium, phosphorus, and parathyroid hormone levels tended to increase. However, this trend in the total study population was not detected in patients performing RM-APD, and it was found that bone mineral metabolism of these patients was similar compared to baseline. It is difficult to explain the exact cause of stable bone mineral metabolism in RM-APD patients. Many factors, including dietary habits, medical and dialysis treatment compliance, and dialysis adequacy, could disturb bone mineral metabolism<sup>21,22</sup>. However, we think that PD treatment compliance is one of the reasons that could explain why bone mineral metabolism remained stable in patients undergoing RM-APD, while it tended to increase in other PD modalities.



The frequency of dialysis interruption was 8% based on our results, and it was mostly observed in patients undergoing APD. However, the overall non-adherence rates to peritoneal dialysis prescription were 2.6% to 85% in the literature, and non-adherence to APD prescription was reported to be 5% to 20%<sup>23,24</sup>. It has been shown that dialysis prescription adherence became more than 90% with the use of RM-APD<sup>7,25</sup>. This platform enables patient treatment data, including peritoneal volume, alerts during treatment, drainage problems, interruption of therapy, loss of dwell time, loss of therapy time to receive, and transmission through to the PD center<sup>7,9</sup>. It has provided many opportunities, such as instant monitoring of treatment adherence, early detection of problems, and resolving most of the problems remotely without admitting to the hospital<sup>9,26</sup>. On the other hand, our clinical assessment was only about whether patients skipped the PD session, and other possible, which were mentioned above, PD treatment incompatibilities did not indicate.

In conclusion, PD is a safe method of renal replacement therapy to protect patients from COVID-19 infection. The data obtained support that PD is successful as well as safe during the pandemic. Additionally, RM-APD may be a better choice in patients with PD because bone mineral metabolism seems to remain more stable. Moreover, evaluating depression and anxiety at phone visits may be important for accurate clinical assessment.

## Declarations

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**Conflict of Interest Disclosure:** non declared

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## Tables

**Table 1:** Demographic characteristics of the study population

|                              | Total<br>n=123 | CAPD<br>n=53(43%) | RM-APD<br>n=40(33%) | APD<br>n=30(24%) | P value |
|------------------------------|----------------|-------------------|---------------------|------------------|---------|
| Age, (years)                 | 51±14          | 51±12             | 49±15               | 53±17            | 0.6     |
| Gender, n(%)                 |                |                   |                     |                  | 0.5     |
| Female                       | 59(48%)        | 29(55%)           | 20(50%)             | 10(33%)          |         |
| Male                         | 64(52%)        | 24(45%)           | 20(50%)             | 20(67%)          |         |
| Etiology of CKD, n(%)        |                |                   |                     |                  |         |
| <i>Diabetes</i>              | 24(20%)        | 10(19%)           | 8(20%)              | 6(20%)           | 0.9     |
| <i>Hypertension</i>          | 54(44%)        | 27(51%)           | 17(43%)             | 10(33%)          | 0.3     |
| <i>Glomerulonephritis</i>    | 16(13%)        | 5(9%)             | 7(17%)              | 4(13%)           | 0.5     |
| <i>Others</i>                | 20(16%)        | 5(9%)             | 7(17%)              | 8(27%)           | 0.1     |
| <i>Unknown</i>               | 9(7%)          | 6(12%)            | 1(3%)               | 2(7%)            | 0.2     |
| School level, n(%)           |                |                   |                     |                  |         |
| <i>Illiteracy or reading</i> | 11(9%)         | 6(12%)            | 3(8%)               | 2(7%)            | 0.7     |
| <i>Elementary</i>            | 46(37%)        | 24(45%)           | 9(22%)              | 13(43%)          | 0.06    |
| <i>High school</i>           | 55(45%)        | 23(43%)           | 18(45%)             | 14(47%)          | 0.9     |
| <i>University</i>            | 11(9%)         | 0                 | 10(25%)             | 1(3%)            | <0.001  |
| Smoking, n(%)                | 11(9%)         | 3(6%)             | 5(13%)              | 3(10%)           | 0.3     |
| RRF, n(%)                    | 98(80%)        | 46(87%)           | 30(75%)             | 22(73%)          | 0.2     |
| People living together, n    | 3(1-7)         | 2(1-7)            | 3(2-5)              | 3(2-7)           | 0.06    |
| Dialysis vintage, (months)   | 41(8-120)      | 34(12-118)        | 48(12-120)          | 48(8-120)        | 0.2     |

**CAPD:** Continuous ambulatory peritoneal dialysis, **RM-APD:** Remote monitoring automatized peritoneal dialysis, **APD:** Automatized peritoneal dialysis, **CKD:** Chronic kidney disease, **RRF:** Residue renal function

**Table 2:** Changes in laboratory parameters of the study population within three months

|  | Total<br>n=123 | CAPD<br>n=53(43%) | RM-APD<br>n=40(33%) | APD<br>n=30(24%) | <i>P</i><br><i>value</i> |
|--|----------------|-------------------|---------------------|------------------|--------------------------|
| Interval between laboratory tests, (d) | 97±31          | 92±29             | 96±28               | 102±37           | 0.2                      |
| Hemoglobin, g/dL                       |                |                   |                     |                  |                          |
| <i>First</i>                           | 10.7±1.83      | 10.64±1.86        | 10.61±1.62          | 10.9±2.12        | 0.8                      |
| <i>Last</i>                            | 10.5±2.01      | 10.34±2           | 10.45±1.74          | 10.88±2.4        | 0.6                      |
| <i>P value</i>                         | 0.1            | 0.3               | 0.6                 | 0.3              |                          |
| Ferritin, ng/mL                        |                |                   |                     |                  |                          |
| <i>First</i>                           | 372±249        | 385±277           | 387±208             | 338±233          | 0.7                      |
| <i>Last</i>                            | 404±299        | 398±335           | 460±237             | 375±278          | 0.2                      |
| <i>P value</i>                         | 0.03           | 0.6               | 0.02                | 0.1              |                          |
| BUN, mg/dL                             |                |                   |                     |                  |                          |
| <i>First</i>                           | 47.7±13.5      | 52.5±15           | 47±11.6             | 41.4±11.2        | 0.002                    |
| <i>Last</i>                            | 48.4±13        | 51.6±11.8         | 46.7±11.2           | 44.7±16.45       | 0.07                     |
| <i>P value</i>                         | 0.8            | 0.5               | 0.4                 | 0.1              |                          |
| Creatinine, mg/dL                      |                |                   |                     |                  |                          |
| <i>First</i>                           | 8.38±3.1       | 8.42±2.82         | 9.1±3.07            | 7.37±3.4         | 0.07                     |
| <i>Last</i>                            | 8.62±3.3       | 9.09±3.05         | 9.18±3.3            | 6.97±3.37        | 0.02                     |
| <i>P value</i>                         | 0.01           | 0.03              | 0.9                 | 0.09             |                          |
| Calcium, mg/dL                         |                |                   |                     |                  |                          |
| <i>First</i>                           | 8.85±0.86      | 8.65±0.85         | 9.2±0.62            | 8.77±1.08        | 0.02                     |
| <i>Last</i>                            | 8.88±0.98      | 8.83±1.17         | 8.98±0.63           | 8.83±1.01        | 0.8                      |
| <i>P value</i>                         | 0.08           | 0.08              | 0.5                 | 0.1              |                          |
| Phosphorus, mg/dL                      |                |                   |                     |                  |                          |
| <i>First</i>                           | 4.98±1.27      | 5.2±1.34          | 4.97±1.34           | 4.66±1           | 0.2                      |
| <i>Last</i>                            | 5.24±1.39      | 5.53±1.22         | 4.99±1.65           | 5.05±1.27        | 0.2                      |
| <i>P value</i>                         | 0.02           | 0.06              | 0.5                 | 0.001            |                          |
| Albumin, g/dL                          |                |                   |                     |                  |                          |
| <i>First</i>                           | 3.64±0.44      | 3.75±0.47         | 3.69±0.28           | 3.43±0.52        | 0.007                    |

|                            |             |              |               |             |      |
|----------------------------|-------------|--------------|---------------|-------------|------|
| <i>Last</i>                | 3.71±0.44   | 3.79±0.49    | 3.76±0.3      | 3.49±0.48   | 0.02 |
| <i>P value</i>             | 0.02        | 0.3          | 0.2           | 0.04        |      |
| Alkaline phosphatase, U/L  |             |              |               |             |      |
| <i>First</i>               | 118(59-862) | 117(59-368)  | 119(62-862)   | 118(42-628) | 0.9  |
| <i>Last</i>                |             |              | 120(63-962)   |             | 0.8  |
| <i>P value</i>             | 125(51-962) | 129(51-355)  | 0.3           | 125(48-330) |      |
|                            | 0.1         | 0.2          |               | 0.8         |      |
| Parathyroid hormone, pg/mL |             |              |               |             |      |
| <i>First</i>               | 367(7-2348) | 330(42-2348) | 413(94-2100)  | 297(7-1956) | 0.2  |
| <i>Last</i>                |             |              |               |             | 0.2  |
| <i>P value</i>             | 395(9-2340) | 386(14-2340) | 426(115-2260) | 398(9-808)  |      |
|                            | 0.05        | 0.09         | 0.4           | 0.01        |      |

**CAPD:** Continuous ambulatory peritoneal dialysis, **RM-APD:** Remote monitoring automatized peritoneal dialysis, **APD:** Automatized peritoneal dialysis, **BUN:** Blood urea nitrogen

**Table 3:** Clinical assessment related to end-stage renal disease of the study population for the last three months

|  | Total<br>n=123 | CAPD<br>n=53(43%) | RM-APD<br>n=40(33%) | APD<br>n=30(24%) | P<br>value  |
|--|----------------|-------------------|---------------------|------------------|-------------|
| Dyspnea, n(%)                              |                |                   |                     |                  |             |
| No   | 82(67%)        | 38(72%)           | 23(58%)             | 21(70%)          | 0.3         |
| Exercise                                   | 12(10%)        | 4(8%)             | 7(18%)              | 1(3%)            | 0.1         |
| Walking                                    | 26(21%)        | 10(19%)           | 9(23%)              | 7(23%)           | 0.8         |
| Resting                                    | 3(2%)          | 1(3%)             | 1(3%)               | 1(3%)            | 0.9         |
| Pitting edema, n(%)                        |                |                   |                     |                  |             |
| No   | 63(51%)        | 32(60%)           | 18(45%)             | 13(43%)          | 0.2         |
| 1-3 times                                  | 35(29%)        | 12(23%)           | 12(30%)             | 11(37%)          | 0.4         |
| More often                                 | 14(11%)        | 5(9%)             | 5(13%)              | 4(13%)           | 0.5         |
| Always                                     | 11(9%)         | 4(8%)             | 5(12%)              | 2(7%)            | 0.1         |
| BP measurement, n(%)                       |                |                   |                     |                  |             |
| No   | 10(8%)         | 5(9%)             | 2(5%)               | 3(10%)           | 0.7         |
| Everyday                                   | 64(52%)        | 20(38%)           | 25(62%)             | 19(63%)          | <b>0.02</b> |
| Once a week                                | 36(29%)        | 21(40%)           | 9(23%)              | 6(20%)           | 0.08        |
| Once a month                               | 13(11%)        | 7(13%)            | 4(10%)              | 2(7%)            | 0.7         |
| Difficult in BP control, n(%) <sup>1</sup> |                |                   |                     |                  |             |
| No   | 78(69%)        | 36(75%)           | 25(66%)             | 17(63%)          | 0.8         |
| Reducing salt consumption                  | 14(12%)        | 4(8%)             | 6(16%)              | 4(15%)           | 0.5         |
| Increasing the dose of drug                | 9(8%)          | 2(4%)             | 5(13%)              | 2(7%)            | 0.3         |
| Add new antihypertensive drug              | 12(11%)        | 6(13%)            | 2(5%)               | 4(15%)           | 0.4         |
| Problem due to high BP, n(%) <sup>1</sup>  |                |                   |                     |                  |             |
| No   | 87(77%)        | 38(79%)           | 28(73%)             | 21(78%)          | 0.8         |
| Headache                                   | 10(9%)         | 6(13%)            | 4(11%)              | 3(11%)           |             |
| Nausea                                     | 5(4%)          | 1(2%)             | 2(5%)               | 2(7%)            |             |
| Weakness                                   | 4(3%)          | 1(2%)             | 4(11%)              | 1(4%)            |             |
| Referring E.R.                             | 2(2%)          | 2(4%)             | 0                   | 0                |             |
| RRF change, n(%) <sup>2</sup>              |                |                   |                     |                  |             |
|  | 85(87%)        | 37(80%)           | 27(90%)             | 21(96%)          | 0.2         |

|  |          |         |         |         |             |
|--|----------|---------|---------|---------|-------------|
| No change                                  | 3(3%)    | 1(2%)   | 1(3%)   | 1(4%)   | 0.9         |
| Increased RRF                              | 10(11%)  | 8(17%)  | 2(7%)   | 0       | 0.06        |
| Extra diuretic for preservation            |          |         |         |         |             |
| PD prescription change due to hypervolemia |          |         |         |         |             |
| No   | 109(88%) | 46(87%) | 39(98%) | 24(80%) | 0.06        |
| Once                                       | 12(10%)  | 7(13%)  | 1(2%)   | 4(13%)  | 0.2         |
| More than once                             | 2(2%)    | 0       | 0       | 2(7%)   | <b>0.03</b> |
| Gain weight, n(%)                          |          |         |         |         |             |
| No   | 70(57%)  | 30(57%) | 20(50%) | 20(67%) | 0.4         |
| 1-3 kg                                     | 41(33%)  | 20(38%) | 13(32%) | 8(27%)  | 0.6         |
| 3-5 kg                                     | 9(7%)    | 3(6%)   | 5(13%)  | 1(3%)   | 0.3         |
| More than 5 kg                             | 3(3%)    | 0       | 2(5%)   | 1(3%)   | 0.3         |
| Weakness, n(%)                             |          |         |         |         |             |
| Frequently (more than once per week)       | 58(47%)  | 26(39%) | 19(48%) | 13(43%) | 0.9         |
| Palpitation, n(%)                          |          |         |         |         |             |
| Frequently (more than once per week)       | 14(11%)  | 4(8%)   | 6(15%)  | 4(13%)  | 0.5         |
| Itching, n(%)                              |          |         |         |         |             |
| Frequently                                 | 23(19%)  | 8(15%)  | 10(25%) | 5(17%)  | 0.5         |
| Loss appetite, n(%)                        |          |         |         |         |             |
| Frequently (more than once per week)       | 24(20%)  | 10(19%) | 9(23%)  | 5(17%)  | 0.8         |
| Bone-muscle pain, n(%)                     |          |         |         |         |             |
| Frequently (more than once per week)       | 39(32%)  | 16(30%) | 14(35%) | 9(30%)  | 0.8         |

**CAPD:** Continuous ambulatory peritoneal dialysis, **RM-APD:** Remote monitoring automatized peritoneal dialysis, **APD:** Automatized peritoneal dialysis, **BP:** Blood pressure, **RRF:** Residue renal function, **PD:** Peritoneal dialysis

<sup>1</sup>113 patients who measured blood pressure during this period

<sup>2</sup>98 patients who had RRF were used for analysis



**Table 4:** Clinical assessment related to peritoneal dialysis of the study population for the last three months

|  | Total<br>n=123 | CAPD<br>n=53(43%) | RM-APD<br>n=40(33%) | APD<br>n=30(24%) | P<br>value |
|--|----------------|-------------------|---------------------|------------------|------------|
| Constipation, n(%)                         |                |                   |                     |                  |            |
| Frequently (more than once per week)       | 16(13%)        | 3(6%)             | 10(25%)             | 3(10%)           |            |
| PD solution discharge problem, n(%)        |                |                   |                     |                  | 0.3        |
| No   | 102(83%)       | 46(87%)           | 34(85%)             | 22(73%)          |            |
| Frequently (more than once per month)      | 21(17%)        | 7(13%)            | 6(15%)              | 8(27%)           |            |
| How the problem was solved, n(%)           |                |                   |                     |                  |            |
| Change position                            | 12(57%)        | 3(42%)            | 4(66%)              | 5(62%)           |            |
| PD nurse call                              | 9(43%)         | 4(58%)            | 2(33%)              | 3(38%)           |            |
| Add heparin to PD solution                 | 5(23%)         | 2(29%)            | 0                   | 3(38%)           |            |
| Redness at the PD catheter exit site, n(%) |                |                   |                     |                  | 0.9        |
| No   | 108(88%)       | 47(89%)           | 35(87%)             | 26(87%)          |            |
| Yes  | 15(12%)        | 6(11%)            | 5(13%)              | 4(13%)           |            |
| How the problem is solved, n(%)            |                |                   |                     |                  |            |
| Daily care                                 | 11(69%)        | 5(83%)            | 2(40%)              | 4(100%)          |            |
| Topical antibiotic                         | 4(31%)         | 1(17%)            | 3(60%)              | 0                |            |
| Abdominal or groin hernia, n(%)            |                |                   |                     |                  |            |
| Yes  | 15(12%)        | 4(8%)             | 6(15%)              | 5(17%)           | 0.4        |
| Increase in size                           | 3(20%)         | 1(25%)            | 2(33%)              | 0                | 0.3        |
| Cause to pain                              | 4(27%)         | 1(25%)            | 2(33%)              | 1(20%)           | 0.9        |
| Dialysis interruption, n(%)                |                |                   |                     |                  |            |
| Frequently (more than once per month)      | 10(8%)         | 3(6%)             | 2(5%)               | 5(17%)           | 0.04       |
| Why did the dialysis interrupted, n(%)     |                |                   |                     |                  |            |
| Weakness                                   | 5(50%)         | 1(33%)            | 1(50%)              | 3(60%)           |            |
| Skipping session not a problem             | 5(50%)         | 2(66%)            | 1(50%)              | 2(40%)           |            |
| Hospitalization, n(%)                      | 12(10%)        | 6(11%)            | 2(5%)               | 4(13%)           | 0.1        |

|                      |       |       |       |       |
|----------------------|-------|-------|-------|-------|
| Peritonitis          | 4(3%) | 2(4%) | 0     | 2(6%) |
| COVID-19             | 0     | 0     | 0     | 0     |
| CVD                  | 2(2%) | 2(4%) | 0     | 0     |
| Others               | 6(5%) | 2(4%) | 2(5%) | 2(6%) |
| Hospitalization time |       |       |       |       |

**CAPD:** Continuous ambulatory peritoneal dialysis, **RM-APD:** Remote monitoring automatized peritoneal dialysis, **APD:** Automatized peritoneal dialysis, **PD:** Peritoneal dialysis, **COVID-19:** Novel coronavirus disease

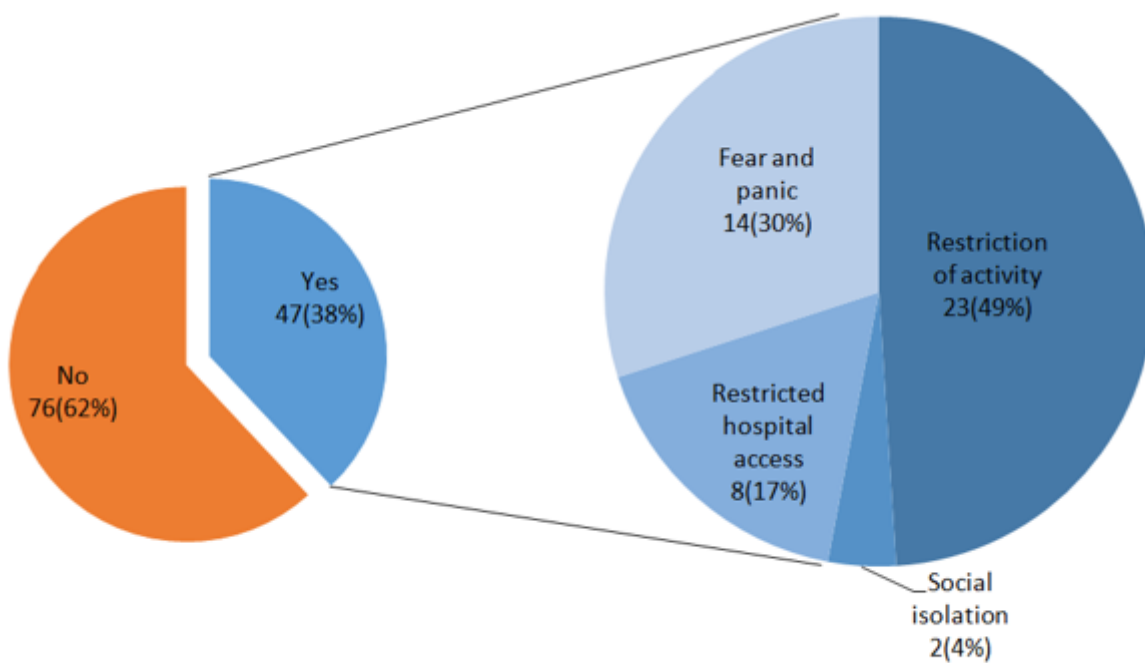
**Table 5:** Assessment of patients' depression

|                                       | Severity of Depression       |                                 |         |
|---------------------------------------|------------------------------|---------------------------------|---------|
|                                       | Minimal to Mild<br>n=66(78%) | Moderate to Severe<br>n=19(22%) | P value |
| Gender, n(%)                          |                              |                                 | 0.3     |
| Female                                | 29(43%)                      | 10(53%)                         |         |
| Male                                  | 37(56%)                      | 9(47%)                          |         |
| PD modality, n(%)                     |                              |                                 |         |
| CAPD                                  | 29(44%)                      | 4(21%)                          | 0.06    |
| RM-APD                                | 28(42%)                      | 10(53%)                         | 0.3     |
| APD                                   | 9(14%)                       | 5(26%)                          | 0.2     |
| Dyspnea, n(%)                         |                              |                                 |         |
| Yes                                   | 20(30%)                      | 11(58%)                         | 0.03    |
| Difficult in BP control, n(%)*        |                              |                                 |         |
| Yes                                   | 20(32%)                      | 7(37%)                          | 0.5     |
| Reducing salt consumption             |                              |                                 |         |
| Increasing the dose of drug           |                              |                                 |         |
| Add new antihypertensive drug         |                              |                                 |         |
| Gain weight, n(%)                     |                              |                                 |         |
| Yes                                   | 27(41%)                      | 10(53%)                         | 0.3     |
| 1-3 kg                                | 22(33%)                      | 6(32%)                          | 0.6     |
| 3-5 kg                                | 5(8%)                        | 2(11%)                          | 0.5     |
| More than 5 kg                        | 0                            | 2(11%)                          | 0.008   |
| Weakness (frequently), n(%)           | 28(42%)                      | 14(74%)                         | 0.01    |
| Palpitation (frequently), n(%)        | 3(5%)                        | 6(32%)                          | 0.003   |
| Loss appetite (frequently), n(%)      | 10(15%)                      | 4(21%)                          | 0.4     |
| Bone-muscle pain (frequently), n(%)   | 16(24%)                      | 7(37%)                          | 0.2     |
| Constipation (frequently), n(%)       | 7(11%)                       | 4(21%)                          | 0.2     |
| Peritonitis, n(%)                     | 2(3%)                        | 2(11%)                          | 0.2     |
| Did COVID-19 effected your life, n(%) |                              |                                 |         |
| Yes                                   | 25(38%)                      | 7(37%)                          | 0.9     |

|                           |         |         |      |
|---------------------------|---------|---------|------|
| Severity of anxiety, n(%) |         |         | 0.03 |
| Low                       | 64(97%) | 16(84%) |      |
| Moderate                  | 2(3%)   | 3(16%)  |      |
| Concerning level          | 0       | 0       |      |

**CAPD:** Continuous ambulatory peritoneal dialysis, **RM-APD:** Remote monitoring automatized peritoneal dialysis, **APD:** Automatized peritoneal dialysis, **PD:** Peritoneal dialysis, **COVID-19:** Novel coronavirus disease

## Figures



**Figure 1**

Effects of the COVID-19 pandemic on patients with peritoneal dialysis

## Supplementary Files

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