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# EFFECT OF PRE-TRANSPLANT DIALYSIS MODALITY ON OUTCOMES IN THE FIRST TWO YEARS AFTER KIDNEY TRANSPLANTATION

*V.A. Berdinsky[1], E.S. Ivanova[1], V.E. Vinogradov[1], N.F. Frolova[1], O.N. Kotenko[1], L.Yu. Artyukhina[1], I.V. Dmitriev[2], P.A. Drozdov[3]*

[1] Municipal Clinical Hospital No. 52, Moscow, Russian Federation
[2] Sklifosovsky Research Institute of Emergency Care, Moscow, Russian Federation
[3] Botkin Hospital, Moscow, Russian Federation

Kidney transplantation (KT) is the treatment of choice for patients with end-stage renal disease (ESRD), offering superior survival and quality of life compared with dialysis. Several observational studies have investigated the influence of hemodialysis (HD) and peritoneal dialysis (PD) on post-transplant outcomes. **Objective:** to assess the effect of dialysis modality prior to KT on outcomes during the first two years after transplantation. **Materials and methods.** The study included 95 KT recipients, divided into two groups: (1) patients previously treated with PD (n = 45) and (2) patients previously treated with HD (n = 50). The groups were comparable in age, dialysis duration, and immunosuppressive therapy regimens. The mean follow-up period was 19.4 ± 6.4 months. **Results.** Delayed graft function (DGF) occurred less frequently in the PD group (17.8%) compared with the HD group (34%), although the difference did not reach statistical significance (p = 0.08). Patients in the HD group required significantly more rehospitalizations, with a median of 2.24 [1–3] compared to 1.9 [0–2.5] in the PD group (p = 0.01). Infectious complications were also more common among HD patients (62% *vs* 42%, p = 0.005). In particular, bacterial infections occurred significantly more often in the HD group (63% *vs* 43%, p = 0.0001), whereas viral and fungal infections were detected at similar frequencies in both groups (p > 0.2). The incidence of graft rejection was comparable between groups. Two-year graft survival (91% in PD *vs* 94% in HD, p = 0.8) and patient survival (94% in PD *vs* 96% in HD, p = 0.9) did not differ significantly. Likewise, serum creatinine and daily proteinuria at the end of follow-up showed no statistically significant differences (p = 0.7 and p = 0.3, respectively). **Conclusion.** In this study, patients who received PD prior to transplantation showed more favorable post-transplant outcomes, including a significantly lower frequency of rehospitalizations and infectious complications, as well as a trend toward reduced DGF. However, two-year graft and patient survival were similar between the PD and HD groups.

*Keywords: kidney transplantation, peritoneal dialysis, hemodialysis.*

## INTRODUCTION

Over the past few decades, the number of patients with end-stage renal disease (ESRD) requiring renal replacement therapy (RRT) has increased substantially [1]. Kidney transplantation (KT) remains the preferred treatment option for patients with ESRD, as it offers significant benefits in terms of improved life expectancy, quality of life, and reduced healthcare costs [2].

However, most patients with ESRD do not undergo pre-dialysis KT due to donor organ shortages, delayed referral to nephrologists, and persistent medical and financial barriers. Consequently, initiation of dialysis therapy becomes necessary. Despite extensive research, the relative advantages and disadvantages of different dialysis modalities and their influence on post-transplant outcomes remain subjects of ongoing debate. Because randomized controlled trials comparing dialysis modalities are difficult to conduct, numerous observational studies have investigated the association between hemodialysis (HD) and peritoneal dialysis (PD) with post-transplant outcomes [3–9]. Yet, the results of these studies remain inconclusive.

The majority of published data suggest clinical equivalence between the two dialysis modalities with respect to both short-term outcomes (such as graft function and early complications) and long-term outcomes (including patient survival and cardiovascular events) following KT.

The present study aimed to evaluate the impact of dialysis modality on outcomes during the first two years of the post-transplant period. This paper reports the initial findings obtained within the framework of a new scientific and practical healthcare project, “Application of innovative approaches to extending the donor kidney waiting list, preparing patients for transplantation (including those with thrombotic microangiopathy [TMA]), and managing recipients in the early post-transplant period”.

**Corresponding author:** Ekaterina Ivanova. Address: 3, Pekhotnaya str., Moscow, 123182, Russian Federation.
Phone: (499) 196-17-94. E-mail: katerineiv@mail.ru

## MATERIALS AND METHODS

The study included 95 kidney transplant recipients, 54 men and 41 women, aged 21 to 73 years (mean age: 45.2 ± 12.0 years), who underwent KT between January 2021 and June 2022 and were subsequently followed up at the Moscow Research and Clinical Center of Kidney Transplant Nephrology and Pathology, Municipal Clinical Hospital No. 52.

Exclusion criteria were: repeat kidney transplantation, combined organ transplantation (kidney plus another organ), RRT exceeding 5 years, and conversion between PD and HD.

All patients were stratified into two groups according to the type of RRT prior to transplantation: PD group (45 patients) and HD group (50 patients). In the HD group, the proportion of men was significantly higher than in the PD group (68% vs. 44%, p = 0.02). There were no significant differences between the groups regarding age at transplantation: 45.3 ± 11.9 years in the PD group versus 45.1 ± 12.2 years in the HD group (p = 0.9) (Table 1).

Similarly, the groups did not differ in the duration of RRT prior to KT or in induction and maintenance immunosuppressive therapy (IST). RRT lasted for 15.3 [5.7; 24.9] months in the PD group and 21.6 [9.3; 39.1] months in the HD group (p = 0.08).

Most patients received basiliximab as induction IST (PD – 93%, HD – 94%). All patients were treated with standard triple-drug maintenance IST consisting of a corticosteroid, a calcineurin inhibitor (CNI), and either mycophenolic acid or everolimus. Tacrolimus was the predominant CNI used (PD – 93%, HD – 92%, p = 0.8). Mycophenolic acid was prescribed to all patients in the PD group and to 98% of those in the HD group (p = 0.3), while 2% of HD patients received everolimus instead.

The average follow-up period for patients was 19.4 ± 6.4 months. The study evaluated the frequency of primary and delayed KT function, rehospitalizations, infectious complications, KT rejection, serum creatinine levels, and daily proteinuria (DPU) at the end of the follow-up period. Primary KT function was defined as the absence of a need for dialysis after transplantation, whereas delayed KT function was defined as the requirement for dialysis within 7 days post-transplant.

All patient readmissions following the initial hospitalization for KT were analyzed, excluding those associated with routine procedures such as removal of the PD catheter, removal of the tunneled central venous catheter, removal of the KT ureteral stent, ligation of the arteriovenous fistula, and routine ophthalmologic or gynecologic surgeries.

Infectious complications were included only when they required hospitalization for treatment. KT rejection was considered only in histologically confirmed cases. Kidney graft function was assessed by serum creatinine levels and DPU at the end of the follow-up period.

Statistical analysis was conducted using IBM SPSS Statistics, version 23. Quantitative data were expressed as mean ± standard deviation for normally distributed variables or as median and percentiles for non-normally distributed data. For frequency comparisons between two independent samples, Fisher's exact test was applied to nominal data, and the Mann–Whitney U test was used for quantitative data. Patient and graft survival were analyzed using the Kaplan–Meier method.

## RESULTS

Analysis of the initial KT function revealed delayed graft function in 8 patients (17.8%) in the PD group and 17 patients (34%) in the HD group (p = 0.08). Patients in the HD group required significantly more frequent hospitalizations during the follow-up period. The median number of readmissions in this group was 2.24 [1; 3], compared to 1.9 [0; 2.5] in the PD group (p = 0.01). The complete spectrum of hospitalization causes is presented in Table 2.

Infections were the most common cause of hospitalization. These occurred significantly more often in the HD group than in the PD group – 69 hospitalizations (63%) versus 28 hospitalizations (46%), respectively

Table 1

**Clinical and demographic characteristics of patients in the PD and HD groups**

| | PD group (n = 45) | HD group (n = 50) | p |
|---|---|---|---|
| Gender, male, n (%) | 20 (44%) | 34 (68%) | 0.02* |
| Age at transplantation, years | 45.3 ± 11.9 | 45.1 ± 12.2 | 0.9 |
| Duration of RRT prior to KT, months | 15.3 [5.7; 24.9] | 21.6 [9.3; 39.1] | 0.08 |
| Induction IST:<br>Methylprednisolone, n (%)<br>Basiliximab, n (%)<br>Antithymocyte globulin, n (%) | <br>3 (7%)<br>42 (93%)<br>0 | <br>0<br>47 (94%)<br>3 (6%) | <br>>0.8<br>>0.8<br>>0.8 |
| Baseline IST:<br>Tacrolimus, n (%)<br>Mycophenolate mofetil, n (%) | <br>42 (93%)<br>45 (100%) | <br>46 (92%)<br>49 (98%) | <br>0.8<br>0.3 |

*, statistically significant differences.

(p = 0.005). Bacterial infections were considerably more frequent in the HD group, with 43 episodes (63%) compared to 12 episodes (43%) in the PD group (p = 0.0001) (Fig. 1a). Viral infections were slightly more common among PD patients (14 cases, 50%) compared to HD patients (20 cases, 29%), though the difference was not statistically significant (p = 0.5). Fungal infections occurred with similar frequency in both groups: 2 cases (7%) in the PD group and 6 cases (8%) in the HD group (p = 0.2).

When analyzing the etiological structure of infectious complications, the most frequent conditions were KT pyelonephritis, pneumonia, COVID-19, and cytomegalovirus (CMV) infection (Fig. 1b). KT pyelonephritis occurred more often in the HD group – 31 cases (45%) versus 6 cases (21%) in the PD group – although this difference did not reach statistical significance (p = 0.058). Pneumonia was likewise more common among HD patients, with 12 episodes (17%) compared to 2 episodes (7%) in the PD group (p = 0.09). COVID-19-related hospitalizations occurred at similar frequencies in both groups: 7 cases (25%) in the PD group and 18 cases (26%) in the HD group (p = 0.9). The incidence of CMV infection was slightly higher in PD patients (5 cases, 18%) compared to HD patients (5 cases, 7%) (p = 0.8).

KT biopsy accounted for 17 hospitalizations (28%) in the PD group and 17 (15%) in the HD group (p = 0.9), with some patients requiring repeat biopsies. The spectrum of KT pathology identified is presented in Fig. 2. In some cases, multiple pathological findings were detected in a single biopsy specimen.

There were no significant differences between groups in the frequency of rejection episodes. Cellular rejection was diagnosed in 3 PD patients and 5 HD patients; antibody-mediated rejection occurred in 1 HD patient; and mixed rejection was identified in 2 PD patients and 2 HD patients. Interstitial fibrosis and tubular atrophy were the most common histological findings, observed in 8 PD patients and 7 HD patients. Acute tubular necrosis occurred with similar frequency in both groups (5 and 4 cases, respectively). Less frequent diagnoses included CNI toxicity, BK virus nephropathy, hypertensive arteriolar nephrosclerosis, and IgA nephropathy.

Surgical interventions were performed 8 times (13%) in patients from the PD group and 8 times (7%) in patients from the HD group (p = 0.8). Among the surgical causes of hospitalization, the most frequent procedu-

Table 2

**Causes of hospitalization in the PD and HD groups**

| Cause of hospitalization | PD group (61 hospitalizations) | HD group (110 hospitalizations) | p |
|---|---|---|---|
| Infections, n (%) | 28 (46%) | 69 (63%) | 0.005* |
| KT biopsy, n (%) | 17 (28%) | 17 (15%) | 0.9 |
| Surgery, n (%) | 8 (13%) | 8 (7%) | 0.8 |
| Cardiovascular disease (CVD), n (%) | 3 (5%) | 4 (4%) | 0.9 |
| Others, n (%) | 5 (8%) | 12 (11%) | 0.1 |
| Total, n (%) | 61 (100%) | 110 (100%) | 0.01* |

*, statistically significant differences.

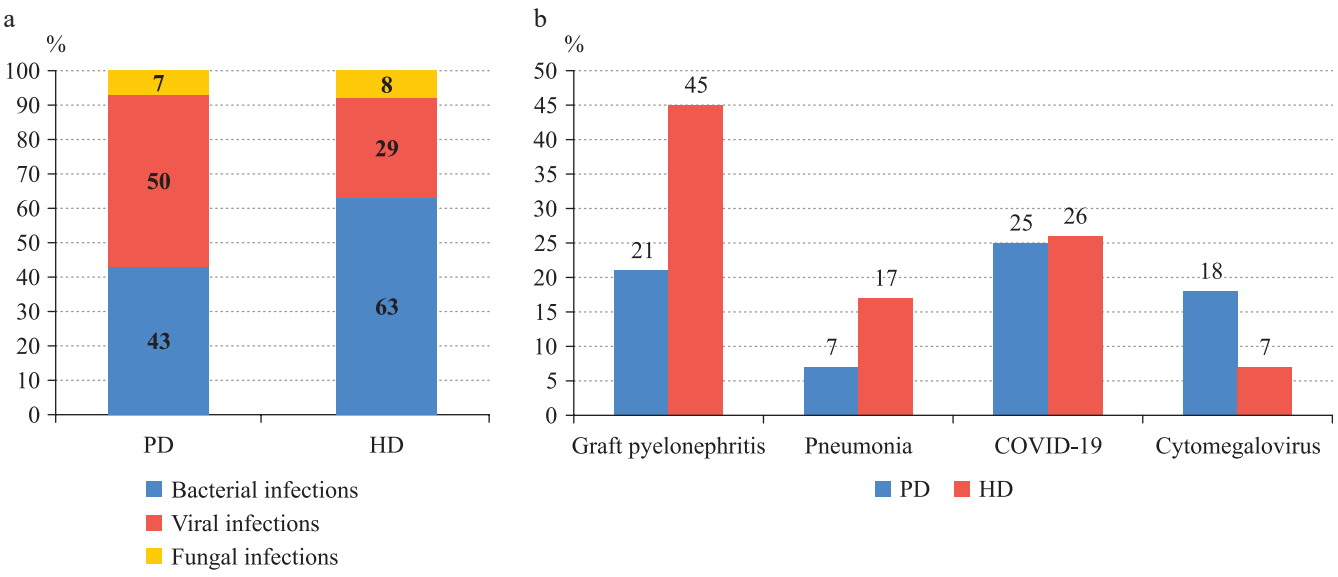


Fig. 1. Infectious complications in PD and HD patients: a, by etiological factor; b, by disease

res were balloon angioplasty (BA) and stenting of the transplant renal artery (TRA), performed in 4 patients from the PD group and 2 patients from the HD group. Percutaneous nephrostomy (PCN) of the transplant was required in 1 patient from the PD group and 3 patients from the HD group. Less common interventions included herniotomy for postoperative hernia, nephrectomy of the native kidneys, and excision of postoperative scar tissue (Fig. 3).

Hospitalizations due to cardiovascular diseases (CVD) occurred with comparable frequency in both the PD and HD groups (Fig. 4). In the HD group, there were two hospitalizations for stroke and its sequelae, one for acute myocardial infarction (AMI), and one for coronary artery disease (CAD) with atrial fibrillation (AF). In the PD group, three hospitalizations due to stroke associated with AMI, myocardial ischemia (MI), and AF.

The two-year KT survival rate was 91% in the PD group and 94% in the HD group (p = 0.8) (Fig. 5a). Causes of graft loss in the PD group included primary non-functioning graft, antibody-mediated rejection (AMR), and BK virus nephropathy. In the HD group, graft loss was primarily associated with primary non-functioning graft, AMR, and KT pyelonephritis complicated by urosepsis.

At the end of the follow-up period, no statistically significant differences were found between the groups in serum creatinine levels or daily proteinuria (DPU) (Fig. 6). The median serum creatinine level in the PD group was 144 [115; 190] μmol/L, compared with 138 [115; 171] μmol/L in the HD group (p = 0.7). Median DPU values were 0.09 [0.02; 0.1] g/day in the PD group and 0.1 [0.02; 0.2] g/day in the HD group (p = 0.3).

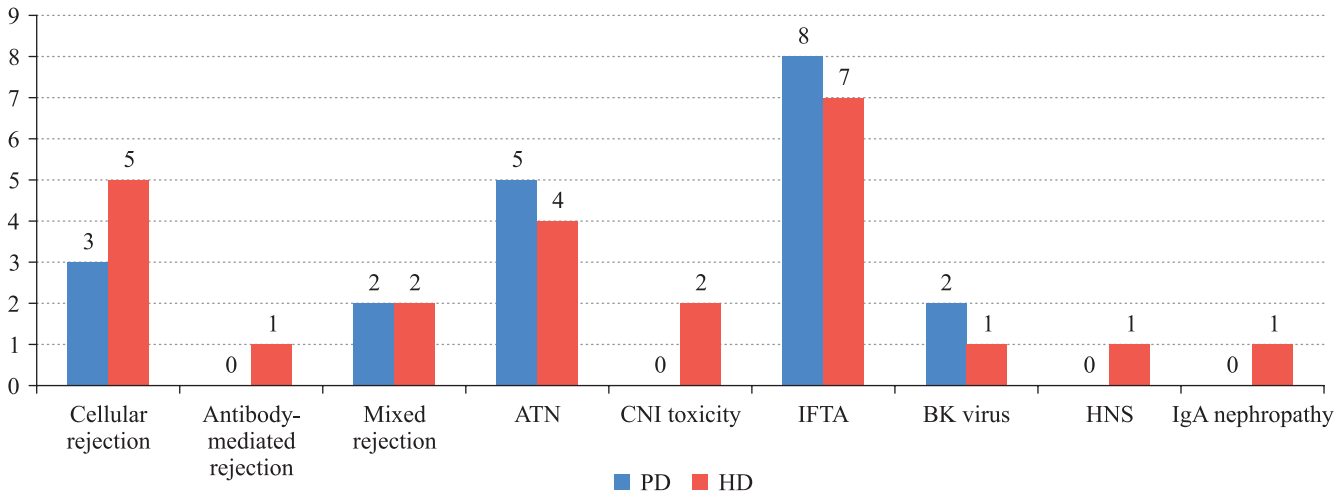


Fig. 2. Results of KT biopsy in the PD and HD groups. ATN, acute tubular necrosis; CNI toxicity, calcineurin inhibitor toxicity; IFTA, interstitial fibrosis and tubular atrophy; BK, BK viral infection; HNS, Hypertensive arteriolar nephrosclerosis

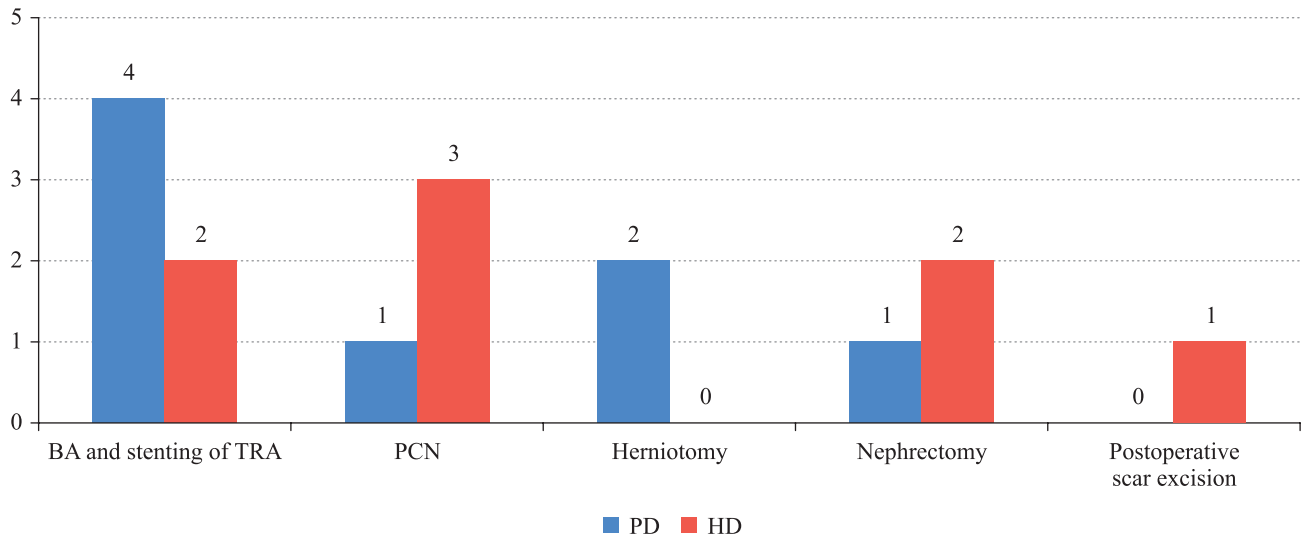


Fig. 3. Reason for surgical interventions in the PD and GD groups. Abbreviations: BA, balloon angioplasty; TRA, transplant renal artery; PCN, percutaneous nephrostomy; HD, hemodialysis; PD, peritoneal dialysis

The two-year patient survival rate did not differ significantly between the PD and HD groups, amounting to 94% and 96%, respectively (p = 0.9) (Fig. 5b). Mortality in the HD group was associated with infectious causes, while in the PD group it was related to CVD. Specifically, deaths in the PD group were due to stroke and AMI, whereas in the HD group they were caused by sepsis secondary to omentobursitis and urosepsis.

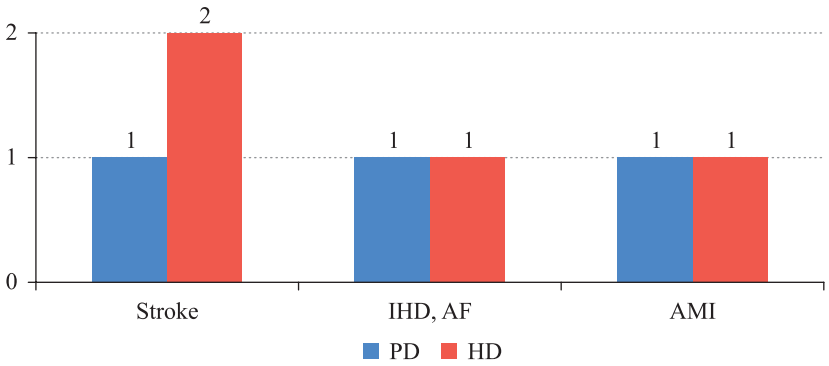


Fig. 4. Causes of hospitalization with cardiovascular disease in PD and HD patients

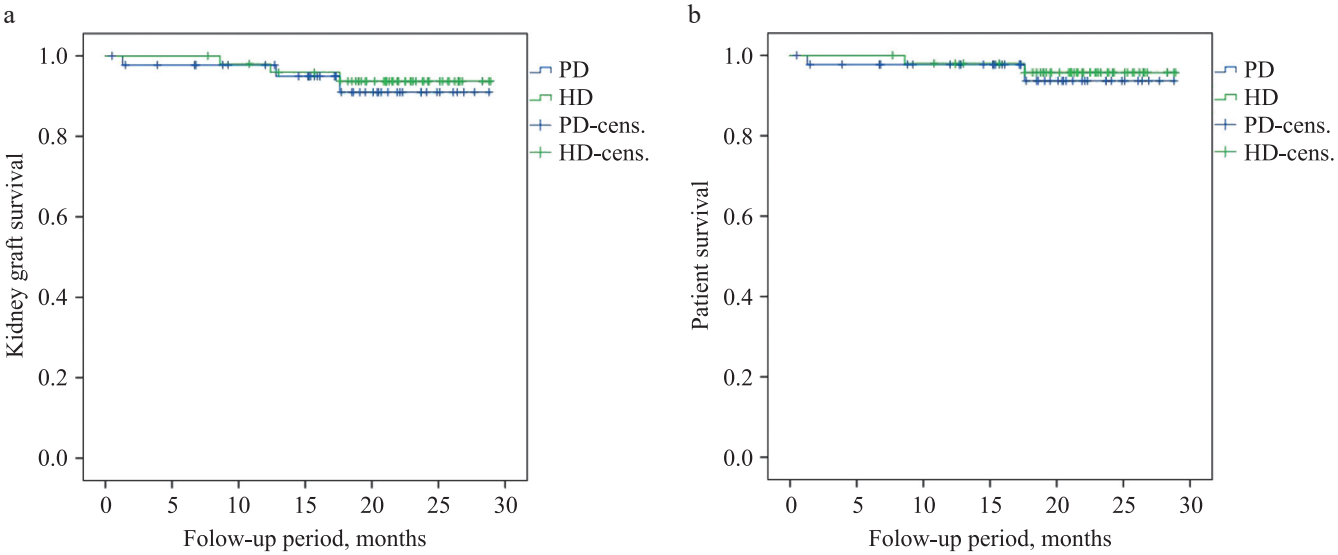


Fig. 5. Two-year survival in PD and HD groups: a, kidney graft survival; b, patient survival

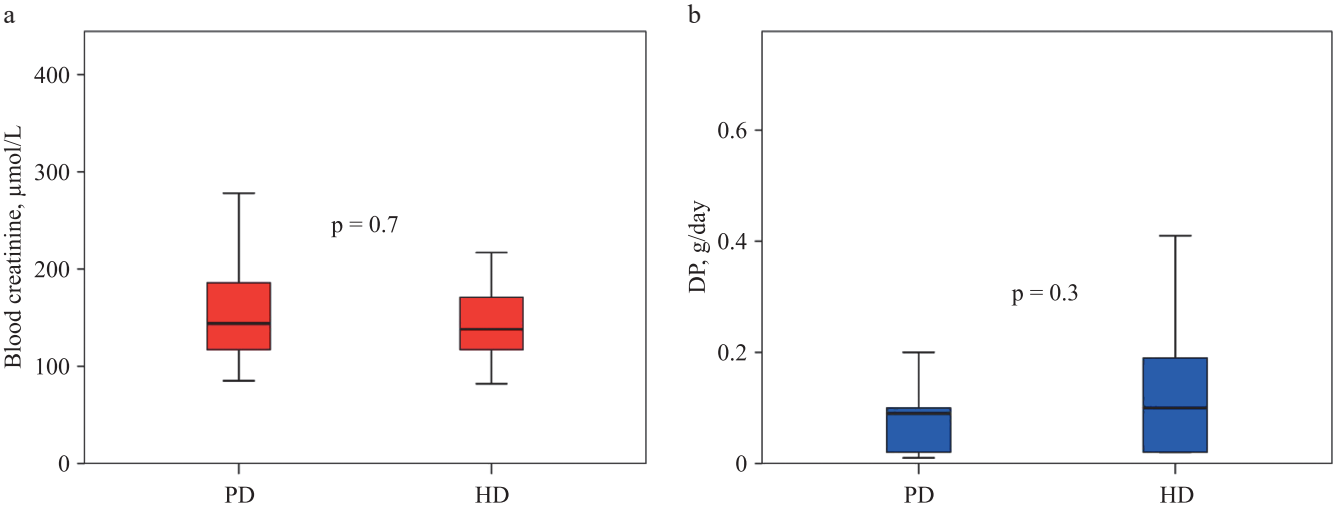


Fig. 6. Levels of (a) blood creatinine and (b) daily proteinuria at the end of follow-up

## DISCUSSION

KT improves both quality of life and overall survival among patients with end-stage renal disease. This study assessed the impact of the type of pretransplant dialysis modality on early post-transplant outcomes, focusing on the first two years after KT, including graft function, postoperative complications, and patient survival.

It is well established that delayed graft function (DGF) is associated with an increased risk of acute rejection and mortality [10, 11]. Most small single-center studies have reported a lower incidence of DGF among patients previously treated with PD compared with HD [12–15], while others have found no significant difference between the two modalities [16–18]. In larger studies using national databases,, Snyder et al. [19] also showed a lower frequency of DGF in the PD group compared with the HD group. Consistent with these findings, our study showed that DGF occurred less frequently in the PD group than in the HD group (17.8% vs. 34%), although the difference did not reach statistical significance ($p = 0.08$).

The reduced risk of delayed KT function observed in PD patients may be down to several factors. One of the most significant is the likelihood of higher residual renal function in PD patients [20, 21]. Furthermore, PD patients are often relatively hypervolemic immediately prior to KT compared to HD patients, which may provide a degree of hemodynamic stability and protection against ischemic injury, thereby reducing the risk of DGF [22, 23]. Another proposed mechanism is less inflammation and oxidative stress due to the biocompatibility of the peritoneum as a kind of peritoneal membrane compared to dialyzer membranes [24, 25].

Most studies have reported no difference in the incidence of infectious complications between PD and HD patients prior to KT [18, 26]. Only one study [5] found that recipients with prior PD had a higher risk of developing peritonitis and urinary tract infections compared with those previously on HD. In contrast, our study demonstrated that infectious complications were more frequent among HD patients. Several factors may explain this finding. HD patients are regularly exposed to larger patient populations within dialysis units, increasing the risk of cross-infection compared to PD patients who perform dialysis at home. Following KT, immunosuppressive therapy further predisposes these patients to reactivation of latent infections. Additionally, HD is associated with greater oxidative stress, as artificial dialysis membranes used in HD can activate complement components and phagocytic leukocytes, leading to enhanced generation of free radicals and a persistent microinflammatory state [27]. The intensity of this oxidative stress tends to decrease gradually within the first year post-transplant.

Conversely, some studies have shown that complement activation capacity is diminished in HD patients relative to healthy controls. This acquired complement protein deficiency may partly account for the increased susceptibility to infection and sepsis observed in HD patients [28]. However, the use of immunosuppressive agents alongside prophylactic antimicrobial therapy during the early post-transplant period may mitigate these differences, resulting in comparable rates of acute rejection, graft survival, infection, and other complications among patients with different pre-transplant dialysis modalities [26].

Vanholder et al. [29] reported a higher rate of acute rejection in patients who received PD prior to KT. They attributed this finding to a potentially greater baseline immunodeficiency among HD patients compared with PD patients. However, several subsequent studies have found no significant difference in rejection rates between the two groups [13, 16, 17]. In a meta-analysis of six studies including 3,283 patients, Tang et al. [25] also found no difference in rejection incidence between PD and HD recipients. Consistent with these findings, our study likewise revealed no difference in the rate of acute rejection between the PD and HD groups.

In the 21st century, multiple large registry-based studies have examined the influence of pre-transplant dialysis modality on graft survival [3, 30, 31]. Initial unadjusted analyses in these studies suggested that pre-transplant PD was associated with a lower frequency of graft loss. However, after applying statistical adjustments for inflammatory and protein-energy malnutrition syndromes and other transplant-related variables using Cox multivariate regression and instrumental variable methods, these differences were no longer significant. The results indicate that the previously observed survival advantage of PD may have been due to baseline differences between patient populations, rather than the dialysis modality itself.

These conclusions are further supported by recent single-center studies, which have consistently demonstrated comparable graft survival between the two groups [4, 18, 32]. Similarly, in our study, two-year graft survival did not differ significantly between PD and HD recipients (91% vs. 94%, $p = 0.8$). In addition, serum creatinine and DPU levels at the end of follow-up were comparable between the two groups.

Several large registry-based studies have reported a survival advantage among patients who underwent PD pre-transplant, showing a reduction in post-transplant mortality compared with those previously treated with HD [3, 4, 30]. However, other studies have found no significant difference in patient survival between the two modalities [5, 19, 31].

Pre-transplant PD may confer certain physiological advantages that persist after KT and contribute to improved outcomes. These include more stable volume and blood pressure control, absence of myocardial stunning, and better preservation of residual renal function, all of which may translate into better cardiovascular outcomes with PD. Nonetheless, results across studies remain inconsistent [33, 34].

In a large registry analysis, Molnar et al. [3] observed lower overall mortality among patients treated with PD pre-transplant, largely attributable to reduced cardiovascular deaths. Similarly, Schwenger et al. [30] reported both lower overall and cardiovascular mortality in recipients with prior PD. In contrast, Kramer et al. [31], who analyzed data from 10,135 PD and 18,953 HD patients using multivariate regression and instrumental variable analysis, found that after statistical adjustment, mortality did not differ between the two groups.

Two meta-analyses published in 2016, combining data from most major studies conducted over the preceding two decades [24, 25], showed better post-transplant survival among patients on pre-transplant PD due to lower cardiovascular mortality, which in turn may be due to better overall health and other factors such as residual kidney function.

In our study, the two-year patient survival following KT did not differ significantly between recipients with prior PD and those with prior HD. Among HD patients, mortality was primarily infection-related, whereas in the PD group, deaths were attributed to CVD. Notably, both PD patients who died had a history of CVD prior to transplantation.

These findings align with results from large meta-analyses, which indicate that the first three months after KT represent a period of elevated mortality risk, predominantly due to cardiovascular events and infections. In the long term, CVD and malignancy remain the leading causes of death among KT recipients [35, 36].

Therefore, it is highly likely that the pre-transplant long-term survival outcomes among PD and HD patients may differ in terms of both causes of mortality and their distribution.

## CONCLUSION

In our study, patients who underwent PD prior to KT had slightly better post-transplant outcomes. Specifically, the PD group showed a significant reduction in the frequency of rehospitalizations and infectious complications, as well as a trend toward a lower incidence of DGF, while no significant differences were observed in graft survival or patient mortality during the first two years following KT. With an increased number of patients and a longer follow-up period, these results may evolve; therefore, continued data collection and ongoing analysis are essential.

*This study was conducted within the framework of the scientific and practical healthcare project of the Moscow Health Department (Application No. 2002-27/23), titled "Application of Innovative Approaches to Expanding the Waiting List for Donor Kidneys, Preparing Patients for Transplantation (Including Patients with Thrombotic Microangiopathy), and Managing Recipients in the Early Post-Transplant Period". The project was financially supported by a grant from the Moscow Center for Innovative Technologies in Healthcare.*

*The authors declare no conflict of interest.*

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