Dialysis Modality and Outcomes in Kidney Transplant Recipients

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Summary

Background and objectives The influence of pretransplant dialysis modality on post-transplant outcomes is not clear. This study examined associations of pretransplant dialysis modality with post-transplant outcomes in a large national cohort of kidney transplant recipients.

Design, setting, participants, & measurements Linking the 5-year patient data of a large dialysis organization to the *Scientific Registry of Transplant Recipients*, 12,416 hemodialysis and 2092 peritoneal dialysis patients who underwent first kidney transplantation were identified. Mortality or graft failure and delayed graft function risks were estimated by Cox regression (hazard ratio) and logistic regression (odds ratio), respectively.

Results Recipients treated with peritoneal dialysis pretransplantation had lower (21.9/1000 patient-years [95% confidence interval: 18.1–26.5]) crude all-cause mortality rate than those recipients treated with hemodialysis (32.8/1000 patient-years [30.8–35.0]). Pretransplant peritoneal dialysis use was associated with 43% lower adjusted all-cause and 66% lower cardiovascular death. Furthermore, pretransplant peritoneal dialysis use was associated with 17% and 36% lower unadjusted death-censored graft failure and delayed graft function risk, respectively. However, after additional adjustment for relevant covariates, pretransplant peritoneal dialysis modality was not a significant predictor of death-censored graft failure delayed graft function, respectively. Similar trends were noted on analyses using a propensity score matched cohort of 2092 pairs of patients.

Conclusions Compared with hemodialysis, patients treated with peritoneal dialysis before transplantation had lower mortality but similar graft loss or delayed graft function. Confounding by residual selection bias cannot be ruled out.

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Introduction

The influence of pretransplant dialysis modality on post-transplant outcomes has been a subject of long-standing interest. However, there are inconsistent data as to whether peritoneal dialysis (PD) patients have better or worse post-transplant outcomes compared with their hemodialysis (HD) counterparts. PD patients in the United States have a 50% higher adjusted odds of receiving a renal transplant compared with HD patients (1). Several studies suggested that pretransplantation dialysis modality affects patients' long-term (such as mortality and graft failure) and short-term (such as delayed graft function) outcomes (2–8). However, others have been unable to show any relationship of pretransplant dialysis modality on post-transplant outcomes (9–12). The two largest studies using national datasets before the 21st century yielded conflicting results. Snyder *et al.* (7) analyzed data of 252,402 patients from 1995 to 1998 and found that mortality risk and long-term graft survival were the same in recipients who had been on PD or HD but that transplantation in PD patients was more frequently associated with early graft failure. Additionally, delayed graft function was less common in PD patients (7). Contrary to this finding, Goldfarb-Rumyantzev *et al.* (6) found that, in a cohort of 92,844 dialysis patients from the 1999 to 2000 period (follow-up through December 31, 2000), HD patients had greater risk for graft failure and recipient death.

There are several compelling reasons to re-examine the association of pretransplant dialysis modality with post-transplant outcomes in a contemporary cohort of kidney transplant recipients with extensive pretransplant data. First, both above-mentioned studies and all others did not account for pretransplantation variables during dialysis treatment (such as obesity, muscle mass, and serum albumin), which have been shown to be associated with post-transplant outcomes (13–15). Second, the previous studies are based on data in the late 20th century when the immunosuppressive protocols and drugs were significantly different (for instance, mycophenolate-mofetil was not available). Third, the most recent studies, analyzing data after 2000, have been rather small and mostly negative (no difference in outcomes), which might be a consequence of the inadequate statistical power

(11,12). Fourth, none of these studies performed subgroup analysis to verify the validity of the associations across diverse subgroups of patients.

We examined associations of pretransplant dialysis modality with post-transplant short- and long-term outcomes in a large national cohort of kidney transplant recipients while accounting for relevant clinical and laboratory data from the dialysis period before transplantation. We hypothesized that PD treatment modality is associated with better post-transplant patient and graft survival and lower risk of delayed graft function (DGF) in a large and contemporary cohort of incident kidney transplant recipients in the United States.

Materials and Methods

Patients

We linked data on all kidney transplant recipients listed in the *Scientific Registry of Transplant Recipients* (SRTR) up to June of 2007 to a list of individuals who underwent maintenance HD or PD treatment from July of 2001 to June of 2006 in one of the outpatient dialysis facilities of a United States-based large dialysis organization (DaVita Inc. before its acquisition of former Gambro dialysis facilities) using patients' Social Security numbers.

Clinical and Demographic Measures

The creation of the national DaVita dialysis patient cohort has been described previously (15–22). Demographic data and details of medical history were collected, with information on age, sex, race, type of insurance, marital status, presence of diabetes, height, body weight (to calculate averaged body mass index), dialysis modality (HD versus PD), and dialysis vintage. Dialysis vintage was defined as the duration of time between the first day of dialysis treatment and the day of kidney transplantation.

Laboratory Measures

Blood samples were drawn using uniform techniques in all of the DaVita dialysis clinics and were transported to the DaVita Laboratory in Deland, Florida, typically within 24 hours. All laboratory values were measured by automated and standardized methods in the DaVita Laboratory. Most laboratory values were measured monthly, including serum urea nitrogen, creatinine, albumin, calcium, phosphorus, bicarbonate, and total iron binding capacity. Serum ferritin and intact parathyroid hormone were measured at least quarterly. Hemoglobin was measured at least monthly in essentially all patients. Most blood samples for HD patients were collected predialysis with the exception of postdialysis serum urea nitrogen to calculate urea kinetics.

Statistical Analyses

Data are summarized using proportions, means (±SD), or medians (interquartile range) as appropriate. Categorical variables were compared using χ^2 test, and continuous variables were compared using t test, Mann–Whitney U test, Kruskal–Wallis H test, or ANOVA as appropriate. Time to event survival analysis using Cox proportional hazards model was used to compare the risk for all-cause and cardiovascular mortality and graft failure (defined as reinitiation of dialysis treatment or retransplantation). Logistic regression analysis was performed to compare the risk for DGF, defined as the need for any dialysis therapy in the first week after transplantation (23). We used the baseline (when patients entered the study cohort) modality in our analysis. In analysis with mortality as the outcome, the patients were followed until event (death) or censoring (graft failure or end of follow-up period), whichever happened first. In the analysis with graft failure as the outcome, the patients were followed until event (graft failure) or censoring (death or end of follow-up period), whichever happened first. In the combined outcome analyses, patients were followed until event (death or graft failure) or censoring (end of follow-up period), whichever happened first.

Propensity scores matched cohort was then built to mitigate the confounding influence of differences in demographic and clinical characteristics of patients treated with PD or HD before transplantation. First, factors that seemed to influence the likelihood of being treated with PD were determined using logistic regression and used to calculate propensity scores (24,25). Supplemental Figure 1 shows the distribution of propensity score in total population (before matching) and matched cohort. Three propensity score strata were also created using the 33rd and 66th percentiles as cutoff points. Additional sensitivity analyses were performed with propensity scores as covariates in the statistical models (Supplemental Table 1).

For each regression analysis, four level of multivariate adjustment were examined. (*1*) An unadjusted model that included only pretransplant modality as the predictor. (*2*) Case mix adjusted models that included the above modality plus age, sex, recipient race/ethnicity (African Americans and other self-categorized blacks, non-Hispanic Whites, Asians, Hispanics, and others), diabetes mellitus, dialysis vintage (<6 months, 6 months to 2 years, 2 to <5 years, and ≥5 years), primary insurance (Medicare, Medicaid, private, and other), marital status (married, single, divorced, widowed, and other or unknown), standardized mortality ratio of the dialysis clinic during entry quarter, and eight comorbidities (atherosclerotic heart disease, congestive heart failure, cancer, chronic obstructive pulmonary disease, cerebrovascular disease, hypertension, peripheral vascular disease, and tobacco use). (*3*) The malnutrition inflammation complex syndrome (MICS) adjusted models that included all of the covariates plus 10 surrogates of nutritional status and inflammation measured during the last calendar quarter before transplantation, including body mass index and nine laboratory variables (*i.e.*, serum or blood concentrations of total iron binding capacity, ferritin, phosphorus, calcium, bicarbonate, peripheral white blood cell count, lymphocyte percentage, albumin, and hemoglobin). (*4*) Case mix, MICS, and transplant data adjusted models included all of the above plus six transplant-related variables: (*1*) donor type (deceased or living), (*2*) donor age, (*3*) donor sex, (*4*) panel reactive antibody titer (last value before transplant), (*5*) number of HLA mismatches, and (*6*) cold ischemia time. All analyses were carried out with STATA version 11.1 (STATA Corporation, College Station, TX).

Results

The 5-year (7/2001 to 6/2006) national database of all DaVita patients included 164,789 adult subjects. Of 65,386

DaVita patients who were identified in the SRTR database, 17,629 had undergone one or more kidney transplantations during their life time, and 14,508 dialysis patients had undergone kidney transplantation for the first time. We examined these 14,508 dialyzed patients (HD: 12,416; PD: 2,092) who underwent a first kidney transplantation during the observation period and who were followed until death, graft failure, loss of follow-up, or survival until June 30, 2007 (Supplemental Figure 2). There were 1016 deaths (7.0%) and 1651 graft failures (11.4%). The median follow-up time was 717 days (IGR = 356–1206 days). The basic characteristics of waitlisted but nontransplanted patients have been described elsewhere (26). Table 1 shows the clinical, demographic, laboratory data, and unadjusted outcomes of the 14,508 transplanted patients. The crude all-cause mortality and cardiovascular mortality, graft loss, and delayed graft function rate were higher in recipients who had been treated with HD than recipients who had been treated with PD. Recipients who had been treated with HD were older, more likely be male and African American, and more likely to have diabetes than those recipients who had been on PD.

The crude all-cause mortality rate for the study cohort was 31.2/1000 patient-years (95% confidence interval [CI]: 29.4–33.2). Recipients who had been on PD had a lower (21.9/1000 patient-years; 95% CI: 18.1–26.5) crude all-cause mortality rate than recipients who had been on HD (32.8/1000 patient-years; 95% CI: 30.8–35.0; $P<0.001$) (Figure 1A). Similar results were found in the propensity scores matched cohort (Figure 2A). The associations of pretransplant dialysis modality with the post-transplant risk of death, graft failure, or the composite of graft failure or death and delayed graft function are shown in Table 2. Compared with pretransplant HD, recipients who had been on PD had 33% (hazard ratio [HR]: 0.67 [0.55–0.82]) lower unadjusted death risk. After additional adjustment for case mix, MICS, and transplant–related variables, pretransplant PD treatment was associated with 43% (HR: 0.57 [0.38–0.87]) lower death risk. Similar results were found in the propensity scores matched cohort (Table 3), as well as in analyses in the entire cohort using models that included propensity scores as covariates (supplemental Table 1). Similar associations were observed in almost all subgroups. Figure 3 shows adjusted HR (and 95% CI) for the association of pretransplant dialysis modality and all-cause mortality in various patient subgroups. Table 4 shows the HR of death using pretransplant modality as the predictor in tertiles of propensity scores. Pretransplant PD was associated with lower death risk in the group with highest likelihood of being treated with PD (HR: 0.56, 95% CI: 0.31–0.99) but not in the intermediate (HR: 0.53, 95% CI: 0.23–1.26) or low (HR: 0.58, 95% CI: 0.21–1.62) likelihood groups.

The crude cardiovascular mortality rate was 8.6/1000 patient-years (95% CI: 7.6–9.6). Recipients who had been on PD had lower (3.5/1000 patient-years; 95% CI: 2.2–5.7) crude cardiovascular mortality rate than recipients who

Table 1. Baseline characteristics of 14,508 dialysis patients who underwent renal transplantation between July of 2001 and June of 2006

	HD	PD	*P* Value
N [%]	12,416 [86]	2092 [14]	N/A
Age (yr)	49±14	44±15	<0.001
Deaths (*n* [crude death rate percent]	911 [7]	105 [5]	<0.001
Cardiovascular deaths (*n*; crude CV death rate percent)	262 [2]	17 [1.0]	<0.001
Graft failure (*n*) [crude graft failure percent]	1446 [12]	205 [10]	0.01
DGF (*n*) [crude DFG percent]	2478 [21]	292 [15]	<0.001
Sex (percent women)	4731 [38]	990 [47]	<0.001
Race (percent African-American)	3262 [28]	415 [21]	<0.001
Diabetes mellitus (%)	4466 [36]	560 [27]	<0.001
BMI (kg/m^2)	27±6	26±6	<0.001
Dialysis vintage (%)			
0–6 mo	12	11	0.42
6–24 mo	28	35	<0.001
2–5 yr	36	38	0.17
>5 yr	24	16	<0.001
Serum creatinine (mg/dl)	10.5±3.2	10.8±4.0	0.002
Blood hemoglobin (g/dl)	12.2±1.3	12.2±1.5	0.36
WBC ($\times 10^3/L$)	6.9±2.1	7.3±2.3	<0.001
Number of HLA mismatch	3.6±1.8	3.5±1.8	0.05
PRA (%)	10±24	10±24	0.96
Donor age (yr)	39±15	38±15	<0.001
Donor type (percent living)	33	36	0.02
EDC kidney (%)	19	16	0.02
Cold ischemia time (h)	14±10	13±9	0.003

Values in parentheses represent the proportion of the dialyzed patients in PD and HD categories. Values in brackets indicate the crude death rate or crude graft failure rate in the indicated group during the 6 years of observation. HD, pretransplant treatment with maintenance hemodialysis; PD, pretransplant treatment with peritoneal dialysis; N/A, not applicable; CV, cardiovascular; DGF, delayed graft function; BMI, body mass index; WBC, white blood cell count; PRA, panel reactive antibody (last value before transplant); EDC, extended donor criteria.

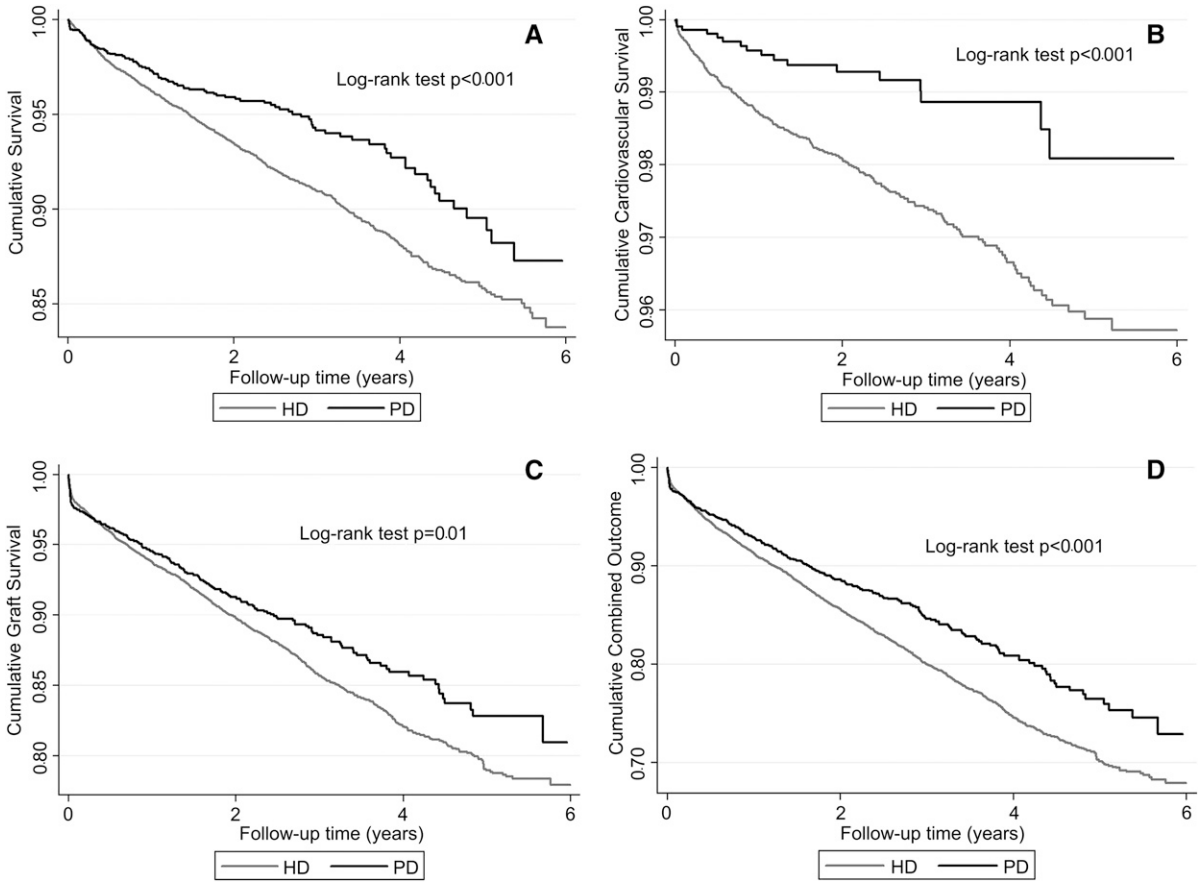

Figure 1. | Association of pretransplant dialysis modality with post-transplant outcomes in the entire study cohort. Kaplan–Meier plots showing unadjusted association between dialysis modality and all-cause mortality (A), cardiovascular mortality (B), death-censored graft loss (C), and combined outcome (D) in 14,508 kidney transplant recipients.

had been on HD (9.4/1000 patient-years; 95% CI: 8.4–10.7; $P<0.001$) (Figure 1B). Similar results were found in the propensity scores matched cohort (Figure 2B). Compared with recipients that had been on HD, recipients with pretransplant PD had 62% (HR: 0.38 [0.23–0.62]) lower unadjusted cardiovascular death risk. After additional adjustment for case mix, MICS, and transplant–related variables, pretransplant PD modality remained an independent and significant predictor of lower cardiovascular mortality (HR: 0.34 [0.14–0.88]). A similar result was found in the propensity scores matched cohort (Table 3), as well as in analyses in the entire cohort using models that included propensity scores as covariates (Supplemental Table 1).

The crude graft failure rate was 50.7/1000 patient-years (95% CI: 48.3–53.2). Pretransplant PD treatment was associated with lower (42.8/1000 patient-years; 95% CI: 37.3–49.1) crude graft failure rate than pretransplant HD (52.1/1000 patient-years; 95% CI: 49.5–54.6; $P=0.01$) (Figure 1C). Similar results were found in the propensity scores matched analyses (Figure 2C). Compared with recipients who had been on HD, pretransplant PD was associated with 17% (HR: 0.83 [0.71–0.96]) lower unadjusted death-censored graft failure risk (Supplemental Figure 3). After additional adjustment for case mix, MICS, and transplant-related variables, PD modality was no longer an independent predictor of death-centered graft failure (HR: 1.08 [0.79–1.47]). A similar result was found in the propensity scores matched cohort (Table 3).

The crude combined outcome rate was 73.7/1000 patient-years (95% CI: 70.8–76.7). Pretransplant PD treatment was associated with lower (58.6/1000 patient-years; 95% CI: 52.2–65.9) crude combined outcome rate than treatment with HD (76.2/1000 patient-years; 95% CI: 73.1–79.6; $P<0.001$) (Figure 1D). Similar results were found in the propensity scores matched cohort (Figure 2D). Compared with recipients who had been on HD, recipients who had been on PD had 23% (HR: 0.77 [0.68–0.87]) lower unadjusted risk of combined outcome. After additional adjustment for case mix, MICS, and transplant-related variables, pretransplant PD modality was no longer an independent predictor of combined outcome (HR: 0.95 [0.74–1.23]) (Supplemental Figure 4). A similar result was found in the propensity scores matched cohort (Table 3). In subgroup of patients with hemoglobin between 12 and 13 g/dl, pretransplant PD was a protective factor against reaching the combined outcome (Supplemental Figure 4).

Compared with recipients who had been on HD, pretransplant PD was associated with 36% (OR: 0.64 [0.56–0.73]) lower unadjusted risk of DGF. After additional adjustment for case mix, MICS, and transplant-related variables, PD modality was no longer an independent predictor of DGF (OR: 0.92 [0.73–1.16]) (Supplemental Figure 5). A similar

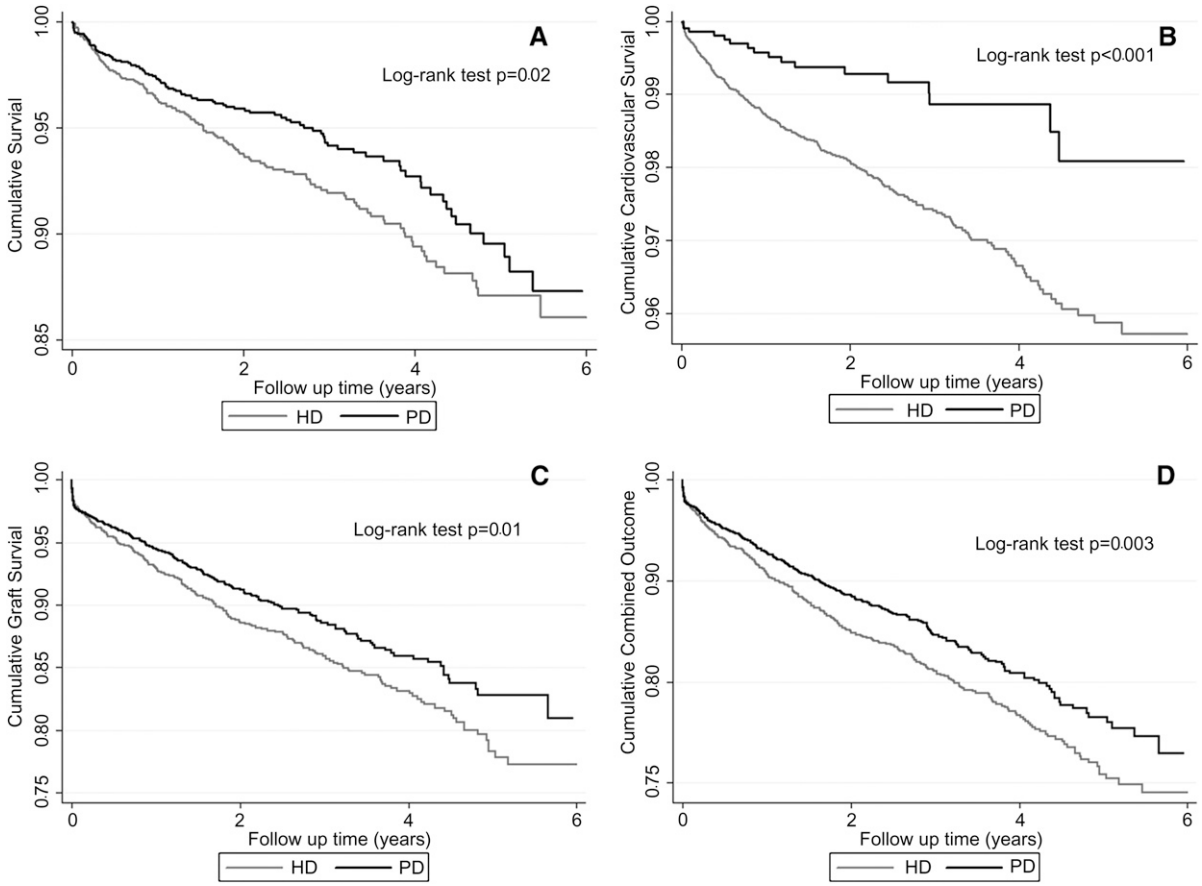

Figure 2. | Association of pretransplant dialysis modality with post-transplant outcomes in the propensity scores matched cohort. Unadjusted association between dialysis modality and all-cause mortality (A), cardiovascular mortality (B), death-censored graft loss (C), and combined outcome (D) according to Kaplan–Meier analysis in 4184 propensity score 1:1–matched patients (pretransplant PD treatment, 2092; pretransplant HD treatment, 2092) who underwent renal transplantation.

result was found in the propensity scores matched cohort (Table 3). In a subgroup of patients with hemoglobin between 12 and 13 g/dl, being on PD was a protective factor against DGF (Supplemental Figure 5).

Discussion

In 14,508 kidney transplant recipients with comprehensive pretransplant data during dialysis treatment who were followed for up to 6 years post-transplantation, pretransplant treatment with PD was associated with lower all-cause and cardiovascular mortality. However, there was no significant difference in the risk of graft failure or DGF.

We found that pretransplant treatment with PD was associated with 43% and 66% lower all-cause and cardiovascular mortality risk, respectively. A large number of studies have examined the relationship of dialysis modality to patient survival with or without transplantation (1,27,28). Although there is no significant difference in 5-year survival of patients in contemporary cohorts, many of the earlier studies have shown a lower risk for death in the first 1–3 years after the start of dialysis. This finding has been attributed to better preservation of native renal function (29). It is possible, although not known, that PD patients may have greater native renal function at the time of transplantation, accounting for the lower risk for death after transplantation. Furthermore, PD patients are healthier than patients treated with HD, and multivariate adjustment may have been insufficient to account for the differences in health (residual confounding).

Prior studies comparing the association of different pretransplant dialysis modalities with transplantation outcomes were based on small patient populations (3,30), evaluated short- rather than long-term outcomes (3,5,31,32), and pertained to cohorts of 15–25 years ago before significant changes in immunosuppressive regimens. Most of these studies examined only graft outcome but not patient survival. To the best of our knowledge, only two large observational studies have been published using national datasets. Both of them used data of subjects treated before 2000 (6,7). Snyder *et al.* (7) determined the association of pretransplant dialysis modality with post-transplant outcomes in 22,776 Medicare beneficiaries and found that, compared with pretransplantation HD therapy, death-censored graft failure was 15% higher in PD patients. Compared with our analysis, the follow-up period of the cohort in the study by Snyder *et al.* (7) was shorter, the study belonged to a previous time period (1995–1998), and the investigators did not have access to the extensive pretransplant laboratory data that we did. Moreover, some

Table 2. Hazard ratio (95% confidence intervals) of post-transplant death (all-cause or cardiovascular) or graft failure or delayed graft function for peritoneal dialysis patients compared with hemodialysis patients (reference) in 14,508 dialysis patients who underwent renal transplantation and were followed for up to 6 yr (7/2001 to 6/2007)

	Minimally Adjusted		+Case Mix Adjusted[a]		+MICS Adjusted[b]		+Transplant Data Adjusted[c]	
	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
Graft failure censored all-cause death	0.67 (0.55–0.82)	<0.001	0.86 (0.69–1.06)	0.15	0.58 (0.39–0.85)	0.006	0.57 (0.38–0.87)	0.009
Graft failure censored cardiovascular death	0.38 (0.23–0.62)	<0.001	0.52 (0.31–0.85)	0.01	0.33 (0.13–0.84)	0.02	0.34 (0.14–0.88)	0.03
Death censored graft failure	0.83 (0.71–0.96)	0.01	0.93 (0.80–1.09)	0.37	1.21 (0.93–1.56)	0.15	1.08 (0.79–1.47)	0.63
Combined all-cause death or graft failure	0.77 (0.68–0.87)	<0.001	0.91 (0.80–1.04)	0.17	1.03 (0.83–1.29)	0.76	0.95 (0.74–1.23)	0.70
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Delayed graft function	0.64 (0.56–0.73)	<0.001	0.74 (0.64–0.85)	<0.001	0.89 (0.72–1.11)	0.31	0.92 (0.73–1.16)	0.48

MICS, Malnutrition inflammation complex syndrome; HR, hazard ratio; OR, odds ratio.

[a]Case mix adjusted models adjusted for age, sex, recipient race/ethnicity, diabetes mellitus, dialysis vintage, primary insurance, marital status, standardized mortality ratio of the dialysis clinic during entry quarter, and eight comorbidities (atherosclerotic heart disease, congestive heart failure, cancer, chronic obstructive pulmonary disease, cerebrovascular disease, hypertension, peripheral vascular disease, and tobacco use).

[b]Malnutrition inflammation complex syndrome adjusted models included all of the covariates plus 10 surrogates of nutritional status and inflammation measured during the last calendar quarter before transplantation including body mass index (BMI) and nine laboratory variables: serum or blood concentrations of total iron binding capacity, ferritin, phosphorus, calcium, bicarbonate, peripheral white blood cell count (WBC), lymphocyte percentage, albumin, and hemoglobin.

[c]Case mix, malnutrition inflammation complex syndrome, and transplant data adjusted models included all of the above plus donor type, donor age, donor sex, panel reactive antibody (PRA) titer (last value before transplant), number of HLA mismatches, and cold ischemia time.

Table 3. Hazard ratio (95% confidence intervals) of post-transplant death (all-cause or cardiovascular) or graft failure or delayed graft function for peritoneal dialysis patients (*n* = 2092) compared with a 1:1 propensity scores matched cohort of hemodialysis patients (*n* = 2092; reference) who underwent renal transplantation and were followed for up to 6 yr (7/2001 to 6/2007)

	Minimally Adjusted		+Case Mix Adjusted[a]		+MICS Adjusted[b]		+Transplant Data Adjusted[c]	
	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
Graft failure censored all-cause death	0.74 (0.58–0.95)	0.02	0.71 (0.54–0.92)	0.01	0.52 (0.33–0.84)	0.008	0.56 (0.33–0.94)	0.03
Graft failure censored cardiovascular death	0.37 (0.21–0.64)	<0.001	0.37 (0.21–0.65)	0.001	0.26 (0.09–0.75)	0.01	0.32 (0.11–0.95)	0.04
Death censored graft failure	0.79 (0.66–0.95)	0.01	0.81 (0.67–0.98)	0.03	1.18 (0.85–1.63)	0.32	0.98 (0.66–1.45)	0.90
Combined all-cause death or graft failure	0.79 (0.68–0.92)	0.003	0.80 (0.68–0.94)	0.008	1.05 (0.80–1.38)	0.73	0.91 (0.66–1.26)	0.58
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Delayed graft function	0.69 (0.58–0.81)	<0.001	0.66 (0.55–0.79)	<0.001	0.81 (0.61–1.07)	0.14	0.82 (0.60–1.13)	0.23

MICS, Malnutrition inflammation complex syndrome; HR, hazard ratio; OR, odds ratio.

[a]Case mix adjusted models adjusted for age, sex, recipient race/ethnicity, diabetes mellitus, dialysis vintage, primary insurance, marital status, standardized mortality ratio of the dialysis clinic during entry quarter, and eight comorbidities (atherosclerotic heart disease, congestive heart failure, cancer, chronic obstructive pulmonary disease, cerebrovascular disease, hypertension, peripheral vascular disease, and tobacco use).

[b]Malnutrition inflammation complex syndrome adjusted models included all of the covariates plus 10 surrogates of nutritional status and inflammation measured during the last calendar quarter before transplantation including body mass index (BMI) and nine laboratory variables: serum or blood concentrations of total iron binding capacity, ferritin, phosphorus, calcium, bicarbonate, peripheral white blood cell count (WBC), lymphocyte percentage, albumin, and hemoglobin.

[c]Case mix, malnutrition inflammation complex syndrome, and transplant data adjusted models included all of the above plus donor type, donor age, donor sex, panel reactive antibody (PRA) titer (last value before transplant), number of HLA mismatches, and cold ischemia time.

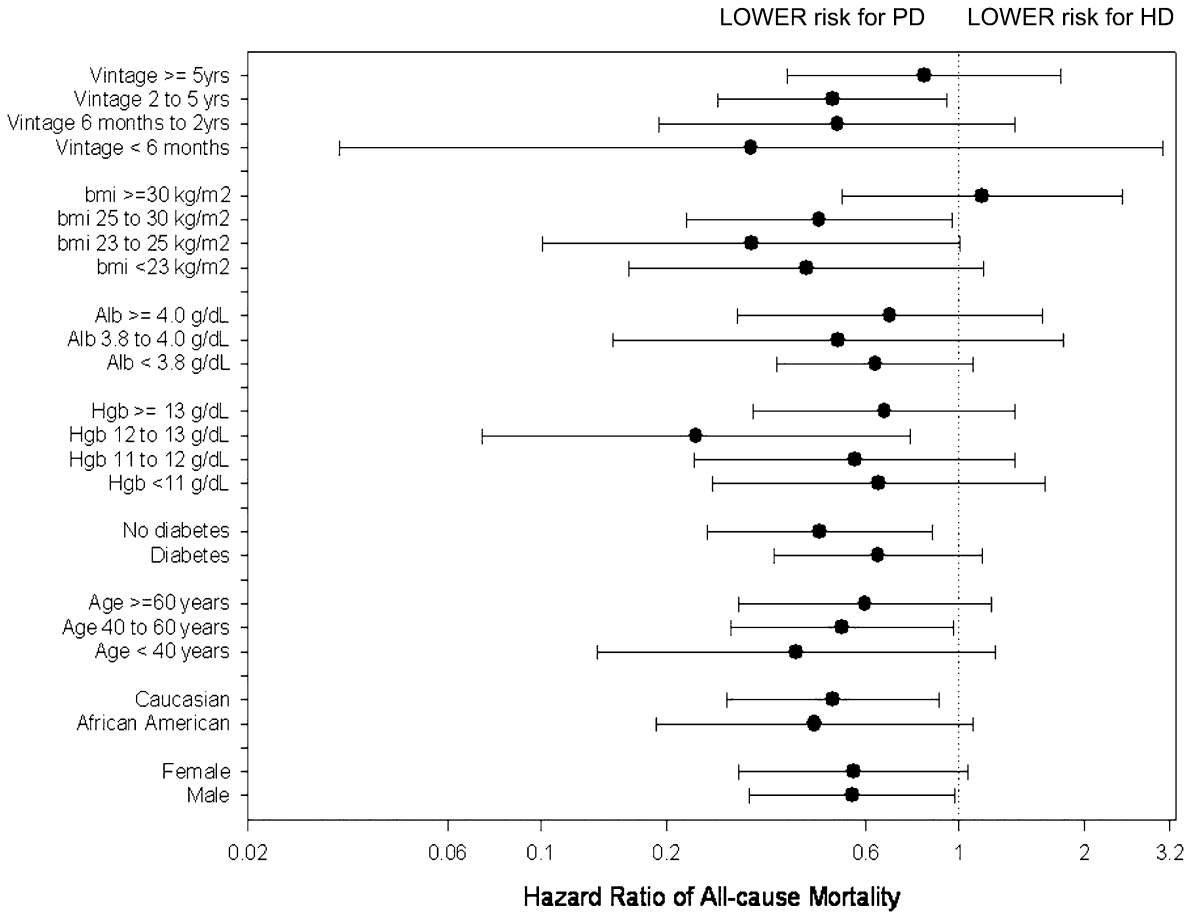

Figure 3. | HR (and 95% CI as error bars) of all-cause mortality of patients treated with PD before transplantation compared with patients treated with HD (reference) in a different subgroup of patients using multivariate fully adjusted (case mix, MICS, and transplant covariates) Cox regression models.

baseline characteristics of the study population were somewhat different in that the study by Snyder *et al.* (7) included more patients with diabetes and women. These facts and the different immunosuppressive regimens may account for the differences in results. Goldfarb-Rumyantzev *et al.* (6) studied allograft and recipient survival by using US Renal Data System records from January 1, 1990, to December 31, 1999, with a follow-up through December 31, 2000. They found that pretransplant treatment with HD was associated with increased risks for graft failure and recipient death (6). Compared with our analysis, the study by Goldfarb-Rumyantzev *et al.* (6) used a larger number of patients, and some baseline characteristics of the study population were different from our study (*i.e.*, they included individuals with a history of previous transplantations). Consistent with our findings, they also found that pretransplant HD treatment was associated with increased risk of recipient death. Although we were unable to show any association between pretransplant dialysis modality and graft failure, these other investigators reported that pretransplant HD treatment was associated with higher risk for graft failure (6). The different population and immunosuppressive regimen may explain the differences in results. We are not aware of any published studies of large ESRD cohorts in the 21st century when the immunosuppressive regimen has been considerably different, including use of mycophenolate-mofetil or rapamycin, greater use of induction therapy, and increasing use of steroid-free regimens.

Our study should be qualified for several potential limitations. Like all observational studies, associations do not prove causality. Post-transplant laboratory values and immunosuppressive and other medical regimens were not available in the SRTR database, but we did adjust for a number of transplant-related variables. Generalizability may be somewhat limited given the lower proportion of patients with diabetes and the exclusion of retransplanted patients in our cohort compared with the entire United States transplant population. However, the transplant selection characteristics were similar to other large nationwide studies. Moreover, the mortality and transplant rates among PD and HD patients are similar between patients treated in DaVita facilities and those rates report by the US Renal Data System for the entire United States dialysis population (33). Our study extends the observations from older cohorts to more contemporary population using robust adjustment for potential covariates. Another potential weakness of our study is the relatively short follow-up

Table 4. Hazard ratio of post-transplant all-cause death in tertiles of propensity scores for the odds of having been treated with peritoneal dialysis in the pretransplant period

Propensity scores tertiles	Minimally Adjusted		+Case Mix Adjusted[a]		+MICS Adjusted[b]		+Transplant Data Adjusted[c]	
	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
Low likelihood of being PD (n = 4836)	0.54 (0.31–0.93)	0.03	0.68 (0.38–1.21)	0.19	0.51 (0.18–1.41)	0.19	0.58 (0.21–1.62)	0.30
Moderate likelihood of being PD (n = 4836)	0.58 (0.38–0.89)	0.01	0.65 (0.42–1.01)	0.06	0.64 (0.32–1.29)	0.22	0.53 (0.23–1.26)	0.15
High likelihood of being PD (n = 4836)	0.91 (0.70–1.19)	0.49	0.79 (0.60–1.05)	0.10	0.52 (0.30–0.90)	0.02	0.56 (0.31–0.99)	0.04

MICS, Malnutrition inflammation complex syndrome; HR, hazard ratio; PD, peritoneal dialysis.

[a]Case mix adjusted models adjusted for age, sex, recipient race/ethnicity, diabetes mellitus, dialysis vintage, primary insurance, marital status, standardized mortality ratio of the dialysis clinic during entry quarter, and eight comorbidities (atherosclerotic heart disease, congestive heart failure, cancer, chronic obstructive pulmonary disease, cerebrovascular disease, hypertension, peripheral vascular disease, and tobacco use).

[b]Malnutrition inflammation complex syndrome adjusted models included all of the covariates plus 10 surrogates of nutritional status and inflammation measured during the last calendar quarter before transplantation including body mass index (BMI) and nine laboratory variables: serum or blood concentrations of total iron binding capacity, ferritin, phosphorus, calcium, bicarbonate, peripheral white blood cell count (WBC), lymphocyte percentage, albumin, and hemoglobin.

[c]Case mix, malnutrition inflammation complex syndrome, and transplant data adjusted models included all of the above plus donor type, donor age, donor sex, panel reactive antibody (PRA) titer (last value before transplant), number of HLA mismatches, and cold ischemia time.

time. To our knowledge, this study is the first that includes patient data from the pretransplant (dialysis treatment) period, which has been shown to have a significant impact on post-transplant outcomes (13–15). Strengths of this study include the large sample size, relatively uniform dialysis treatment practice pattern across all DaVita clinics, extensive pretransplantation laboratory and clinical data, and multilevel adjustment, including several important pretransplant measures.

In our large and contemporary national database of 14,508 kidney transplant recipients between 2001 and 2006, pretransplant treatment with PD was associated with lower all-cause and cardiovascular mortality. There was no association between pretransplant dialysis modality and risk of graft failure and delayed graft function in multivariate adjusted models. However, in subgroup analyses, pretransplant treatment with PD was associated with lower risk of graft failure and DGF in those patients with hemoglobin between 12 and 13 g/dl. Future studies should determine if there are interventions in the pretransplant period that could have a salutary effect on post-transplant patient outcomes.

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