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A comparison of transplant outcomes in peritoneal and hemodialysis patients

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A comparison of transplant outcomes in peritoneal and hemodialysis patients.

Background. Studies examining the effect of pre-transplant dialysis modality on graft and patient survival after kidney transplantation have produced conflicting results. Therefore, we studied the effects of pre-transplant dialysis modality on outcomes in a large United States cohort.

Methods. We compared rates of transplantation between peritoneal dialysis and hemodialysis patients from the years 1995 to 1998 in the United States ($N = 252,402$) and outcomes after transplantation ($N = 22,776$), using data from the Centers for Medicare and Medicaid Services.

Results. In a Cox proportional hazards analysis that was adjusted for multiple patient characteristics, kidney transplantation was 1.39 (95% CI = 1.35 to 1.43) times more likely in peritoneal dialysis vs. hemodialysis patients ($P < 0.0001$). Over the entire follow-up period, the adjusted risk for death-censored graft failure was 1.15 (1.04 to 1.26) times higher in peritoneal dialysis vs. hemodialysis ($P < 0.05$), but mortality and overall graft failure rates were not different. Pre-transplant dialysis modality did not affect outcomes for patients who survived with a functioning kidney for at least 3 months. However, in adjusted Cox analyses restricted to the first 3 months, peritoneal dialysis was associated with a 1.23 (1.09 to 1.39) times higher risk for early graft failure ($P < 0.001$) and a 1.33 (1.16 to 1.53) times higher risk for death-censored graft failure ($P < 0.001$). Peritoneal dialysis patients, however, were seen to have a lower incidence of delayed graft function. In a smaller sample of patients with data on causes of early graft failure, graft thrombosis was more commonly listed as a cause of graft failure among peritoneal dialysis patients, 41% (64/156), compared to hemodialysis patients, 30% (106/349), $P < 0.05$.

Conclusions. Kidney transplantation is more frequent in peritoneal dialysis than in hemodialysis patients, and transplantation in peritoneal dialysis patients is more frequently associated with early, but not late, graft failure. Delayed graft function was less common in peritoneal dialysis patients but this potential benefit appears to be offset by other factors which are associated with early graft loss. Additional studies are needed to determine what factors may help understand this early risk of graft failure.

Key words: kidney transplantation, delayed graft function, allograft survival, graft thrombosis.

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The role of pre-transplant dialysis modality in affecting transplant outcomes has been the subject of long-standing interest. Recent studies have reported that peritoneal dialysis is associated with a lower incidence of post-transplant delayed graft function (DGF) compared to hemodialysis [1–5]. On the other hand, there have been reports that patients receiving peritoneal dialysis are more likely to have graft thrombosis compared to patients treated with hemodialysis [6–9]. Most previous studies have reported that graft survival is not affected by the modality of dialysis treatment prior to transplantation [2, 9–14]. However, many of these studies were small, had a limited number of factors that were addressed in the analysis and may have lacked adequate statistical power to determine whether dialysis treatment modality is independently associated with graft survival.

Fundamental to assessing the relationship between dialysis modality and post-transplant outcomes is the likelihood of receiving a renal transplant based on the choice of peritoneal dialysis or hemodialysis as the initial treatment for end-stage renal disease (ESRD). Since the number of factors that may be associated with the transplant process are considerable, we chose to study a large cohort of United States ESRD patients with information not only on their dialysis treatment period but also their profile of transplant donor and recipient characteristics. This report summarizes our finding from data supplied by the United States Centers for Medicare and Medicaid Services (CMS).

METHODS

Patient population

We included Medicare beneficiaries who (*1*) were 18 years old or older, (*2*) first started therapy for ESRD between 1995 and 1998, and (*3*) had been on the same dialysis modality (hemodialysis or peritoneal dialysis) for at least 60 days on day 90 of ESRD therapy [$N = 252,402$; hemodialysis = 219,240 (87%); and peritoneal dialysis = 33,162 (13%)]. In our study of the effects of

dialysis modality on outcomes after kidney transplantation, we included those patients described above who received a kidney-only transplant and had no prior history of other organ transplantation ($N = 22,776$).

Analytical methods

To determine the relative likelihood of peritoneal dialysis vs. hemodialysis patients to receive a kidney transplant, we used Cox proportional hazards analyses with kidney transplantation occurring before November 30, 2000, as the end point. In two separate analyses we used both "intent-to-treat" based on dialysis modality on day 90, and "on treatment" with patients censored at a change in dialysis modality (change of at least 60 days) or if lost to follow-up. For both of these analyses, patients were censored at death. These analyses were adjusted for age, gender, race, Hispanic ethnicity, year of ESRD initiation, body size measured as body surface area (BSA) calculated from height and weight [15], obesity defined as body mass index (BMI) greater than 29 kg/m^2, estimated baseline glomerular filtration rate (GFR) at dialysis initiation (as calculated from serum creatinine, age, gender, and race), diabetes as primary cause of renal failure, ability to work, and baseline co-morbidities. Baseline co-morbidities were determined from the CMS Medical Evidence Form (Form 2728, End-Stage Renal Disease Medical Evidence Report Medicare Entitlement and/or Patient Registration). Co-morbidities included cardiovascular disease (congestive heart failure, ischemic heart disease, myocardial infarction, cardiac arrest, cardiac dysrhythmia, and pericarditis), peripheral vascular disease (PVD), and hypertension. In the end, both the "intent-to-treat" and "on treatment" analyses gave similar results, and therefore only the "intent-to-treat" results are presented.

To determine the effect of pre-transplant dialysis modality on graft survival, three different approaches were used: (*1*) the dialysis modality was determined on day 90 of ESRD care and patients were assumed to be on this modality until the time of transplantation (similar to intent-to-treat); (*2*) for patients switching modality more the 60 days prior to transplantation and for a period of no less than 60 days, the new modality was taken as the pre-transplant dialysis modality; and (*3*) the pre-transplant dialysis modality was determined from the United Network for Organ Sharing (UNOS) Transplant Recipient Registration Form at the time of transplant. In the event this information was missing from the UNOS form, the last known modality based on Medicare data was used. In the end, the results did not differ significantly between these three approaches, and therefore only the results from the third approach are presented.

Separate Cox proportional hazards analyses were used to assess the relative risk of pre-transplant peritoneal dialysis vs. hemodialysis on patient survival, graft failure, including death, and return to dialysis or re-transplant (death-censored graft failure). Models were adjusted for dialysis exposure time, dialysis modality switch (whether a patient had switched modalities prior to transplantation), the year of transplantation, gender, race, age at time of transplantation, Hispanic ethnicity, body size (BSA), obesity (BMI of 30 kg/m^2 or more), baseline GFR, baseline co-morbidity, education level, ability to work, human lymphocyte antigens (HLA) mismatches, donor type, donor gender, donor age, donor race, panel reactive antibody (PRA), and cold ischemia time. Due to non-proportionality of the hazards over time, additional Cox models were run on outcomes in the first 3 months post-transplant and conditional graft loss following the first 3 months. All analyses used SAS version 8.2 (Cary, NC, USA).

RESULTS

Likelihood of transplantation

During the follow-up period, a greater proportion of peritoneal dialysis vs. hemodialysis patients received a kidney transplant (Fig. 1). By 1, 3, and 5 years after starting dialysis for ESRD, the proportions of peritoneal dialysis and hemodialysis patients receiving a kidney transplant (by Kaplan-Meier analysis) were 9.2% (95% CI = 8.8 to 9.5%) vs. 3.8% (3.7 to 3.9%), 23.6% (23.0 to 24.1%) vs. 10.9% (10.7 to 11.0%), and 31.7% (30.9 to 32.6%) vs. 15.7% (15.5-16.0%), respectively. Similarly, in unadjusted Cox proportional hazards analysis, the relative likelihood of receiving a kidney transplant was 2.34 (2.28 to 2.41, $P < 0.0001$) times greater for peritoneal dialysis than for hemodialysis patients. However, most of this difference can be explained by differences in the patients selected for peritoneal dialysis and hemodialysis. Indeed, after adjustments were made for differences in peritoneal dialysis and hemodialysis patients, the relative likelihood of receiving a kidney transplant was only 1.39 (1.35 to 1.43, $P < 0.0001$) times greater for peritoneal dialysis than for hemodialysis patients (Table 1).

The difference in the likelihood of transplantation between peritoneal dialysis and hemodialysis patients does not appear to be a result of differences in the likelihood of making it to the waiting list for cadaveric renal transplantation. In this population, 87% of hemodialysis patients were listed and 86% of peritoneal dialysis patients were listed (χ^2 $P = 0.4669$). When only considering patients who received a cadaveric transplant, 99.8% of both hemodialysis and peritoneal dialysis patients had been listed (χ^2 $P = 0.8018$). Similarly, for patients who went on to receive a living donor transplant, 59% of both hemodialysis and peritoneal dialysis patients had been listed (χ^2 $P = 0.9877$).

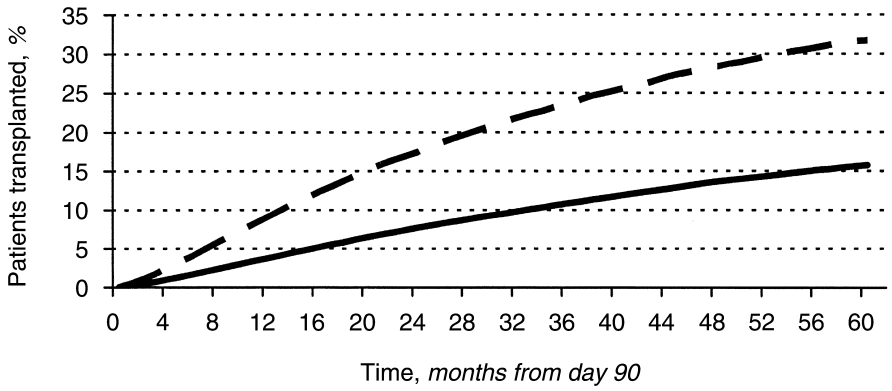

Fig. 1. The percentages of new hemodialysis (HD, solid line) and peritoneal dialysis (PD, dashed line) patients who received a kidney transplant by Kaplan-Meier analysis. Patients shown here were analyzed by intention-to-treat, where a change in dialysis modality was ignored.

Table 1. Characteristics of peritoneal and hemodialysis patients that are associated with the relative likelihood of kidney transplantation

Characteristic	Percent with characteristic		Likelihood of transplantation	
	Among PD patients %	Among HD patients %	RR (95% CI)	*P* value
PD vs. HD	—	—	1.39 (1.35–1.43)	<0.0001
Female gender	46	47	0.85 (0.82–0.87)	<0.0001
Age *years*				
18 to 19	5	3	Reference	—
30 to 44	35	52	0.65 (0.63–0.68)	<0.0001
45 to 64	41	34	0.32 (0.31–0.33)	<0.0001
65+	18	11	0.03 (0.03–0.03)	<0.0001
Race				
Caucasian	65	52	Reference	—
African American	21	32	0.34 (0.33–0.35)	<0.0001
Other	14	15	0.56 (0.53–0.60)	<0.0001
Hispanic ethnicity	9	11	1.03 (0.96–1.10)	0.4133
ESRD from diabetes	45	44	0.83 (0.81–0.86)	<0.0001
Year of ESRD				
1995	28	22	Reference	—
1996	27	24	0.94 (0.90–0.97)	0.0006
1997	24	26	0.89 (0.85–0.92)	<0.0001
1998	21	28	0.75 (0.72–0.79)	<0.0001
Body Size (BSA)				
Small (<1.7 m^2)	26	30	0.92 (0.88–0.95)	<0.0001
Medium (1.7 to 1.9 m^2)	43	41	Reference	—
Large (>1.9 m^2)	31	29	1.08 (1.04–1.12)	<0.0001
Obese (BMI >29 kg/m^2)	18	20	0.68 (0.65–0.71)	<0.0001
Baseline GFR *mL/min*				
Low (<6.1)	27	28	1.04 (1.01–1.07)	0.0215
Intermediate (6.1 to 8.7)	46	43	Reference	—
High (>8.7)	27	28	0.81 (0.78–0.84)	<0.0001
Ability to work	49	48	1.66 (1.61–1.70)	<0.0001
Co-morbidities				
CVD	32	41	0.60 (0.58–0.63)	<0.0001
PVD	11	13	0.61 (0.57–0.65)	<0.0001
Hypertension	64	65	1.15 (1.12–1.19)	<0.0001

Shown are the percent of pre-transplant PD (column 2, $N = 33{,}162$) and HD (column 3, $N = 219{,}240$) patients with characteristics in column 1, and the relative likelihood of transplantation (columns 4 and 5). Abbreviations are: PD, peritoneal dialysis; HD, hemodialysis; RR, relative risk; CI, confidence interval; ESRD, end-stage renal disease; BMI, body mass index; GFR, glomerular filtration rate; CVD, cardiovascular disease; PVD, peripheral vascular disease.

Transplant outcomes

Pre-transplant dialysis modality was associated with differences in outcomes after transplantation. There were 5621 (25%) patients on peritoneal dialysis and 17,155 (75%) patients on hemodialysis prior to transplantation. In unadjusted (Kaplan-Meier) analysis, mortality was less for those treated with peritoneal dialysis vs. hemodialysis (Fig. 2A), death-censored graft failure was more frequent for peritoneal dialysis vs. hemodialysis patients (Fig. 2C), and there was no difference in overall graft failure in patients treated with peritoneal dialysis vs. hemodialysis (Fig. 2B). However, using a Cox proportional hazards model to adjust for multiple risk factors, peritoneal dialysis patients had similar rates of

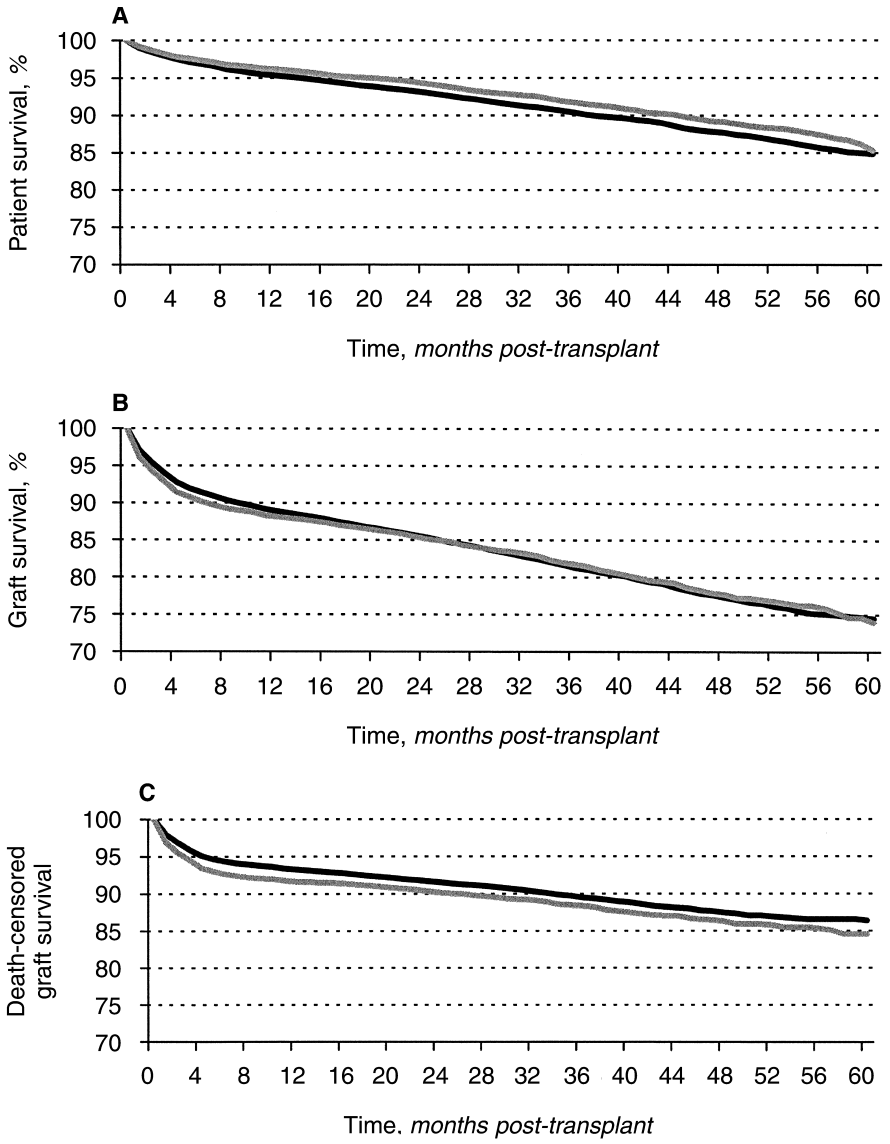

Fig. 2. Unadjusted (Kaplan-Meier) outcomes comparing transplant recipients treated with either peritoneal dialysis (PD, gray line) or hemodialysis (HD, black line) pre-transplant. Shown are mortality (*A*), graft failure due to death, return to dialysis or re-transplantation (*B*), or death-censored graft failure due to dialysis or re-transplantation (*C*). Log rank, $P = 0.001$; Wilcoxon, $P = 0.0002$.

death and graft failure, but a 15% increased risk of death-censored graft failure (Table 2).

Most of the risk attributable to pre-transplant dialysis modality was manifest in the first 3 months following transplantation (Fig. 2 B and C). In Cox proportional hazards analyses adjusted for multiple risk factors, but restricted to the first 3 months of follow-up, peritoneal dialysis was clearly associated with a higher risk for graft failure and death-censored graft failure, but not mortality (Table 3). On the other hand, in adjusted Cox analyses that included only patients whose grafts functioned for at least 3 months, there was little effect of dialysis modality on outcomes, emphasizing that the increased risk in the peritoneal dialysis population occurs early in the post-transplant period (Table 3).

The cause of graft failure was investigated for patients whose grafts failed within the first 3 months post-transplant. Data on the cause of graft failure were available for only 1030 (33%) of hemodialysis patients and 401 (38%) of peritoneal dialysis patients on the UNOS transplant recipient and follow-up forms. Of all of the causes examined, only graft thrombosis was more frequent in peritoneal dialysis vs. hemodialysis patients [odds ratio = 1.59 (1.08 to 2.36), $P = 0.0192$, Table 4].

Delayed graft function

We used logistic regression analysis to examine the associated role of dialysis modality on the incidence of delayed graft function (DGF), defined by the need for dialysis during the first week after transplantation. Among hemodialysis patients, 16% of patients had DGF, while only 12% of peritoneal dialysis patients had DGF. Pre-transplant peritoneal dialysis was associated with a lower risk for DGF, with the odds ratio (peritoneal dial-

Table 2. Effects of pre-transplant dialysis modality and other factors on outcomes after kidney transplantation

	Relative risk (95% CI)		
Characteristics	Graft failure	Death-censored graft failure	Death
PD vs. HD	1.05 (0.97–1.13)	1.15 (1.04–1.26)[a]	0.95 (0.85–1.06)
Dialysis duration *months*	1.00 (0.99–1.00)	0.98 (0.98–0.99)[c]	1.02 (1.01–1.02)[c]
Changed dialysis modality	1.02 (0.90–1.14)	1.00 (0.85–1.17)	1.06 (0.90–1.24)
Transplant era			
1995–1996	Reference	Reference	Reference
1997–1998	0.68 (0.63–0.74)[c]	0.56 (0.50–0.62)[c]	0.86 (0.76–0.98)[a]
1999–2000	0.82 (0.73–0.93)[a]	0.83 (0.72–0.97)[a]	0.78 (0.64–0.94)[a]
Female (vs. male)	1.08 (1.00–1.16)[a]	1.10 (1.00–1.21)	1.06 (0.95–1.17)
Age *years*			
18 to 29	Reference	Reference	Reference
30 to 44	0.90 (0.80–1.01)	0.82 (0.72–0.93)[a]	1.39 (1.09–1.77)[a]
45 to 64	1.11 (1.00–1.24)	0.73 (0.64–0.83)[c]	2.87 (2.28–3.60)[c]
65+	1.51 (1.32–1.74)[c]	0.64 (0.53–0.78)[c]	5.14 (4.02–6.58)[c]
Race			
Caucasian	Reference	Reference	Reference
African American	1.03 (0.95–1.12)	1.19 (1.06–1.33)[a]	0.84 (0.75–0.95)[a]
Other	0.73 (0.62–0.86)	0.76 (0.61–0.95)[a]	0.66 (0.52–0.84)[b]
Hispanic ethnicity	1.04 (0.86–1.25)	1.15 (0.90–1.48)	0.93 (0.70–1.22)
ESRD from diabetes	1.13 (1.05–1.22)[b]	0.80 (0.72–0.89)[c]	1.65 (1.50–1.82)[c]
Body size (BSA)			
Small (<1.7 m^2)	1.03 (0.94–1.13)	0.99 (0.87–1.12)	1.11 (0.97–1.26)
Medium (1.7 to 1.9 m^2)	Reference	Reference	Reference
Large (>1.9 m^2)	1.01 (0.93–1.10)	1.08 (0.96–1.21)	0.91 (0.80–1.03)
Obese (BMI >29 kg/m^2)	1.00 (0.91–1.10)	0.95 (0.84–1.09)	1.06 (0.93–1.22)
Baseline GFR *mL/min*			
Low (<6.1)	0.94 (0.88–1.02)	0.97 (0.88–1.07)	0.90 (0.80–1.00)
Intermediate (6.1 to 8.7)	Reference	Reference	Reference
High (>8.7)	1.13 (1.03–1.25)[a]	1.14 (1.00–1.30)	1.14 (1.00–1.31)[a]
Co-morbidities			
CVD	1.11 (1.02–1.21)[a]	0.90 (0.78–1.03)	1.32 (1.17–1.48)[c]
PVD	1.21 (1.04–1.41)[a]	1.06 (0.83–1.36)	1.31 (1.09–1.58)[a]
Hypertension	0.94 (0.87–1.01)	0.92 (0.84–1.01)	0.95 (0.86–1.06)
HLA mismatches			
0	0.85 (0.76–0.95)[a]	0.89 (0.76–1.03)	0.82 (0.70–0.96)[a]
1	0.98 (0.83–1.15)	0.95 (0.76–1.18)	1.03 (0.83–1.29)
2	0.91 (0.82–1.02)	0.98 (0.85–1.13)	0.89 (0.76–1.04)
3	Reference	Reference	Reference
4	1.10 (0.99–1.21)	1.19 (1.04–1.36)[a]	0.98 (0.85–1.13)
5	1.13 (1.01–1.26)[a]	1.16 (1.00–1.34)[a]	1.10 (0.94–1.28)
6	1.27 (1.10–1.46)[b]	1.33 (1.10–1.60)[a]	1.23 (1.02–1.50)[a]
Living donor	0.88 (0.79–0.98)[a]	0.98 (0.86–1.13)	0.71 (0.60–0.83)[c]
Female donor	1.08 (1.01–1.15)[a]	1.09 (1.00–1.19)[a]	1.03 (0.94–1.13)
Donor age *years*			
0 to 17	0.96 (0.84–1.10)	1.07 (0.90–1.27)	0.91 (0.75–1.09)
18 to 29	Reference	Reference	Reference
30 to 44	1.10 (1.00–1.22)	1.12 (0.98–1.29)	1.09 (0.94–1.26)
45 to 64	1.41 (1.28–1.56)[c]	1.51 (1.32–1.72)[c]	1.37 (1.19–1.57)[c]
65+	1.99 (1.69–2.34)[c]	2.43 (1.95–3.04)[c]	1.84 (1.49–2.28)[c]
Donor race			
Caucasian	Reference	Reference	Reference
African American	1.24 (1.11–1.37)[c]	1.21 (1.05–1.39)[a]	1.30 (1.11–1.51)[b]
Other	0.96 (0.83–1.10)	0.95 (0.79–1.14)	0.96 (0.78–1.18)
PRA >50%	1.20 (0.97–1.48)	1.32 (1.01–1.74)[a]	1.13 (0.84–1.53)
Cold ischemia time *hours*			
0	Reference	Reference	Reference
1 to 12	1.20 (1.03–1.40)[a]	1.31 (1.07–1.61)[a]	0.96 (0.76–1.20)
13 to 24	1.43 (1.20–1.71)[c]	1.62 (1.29–2.05)[c]	1.05 (0.81–1.36)
25+	1.43 (1.19–1.71)[b]	1.73 (1.36–2.19)[c]	1.02 (0.79–1.33)
College educated	0.88 (0.80–0.97)[a]	0.89 (0.78–1.01)	0.86 (0.75–0.99)[a]
Ability to work	0.92 (0.85–0.99)[a]	0.98 (0.89–1.09)	0.80 (0.71–0.89)[c]

Abbreviations are: PD, peritoneal dialysis; HD, hemodialysis; ESRD, end-stage renal disease; BSA, body surface area; BMI, body mass index; GFR, glomerular filtration rate; CVD, cardiovascular disease; PVD, peripheral vascular disease; HLA, human leukocyte antigen; PRA, panel reactive antibody.

[a] $P < 0.05$; [b] $P < 0.001$; [c] $P < 0.0001$

Table 3. Effects of pre-transplant dialysis modality on outcomes early vs. late after kidney transplantation

	Relative risk (95% CI) PD:HD		
Post-transplant period	Graft failure	Death-censored graft failure	Death
During the first 3 months	1.23 (1.09–1.39)[a]	1.33 (1.16–1.53)[b]	1.03 (0.81–1.30)
Beyond the first 3 months	0.96 (0.87–1.05)	1.02 (0.89–1.16)	0.91 (0.80–1.04)

Results of Cox proportional hazards analyses (adjusted for covariates in Table 2) during the first 3 months after transplantation and beyond the first 3 months after transplantation (among those patients who survived with functioning grafts for at least 3 months).
[a] $P < 0.001$; [b] $P < 0.0001$

Table 4. Causes of graft failure (primary or contributing) for patients whose graft failed within the first 3 months[a]

	Percent with characteristic		
Cause	Among PD patients (%, *N*)	Among HD patients (%, *N*)	*P* value[b]
Hyperacute rejection[c]	3 (3/95)	4 (7/195)	1.0000
Surgical complications[c]	3 (3/95)	6 (11/195)	0.5602
Acute rejection[d]	27 (42/156)	27 (95/349)	0.9446
Primary failure[d]	13 (21/156)	15 (52/349)	0.6711
Graft thrombosis[d]	41 (64/156)	30 (106/349)	0.0192
Infection[d]	8 (12/156)	10 (34/349)	0.4595
Urological complications[d]	2 (3/156)	2 (7/349)	1.0000
Recurrent disease[d]	3 (4/156)	2 (6/349)	0.5071
Other[d]	15 (23/156)	19 (66/349)	0.2561

[a] Patients may have more than one cause of graft failure
[b] *P* value from Fisher's exact test (when fewer than five expected events) or Chi-square test
[c] For patients whose graft failed immediately
[d] For patients whose graft failed immediately or after discharge

ysis:hemodialysis) for DGF being 0.74 (0.67 to 0.81, $P < 0.0001$) after adjustment for multiple covariates. For patients whose graft survived at least 7 days, DGF was associated with a 2.8 (2.2 to 3.6, $P < 0.0001$) times greater risk of death, a 2.9 (2.6 to 3.4, $P < 0.0001$) times greater risk of graft failure, and a 2.9 (2.5 to 3.5, $P < 0.0001$) times greater risk of death-censored graft failure, regardless of pre-transplant dialytic modality. The observed increased risk of graft failure and death-censored graft failure in the peritoneal dialysis population in the first 3 months post-transplant is present despite the apparent beneficial effects of a lower incidence of DGF in the peritoneal dialysis population.

DISCUSSION

In our analysis, peritoneal patients were approximately 50% more likely to undergo kidney transplantation compared to hemodialysis patients. Few others have compared the rates of transplantation for peritoneal and hemodialysis patients. More than a decade ago, Held et al found that the rate of transplantation among 3393 children was similar, albeit slightly higher, for peritoneal dialysis vs. hemodialysis patients [16]. These investigators did not examine the rates of transplantation among adult peritoneal dialysis and hemodialysis patients.

We cannot discern from our analysis why peritoneal dialysis patients were more likely to receive a kidney transplant compared to hemodialysis patients. While many of the factors associated with increased transplant utilization may be more represented in the peritoneal dialysis population, the difference in transplant utilization persisted after adjusting the analysis for differences in patient characteristics (Table 1). There may be a perception among patients and their physicians that peritoneal dialysis is the dialysis treatment modality of choice for transplant candidates [3, 17]. If placement of a peritoneal dialysis catheter is thought to cause less morbidity and mortality than placement of a hemodialysis access, then peritoneal dialysis may be selected more often than hemodialysis when it is perceived to be a better short-term bridge to kidney transplantation. On the other hand, if there is a perception that hemodialysis offers better long-term dialysis treatment, then patients less likely to undergo transplantation may be selected for hemodialysis more often than peritoneal dialysis. In any case, it is plausible that the observed difference in the likelihood for peritoneal dialysis vs. hemodialysis patients to receive a kidney transplant could be due to a selection bias, whereby transplant candidates were more likely to be placed on peritoneal dialysis than hemodialysis.

An important and surprising finding in this study is the higher rate of early graft failure in peritoneal dialysis compared to hemodialysis patients even after adjusting for multiple patient characteristics that may also influence outcomes. Most other studies have reported that

pre-transplant dialysis modality has no effect on patient or graft survival [2, 9–14]. Similarly, most investigators found no difference in the rates of acute rejection in peritoneal dialysis vs. hemodialysis [2, 4, 9, 13]. However, Vanholder et al reported a greater number of peritoneal dialysis patients developed acute rejection after transplantation compared to hemodialysis [3]. Most of these studies were smaller than the current investigation, and the investigators did not separately examine the effects of dialysis modality on short-term and long-term graft survival. This is an important issue since the hazard functions are not proportional over time. As a result, it is not surprising that others did not find the association between dialysis modality and early graft failure that we report here.

We could not determine how pre-transplant dialysis modality influenced early post-transplant graft failure. The result seems unlikely to be explained by a higher rate of infection in peritoneal dialysis patients, since this would be expected to have a greater effect on mortality than death-censored graft failure. In addition, previous studies comparing the rates of post-transplant infections between peritoneal dialysis and hemodialysis patients have produced conflicting results. Passalacqua et al found a higher incidence of infection in the first 30 days post-transplant, and this higher rate of infection was associated with rejection and longer hospital stays [18]. Binaut et al reported no overall difference in bacterial infections, but a higher rate of sepsis was seen in peritoneal dialysis vs. hemodialysis patients [2]. Others have found no difference in the rate of post-transplant infections in peritoneal vs. hemodialysis patients [3, 19]. Still others have reported that hemodialysis patients have a higher rate of infections after transplantation [20]. Thus, it seems unlikely that a higher rate of infection in peritoneal dialysis patients could explain the association between dialysis modality and early graft failure.

In a subset of about one third of patients with data on the cause of graft failure, graft thrombosis was more common in peritoneal dialysis vs. hemodialysis patients (Table 4). Graft thrombosis has also been reported by others to be more common in peritoneal dialysis vs. hemodialysis patients [6–9]. Indeed, we found only one study that examined the incidence of graft thrombosis and failed to find a difference in peritoneal dialysis vs. hemodialysis patients [21]. Thus, it is likely that early graft thrombosis contributed to the higher rate of early graft failure associated with pre-transplant peritoneal dialysis. However, our results should be interpreted cautiously, given that the large proportion of missing data on the cause of graft failure could bias the results.

We found that DGF is less common in patients treated with peritoneal dialysis vs. hemodialysis pre-transplant. This finding is consistent with those of others [1–5]. One explanation for a lower rate of DGF in peritoneal dialysis vs. hemodialysis patients is the possibility that residual native kidney function is better preserved in peritoneal dialysis than in hemodialysis [22–24]. The reduced early graft survival associated with peritoneal dialysis compared to hemodialysis is all the more remarkable given the lower incidence of DGF in peritoneal dialysis patients.

We attempted to determine which dialysis modality patients with DGF were treated with by searching Medicare Part B claims within 1 month of the transplant date. In this study population, DGF was indicated for 3533 patients. Claims could only be reliably searched for 2626 of these patients for whom Medicare appeared to be the primary payer. Of these patients, we were able to determine which modality patients were treated with for 1925 (73%) patients. For the 351 peritoneal dialysis patients, 166 (47%) were treated with peritoneal dialysis following transplantation. In the 1574 hemodialysis patients, 1551 (99%) were treated with hemodialysis following transplantation. These differences suggest it is possible that the effects of pre-transplant dialysis modality on early graft failure may have been influenced by the effects of dialysis modality during DGF. Few studies have examined the effects of dialysis modality on the pharmacokinetics of immunosuppressive agents. In a recent study, the active metabolite of mycophenolate mofetil, mycophenolic acid, was found to be readily removed by peritoneal dialysis [25]. Thus, it is possible that rejection rates in patients with DGF could be indirectly influenced by pre-transplant dialysis modality, if levels of immunosuppressive medications are altered. More work in this area is needed to determine the possible risk factors and the associated complications post-transplant that may be amenable to interventions.

CONCLUSION

In summary, this analysis demonstrated that the rate of transplantation is higher in patients treated with peritoneal dialysis compared to patients treated with hemodialysis, and this difference could not be entirely explained by differences in the two patient populations. Interestingly, the rate of early, but not late, graft failure was higher in patients treated with peritoneal dialysis compared to hemodialysis prior to transplantation. Although we cannot determine the cause of this associated higher rate of graft failure, an analysis of a subset of patients with data on the cause of graft failure suggested that a higher rate of graft thrombosis might have contributed. Additional studies are needed to better understand the slightly higher rate of early graft failure in the peritoneal dialysis population.

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