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Choice of dialysis modality prior to kidney transplantation: Does it matter?

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Abstract

The population of patients with end stage renal disease (ESRD) is increasing, lengthening waiting lists for kidney transplantation. Majority of the patients are not able to receive a kidney transplant in timely manner even though it is well established that patient survival and quality of life after kidney transplantation is far better when compared to being on dialysis. A large number of patients who desire a kidney transplant ultimately end up needing some form of dialysis therapy. Most of incident ESRD patients choose hemodialysis (HD) over peritoneal dialysis (PD) as the modality of choice in the United States, even though studies have favored PD as a better choice of pre-transplant dialysis modality than HD. PD is largely underutilized in the United States due to variety of reasons. As a part of the decision making process, patients are often educated how the choice regarding modality of dialysis would fit into their life but it is not clear and not usually discussed, how it can affect eventual kidney transplantation in the future. In this article we would like to discuss ESRD demographics and outcomes, modality of dialysis and kidney transplant related events. We have summarized the data comparing PD and HD as the modality of dialysis and its impact on allograft and recipient outcomes after kidney transplantation.

Key words: Dialysis; Kidney transplant; Outcomes; Peritoneal dialysis; Health literacy

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Core tip: Patients with end stage renal failure need some form of dialysis therapy as a bridge while they wait for kidney transplantation. In this paper we discuss if dialysis modality pre transplantation has any impact on transplant related outcomes.

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INTRODUCTION

Kidney transplantation is the ideal form of renal replacement therapy (RRT) in patients with end stage renal disease (ESRD). Preemptive kidney transplantation is ideal for many, as it is associated with lower rates of acute rejection, increased allograft and patient survival^[1]. However, a preemptive kidney transplant (17% overall) is not always possible for many reasons which were explored by Jay *et al*^[2], which included disparities in health insurance, race/ethnicity, patient education level, socioeconomic status, access to healthcare, diabetes status and regional variations. It is also well established that patient survival and quality of life after kidney transplantation is far better when compared to being on dialysis^[3].

According to statistics, close to 10% of the population are diagnosed with chronic kidney disease around the world. Also only appropriate 10% of this patient population receives some treatment in the form of dialysis or transplant to stay alive. There were 30869 adults patients newly added to the waiting list and 33291 patients were removed from the list according to annual report from SRTR registry released in 2016. Unfortunately, a quarter of those patients were removed due to death or decline in medical condition^[4]. Patients waiting for kidney transplant are also gradually getting older (median wait for a newly listed 2010 candidates was 3.9 years^[5]), thereby the burden of kidney disease is rising in the elderly population. There has been some improvement in the dialysis related mortality overall but the organ shortage and continued increasing list of patients waiting for a transplant is still haunting the nephrology community. The average time on the waitlist for a deceased donor can be quite variable depending on age, blood group, panel reacting antibodies, history of prior transplantation, race/ethnicity and regional factors^[4]. Hence, patients end up needing some form of RRT while they wait for transplantation.

Peritoneal dialysis (PD) leads to minimal disruption of the patient's life, thereby allowing the patient to continue to work or school or other usual activities, along with encouraging patient empowerment in self-management. Hence, for the patients who plan on receiving a transplant after starting dialysis, it can be a better bridge therapy to kidney transplantation, especially, when a lot of patients initiating hemodialysis (HD) *via* catheters are associated with adverse outcomes^[6]. As a part of the decision making process, the education generally includes how the choice of therapy would fit into the patient's life however it is not clear and hence not discussed, how a dialysis modality may affect eventual kidney transplantation in the future. A number of studies have addressed the outcome of kidney transplantation after PD versus in-center HD, reporting mixed results. A meta-analysis by Tang *et al*^[7] in 2016 concluded that PD was a better choice of pre-transplant dialysis modality than HD. Another study by Jones *et al*^[7] in 2018 found PD as a viable bridge therapy for patients waiting for simultaneous liver-kidney transplantation. In another Cohort of 92884 patients, HD as a choice of RRT was associated with an increased risk for graft failure and recipient death^[9]. On the other hand, study by Resende *et al*^[10] and Dpalma *et al*^[11] did not find any impact of dialysis modality on graft function or patient's survival after transplantation.

Our goal of this discussion is to review the current evidence in regards to choice of RRT and impact on kidney transplantation outcomes. We have organized the review into two categories: short-term outcomes, including delayed graft function (DGF), and allograft thrombosis; and long-term outcomes, including mortality. At first, we would like to review the demographics and outcomes of ESRD in the United States, as this crucial decision regarding modality choice can have large impact on choices of significant number of ESRD patients.

ESRD DEMOGRAPHICS

As per the United Network for Organ Sharing, in 2017, there were 94897 patients on the waiting list for kidney transplantation. Among those, majority were aged 50+ years (43% of patients were between 50-64 years of age and 23% of patients were 65+

years of age). Only, 19849 patients (40% of patients were age 50-64 years and 18% of patients were 65+ years of age) received kidney transplantation alone in the United States of America (USA) in the year of 2017^[12].

United States Renal Data System (USRDS) is the most robust national database in the USA on all patients with ESRD covered by Medicare and Medicaid. At the end of 2015, there were 207810 patients living with a functioning kidney transplant and 83978 dialysis patients (17% of all prevalent dialysis patient population) were on waiting list for kidney transplantation^[5]. In the USA, there were 124114 incident ESRD patients in the year 2015 with an unadjusted incident rate of 378 per million population, which is increasing steadily since 2012^[13]. Unfortunately, approximately one third (36%) of those patients did not receive significant pre-ESRD care and 80% of patients initiated HD with a catheter as opposed to preferred arteriovenous access^[6,13]. Majority of incident ESRD patients chose HD (87.8%) over PD (9.6%) as the modality of choice in the USA^[13]. As per the latest data, there were 703243 prevalent ESRD patients in the USA (on December 2015) with an unadjusted prevalence rate of 2128 per million populations, which is also steadily increasing by adding about 20000 patients each year^[13]. Among all prevalent ESRD patients, 63.2% of patients were on HD, 29.6% had a functioning kidney transplant and only 7% of patients were utilizing PD. In-center HD accounts for almost all of HD (98%) modality and only a very small percentage of patients perform home HD (2%)^[13].

It is in stark contrast to countries like Hong Kong (70%), the Jalisco region of Mexico (51%), New Zealand (30%), Thailand (29%), Qatar (27%), Colombia (27%), Australia (20%) and Canada (20%), where much higher proportion of patients utilize PD as compared to the patients in the USA^[14]. PD is an acceptable and could be a preferred form of RRT owing to flexibility, autonomy, care satisfaction^[15], better preservation of residual renal function^[16], better hypertension control^[17], lower intra-dialytic hypotension episodes^[18], lower risk of dementia, slower cognitive decline^[19,20], better anemia management with lower doses of erythropoietin stimulating agents (ESA) and lower proportions of patients needing ESAs^[21]. It is largely underutilized in the USA due to variety of reasons which have been explored by many researchers and found causes to be multifactorial which were physician specific (lack of experience, inadequate training, comfort with HD); patient specific (lack of adequate PD education, health literacy, burden of therapy, age, comorbidities); modality specific (concerns for mortality, solute clearance, peritonitis, treatment failure, regulatory issues on PD fluid, easy availability of HD); and financial incentives for HD units^[22-24].

ESRD OUTCOMES

In recent times, success of PD technique has improved and risk of peritonitis had dwindled^[22,23]. Review of the data also suggests that as per the USRDS^[25], in 2015, adjusted mortality rate for patients on HD was slightly higher than patients on PD (169 per 1000 patients years *vs* 159 per 1000 patients years; respectively) and much higher than patients who received kidney transplantation (29 per 1000 patients years). A very interesting trend of mortality with age and time on dialysis has been noted.

Among those patients who started RRT with HD in 2015, mortality rates in patients < 65 years of age decreased from 200 deaths per 1000 patient-years in month 2 to 134 deaths per 1000 patient-years in month 12. Mortality rates in patients aged ≥ 65 years were much higher as compared to patients with < 65 years but also noted to decrease similarly (615 deaths per 1000 patient-years in month 2 to 278 deaths per 1000 patient-years in month 12).

In contrast, among patients who started RRT with PD^[25], mortality increased in both patients < 65 years of age (28 deaths/1000 patient-years in month 1 to 64 deaths/1000 patient-years in month 12) and ≥ 65 years of age (124 deaths per 1000 patient-years in month 1 to 223 deaths per 1000 patient-years in month 12). This study showed two important findings, mortality rates for PD patients were much lower as compared to HD and secondly elderly patients tend to do better on PD versus HD. However, one concern from this mortality data arises that whether it is PD or HD, elderly patients age ≥ 65 years suffer from far more increased risk of mortality as compared to patients < 65 years of age. As the ESRD patient population is aging and dying waiting for a transplant, it will be imperative to increase utilization of kidney transplantation at the earliest and offer a better RRT modality.

In-fact, overall adjusted survival probability of incident patients on PD is much better at the end of 3 years than patients on HD (68% *vs* 57%). Expenditure of PD is also better than HD (75140 \$ per patient per year *vs* 88750 \$ per patient per year) but much higher than cost for transplant patients (34084 \$ per patient per year)^[26]. HD and PD patients have similar hospitalizations rate (1.7 per patient year) but almost double

of patients with kidney transplantation (0.8 per patient year). Patients on HD gradually has lower hospitalization rates as time goes on but patients on PD tends to have slightly higher hospitalization rates with time (1.4 PPY in 2013 but increased to 1.6 PPY at end of 3rd year) but still remained lower than HD cohort (1.7 PPY)^[27]. This data suggests that PD is a more cost effective modality with somewhat lower risk of mortality as compared to HD in pre-transplant period.

While on the waitlist for a kidney transplant, mortality for PD and in-center HD patients was found to be similar by Inrig *et al*^[28]. This prospective observational study used a cohort of patients placed on the transplant list who initiated dialysis ($n = 12568$) between May 1, 1995 and October 31, 1998. Two-year mortality was 6.6% among PD patients and 6.9% among HD patients, with no significant differences [hazard ratio (HR) 1.01; 95% confidence interval (CI) 0.82 to 1.23] when controlled for baseline characteristics, comorbidities, and laboratory variables. This study used the modality the patient was on at 90 d of dialysis as the treatment group, and excluded those who died in the first 90 d. Of note, in this study 24% of the patients were on PD, indicating that PD patients are much more likely to be listed for a kidney transplant early since the percentage of PD utilization nationally is much lower.

Delayed graft function for kidney transplant

DGF defined as need of dialysis within seven days of kidney transplantation, occurred in 21.3% of patients transplanted in 2008 in the USA^[29].

Numerous studies as mentioned in Table 1 have investigated DGF rates and have found mostly similar to lower rates of DGF in PD versus HD patients^[29-39]. Some of the earlier studies were performed in an era when different immunosuppressive regimens were used^[31-34]. A large study by Snyder *et al*^[38] investigated this question in 2002 using USRDS data with over 22000 patients; also found a lower incidence of DGF among PD patients (RR = 0.74, 95% CI: 0.67-0.81, $P < 0.0001$) after adjustment of multiple clinical covariates. They also noted that PD patients were 1.39 times more likely to get transplanted as compared to HD patients (95% CI: 1.35-1.43, $P < 0.0001$). In a more recent study by Molnar *et al*^[39] of 14508 dialysis patients who underwent kidney transplantation for the first time, the case-mix-adjusted risk of DGF was 34% lower for patients on PD vs HD (HR = 0.66 with 95% CI of 0.55-0.79, $P < 0.001$). However, once adjusted for malnutrition inflammation complex syndrome and donor characteristics, PD was no longer an independent predictor for decreased DGF (HR = 0.82 with 95% CI of 0.60-1.13, $P = 0.23$)^[31]. But, PD was found to be protective against DGF in a subgroup of patients with hemoglobin between 12 and 13 gram/dL. A meta-analysis by Tang *et al*^[7] found significantly lower risk of DGF in PD patients as compared to HD patients (OR 0.67, 95% CI: 0.62-0.72, $P = 0.024$). Lin *et al*^[41] also postulated higher risk of DGF in HD patients based upon the observation that there more dialysis events were noted in HD group (1.59 in HD vs 0.71 in PD, $P < 0.05$).

In a retrospective observation study of patients with DGF requiring HD or PD, Thomson *et al*^[42] found an increased risk of wound infection/leakage (PD 5/14 vs HD 6/63, $P = 0.024$), shorter length of hospitalization (PD 13.7 d vs HD 18.7 d, $P = 0.009$) and lesser time requiring dialysis post-operatively (PD 6.5 d vs HD 11.0 d, $P = 0.043$) with use of PD however no differences in readmission to hospital within 6 mo, graft loss or acute rejection episodes at one year. GFR also did not differ between the PD and HD groups at one month, six months or at one year^[42].

Reasons for better outcome in terms of DGF in PD patients are not entirely clear. PD patients have better preservation of residual renal function^[37,38]. There may be lead time bias as well because, generally PD patients may be more motivated and hence may have increased transplant access. Few other reasons like difference in immune function, cytokine production, and different response to ischemic kidneys among PD vs HD patients have been proposed as well^[37]. In fact, maintenance dialysis prior to transplantation is noted to be a major contributor to DGF^[29]. Since, PD is performed daily and patients are less likely to be hyperkalemic, hence are less likely to require additional treatments just prior to kidney transplantation. PD patients are not likely to be volume depleted either; this will also ensure adequate perfusion of the allograft. HD prior to transplant may be associated with volume removal, which in turn may result in eventual decreased perfusion of the transplanted organ and some tubular necrosis^[43]. In addition, intra-op aggressive hydration has been proved to be effective in reducing DGF^[29,43], which may have been countered against by pre-transplant HD.

Thrombosis of the allograft: Comparing prior HD to PD

In contrast to DGF, thrombosis of the graft may be surprisingly higher in the PD patients (Table 2) as compared to their HD counterparts^[38,44-46].

In Snyder *et al*'s^[38] subgroup analysis of allografts surviving < 3 mo, patients on PD prior to the transplant had higher adjusted risk for both allograft failure (RR 1.23, 95% CI: 1.09-1.39, $P < 0.001$) and death-censored allograft failure (RR 1.33, 95% CI: 1.16-

Table 1 Pre-transplant dialysis modality and delayed graft function

Study Period	Authors	Study Design	Study Participants	DGF Incidence	Favors
1983-2006	Caliskan <i>et al</i> ^[30]	Retrospective observational	44 PD and 44 HD patients	No difference in DGF incidence	None
1983-1989	Cacciarelli <i>et al</i> ^[31]	Retrospective observational	cohort of 662 patients	26% of PD and 36% of HD patients	PD
1984-1988	Triolo <i>et al</i> ^[32]	Retrospective observational	18 PD and 18 HD patients	27% patients on PD and 27% patients on HD	None
1988-1995	Fontan <i>et al</i> ^[33]	Retrospective observational	92 PD and 587 HD patients	22.5% in PD and 39.5% of HD patients	PD
1989	Cardella <i>et al</i> ^[34]	Retrospective observational	31 PD and 37 HD patients	35% in PD and 35% in HD patients	None
1990s	Vanholder <i>et al</i> ^[35]	Case-control	117 PD and 117 HD patients	23.1% in PD and 50.4% in HD	PD
1993-2014	Song <i>et al</i> ^[36]	Retrospective observational	97 PD and 178 HD patients	19.6% in PD and 32% in HD	PD
1994- 1995	Bleyer <i>et al</i> ^[37]	Retrospective observational	Cohort of 9291 patients	20% of PD and 28.6% of HD patients	PD
1995-1998	Snyder <i>et al</i> ^[38]	Retrospective observational	5621 PD and 17155 HD patients	12% in PD and 16% in HD	PD
2001-2006	Molnar <i>et al</i> ^[39]	Retrospective observational	2092 PD and 12,416 HD patients	15% in PD and 21% in HD	PD
2002-2011	Prasad <i>et al</i> ^[40]	Retrospective observational	45 PD and 45 HD patients	8.8% in PD and 11.1% in HD	None

DGF: Delayed graft function; PD: Peritoneal dialysis; HD: Hemodialysis.

1.53, $P < 0.0001$) than HD patients^[38]. Forty one percent of those on prior PD, who had allograft failure in the first 3 mo, had thrombosis *vs* 30% of those on prior HD (OR 1.59, 95%CI: 1.08-2.36, $P = 0.02$). All other early causes of allograft loss were similar between the two groups. In another study of 84513 renal transplant recipients between 1990-1996, Ojo *et al*^[48] found much higher odds of renal vein thrombosis (RVT) in PD patients as compared to HD patients (OR = 1.87, $P = 0.001$). Change in pre-transplant dialysis modality was also predictive of RVT among patients who switched from HD to PD (OR = 3.59, $P < 0.001$) as compared to HD patients who never switched and among patients who switched from PD to HD as compared to HD patients who never switched (OR = 1.62, $P = 0.047$)^[48]. In another study of 119 HD and 39 PD patients who underwent simultaneous kidney-pancreas transplantation, renal allograft loss due to thrombosis was much more common in PD patients as compared to HD patients (5.1% *vs* 0%, $P = 0.058$)^[50].

Since most patients on PD do not have an arteriovenous access, underlying thrombotic tendencies may be masked, and only uncovered at the time of transplantation. In addition, some PD patients may have been driven to switch after repeated thrombosis of the HD access. Moreover, PD patients are noted to have increased pro-coagulant factors such as apolipoprotein A, factors II, VII, VIII, IX, X, XI and factor XII, and hemo-concentration as compared to HD patients which can predispose them at higher risk of allograft thrombosis^[46,48]. The reasons behind increase in such factors are likely due to moderate non-specific inflammatory cell harvesting when the peritoneal membrane gets exposed to dialysis solutions. This leads to macrophage activation and increased presence of thromboplastin and plasminogen activator in the peritoneal cavity.

On the contrary, a study by Pérez Fontán *et al*^[47] on 827 patients (127 PD and 700 HD patients), who received deceased donor kidney transplantation between 1988 and 1997, there were similar incidence of primary allograft thrombosis between PD and HD patients (4.7% *vs* 6.1%, $P = \text{NS}$). Arterial and venous thrombosis was also similar in both groups^[47]. Studies by Lin *et al*^[41] and Escuin *et al*^[49] also reported similar results whereby they found no difference in incidence of graft thrombosis among PD versus HD patients.

Risk of infection and diabetes mellitus after transplantation

Patients receive multiple immunosuppressive medications in post-transplant period which increases the risk of infections. Infectious complications related with PD catheter after transplantation remain a concern^[42,50]. In a study by Rizzi *et al*^[51] on 313 PD patients who underwent transplantation between 2000 to 2015, authors found that 8.9% patients had post-transplant peritonitis especially among those who had DGF requiring dialysis. In addition, PD catheter was associated with an increased risk of exit-site infection and peritonitis even if it's not used^[52]. There is also a report of increased conversion from PD to HD after transplant due to leakage of dialysate fluid from surgical incision^[52]. Hence, authors had suggested low threshold for PD catheter removal at time of transplantation in patients with low risk of DGF. In patients with an increased risk of DGF, PD catheter could be left in place but to be removed at the

Table 2 Pre-transplant dialysis modality and allograft thrombosis

Study Period	Authors	Study Design	Study Participants	Thrombosis Incidence	Odds Ratio (OR)
1980s-1990s	Van der Vliet <i>et al</i> ^[44]	Retrospective observational	303 PD and 612 HD patients	7.3% in PD and 3.6% in HD patients	$P < 0.02$
1988-1997	Pérez Fontán <i>et al</i> ^[47]	Retrospective observational	127 PD and 700 HD patients	4.7% in PD and 6.1% in HD patients	$P = \text{NS}^b$
1989-1992	Murphy <i>et al</i> ^[45]	Retrospective observational	202 renal transplant procedures	9 PD versus 0 HD patients	Chi-squared = 9.63; $P < 0.01$
1990-1996	Ojo <i>et al</i> ^[48]	Retrospective Case-control match	63 PD and 161 HD patients	30.7% in PD and 18.9% in HD	OR = 1.87, 95%CI ^c 1.28-2.72, $P < 0.001$
1990-1994	Escuin <i>et al</i> ^[49]	Retrospective observational	138 PD and 892 HD patients	2.17% in PD and 3.47% in HD	$P = \text{NS}$
1992-1996	Vats <i>et al</i> ^[46]	Retrospective observational	1090 PD and 780 HD children	20% in PD and 10% in HD ^a	$P = 0.04$
1995-1998	Snyder <i>et al</i> ^[38]	Retrospective observational	156 PD and 349 HD patients	41% in PD and 30% in HD	OR 1.59, 95%CI 1.08-2.36, $P = 0.02$
1998-2011	Lin <i>et al</i> ^[41]	Retrospective cohort	603 PD and 1209 HD patients	Not available	$P = \text{NS}$

^a:vascular thrombosis as cause of graft failure;^b:non-significant;^c:Confidence Interval. PD: Peritoneal dialysis; HD: Hemodialysis.

earliest once no longer needed. Also, incidence of post-operative infections after transplantation was found to be increased in PD patients as compared to HD patients (67.5% *vs* 25.9%, $P < 0.00001$) with an increased median length of hospital stay^[53]. Lin *et al*^[41] also found higher risks of peritonitis and urinary tract infection in PD patients after transplantation. But, authors reported higher risk of new onset tuberculosis and chronic hepatitis C in patients after 90 d of kidney transplantation treated with prior HD^[41].

Risk factors for post-transplant diabetes mellitus (PTDM) was evaluated by Courivaud *et al*^[54] among 137 patients and did not find any impact of dialysis modality on development of PTDM. On the contrary, in a cohort of 72 patients, Madziarska *et al*^[55] found that PD was associated with an increased risk of PTDM ($P = 0.007$) in the multivariate analysis. In another study of 121 non-diabetic patients by Seifi *et al*^[56], authors found when used as pre-transplant modality, PD was associated with an increased risk for PTDM in univariate analysis, but not in multivariate analysis. The factors associated with new onset of diabetes after transplantation are multiple and variable, but not limited to presence of pre diabetes, immunosuppressive medication regimen, improved appetite and weight gain post-transplant among other.

Long-term outcome: Comparing those on prior HD vs PD

Preemptive kidney transplant without dialysis was associated with excellent patient survival compared to HD prior to transplant (HR 0.81 with 95%CI of 0.73-0.89, $P < 0.001$)^[9]. Data on long-term graft survival after PD and HD is mixed from most studies. Goldfarb *et al*^[9] analyzed 92844 patients who underwent kidney or kidney-pancreas transplants in 1990-1999. They reported better graft outcomes in patients previously treated predominantly with PD as compared to HD patients (HR 0.97 with 95%CI of 0.94-1.0, $P < 0.05$), after controlling for multiple variables. Lin *et al*^[41] also reported higher risk of death censored graft failure in a multivariate analysis in HD patients as compared to PD patients after 10 years of follow up (HR 1.31, 95%CI 1.03-1.84, $P = 0.031$). Although, Tang *et al*^[7] did not found 5 years graft survival rate to be different with pre-transplant PD as compared to HD technique in their meta-analysis (HR 0.92, 95%CI: 0.84-1.01, $P = 0.08$). Ten year graft survival was reported to be similar between a cohort of 80 HD and 80 PD patients^[11]. In another study of 11664 PD and 45561 HD patient, a similar death-censored graft survival was reported ($P = 0.39$)^[57]. Discrepancies in these results were evaluated by Kramer *et al*^[58] in a cohort of 29088 patients who received kidney transplantation between 1999 and 2008 and found that statistically significant association of PD with better allograft and patient survival in a multivariable cox regression analysis disappeared when used instrumental variable method that used the case-mix adjusted center percentage of PD as predictor variable.

Patient survival may also be better after kidney transplantation in those on preceding PD as compared to HD. The Goldfarb *et al*^[9] study also revealed that predominate PD prior to transplant was independently associated with better recipient survival compared to patients on preceding HD (HR 0.96 with 95%CI of 0.92-0.99, $P < 0.05$). Authors also looked at various RRT combinations and outcomes. They found that patient survival was significantly better in those on prior PD only when compared to those whose prior treatment consisted of solely HD (HR 0.90 with CI of 0.86 to 0.94, $P < 0.001$)^[9]. In another study by López-Oliva *et al*^[59], authors looked at a cohort of 236 patients and reported that long term patient survival was higher for the PD group than the HD group ($P = 0.04$). Interestingly the combination of prior PD and HD had a worse survival than those on HD alone (HR 1.10, with 95%CI of 1.06 to 1.15, $P < 0.001$).

Similarly, a European center in 2006 reported that prior-PD patients fare better and have lower post-transplant mortality than those on preceding HD. The same authors had postulated that exposure to the HD dialyzer membrane could be immunogenic and lead to an increased risk of graft loss. They found that despite using the biocompatible membranes, patient survival on pre-transplant PD was still superior to the HD counterparts^[60].

Mortality benefits in PD patients were again seen in the results reported by Molnar *et al*^[39] from 2012. They reported that patients who had been on PD before receiving a kidney transplant have an adjusted 43% lower death risk compared to those on prior HD (HR 0.57 with CI of 0.38-0.87). Using propensity matching, those with a high likelihood of being on PD ($n = 4836$) when adjusted for many variables including transplant donor variables had a HR of 0.56 (0.31-0.99, $P = 0.04$) of all-cause death in comparison to previous HD^[39]. Cardiovascular mortality in recipients who were on prior PD was lower compared to those on prior HD, controlling for many variables (HR 0.94)^[39]. In another study, superior survival of PD patients after transplantation was reported to be due to lower risk of cardiovascular death in a cohort of 60008 patients^[57]. Still, there are many studies reported whereby authors didn't find survival benefit of PD over HD after transplantation^[10,11,58]. Reasons for these mixed results is that even though most of the studies looked at standard variables like time and duration of dialysis, comorbidity index, it still does not take into account many other factors which may determine the long term survival benefits post transplantation. The choice of dialysis modality for any patient also leads to selection bias which may confound the end results like patient or graft survival post transplantation.

Mehrotra *et al*^[61] looked at the USRDS database to compare the impact of dialysis modality on survival. They reported no significant difference in the risk of death for PD and HD patients during the 5-year follow-up period. Earlier studies from other countries reported to have shown a marked early survival advantage for PD compared to in-center HD^[62-64]. The reasons for this are, may be due to better planning before starting PD, as opposed to HD. PD patients are better prepared and more motivated which might lead to increased access to transplantation care both pre and post. In addition, this could be explained by the better preservation of residual kidney function on PD, which has been repeatedly shown to enhance survival^[65,66].

CONCLUSIONS

Incidence and prevalence of ESRDs in the USA is rising; adding to already a large number of patients on dialysis despite the knowledge that kidney transplantation is ideal and associated with far superior clinical outcomes for patients with ESRD than being on dialysis. Majority of patients in the USA choose HD over PD and initiate dialysis with catheters as opposed to preferred arteriovenous access. Current evidence favors PD over HD as modality of choice as it is associated with lower risk of hospitalizations, healthcare expenditures and mortality. Although, conflicting data exists on mortality benefit of PD versus HD; as mortality for PD and in-center HD patients was found to be similar while on the waitlist^[28]. In regards to kidney transplantation outcomes, PD was associated with lower risk of DGF and cardiovascular mortality as compared to HD but with higher risk of infectious complications. Reports on allograft thrombosis, 5 years and 10 years graft survival and patient survival showed mixed results.

Overall, we believe that the choice of dialysis modality prior to kidney transplantation matters. While it is difficult to do a large numbered randomized controlled trial in an attempt to answer this extremely question, education regarding pre-transplant dialysis modality choices needs to be multi-faceted and should include all considerations including impact on kidney transplantation; its short term and long

term outcomes along with the impact on lifestyle^[67-69]. This education should not be biased on health literacy levels, and no matter what modality patients choose, the education and training must be patient centered, using universal approach. PD is an underutilized modality in the USA and can be a therapy of choice with a potential to be associated with improved outcome for transplantation. Further research and attention from nephrologist and transplantation community is needed in this regard.

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