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Early Kidney Transplantation or Conversion to Peritoneal Dialysis after First-Time Arteriovenous Access Creation

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Background: After autogenous arteriovenous (AV) access creation for end-stage renal disease, a majority of patients will continue on hemodialysis (HD), a minority will receive definitive treatment with kidney transplantation, and a subset of patients will convert to peritoneal dialysis (PD). Our goal was to identify patient factors associated with early transition from HD to either kidney transplantation or PD.

Methods: This is a case-control study of all patients with first-time AV access creation in the Vascular Quality Initiative (2011−2022) who had long-term follow-up. Patients who remained on HD after AV access creation were the control group while patients who received early kidney transplant or who converted to PD were the 2 case groups. Relationship among demographics, comorbidities, neighborhood social disadvantage, and functional status as they relate to renal replacement therapy modality was assessed.

Results: There were 19,782 patients included; the average age was 62 ± 15 years and 57% were male. During the follow-up period of a median 306 (71−403) days, 1.3% underwent a kidney transplantation and 2.3% underwent conversion to PD. On univariable analysis, rates of kidney transplantation or conversion to PD varied with race ($P < 0.001$), insurance status ($P < 0.001$), area deprivation index (ADI) quintile ($P < 0.001$), and several medical comorbidities. On multivariable analysis, impaired ambulation, current smoking, Medicaid or Medicare insurance, Black race, heart failure, body mass index, and older age were associated with decreased transplantation rates. Conversion to PD was associated with ADI Q5, Q4, and Q3. Decreased conversion to PD was associated with impaired ambulation, Hispanic ethnicity, Black race, former smoking, medication-controlled diabetes, and older age.

Conclusions: Decreased kidney transplantation was associated with Black race and noncommercial health insurance but not ADI quintile, suggesting disparities exist beyond community-level access to care. Early kidney transplantation conveyed a 3-year survival benefit compared with HD and PD, which had similar survival. Furthermore work is required to increase access to kidney transplantation and PD.

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INTRODUCTION

Most patients approaching end-stage renal disease (ESRD) are referred to access surgeons for autogenous arteriovenous (AV) access creation 6 months before the anticipated start of requiring renal replacement therapy. However, hemodialysis (HD) is meant to only serve as a bridge to destination therapy of kidney transplantation, given the clear survival benefits and improved quality of life of transplant more than dialysis.[1,2] Unfortunately, due to the shortage of donor kidneys, few patients are able to successfully receive a kidney transplant, especially given the long waitlist times and close to 50% mortality rate while waiting for transplantation.[1,3,4]

The 2020 Kidney Disease: Improving Global Outcomes Clinical Practice Guideline provides recommendations for which medical comorbidities may exclude a patient from kidney transplantation.[5] However, beyond medical comorbidities, disparities exist in which patients are successfully referred for transplantation evaluation and ultimately receive a kidney transplant.[6–9] International studies have suggested that social factors such as race, sex, low socioeconomic status, and limited health literacy all serve as barriers toward receiving a kidney transplant.[10–13] However, no studies have assessed social disparities and modifiable risk factors that influence kidney transplantation rates to improve equity in access to kidney transplant in the United States.

Furthermore, little is known about the factors influencing the decision for a patient to switch to peritoneal dialysis (PD) after autogenous AV access creation for HD. PD is underutilized compared with HD due to barriers of requiring patients to manage their own dialysis at home, but the 2011 Medicare ESRD Prospective Payment System saw expansion of Medicare coverage to pay for PD and resulted in an increase in PD usage.[14] Despite difficulty in managing one's own dialysis, previous studies suggest that PD may lead to improved quality of life more than HD given convenience of at-home dialysis.[15] Current literature suggests that there are no differences in survival between patients receiving HD versus PD, although studies have suggested that patients who convert between modalities have decreased survival.[16–19]

Herein, we describe a retrospective case-control study of first-time autogenous AV access creation patients from the Vascular Quality Initiative (VQI). Our goal was to characterize the medical and social factors associated with early kidney transplantation or conversion to PD compared with patients who remained on HD and assess 3-year survival for these groups.

METHODS

Data Source

The VQI was queried for all patients who had undergone first-time autogenous AV access creation between July 2011 and May 2022 with corresponding long-term follow-up (LTF) data. This study was approved by the Boston University Chobanian and Avedisian School of Medicine institutional review board as nonhuman subjects research. Requirements for patient informed-consent were waived due to the deidentified nature of this study.

Study Design

This was a case-control study. Inclusion criteria consisted of all patients that had matched LTF data to assess kidney transplantation or conversion to PD. Exclusion criteria were any previous autogenous AV access, AV graft, or PD, to assess what factors affect early transplantation or conversion to PD after first-time initiation on renal replacement therapy. Patients who remained on HD after autogenous AV access creation were defined as controls, whereas patients who received early transplantation or converted to PD within a couple years after autogenous AV access creation were defined as 2 separate case groups.

Variables

Demographic factors analyzed included age, sex, race, Hispanic ethnicity, and insurance status. Comorbidities analyzed included body mass index (BMI), ambulatory status, smoking status, diabetes, hypertension, heart failure, coronary artery disease (CAD), peripheral artery disease (PAD), and chronic obstructive pulmonary disease (COPD). Social disadvantage was characterized using the area deprivation index (ADI), which factors in community measures of income, education, housing, and employment. Patients were assigned a score between 1 and 100 according to the median 2019 ADI score of all 9-digit zip codes within the same 5-digit prefix, due to the limitation of the VQI only storing 5-digit zip codes. ADI scores were separated into quintiles (Q), with the lowest quintile Q1 representing the least social disadvantage, and the highest quintile Q5 representing the greatest social disadvantage, consistent with previous literature.[20–22]

Table I. Demographics of study population stratified by renal replacement therapy outcome

Demographic	Hemodialysis ($N = 19,063$)	Early transplant ($N = 263$)	Conversion to peritoneal dialysis ($N = 456$)	P
Age, mean ± SD	62.4 ± 14.5	52.2 ± 16	58.8 ± 15.2	**< 0.001**
Female sex, *n* (%)	8,129 (42.7%)	106 (40.3%)	192 (42.1%)	0.73
Race, *n* (%)				
White	10,292 (58%)	159 (67.1%)	286 (66.2%)	**< 0.001**
Black	6,364 (35.8%)	55 (23.2%)	127 (29.4%)	
Asian	640 (3.6%)	17 (7.2%)	11 (2.5%)	
Other	462 (2.6%)	6 (2.5%)	8 (1.9%)	
Hispanic ethnicity, *n* (%)	1,844 (9.7%)	34 (13.1%)	27 (6.1%)	**0.006**
Insurance, *n* (%)				
Commercial	6,410 (33.6%)	142 (54%)	167 (36.6%)	**< 0.001**
Medicaid	2,521 (13.2%)	31 (11.8%)	60 (13.2%)	
Medicare	9,493 (49.8%)	90 (34.2%)	211 (46.3%)	
Other insurance	164 (0.86%)	0 (0%)	6 (1.3%)	
Self-pay	469 (2.5%)	0 (0%)	12 (2.6%)	
LTF days, median (IQR)	303 (69–401)	386 (320–523)	349.5 (150–439.5)	**< 0.001**

Bold signifies statistical significance.
SD, standard deviation.

Statistical Analysis

Univariable analyses consisted of analysis of variance tests for continuous variables and χ^2 with Fisher's exact tests for categorical variables when comparing among cases and controls. Cuzick's test for trend across ordered ADI quintile groups was used to assess association between ADI quintile and rates of early transplantation or conversion to PD. Multivariable logistic regression was performed to assess association of ADI quintile, age, sex, race, ethnicity, insurance, BMI, ambulatory status, smoking, diabetes, hypertension, heart failure, CAD, and COPD with outcome groups. Results are represented in odds ratios (ORs) with 95% confidence intervals (CIs). Kaplan-Meier survival analysis with log-rank test was performed at 3 years status post AV access creation to assess survival amongst patients who remained on HD versus those who received early kidney transplant or converted to PD. All statistics were performed using Stata version 17.0. $P \leq 0.05$ was considered statistically significant.

RESULTS

There were 19,782 total patients in the VQI dialysis access registry included in this study. Compared with patients who remained on HD or who converted to PD, patients who received a kidney transplant were more likely to be younger (52.2 ± 16 years vs. 62.4 ± 14.5 years for HD, $P < 0.001$; 58.8 ± 15.2 for PD, $P < 0.001$; combined $P < 0.001$), less likely to be of Black race (23.2% vs. 35.8% for HD, $P < 0.001$; 29.4% for PD, $P = 0.016$; combined $P < 0.001$), were more likely to be of Hispanic ethnicity (13.1% vs. 9.7% for HD, $P = 0.068$; 6.1% for PD, $P = 0.001$; combined $P = 0.006$), were more likely to have commercial insurance (54% vs. 33.6% for HD, $P < 0.001$; 36.6% for PD, $P < 0.001$; respectively, $P < 0.001$), and were likely to have longer postoperative follow-up (median 386 days with interquartile range [IQR] 320–523 vs. 303 days [IQR 69–401] for HD, $P < 0.001$; 349.5 days [IQR 150–439.5] for PD, $P < 0.001$; combined $P < 0.001$). Demographic factors are summarized in Table I. On univariable analysis, increasing ADI quintile (greater social disadvantage) was associated with decreased rates of kidney transplantation and increased rates of conversion to PD ($P < 0.001$ for each). These results are summarized in Table II.

With respect to medical comorbidities, patients who received early kidney transplants were likely to be of lower BMI (28 ± 5.8 vs. 30 ± 7.8 for those remaining on HD, $P < 0.001$; 30.9 ± 7.8 for those converting to PD, $P < 0.001$; combined $P < 0.001$) and less likely to be current smokers (4.9% vs. 14.3% for HD, $P < 0.001$; 16.2% for PD, $P < 0.001$; combined $P < 0.001$). Compared with patients remaining on HD and patients converting to PD, patients who received early transplantation were less likely to have diabetes (50.6% vs. 62.7%

Table II. ADI quintiles stratified by renal replacement therapy outcome

Outcome	Q1 ($N = 3,245$)	Q2 ($N = 3,438$)	Q3 ($N = 3,952$)	Q4 ($N = 4,494$)	Q5 ($N = 4,530$)	*P*
Hemodialysis, *n* (%)	3,148 (97%)	3,312 (96.3%)	3,794 (96%)	4,335 (96.5%)	4,353 (96.1%)	0.098
Kidney transplant, *n* (%)	56 (1.7%)	64 (1.9%)	55 (1.4%)	43 (0.96%)	44 (0.97%)	**< 0.001**
Peritoneal dialysis, *n* (%)	41 (1.3%)	62 (1.8%)	103 (2.6%)	116 (2.6%)	133 (2.9%)	**< 0.001**

Q1 denotes least social disadvantage and Q5 denotes greatest social disadvantage.
Bold signifies statistical significance.

for HD, $P < 0.001$; 57.9% for PD, $P = 0.128$,; combined $P < 0.001$), heart failure (12.6% vs. 29.9% for HD, $P < 0.001$; 23.7% for PD, $P < 0.001$; combined $P < 0.001$), CAD (12.2% vs. 22.8% for HD, $P < 0.001$; 17.8% for PD, $P = 0.047$; combined $P < 0.001$), and COPD (10.3% vs. 17.3% for HD, $P = 0.003$; 17.3% for PD, $P = 0.01$; combined $P = 0.011$), as shown in Table III.

On multivariable logistic regression, factors that were associated with decreased rates of kidney transplantation included older age (OR 0.96, 95% CI 0.95−0.97, $P < 0.001$), Black race (OR 0.55, 95% CI 0.38−0.81, $P = 0.003$), Medicaid insurance (OR 0.42, 95% CI 0.24−0.73, $P = 0.002$), Medicare insurance (OR 0.67, 95% CI 0.47−0.95, $P = 0.026$), higher BMI (OR 0.95, 95% CI 0.93−0.98, $P < 0.001$), requiring assist for ambulation compared with being fully ambulatory (OR 0.39, 95% CI 0.19−0.81, $P = 0.011$), nonambulatory status compared with being fully ambulatory (OR 0.23, 95% CI 0.06−0.93, $P = 0.039$), current smoking (OR 0.21, 95% CI 0.1−0.45, $P < 0.001$), and heart failure (OR 0.52, 95% CI 0.32−0.84, $P = 0.008$). Notably, ADI quintile no longer affected rates of early kidney transplantation (Table IV).

With respect to conversion to PD, compared with ADI Q1, conversion was associated with ADI Q3 (OR 1.9, 95% CI 1.2−3, $P = 0.01$), Q4 (OR 1.9, 95% CI

Table III. Comorbidities of study population stratified by renal replacement therapy outcome

Comorbidities	Hemodialysis ($N = 19,063$)	Early transplant ($N = 263$)	Conversion to peritoneal dialysis ($N = 456$)	*P*
BMI, mean ± SD	30 ± 7.8	28 ± 5.8	30.9 ± 7.8	**< 0.001**
Ambulatory status, *n* (%)				
Nonambulatory	891 (5.7%)	2 (1%)	9 (2.4%)	**< 0.001**
Ambulatory with Assist	2,439 (15.7%)	8 (4.2%)	31 (8.4%)	
Ambulatory	12,248 (78.6%)	182 (94.8%)	329 (89.2%)	
Preoperative smoking, *n* (%)				
Never smoker	9,325 (49%)	165 (62.7%)	238 (52.2%)	**< 0.001**
Former smoker	6,996 (36.7%)	85 (32.3%)	144 (31.6%)	
Current smoker	2,723 (14.3%)	13 (4.9%)	74 (16.2%)	
Diabetes, *n* (%)				
None	7,075 (37.3%)	130 (49.4%)	191 (42.1%)	**< 0.001**
Diet-controlled	1,871 (9.9%)	16 (6.1%)	46 (10.1%)	
Medication-controlled	2,024 (10.7%)	19 (7.2%)	32 (7.1%)	
Insulin-dependent	8,006 (42.2%)	98 (37.3%)	185 (40.8%)	
Hypertension, *n* (%)	17,955 (95%)	240 (92.7%)	431 (95.4%)	0.229
Heart failure, *n* (%)	5,696 (29.9%)	33 (12.6%)	108 (23.7%)	**< 0.001**
PAD, *n* (%)	1,276 (6.8%)	10 (3.9%)	22 (4.9%)	0.057
CAD, *n* (%)	4,342 (22.8%)	32 (12.2%)	81 (17.8%)	**< 0.001**
COPD, *n* (%)	3,301 (17.3%)	27 (10.3%)	79 (17.3%)	**0.011**
Creatinine, mean ± SD	4.7 ± 1.9	5.2 ± 2.1	5.2 ± 2.5	**< 0.001**

Bold signifies statistical significance.
SD, standard deviation.

Table IV. Multivariable logistic regression of factors associated with early transplantation

	Early transplan		
Covariate	OR	95% CI	*P*
Age	0.96	[0.95, 0.97]	**< 0.001**
Female sex	1	[0.75, 1.4]	0.829
Race (ref. = White)			
Black	0.55	[0.38, 0.81]	**0.003**
Asian	1.4	[0.75, 2.6]	0.293
Other	0.68	[0.21, 2.2]	0.514
Hispanic ethnicity	1.1	[0.61, 2]	0.756
Insurance (ref. = commercial)			
Medicaid	0.42	[0.24, 0.73]	**0.002**
Medicare	0.67	[0.47, 0.95]	**0.026**
ADI quintile (ref. = Q1)			
Q2	1.1	[0.67, 1.9]	0.659
Q3	1.3	[0.77, 2.1]	0.339
Q4	0.92	[0.54, 1.5]	0.741
Q5	0.69	[0.38, 1.2]	0.215
BMI	0.95	[0.93, 0.98]	**< 0.001**
Ambulatory status (ref. = ambulatory)			
Ambulatory with assist	0.39	[0.19, 0.81]	**0.011**
Nonambulatory	0.23	[0.06, 0.93]	**0.039**
Preoperative smoking (ref. = never smoker)			
Former smoker	0.91	[0.64, 1.3]	0.595
Current smoker	0.21	[0.1, 0.45]	**< 0.001**
Diabetes (ref. = none)			
Diet-controlled	0.78	[0.39, 1.6]	0.481
Medication-controlled	1	[0.56, 1.8]	0.977
Insulin-dependent	1.2	[0.83, 1.7]	0.351
Hypertension	1.1	[0.6, 2]	0.761
Heart failure	0.52	[0.32, 0.84]	**0.008**
CAD	0.69	[0.41, 1.2]	0.17
COPD	1.2	[0.76, 2]	0.397

Bold signifies statistical significance.
ref., reference.

1.2−3, $P = 0.007$), and Q5 (OR 2.4, 95% CI 1.5−3.7, $P < 0.001$). Other factors that was associated with decreased conversion to PD on adjusted analysis included older age (OR 0.99, 95% CI 0.98−0.99, $P < 0.001$), Black race (OR 0.61, 95% CI 0.47−0.78, $P < 0.001$), Hispanic ethnicity (OR 0.44, 95% CI 0.23−0.85, $P = 0.014$), requiring assist for ambulation compared with being fully ambulatory (OR 0.51, 95% CI 0.34−0.76, $P = 0.001$), nonambulatory status compared with being fully ambulatory (OR 0.34, 95% CI 0.16−0.73, $P = 0.005$), former smoking (OR 0.7, 95% CI 0.54−0.91, $P = 0.007$), and medication-controlled diabetes (OR 0.58, 95% CI 0.36−0.94, $P = 0.028$). Full multivariable analyses are summarized in Table V.

At 3 years status post autogenous AV access creation, Kaplan-Meier survival analysis showed that early kidney transplantation was associated with significantly higher all-cause survival compared with patients remaining on HD or converting to PD (95.4% vs. 85.6% for those remaining on HD, $P < 0.001$; 85.1% for those converting to PD, $P < 0.001$; combined $P < 0.001$). Survival curves are shown in Figure 1. There was no difference in 3-year survival between patients remaining on HD and those converting to PD ($P = 0.828$).

DISCUSSION

In this VQI study, decreased early kidney transplantation was found to be associated with social and modifiable risk factors such as Black race, noncommercial insurance, impaired ambulatory

Table V. Multivariable logistic regression of factors associated with conversion to peritoneal dialysis

	Conversion to peritoneal dialysis		
Covariate	OR	95% CI	*P*
Age	0.99	[0.98,0.99]	**< 0.001**
Female sex	0.96	[0.77, 1.2]	0.756
Race (ref. = White)			
Black	0.61	[0.47, 0.78]	**< 0.001**
Asian	0.65	[0.3, 1.4]	0.282
Other	0.59	[0.24, 1.4]	0.248
Hispanic ethnicity	0.44	[0.23, 0.85]	**0.014**
Insurance (ref. = commercial)			
Medicaid	1	[0.72, 1.5]	0.849
Medicare	1.2	[0.9, 1.5]	0.264
ADI quintile (ref. = Q1)			
Q2	1.3	[0.81, 2.2]	0.254
Q3	1.9	[1.2, 3]	**0.01**
Q4	1.9	[1.2, 3]	**0.007**
Q5	2.4	[1.5, 3.7]	**< 0.001**
BMI	1	[0.99, 1]	0.388
Ambulatory status (ref. = ambulatory)			
Ambulatory with assist	0.51	[0.34, 0.76]	**0.001**
Nonambulatory	0.34	[0.16, 0.73]	**0.005**
Preoperative smoking (ref. = never smoker)			
Former smoker	0.7	[0.54, 0.91]	**0.007**
Current smoker	0.85	[0.62, 1.2]	0.321
Diabetes (ref. = none)			
Diet-controlled	1.2	[0.83, 1.8]	0.296
Medication-controlled	0.58	[0.36, 0.94]	**0.028**
Insulin-dependent	1	[0.77, 1.3]	0.974
Hypertension	1.2	[0.74, 2.1]	0.410
Heart failure	0.86	[0.66, 1.1]	0.297
CAD	0.75	[0.55, 1]	0.085
COPD	1.1	[0.85, 1.6]	0.377

Bold signifies statistical significance.
ref., reference.

status, and current smoking, and medical comorbidities such as older age, higher BMI, and heart failure. Increased conversion to PD was found to be associated with increasing ADI quintile, whereas decreased conversion was associated with older age, Black race, Hispanic ethnicity, impaired ambulatory status, former smoking, and diabetes.

Although strict criteria exist outlining medical comorbidities which prohibit a patient from being eligible for kidney transplant, sociodemographic factors and modifiable medical risk factors still exist that are associated with decreased rates of receiving a kidney transplant. Notably, neighborhood social disadvantage, as approximated by ADI, was not associated with decreased rates of kidney transplantation on adjusted analysis, suggesting that decreased transplant rates in lower socioeconomic neighborhoods may be more likely related to racial prejudice and insurance status at the individual rather than at the community level. Furthermore work is needed to explore provider biases in kidney transplant referrals and to address misconceptions. Furthermore, impaired ambulatory status and current smoking were associated with decreased rates of kidney transplantation, suggesting possible modifiable risk factors that can be optimized, such as with physical therapy or smoking cessation referrals, to increase rates of transplant eligibility. Currently, it is unclear if unoptimized modifiable risk factors are related to patient racial/ethnic identity or socioeconomic status. As most patients are referred to vascular surgeons for autogenous AV access creation, they can serve as a checkpoint for transplant eligibility assessment and medical optimization to ensure equity in this process regardless of race or socioeconomic status.

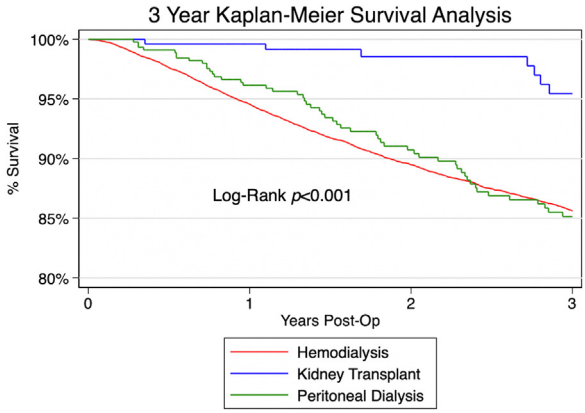

Fig. 1. Kaplan-Meier 3-year survival analysis stratified by renal replacement therapy.

Conversion to PD occurred in 2.3% of the study population. Black race and Hispanic ethnicity were associated with decreased rates of conversion to PD, suggestive of racial and ethnic disparities in usage of PD consistent with previous literature.[23,24] Increased ADI quintile, or greater social disadvantage, was associated with increased rates of conversion to PD, possibly reflecting increased rates of failure for autogenous AV access to mature in more socially disadvantaged neighborhoods, thus necessitating conversion to PD.[20] As evidenced by survival analysis, early kidney transplantation will continue to remain destination therapy for ESRD more than HD or PD. However, given lack of survival difference between patients remaining on HD or converting to PD, it is reasonable to consider greater encouragement of PD amongst higher ADI populations. PD requires a higher level of health literacy for a patient to manage their own dialysis at home, and given higher ADI neighborhoods tend to have lower health literacy, it is likely underutilized amongst patients in these areas. However, given higher quality of life associated with PD, lower overall cost compared with HD, and alleviating the need to attend tri-weekly HD sessions (an especially burdensome barrier in low-resourced neighborhoods), improving patient education on PD may be a worthwhile intervention for high ADI neighborhoods.[15,25] When patients are referred for autogenous AV access creation, it is imperative for surgeons to be cognizant of implicit biases and ensure all patients are properly assessed for transplant eligibility and educated on the benefits of HD versus PD to ensure equity in access to various renal replacement therapies for ESRD.

There are several limitations to this study. First, we were unable to assess patients who received a kidney transplant as first-line renal replacement therapy or who were initiated on PD without AV access creation because the VQI only captures patients who received autogenous AV access formation. We were also unable to evaluate patients who received initial autogenous AV access creation at non-VQI-participating sites. Similarly, factors assessed relating to early kidney transplantation or conversion to PD were limited to those available within the VQI. Furthermore, the ability to detect if patients received early transplantation or converted to PD relied on LTF data, which were limited by loss to follow-up. The VQI does not record date of kidney transplantation or initiation of PD, so the exact duration between AV access creation and switch to alternate renal replacement therapy cannot be measured.

CONCLUSION

Among first-time autogenous AV access creation patients in the VQI, several sociodemographic disparities and modifiable risk factors including Black race, noncommercial insurance, impaired ambulatory status, and current smoking were found to decrease rates of early kidney transplantation. Kidney transplant was associated with a 3-year survival benefit compared with remaining on HD or converting to PD after AV access creation, which both had similar survival rates. Furthermore work is required from multidisciplinary teams to improve access to kidney transplant for all patients and to better understand the utility of PD in socially disadvantaged neighborhoods.

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