Pretransplant Dialysis and Preemptive Transplant in Living Donor Kidney Recipients

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Key Points

- Peritoneal dialysis and multimodal dialysis were the most prevalent access modalities among living donor transplant recipients.
- Living donor transplant recipients may benefit from a case-by-case approach for dialysis access given shorter time to transplant.

Abstract

Background The optimal timing of dialysis access placement in individuals with stage 5 CKD is challenging to estimate. Preemptive living donor kidney transplant (LDKT) is the gold-standard treatment for ESKD due to superior graft survival and mortality, but dialysis initiation is often required. Among LDKT recipients, we sought to determine which clinical characteristics were associated with preemptive transplant. Among non-preemptive LDKT recipients, we sought to determine what dialysis access was used, and their duration of use before receipt of living donor transplant.

Methods We retrospectively extracted data on 569 LDKT recipients, ≥18 years old, who were transplanted between January 2014 and July 2019 at UCSF, including dialysis access type (arteriovenous fistula [AVF], arteriovenous graft [AVG], peritoneal dialysis catheter [PD], and venous catheter), duration of dialysis, and clinical characteristics.

Results Preemptive LDKT recipients constituted 30% of our cohort and were older, more likely to be White, more likely to have ESKD from polycystic kidney disease, and less likely to have ESKD from type 2 diabetes. Of the non-preemptive patients, 26% used AVF, 0.5% used AVG, 32% used peritoneal catheter, 11% used venous catheter, and 31% used more than one access type. Median (IQR) time on dialysis for AVF/AVG use was 1.86 (0.85–3.32) years; for PD catheters, 1.12 (0.55–1.92) years; for venous catheters, 0.66 (0.23–1.69) years; and for multimodal access, 2.15 (1.37–3.72) years.

Conclusions We characterized the dialysis access landscape in LDKT recipients. Venous catheter and PD were the most popular modality in the first quartile of dialysis, and patients using these modalities had shorter times on dialysis compared with those with an AVF. Venous catheter or PD can be considered a viable bridge therapy in patients with living donor availability given their shorter waitlist times. Earlier referral of patients with living donor prospects might further minimize dialysis need.

Introduction

The optimal timing of dialysis access placement in individuals with stage 5 CKD is challenging to determine due to variations in access outcomes (1). Shorter time on dialysis has been associated with improved graft and recipient longevity (2). Furthermore, preemptive transplant has been shown to have superior post-transplant outcomes and is the treatment of choice for patients with ESKD. It is associated with both improved patient and graft survival time (2–6), and provides significant benefit in patient quality of life and societal cost (7).

From the time of transplant listing to successful renal transplantation, many clinical hurdles must be overcome, with financial and systemic barriers further hindering preemptive transplant (8). Orchestrating a preemptive transplant is challenging, with the majority of patients listed for transplant eventually requiring access placement and dialysis (9). Nevertheless, living donor availability for kidney transplant may influence the choice of dialysis access, given the prospect of shorter time on dialysis.

The Fistula First Initiative, the National Kidney Foundation, and other entities emphasize arteriovenous

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fistula (AVF) as the preferred access method for patients with CKD due to longer access durability and lower infection rates (10). However, an indiscriminate push for long-term AVF may not be best for patients with living donor availability, who represent a unique subset of kidney transplant recipients. They benefit from both shorter time with ESKD until transplant listing, and shorter time until transplant compared with their deceased donor counterparts (11). Dialysis access, in particular AVF, has been associated with numerous cardiovascular complications, including heart failure, with some patients eventually requiring surgical takedown of AVF to reduce cardiovascular complications (12,13).

The ESKD landscape has evolved significantly in recent years, with an aging ESKD population and growing organ transplant waiting lists (14). Among recipients of preemptive living donor transplants, we sought to determine which clinical characteristics were predictive of preemptive transplant. Among recipients of non–preemptive living donor transplants, we sought to characterize the dialysis access landscape and dialysis experience before transplant.

Materials and Methods

Using the University of California San Francisco (UCSF) database derived from the Scientific Registry of Transplant Recipients database, we identified 569 living donor kidney transplant (LDKT) recipients, >18 years old, who underwent transplant between January 2014 and July 2019 at UCSF. Deceased donor kidney transplants or combined organ transplants were excluded (Supplemental Figure 1). Institutional review board approval was obtained (number 14-13041). Data from repeat living transplants and associated dialysis were censored to reduce bias from possible preexisting vascular access. We retrospectively extracted data on dialysis access type (AVF, arteriovenous graft [AVG], peritoneal dialysis catheter [PD], and venous catheter), duration of dialysis, one or more positive blood cultures, and clinical characteristics by chart review, including in partnered hospital systems sharing electronic medical data. Demographic information, including race and ethnicity, were derived from the electronic medical record (EMR). Donor relationship information was derived from an established UCSF transplant database (Supplemental Table 5). Dialysis access creation date was recorded as the earliest documented access procedure matching the modality of initial dialysis. Subsequent access creation after the first procedure was not documented. Dialysis start date was defined as first documented dialysis run or a retrospectively documented date of initiation. Dialysis end date was defined as last documented day of dialysis noted in the transplant note, or the day of transplant if no post-transplant dialysis was documented. All access-related complications were tracked from the time of access creation or dialysis initiation until July 1, 2019. Infection rates were defined as one or more positive blood cultures, including in partnered hospital systems sharing electronic medical data. Central vein stenosis was defined as superior vena cava (SVC) or brachiocephalic/subclavian vein stenosis documented in a procedure, in imaging, or in medical history. SVC syndrome was defined as clinician-documented definite or probable SVC syndrome. Peritoneal peritonitis was defined as clinician-documented peritonitis, peritoneal fluid with white blood cells >100 cells/mm³, or positive effluent culture. Leak and obstruction were defined as any documented leak of fluid from the catheter exit site or obstruction of the catheter, respectively. Hernia was defined as any documentation of umbilical or inguinal hernia, or a procedure note for hernia repair. Follow-up was determined from LDKT to most recent clinical encounter preceding July 1, 2019. The clinical and research activities being reported are consistent with the Declaration of Helsinki and the Principles of the Declaration of Istanbul, as outlined in the Declaration of Istanbul on Organ Trafficking and Transplant Tourism.

We compared characteristics of individuals who underwent preemptive versus non–preemptive transplants with two-sample $t$ tests, chi-squared tests, and Fisher exact tests, as appropriate. Among those who did not receive preemptive transplants and required dialysis, we evaluated length of dialysis by access type. In analyses where AVF and AVG are combined, this denotes exclusively using either AVF or AVG. Individuals who required more than one type of dialysis access (for example, temporary catheter and AVF, or both AVF and AVG) were categorized as “multimodal.” This also included individuals who underwent both PD and hemodialysis (HD).

All variables had complete data across all variables, except for time from access creation procedure date to dialysis initiation, which had missing values (20%). These individuals did not have a documented procedure date viewable in the UCSF EMR or in partnered hospital systems.

Multivariate logistic regression was used to determine clinical covariate associations with preemptive transplant, and association with dialysis longer than the first quartile (0.76 years or 9 months) among non–preemptive LDKT recipients. Clinical covariates were determined $a$ priori, including recipient sociodemographic characteristics and etiology of ESKD. Socioeconomic status (SES) by household income was defined as a binary variable, stratified by the median income for US households in 2019 ($68,703), and using estimates for household income on the basis of patient zip code. Statistical analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC) and R (version 4.0.5; R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline Characteristics

In our cohort of 569 patients, 30% of patients received preemptive living transplant, and 70% of patients received non–preemptive living transplant. At baseline, preemptive LDKT recipients were older, more likely to be White ($P<0.001$), less likely to have type 2 diabetes as the etiology of ESKD ($P=0.004$), and more likely to have polycystic kidney disease (PKD; $P<0.001$; Table 1). Additionally, preemptive LDKT recipients had different baseline cardiac comorbidities (hypertension, vascular complications, coronary artery disease, heart failure, dysrhythmia) compared with their non–preemptive counterparts ($P<0.001$; Table 1). Etiology of ESKD differed by race ($P<0.001$; Supplemental Table 1).
Table 1. Sociodemographic and clinical characteristics of living donor kidney recipients

| Characteristics | Non-Preemptive (N=400) | Preemptive (N=169) | P Value |
|-----------------|------------------------|--------------------|---------|
| Age at transplant, mean (SD) | 49.7 (14.9) | 52.3 (14.5) | 0.05* |
| Men, n (%) | 235 (59) | 100 (59) | 0.93 |
| Race, n (%) | 103 (26) | 29 (17) | <0.001* |
| Asian or Pacific Islander | 45 (11) | 8 (5) | |
| White | 155 (39) | 100 (59) | |
| Unknown | 97 (24) | 32 (19) | |
| Ethnicity, n (%) | 94 (24) | 32 (19) | 0.29 |
| Hispanic/Latin | 94 (24) | 32 (19) | |
| Non-Hispanic/Latin | 305 (76) | 136 (81) | |
| Unknown | 1 (0.3) | 1 (0.6) | |
| Cause of ESKD, n (%) | 40 (10) | 45 (27) | <0.001* |
| Polycystic kidney disease | 115 (29) | 46 (27) | |
| Glomerular disease | 52 (13) | 17 (10) | |
| Hypertension | 118 (30) | 30 (18) | |
| Diabetes | 75 (19) | 31 (18) | |
| Other | 66 (17) | 11 (7) | |
| Cardiac comorbidities at baseline, n (%) | 265 (69) | 136 (85) | <0.001* |
| Hypertension | 13 (3) | 7 (4) | |
| Vascular/stroke and associated Coronary artery disease and associated Heart failure | 27 (7) | 3 (2) | |
| Dysrhythmia | 14 (4) | 3 (2) | |

*P<0.05.

Dialysis Modality and Access Usage

The median (interquartile range [IQR]) time on dialysis was 1.51 (0.76–3.01) years in our non-preemptive cohort. None of the individuals had time on dialysis missing. Among individuals who underwent non-preemptive living transplant, 48% received HD, 33% received PD only, and 19% received both treatments. By access type, 26% of non-preemptive patients used AVF, 0.5% used AVG, 32% used PD, 11% used venous catheter, and 31% used more than one access type (Table 2). Median (IQR) time on dialysis for AVF/AVG use was 1.86 (0.85–3.32) years; for PD, 1.12 (0.55–1.92) years; for venous catheters, 0.66 (0.23–1.69) years; and for multimodal access, 2.15 (1.37–3.72) years (Figure 1 and Table 2). In patients on dialysis for ≤0.76 years (first quartile of time on dialysis), venous catheters were the sole access used in 25% of patients, PD in 45%, and AVF/AVG in 22% of patients (Figure 2). Component access types for patients with multimodal dialysis are shown in Figure 3 and Supplemental Table 3. Black patients had higher proportions of multimodal dialysis (P=0.01) and lower proportions of AVF/AVG than non-Black patients (P=0.04; Figure 4). The makeup of multimodal dialysis access types in Black patients is seen in Figure 5.

Predictors of Preemptive Transplant and Dialysis Duration

In multivariate logistic regression, PKD as the etiology of ESKD was associated with preemptive transplant, with
diabetes as the reference group (odds ratio, 3.96; 95% CI, 2.14 to 7.30; \( P \leq 0.001 \)). No other demographic factors, including sex, race, SES as measured by household income, or other etiologies of ESKD were predictive of preemptive transplant in multivariate analysis (Table 5).

No demographic factors, including SES as measured by household income approximated by zip code, were associated with duration of dialysis \( \geq 9 \) months in non-preemptive LDKT recipients (Table 6).

In Cox proportional hazards regression, we did not find any differences of graft failure hazard in preemptive compared with non-preemptive transplant, HD compared with PD, nor AVF/AVG compared with venous catheter (Table 7). Median follow-up time post-transplant was 19 months.

**Discussion**

**Clinical Characteristics**

Preemptive transplant remains the gold-standard treatment for ESKD, with preemptive transplant associated with lower rates of graft failure and patient

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**Figure 1.** Differences in length of dialysis by access type. Box-and-whisker plot of length of dialysis use before living donor transplant by access type. Patients in the AVF/AVG group had either only AVF or AVG. Patients with both AVF and AVG were included in the multimodal group. AVF, arteriovenous fistula; AVG, arteriovenous graft.

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**Figure 2.** Trends in dialysis access modality by length of dialysis quartile. Dialysis modality distribution by quartile of length on dialysis. Peritoneal and venous catheter use was lower in higher quartiles of dialysis usage, whereas multimodal and AVF/AVG access was higher with increasing dialysis vintage. Patients in the AVF/AVG group had either only AVF or AVG. Patients with both AVF and AVG access types were documented in the multimodal group.
mortality (2–5,15). This is particularly salient for patients with living donor availability, who tend to have higher rates of preemptive transplant than those awaiting deceased donor kidneys (16). Our preemptive cohort had different cardiovascular comorbidities and were more likely to have PKD as the etiology of ESKD compared with non–preemptive LDKT recipients. This may reflect a population overall better connected to healthcare services and, consequently, more likely to have more gradual progression of renal disease. Our findings corroborated past studies demonstrating that preemptive LDKT are more likely to be White (17). Racial disparities are pervasive in kidney transplantation, and this is reflected in rates of living donor transplant overall, rates of referral for preemptive transplant, and transplant wait times, with Black patients 70% less likely to receive preemptive transplants than White patients (8,9,11,17–18). Our study highlights dialysis and access inequities because Black patients had higher rates of multimodal dialysis and lower rates of AVF compared with their White counterparts. Further research is needed to investigate these transplant disparities, followed by championed action to advance equity in dialysis care.

Preemptive Transplant

Coordinating a successful kidney transplant is challenging. Organizing preemptive transplant is even more difficult. Among living donor transplants, 31% were preemptive in the United States from 2003 to 2012 (19). Our cohort of LDKT recipients saw a similar proportion of 30% undergoing preemptive transplant. PKD as the etiology of ESKD compared with non–preemptive LDKT recipients. This may reflect a population overall better connected to healthcare services and, consequently, more likely to have more gradual progression of renal disease. Our findings corroborated past studies demonstrating that preemptive LDKT are more likely to be White (17). Racial disparities are pervasive in kidney transplantation, and this is reflected in rates of living donor transplant overall, rates of referral for preemptive transplant, and transplant wait times, with Black patients 70% less likely to receive preemptive transplants than White patients (8,9,11,17–18). Our study highlights dialysis and access inequities because Black patients had higher rates of multimodal dialysis and lower rates of AVF compared with their White counterparts. Further research is needed to investigate these transplant disparities, followed by championed action to advance equity in dialysis care.

Figure 3. | Venn diagram of dialysis access types among living donor kidney transplant recipients. Areas contained in overlapping circles represent “multimodal access” patients. Patients in the AVF/AVG group had either AVF or AVG only.

Figure 4. | Dialysis access modalities by race. Types of access used by self-identified race. Black patients had a lower proportion of AVF/AVG and higher proportion of multimodal dialysis than White patients. Patients in the AVF/AVG group had either only AVF or AVG. Patients with both AVF and AVG access types were documented in the multimodal group.
circles represent kidney transplant recipients. Areas contained in overlapping and AVG access were documented in the multimodal group. AVG group had either AVF or AVG only. Patients with both AVF and AVG usage were low at our center (there is center-dependent variation (20). Notably, rates of were roughly consistent with national levels, although Dialysis Distribution preemptive LDKT. advanced CKD and ESKD could facilitate successful discussion of living donor transplant in patients with patient-centric decision, reflected by recent Kidney Disease Improving Global Outcomes statements to move away from a “one-size-fits-all” approach and incorporate patient goals, in addition to best practices, when selecting initial dialysis access (1). In this study, we report venous catheter–, AVF–, and PD-associated complications among living donor kidney recipients, each of which should be considered when deciding on access type. Tunneled dialysis catheters, although often viewed as the last choice due to higher overall costs and infection rates, are significantly easier to remove than AVFs and have fewer cardiovascular complications persisting post-transplant than AVFs (23). They can also provide short-term survival comparable with AVFs of 86% at 1 year, and 79% at 2 years (24,25). Among those using venous catheters, we observed prevalence of central venous stenosis somewhat lower than previous studies (26,27). Venous catheters historically result in higher rates of bacteremia, which has significant clinical consequences (28). We did not observe a higher rate of bacteremia among our venous catheter group. This is likely due to a small sample size, but is nevertheless reassuring that use of venous catheters for individuals with a prospective living donor may be reasonable and may obviate the need for a permanent access type that would be used for only a limited period of time. Among those with PD catheters, we observed prevalence of peritonitis and other PD-associated complications comparable with previous estimates (9,29).

**Dialysis Access Types**

**Distribution of dialysis access usage times in our study were roughly consistent with national levels, although there is center-dependent variation (20). Notably, rates of AVG usage were low at our center (N=2). Patients using AVF or multimodal dialysis on average had longer total dialysis usage times. This is appropriate considering current guidelines recommending AVF as permanent dialysis access. Patients using venous catheters had the shortest dialysis times on average, followed closely by PD use. Notably, a high percentage of LDKT recipients used PD as the sole access modality before transplant. In the first quartile of dialysis duration, exclusive PD and venous catheter use together make up 70% of LDKT recipients (45% and 25%, respectively). Given that incident patients with ESKD typically initiate on venous catheter in the United States (21), it is not surprising that venous catheters account for a high proportion of dialysis in the first quartile of dialysis vintage. This is comparable to national trends, with the United States Renal Data System (USRDS) reporting 80% of patients initiating HD on venous catheter in 2017. Notably, in our study, 45% of patients in the first quartile of dialysis vintage exclusively used PD (and thus initiated on PD), compared with 10% of patients initiating dialysis with PD in the 2017 USRDS (Table 2) (22). Because complications of every access type are expected to accrue with increasing dialysis vintage, longer median time on dialysis for patients with multimodal dialysis is expected. We speculate that patients on multimodal dialysis generally initiated dialysis on venous catheter or PD, and subsequently switched to AVF or PD for more permanent access or due to complications from their initial access type (Figure 4). Indeed, the short median time from access creation to dialysis initiation for multimodal dialysis better approximates the short initiation times for venous catheter and PD.

**Figure 5.** Venn diagram of access types in Black living donor kidney transplant recipients. Areas contained in overlapping circles represent “multimodal access” patients. Patients in the AVF/AVG group had either AVF or AVG only. Patients with both AVF and AVG access were documented in the multimodal group.

**Table 3.** Bacteremia in non-preemptive transplant recipients using hemodialysis

| Complication                  | AVF/AVG (N=105) | Venous Catheter (N=43) | Multimodal (at least one is hemodialysis) (N=119) | P Value |
|-------------------------------|-----------------|------------------------|--------------------------------------------------|---------|
| Positive culture, n (%)       | 5 (5)           | 0 (0)                  | 2 (2)                                            | 0.24    |

Bacteremia was defined as one or more documented positive bloodstream cultures. Patients in the AVF/AVG group had either only AVF or AVG. Patients with both AVF and AVG were included in the multimodal group. AVF, arteriovenous fistula; AVG, arteriovenous graft.
AVF Drawbacks

AVFs remain the gold standard for HD access, with lower rates of hospitalizations and complications and superior durability (25). However, AVF is not without its drawbacks, with some post-transplant AVF recipients suffering from high-output cardiac failure and increased left ventricular end diastolic volume (30,31). Aneurysm, pseudoaneurysm, and cosmetic concerns may also prompt AVF takedown (32,33). In our study, we saw median time from AVF access creation to dialysis initiation of 6 months, likely reflecting a combination of early access creation and time to maturation. We did not see differences in cardiovascular complications by access type; however, we lacked sufficient power and follow-up time to detect cardiovascular events.

Strengths and Limitations

This study has several limitations. As a single-academic-center study, the results may not be generalizable to other centers, particularly if the demographics of the patients with ESKD differ from this study. Notably, the individuals in our cohort differ from the general ESKD population because they all reached living donor transplant, whereas the majority of the ESKD population do not make it to transplant. Comparison to 2019 United Network for Organ

### Table 4. Dialysis access complications

| Complication                  | Nonmultimodal Access | Multimodal Access | P Value |
|-------------------------------|-----------------------|-------------------|---------|
| Arteriovenous fistulas, n, n (%) | 103                   | 75                |         |
| Bacteremia                    | 5 (5)                 | 0 (0)             | 0.07    |
| Venous catheters, n, n (%)    | 43                    | 93                |         |
| Bacteremia                    | 0 (0)                 | 2 (2)             | >0.99   |
| SVC syndrome                  | 0 (0)                 | 2 (2)             | >0.99   |
| Central stenosis              | 3 (7)                 | 7 (8)             | >0.99   |
| Peritoneal dialysis catheters, n, n (%) | 127               | 86                |         |
| Peritonitis                   | 15 (12)               | 30 (35)           | <0.01*  |
| Catheter exit/tunnel infection| 6 (5)                 | 6 (7)             | 0.55    |
| Hernia                        | 15 (12)               | 13 (15)           | 0.48    |
| Leak                          | 4 (3)                 | 3 (4)             | >0.99   |
| Pain                          | 0 (0)                 | 1 (1)             | 0.40    |
| Obstruction                   | 1 (0.8)               | 0 (0)             | >0.99   |
| Sclerosing encapsulating peritonitis | 0 (0)                | NA                |         |

Multimodal indicates multiple dialysis access modalities, including the access named in the row. SVC, superior vena cava; NA, not applicable. *P<0.05.

### Table 5. Multivariate analysis of preemptive transplant versus non-preemptive transplant

| Recipient Characteristics | Odds Ratio (95% Confidence Interval) | P Value |
|---------------------------|--------------------------------------|---------|
| Age at transplant (unit=10 yr) | 1.13 (0.98 to 1.30) | 0.09    |
| Women (men as reference)   | 1.03 (0.70 to 1.53) | 0.86    |
| Race (White as reference)  |                        |         |
| Asian or Pacific Islander  | 0.53 (0.32 to 0.88) | 0.49    |
| Black                      | 0.39 (0.17 to 0.88) | 0.14    |
| Other or unknown           | 0.67 (0.40 to 1.11) | 0.65    |
| ESKD etiology (diabetes as reference) |                        |         |
| PCKD                       | 3.96 (2.14 to 7.30) | <0.001* |
| Glomerular disease         | 1.82 (1.03 to 3.23) | 0.19    |
| Hypertension               | 1.53 (0.76 to 3.07) | 0.53    |
| Other                      | 1.62 (0.84 to 2.99) | 0.06    |
| Median household income ≥$68,703 | 1.36 (0.88 to 2.12) | 0.17    |

Shown are odds ratio estimates (with 95% Wald CIs) for preemptive transplant. PCKD, polycystic kidney disease; CI, confidence interval. *P<0.05.

### Table 6. Multivariate analysis of associations with length of dialysis ≥9 months

| Recipient Characteristics | Odds Ratio (95% Confidence Interval) | P Value |
|---------------------------|--------------------------------------|---------|
| Age at transplant (per 10 yr) | 1.07 (0.90 to 1.27) | 0.47    |
| Women (men as reference)   | 1.28 (0.79 to 2.09) | 0.31    |
| Race (White as reference)  |                        |         |
| Asian or Pacific Islander  | 1.48 (0.81 to 2.70) | 0.80    |
| Black                      | 1.27 (0.57 to 2.81) | 0.73    |
| Other or unknown           | 2.04 (1.04 to 3.98) | 0.12    |

Shown are odds ratio estimates (with 95% Wald CIs) for length of dialysis ≥9 months. PCKD, polycystic kidney disease; CI, confidence interval.

### Table 7. Graft failure by preemptive status and dialysis access used

| Predictor                     | Hazard Ratio (95% Confidence Interval) | P Value |
|-------------------------------|----------------------------------------|---------|
| Preemptive versus non-preemptive transplant | 0.46 (0.10 to 2.07) | 0.31    |
| Hemodialysis versus peritoneal dialysis | 1.32 (0.33 to 5.27) | 0.70    |
| AV fistula/AV graft versus venous catheter | 1.45 (0.15 to 13.94) | 0.75    |

Results from an unadjusted Cox proportional hazard model for graft failure. Median time from transplant to last clinical follow-up was 19 months. AV, arteriovenous.
Sharing (UNOS) data for living donors shows our cohort is comparable in terms of age and sex, but differed in terms of race; our cohort had more Asian recipients and fewer Black recipients. We also had a limited time of post-transplant follow-up, lowering our ability to capture long-term effects, such as cardiovascular complications and graft failure. We did not differentiate between acute venous catheters and planned tunneled dialysis catheters. The number of study subjects was relatively small, which may limit our ability to detect true effects and associations. The study also only included patients who successfully underwent LDKT, which limits the ability to observe effects of dialysis on patients who die while awaiting living donor transplant, although this number is likely to be small. Data were derived from the EMR and a network of linked partner hospital systems, leading to relatively robust and complete data. In particular, dialysis access characteristics and transplant details were largely complete due to detailed transplant workup documentation in our EMR, supplemented by the UNOS and Medicare Form 2728. We cannot rule out the possibility that some acute access complication events or post-transplant events at nonlinked medical centers were missed. Nevertheless, although some access complications may have been missed, the linked partner hospital systems records cover a wide geographic area and our detailed review of physician notes in our own system also allowed capture of outside events reported by patients. We also had a very small number of patients with AVG in our study, limiting the ability to assess relative benefits or deficits of this access strategy. Finally, we were not able to formally assess risk of central venous stenosis or SVC syndrome according to length of catheter use, although the overall rates of these complications were lower than those observed in dialysis populations.

Although preemptive LDKT and AVF remain the gold standard for transplant and dialysis access, respectively, use of preemptive kidney transplant remains limited due to various challenges. PD and venous catheters may provide viable access until transplant in the right patient population, namely patients with available living donors and shorter waitlist times, or in patients with limited vascular access options. Given the prospect of earlier transplant, PD and venous catheters should be considered as viable bridge therapy options in patients with living donor availability, if prospective time to transplant is deemed reasonable and patients are counseled about existing risks and benefits of all modalities of dialysis access. These short-to-intermediate-termlong-term access types may avoid some long-term effects on cardiovascular health caused by post-transplant AVF and avoid dialysis delays due to maturation time or primary fistula failure. Dialysis access in living donor transplant candidates should not use a one-size-fits-all approach for timing nor access type, but rather should be considered on a case-by-case basis using shared decision making, given their shorter time to transplant and inherent variability in the transplant process.

Disclosures

B.K. Lee reports serving on the American Society of Transplantation Living Donor Community of Practice Education Subcommittee. M. Park reports having consultancy agreements with Abalone Bio and Acelink Therapeutics; receiving honoraria from Grand Rounds and Healthcare Consultancy Group; having other interests in, or relationships with, Kadmon (as site principal investigator [PI] for a tesevatinib trial), Reata (site PI for A Trial of Bar-doxolone Methyl in Patients with ADPKD - FALCON), and Sanofi (site PI for A Medical Research Study Designed to Determine if Venglustat Can be a Future Treatment for ADPKD Patients (STAGED-PKD) [now terminated]); having ownership interest in Merck (via spouse); and serving as an advisory board participant for Otsuka, Reata, and Sanofi. All remaining authors have nothing to disclose.

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Author Contributions

M. Lai and M. Park conceptualized the study and wrote the original draft; Y. Gao was responsible for formal analysis and visualization; Y. Gao and M. Lai were responsible for data curation; M. Park provided supervision; and all authors reviewed and edited the manuscript.

Data Sharing Statement

All data is included in the manuscript and/or supporting information.

Supplemental Material

This article contains supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0007652021/*/DCSupplemental.

Supplemental Table 1. Etiology of ESRD stratified by race.
Supplemental Table 2. Cardiovascular event prevalence at follow-up amongst dialysis modalities.
Supplemental Table 3. Distribution of non-preemptive LDKT recipients with multimodal access by race.
Supplemental Table 4. Unused dialysis access among preemptive transplant recipients.
Supplemental Table 5. Donor characteristics of living donor transplants.

Supplemental Figure 1. Cohort selection process.

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