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Impact of Prolonged Dialysis Prior to Renal Transplantation

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Abstract

Introduction—The new Kidney Allocation System (KAS) prioritizes patients based on date of dialysis initiation or wait-listing, whichever is earlier. We hypothesized that this change would increase transplant rates for patients with prolonged pre-transplant dialysis times (DT) and aimed to assess the impact of prolonged DT on post-transplant outcomes

Methods—We used United Network for Organ Sharing registry data to assess outcomes for patients added to the renal transplant waitlist from Jan 1 1998 – Dec 31 2010 and patients transplanted from Jan 1 1998 – Dec 3 2012.

Results—Compared with patients transplanted preemptively, patients with <5 years, 5–9 years, and ≥10 years DT had progressively decreased graft and patient survival ($p<0.001$). The rates of short-term complications including delayed graft function, graft loss within 30 days, and patient death within 30 days were significantly higher in cohorts with ≥10 years DT than in cohorts with less DT ($p<0.001$).

Conclusions—Patients with pre-transplant DT of ≥10 years had worse outcomes than patients pre-emptively transplanted or transplanted with shorter DT. Durations of dialysis dependence beyond 10 years were associated with further deterioration in short-term but not long-term post-transplant outcomes.

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Conflict of Interest Statement

The authors have no conflicts of interest to disclose. The results presented in this paper have not been published previously in whole or part, except in abstract form.

Authors' Contributions

DDA, AWP, PLA, PPR, and MHL participated in research design.. DDA, DRM, SJC, PLA, DS, RDB, PPR, and MHL participated in writing the manuscript.. DDA, AWP, DRM, SJC, and MHL participated in performance of research. DDA, AWP, PLA, DS, RDB, PPR, and MHL participated in data analysis.

Keywords

Dialysis; end stage renal disease; graft failure; graft survival; kidney transplantation

Introduction

Kidney transplant offers a survival benefit compared to dialysis (1, 2), but there are substantial socioeconomic and racial disparities in access to transplantation (3–6). Multiple studies have demonstrated that African-American, female, lower income, and less well-educated patients are referred to the waiting list later than other patients (3–9). The new Kidney Allocation System (KAS) was introduced on December 4, 2014 in part to mitigate such disparities. The new KAS credits waitlist time from chronic dialysis initiation or date of waitlisting, whichever is earlier (10, 11). As a result, patients with multiple years of dialysis time (DT) whose referral for transplant had been delayed gained additional waitlist priority vs. the prior allocation system. In concert with new priority for highly-sensitized (panel reactive antibody [PRA] ≥ 98%) patients (another major modification of the allocation system), recalculated waitlist time resulted in a "reordering" of the waitlist and patients with delayed referral to transplantation gaining improved access to organs (12).

Pre-emptive transplantation before the initiation of dialysis is associated with graft survival benefit compared to transplantation after the initiation of dialysis (13–15). Several studies have demonstrated a dose-response relationship between duration of dialysis and adverse post-transplant outcomes, but they focused their analysis on periods of dialysis of <6 years (16–22). Notably, two of these studies concluded that a long interval of dialysis exposure prior to waitlisting was, compared to the interval of time after waitlisting, a stronger predictor of death after transplant (21, 22). This difference was attributed to time to waitlisting reflecting not only the risk of dialysis but also access to healthcare and degree of comorbidity. Prior work on the effect of prolonged DT prior to transplantation was derived from single center studies and reached contradictory conclusions (23, 24).

Given the absence of clear data on the relationship between DT ≥10 years and transplant outcomes and the substantial changes in waitlist priority with KAS, we aimed to answer three questions. First, how frequently did patients with prolonged DT (≥10 years) receive deceased donor renal transplants in the era before the implementation of the new KAS and how did this frequency compare to patients with less substantial dialysis exposure? Second, is dialysis exposure longer than 10 years associated with worse post-transplant outcomes? Finally, to what extent is prolonged dialysis exposure for waitlisted patients the result of difficulty finding compatible organs for highly sensitized patients? These questions are crucial to contextualize the assessment of patterns of organ use and post-transplant outcomes following the implementation the new KAS.

Patients and Methods

Data Source

Analyses were conducted using a Standard Transplant Analysis and Research (STAR) file provided by the United Network for Organ Sharing (UNOS)/Organ Procurement and Transplantation Network (OPTN).

Study Populations

The study included two cohorts of patients. The first, the waitlist cohort, included patients ≥ 18 years of age who were placed on the renal transplant waitlist from Jan 1 1998 – Dec 31 2010. Patients listed as receiving renal replacement therapy but missing the date of dialysis initiation were excluded. Prior renal transplant recipients being relisted or re-transplanted were excluded to avoid misclassification of their degree of dialysis exposure over multiple listings. Multi-organ transplant candidates were excluded because allocation occurs through separate policy. The second, the transplant cohort, included patients ≥ 18 years of age who a received renal transplant between Jan 1 1998 – Dec 3 2015. Patients listed as receiving renal replacement therapy but missing the date of dialysis initiation were again excluded. Patients with history of prior renal transplant or receiving multiple-organs were excluded for the reasons listed above. Living donor renal transplant recipients were excluded in the transplant cohort because the majority are directed rather than distributed through the allocation system.

Analytic Approach

Outcomes of renal transplant candidates were analyzed within the waitlist cohort. The primary outcomes were 1) transplantation and 2) death or delisting. The primary exposure was DT *at waitlist registration*, calculated as the difference between the date of dialysis initiation and the date of placement on the waitlist. Patients were followed from date of registration on the waitlist until transplant, death or delisting, or the end of follow-up (Dec 3 2014). The ending date was selected to ensure at least four years of follow-up data prior to the initiation of the new KAS (Dec 4 2014). A multivariable model for the outcome from waitlisting was fit using Fine -Grey competing risk regression (25). Variables included major determinants of access to transplantation including blood group and UNOS-defined geographic region.

Outcomes of kidney transplant recipients were analyzed within the transplant cohort using patients who received renal allografts between Jan 1 1998 – Dec 31 2012. The primary outcome was graft survival defined as time from initial transplant to initiation of maintenance renal replacement therapy, retransplant, or death (i.e. all-cause allograft failure). The mortality outcome is determined by the SRTR from reports from transplant centers as well as verified external sources, such as the Social Security Administration Death Master File (26). The secondary outcome was patient survival. The primary exposure was DT *at transplant*, calculated as the difference between the date of dialysis initiation and the date of transplantation. To categorize patients based on DT, 3-year graft survival was graphically inspected by years of DT (Supplemental Figure 1). Because the data did not reveal clear cutpoints, patients were stratified by DT in 5 years increments to ensure

sufficient numbers for analysis in each category. Patients were followed from date of transplant until death or end of follow-up (Mar 31 2016). The ending date was selected to insure at least three years of follow-up data on transplantation outcomes. Subjects were censored if they had a functioning graft at the end of follow-up or at 12.5 years.

Post-transplant graft or patient survival was examined using Kaplan-Meier curves and compared using a log-rank test for equality of survivor functions. A multivariable model for graft failure was fit using Cox regression. The proportional hazards assumption was confirmed with graphical inspection of log-log plots. We adjusted for recipient, donor and allograft characteristics that were selected based on prior literature and clinical judgment (27–33). Covariates included gender, age, ethnicity, PRA, etiology of end stage renal disease (ESRD), KDPI (calculated from the 2013 reference population), degree of human leukocyte antigen (HLA) mismatch, diabetes status (as reported on transplant candidate registrations), and hepatitis C virus (HCV) status (as reported on transplant recipient registrations).

Finally, the transplant cohort was used to compared the distribution of deceased donor renal allografts to patients with different DT in the year before KAS (Dec 4 2013 – Dec 3 2014) and the year after KAS (Dec 4 2014 – Dec 3 2015) implementation. The primary exposure was DT at transplantation, again calculated from the difference between the date of dialysis initiation and the date of transplant. All analyses have follow-up data until Mar 31 2016.

Statistical analyses were performed with STATA SE for MAC OS X version 14.2 (StataCorp LP, College Station, TX). Continuous variables were compared between groups using the Student's t test or Analysis of Variance, as appropriate. Categorical variables were compared using $\chi 2$ or the Fisher exact test, as appropriate.

Missing data

Two covariates had data missing from >1% of patients: PRA (46% in the waitlist cohort and 28% in the transplant cohort) and HCV status (8% in the transplant cohort). For each of these variables, sensitivity analyses were performed where patients with missing data were first assigned to the lowest category (0% PRA and HCV negative, respectively) and then to the highest category (98–100% PRA and HCV positive, respectively). For final analysis, multiple imputation was used to generate PRA, and HCV status values for individuals with missing values. PRA data was more complete in the year before and the year after KAS implementation with <1% of patients missing data.

Results

Impact of Dialysis Time on Likelihood of Renal Transplantation: Waitlist Cohort

Between Jan 1 1998 – Dec 31 2010, a total of 257,551 patients were added to the renal transplant waitlist and met criteria for inclusion. The majority of patients had either not started dialysis (n=65,972, 26%) or had been on dialysis for <5 years (n=175,893, 71%, Table 1). Five percent (n=12,953) had 5–9 years of DT, 1% (n=2,016) had 10–14 years, 0.2% (n=462) had 15–19 years, and 0.1% (n=262) had ≥20 years of dialysis *at the time of listing*. High PRA (≥86%) patients were relatively more frequent among patients with DT

≥10 years (p<0.01, Supplemental Table 1), although they composed <10% of registered patients in all cohorts and a substantial number of records were missing PRA data.

As of the conclusion of the period of analysis (31 Mar 2016), pre-emptively listed patients were significantly more likely to have received a transplant than patients on dialysis at the time of listing (68% vs. 55%, p <0.001, Table 1). The difference in likelihood of receiving a living donor transplant was particularly pronounced at 29% in pre-emptively listed patients and 12% in those on dialysis (p<0.001). Pre-emptively listed patients were also significantly less likely to have died or been delisted without transplant (27% vs. 41%, p<0.001). As DT at listing increased, patients were progressively less likely to have received a transplant and progressively more likely to have died or been delisted by the end of follow-up. In competing risk regression analysis with death or delisting categorized as a competing risk, increasing durations of dialysis dependence were associated with decreased subhazard ratios (SHR) of receiving a transplant (Supplemental Table 2). This association persisted after adjusting for blood group and UNOS-defined geographic region. PRA was omitted from this model because of the degree of missing data, but, in sensitivity analyses, PRA did not substantially impact the SHR associated with duration of pre-registration dialysis dependence.

Outcomes after Transplant by Pre-Operative Dialysis Time: Transplant Cohort

Between Jan 1 1998 and Dec 31 2012, 109,079 patients received a renal transplant and met criteria for analysis. Demographic characteristics by pre-transplant DT are summarized in Table 2. The cohorts of patients with longer DT were younger, had a lower prevalence of diabetes, and had a higher prevalence of female gender, black ethnicity, high PRA, and hepatitis C infection (p<0.001). The greater sensitization in long DT cohorts occurred primarily due to increased frequencies of patients in the 21–85% PRA range; increases in the 86–97% and 98–100% PRA categories also occurred with longer DT but the magnitude of the increase was smaller. These results must be viewed in the context of missing PRA data for 26% of patients. The kidney donor profile index (KDPI) of transplanted organs was higher in patients on dialysis compared to those with no dialysis exposure but the magnitude of the difference was small (p<0.001).

The rates of delayed graft function (DGF), graft failure within 30 days, and patient death within 30 days were higher among groups with more years of DT (p<0.001, Table 3). In multivariate logistic regression analysis, longer DT remained associated with each of these three early complications (Supplemental Tables 3–5). In Kaplan-Meier analysis of long-term transplant outcomes, pre-emptively transplanted patients had superior graft and overall survival compared to all other groups (p<0.001, Figure 1). Patients with <5 years, 5–9 years and ≥10 years of DT had overlapping graft and overall survival curves. Substratifying further, compared to patients with 10–14 years DT, those with 15–19 years and ≥ 20 years DT had similar graft (p =0.86 and 0.60 respectively, Supplemental Figure 2A) and overall survival (p=0.40 and 0.06, respectively, Supplemental Figure 2B), although sample size was small.

In multivariable Cox regression analysis, longer DT remained associated with progressively greater hazard of graft failure (Table 4). The magnitude of difference between cohorts was

highest between the pre-emptive transplantation group and <5 years dialysis (HR 1.00 [ref] vs. 1.37 [1.34 – 1.41]) and the 5–9 years (HR 1.57 [1.52 −1.61]) groups. Longer duration of DT was associated with less pronounced increases in the HR with minimal differences between 10–14 years, 15–19 years, and ≥20 years groups (HR 1.76 [1.68 – 1.85] vs. 1.62 [1.46 – 1.81] vs. 1.60 [1.37 – 1.8] respectively with overlapping 95% C.I.).

Changes in Renal Transplantation Patterns with new Kidney Allocation System

The total number of deceased donor kidney transplants was nearly identical in the year prior to and the year following implementation of KAS (9,036 and 9,031, respectively, Supplemental Table 6). However, patients with DT of 5–9 years, 10–14 years, 15–19 years, and ≥20 years received a substantially higher proportion of the allografts transplanted, and patients with no dialysis exposure or 1–4 years DT received a reduced share of transplants after KAS (p<0.001, Supplemental Table 6, Figure 2). The magnitude of the increase was greatest in patients with 5–9 years DT (28% to 37% of renal transplants, p<0.001). The same trend was observed comparing the year after KAS to any year in the decade before KAS implementation (Supplemental Table 6). Interestingly, among patients placed on the waitlist in the year prior to and the year following KAS implementation, the number with ≥10 years of dialysis time at time of *registration* was nearly identical (1% vs. 1%, p=0.37)

Highly sensitized patients (PRA 98–100%) received a significantly greater proportion of renal allografts in the year following KAS implementation compared to the year prior (7% vs. 2%, p<0.001, Supplemental Table 7). However, the increase in transplants to highly sensitized recipients accounted for only 7% for the total increase in transplants to patients with ≥10 years DT.

Discussion

Prolonged DT patients exemplify the challenge of balancing equity of access to transplantation with utility of organ allocation. The present study examining how patients with prolonged DT fared while before, during and after their transplantation adds several novel findings to this challenge. First, these results demonstrate that patients with ≥10 years of DT experience a much higher incidence of short-term post-transplant complications but do not have continued detrimental dose effects of DT on long-term graft function. Second, high PRA is infrequent in prolonged DT patients, suggesting that the primary causes of the accumulation of DT ≥ 10 are likely separate from the immunological challenge of HLA incompatibility. Finally, the study confirms that prolonged DT patient are gaining increased access to renal transplantation under the new KAS policy (12). These findings reveal that the KAS achieved gains in equity at limited cost to short-term utility.

Prior reports of post-transplant outcomes in patients with extended periods of dialysis dependence focused on patients with <6 years of DT (16–22). Patients with ≥10 years of pre-transplant dialysis dependence have not been discussed in prior literature or SRTR yearly reports, possibly because of the small number of transplants within this group before the KAS policy change. However, nearly 1000 kidney transplants annually have been performed in this cohort after KAS, and it is important to understand expected outcomes and ramifications for the transplant system. Among this group, we observed no decrements in

long-term graft survival between those with 10–14, 15–19, and ≥20 years of DT in the pre-KAS era. The absence of dose effect within these groups likely reflects inherent selection of patients able to survive a prolonged dialysis burden and remain transplant candidates (i.e. unmeasured confounding). Transplant recipients with ≥10 years of DT had an almost 50% lower prevalence of diabetes (and by extrapolation, associated comorbidities) compared to recipients with <10 years of DT. Moreover, despite spending years on dialysis, recipients with ≥10 years of DT had a slightly younger age at the time of transplant, indicating younger age at the onset of renal failure and perhaps higher fitness at dialysis initiation.

However, short-term post-transplant complications—including DGF, graft failure within 30 days, and patient death within 30 days—were markedly elevated in patients with ≥10 years DT and increased between the 10–14 years, 15–19 years, and ≥20 years cohorts. This finding suggests that adverse perioperative events and residual unidentified comorbidities (e.g. vascular calcifications or heart disease) may be more common in prolonged DT patients. Careful cardiovascular screening and perioperative management, pre-operative vascular assessment, and assessment of the global health of waitlisted patients may help mitigate these early surgical complications (34–36).

Although our study examined only deceased donor transplants, the dual findings of detrimental effects of prolonged DT on short- and long-term post-transplant outcomes and the decreased renal allograft allocation to patients with no or <5 years of DT in the new KAS has important implications for living donor transplantation. As barriers to preemptive deceased donor transplants increase, living donor transplantation becomes an even more important as a source of preemptive transplants and as a way to secure the superior post-transplant outcomes that result from avoiding dialysis.

This study has several limitations. First, the group of prolonged DT patients who are listed-for or received renal transplantation are a highly selected group of patients. The multivariable analyses described in the paper only partially adjust for this inherent selection bias and the outcomes described may under-estimate the detrimental effects of prolonged DT in less rigorously selected patients. Important aspects of patient selection cannot be elucidated from SRTR data, as many long-term dialysis patients may never have been referred to transplant evaluation or may have been declined for listing and, in either case, would not appear in SRTR data. This absence limits analysis to candidates who at least were listed for transplant and may provide the most optimistic outcomes that could be expected from this cohort if selection practices significantly change. Second, this study does not identify the cause of the long dialysis times seen in some patients. Poor medical compliance, socioeconomic status, late referral, geography, distance to a transplant center, and lack of awareness of transplantation benefits may all reduce access to transplantation (37–40). These factors are not determinable using registry data but should motivate studies using more granular data. Moreover, these factors may impact post-transplant outcomes and may confound the analysis. Third, our analysis included incomplete records. We have addressed the missing data to estimate maximum effect of missing data on associations between study outcomes and the primary exposure of interest – dialysis time. Fourth, the long-term outcomes of patients transplanted after the new KAS implementation may be different from pre-KAS patients because of potential differences in patient selection between these periods.

The new priority provides substantial incentive to transplant centers to list long DT patients; the prospect of rapidly securing an allograft for these patients may increase programmatic risk tolerance and willingness to list high-risk patients and may unmask differences in outcome that were not evident with prior patient selection patterns. Insufficient follow-up time is available to directly assess these possible impacts on center practice.

In conclusion, prolonged pre-operative dialysis exposure is associated with increased risk of graft loss, with dose effects up to 10 years of dialysis time. Prolonged pre-transplant dialysis exposure is also associated with markedly increased early post-transplant complications including DGF, graft failure within 30 days, and patient death within 30 days. The new KAS has increased access to renal transplantation for patients with prolonged pre-operative dialysis exposure with highly HLA sensitized patients comprising only a minority of the increase in prolonged DT transplants. Examinations of the effects of the new KAS on long-term graft outcomes must account for higher-risk recipients prioritized in the new allocation scheme.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

CI	confidence interval
DGF	delayed graft function
DM	diabetes mellitus
DT	dialysis time
ESRD	end stage renal disease
HCV	hepatitis C virus
HLA	human leukocyte antigen
HR	hazard ratio
IQ	interquartile
KAS	kidney allocation system
KDPI	kidney donor profile index

OPTN	organ procurement and transplantation network
PRA	panel reactive antibody
SHR	subhazard ratio
STAR	standard transplant analysis and research
UNOS	united network for organ sharing

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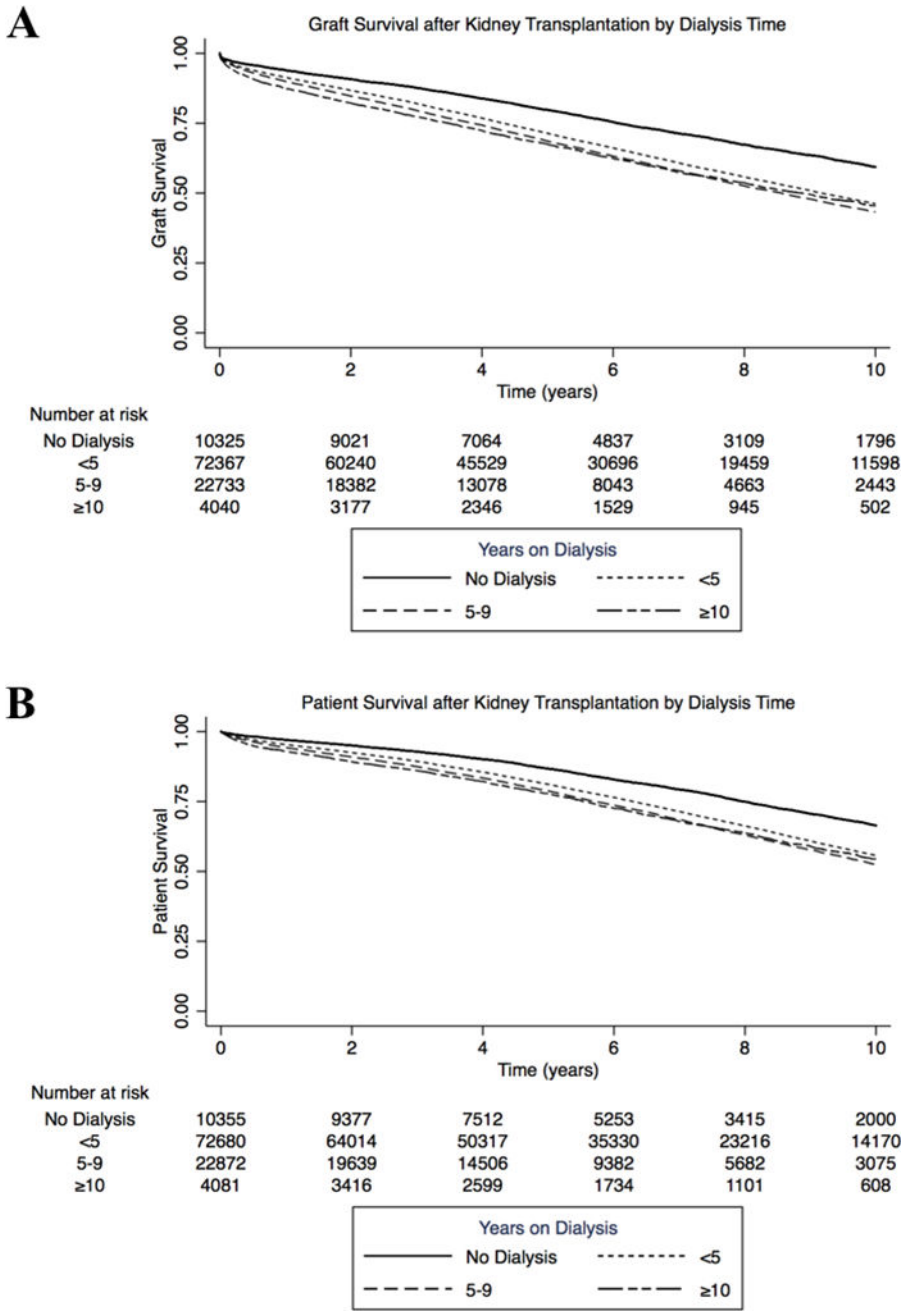

Figure 1.

Renal allograft and overall survival by length of pre-transplant dialysis. **A**. Patients without dialysis exposure had superior graft survival to patients with any DT ($p<0.001$). **B**. Patients without dialysis exposure had superior overall survival to patients with any DT ($p<0.001$).

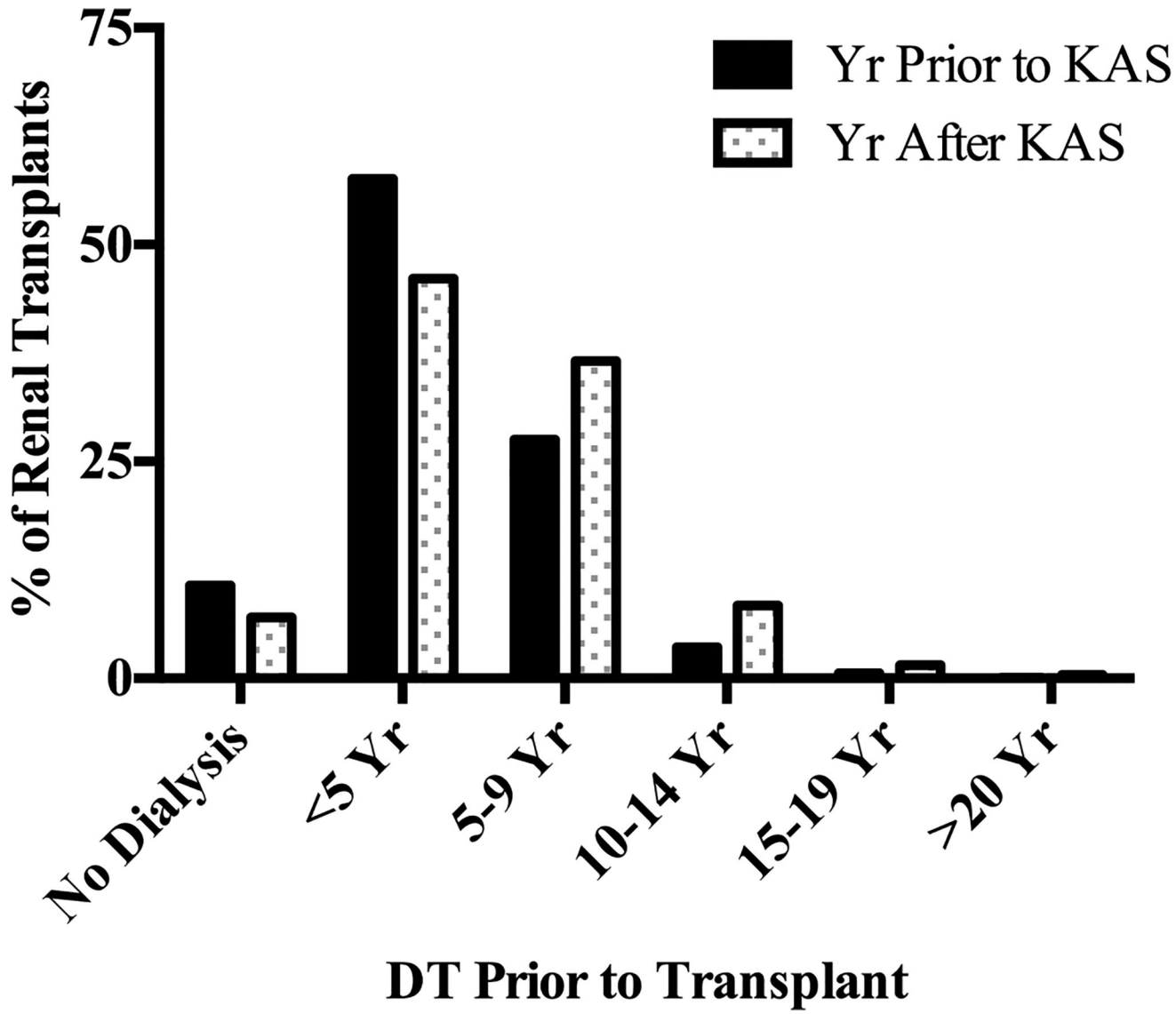

Figure 2.

Changes in Kidney Allocation by DT with KAS. In the first year following implementation of KAS, patients with DT of 5–9 years, 10–14 years, 15–19 years, and ≥20 years received a significantly higher proportion of the allografts transplanted and patients with no dialysis exposure or 1–4 years DT received a significantly reduced share of transplants compared to the year before implementation ($p<0.01$).

Table 1

Outcome of Waitlisted Patients by Length of Dialysis at Registration *

Outcome	No Dialysis	<5 yr	5–9 yr	10–14 yr	15–19 yr	≥20 yr	p
	n=65,968	**n=175,890**	**n=12,953**	**n=2,016**	**n=462**	**n=262**	
Deceased Donor Transplant	25,998 (39%)	75,488 (43%)	6,021(47%)	909 (45%)	185 (40%)	101 (39%)	
Living Donor Transplant	19,147 (29%)	22,839 (13%)	691 (5%)	96 (5%)	23 (5%)	23 (9%)	**<0.001**
Death or Delisted	17,869 (27%)	71,149 (40%)	5,851 (45%)	943 (47%)	230 (50%)	134 (51%)	
Waitlisted	2,954 (5%)	6,414 (4%)	390 (3%)	68 (3%)	23 (5%)	4 (2%)	

* Patients were followed from date of registration on the waitlist until transplant, death or delisting, or the end of follow-up (Dec 3 2014)

Table 2

Demographic and Clinical Characteristics of 109,097 Deceased Donor Renal Transplant Recipients, Categorized by Length of Dialysis Dependence

Characteristic	No Dialysis	<5 yr	5–9 yr	10–14 yr	15–19 yr	≥20 yr	p
	n=10,360	n=72,723	n=22,894	n=2,473	n=451	n=178	
Age, median (IQ range)	55 (46–63)	54 (43–62)	52 (42–60)	49 (40–58)	49 (40–57)	51 (38–64)	
Age, n (%)							
18–25	322 (3%)	2,718 (4%)	464 (2%)	18 (0.8%)	6 (1%)	2 (1%)	
26–40	1,326 (13%)	11,763 (16%)	4,534 (20%)	625 (26%)	108 (24%)	22 (13%)	**<0.001**
41–60	4,739 (46%)	33,132 (46%)	11,103 (49%)	1,241 (52%)	248 (56%)	111 (64%)	
>60	3,819 (37%)	23,920 (33%)	6,350 (28%)	522 (22%)	80 (18%)	39 (22%)	
Male, n (%)	5,603 (54%)	44,881 (62%)	13,765 (60%)	1,081 (44%)	186 (41%)	81 (45%)	**<0.001**
Ethnicity, n (%)							
White	7,036 (68%)	37,137 (51%)	5,922 (26%)	476 (19%)	94 (21%)	62 (35%)	
Black	1,960 (19%)	20,872 (29%)	10,171 (44%)	1,339 (54%)	224 (50%)	82 (46%)	**<0.001**
Other	1,364 (13%)	14,710 (20%)	6,801 (30%)	658 (27%)	133 (30%)	34 (19%)	
Etiology of ESRD, n (%)							
Diabetes	2,027 (20%)	20,522 (28%)	5,565 (24%)	287 (12%)	14 (3%)	18 (10%)	
Hypertension	2,012 (19%)	17,337 (24%)	7,348 (32%)	941 (39%)	155 (35%)	50 (28%)	
Glomerulonephritis	602 (6%)	4,512 (6%)	1,488 (7%)	205 (8%)	51 (12%)	28 (16%)	**<0.001**
Polycystic Kidney Disease	1,723 (17%)	6,734 (9%)	1,353 (6%)	153 (6%)	29 (7%)	14 (8%)	
Other	3,988 (39%)	23,559 (32%)	7,018 (31%)	860 (35%)	191 (43%)	66 (38%)	
PRA, % (n)							
0–20	6,218 (60%)	45,418 (663%)	11,896 (52%)	1,103 (45%)	192 (43%)	75 (42%)	
21–85	801 (8%)	6,142 (9%)	2,506 (11%)	325 (13%)	61 (14%)	33 (19%)	
86–97	203 (2%)	1,571 (2%)	644 (3%)	85 (3%)	25 (6%)	6 (3%)	**<0.001**
98–100	73 (0.7%)	785 (1%)	412 (2%)	77 (3%)	10 (4%)	9 (5%)	
Missing	3,065 (30%)	18,807 (26%)	7,436 (33%)	883 (36%)	157 (35%)	55 (31%)	
Zero HLA Mismatch, n (%)	1,695 (16%)	7,667 (11%)	928 (4%)	106 (4%)	28 (6%)	15 (8%)	**<0.001**
KDPI, median (IQ range)	44 (21–61)	47 (23–71)	48 (25–71)	45 (23–68)	46 (23–65)	52 (25–75)	**<0.001**
DM, n(%)							
Yes	2,780 (27%)	25,851 (36%)	6,906 (31%)	386 (16%)	26 (6%)	26 (15%)	**<0.001**

Characteristic	No Dialysis	<5 yr	5–9 yr	10–14 yr	15–19 yr	≥20 yr	p
	n=10,360	**n=72,723**	**n=22,894**	**n=2,473**	**n=451**	**n=178**	
HCV, n (%)							
Seropositive	387 (4%)	3,831 (6%)	1,460 (7%)	231 (10%)	65 (15%)	33 (20%)	**<0.001**
Missing	374 (4%)	1,367 (2%)	1459 (2%)	52 (2%)	11 (3%)	5 (3%)	

IQ: interquartile; ESRD: end stage renal disease; PRA: panel reactive antibody; KDPI: kidney donor profile index; DM: diabetes mellitus; HCV: hepatitis C virus.

Table 3

Early Outcomes of 109,079 Deceased Donor Renal Transplant Recipients, Categorized by Length of Dialysis Dependence

Characteristic	No Dialysis	<5 yr	5–9 yr	10–14 yr	15–19 yr	≥20 yr	p
	n=10,360	**n=72,723**	**n=22,894**	**n=2,473**	**n=451**	**n=178**	
DGF, n (%)	847 (8%)	17,733 (24%)	7,546 (33%)	858 (35%)	180 (40%)	64 (36%)	**<0.001**
Graft failure within 30 days, n (%)	267 (3%)	2,567 (4%)	909 (4%)	107 (4%)	27 (6%)	14 (8%)	**<0.001**
Patient death within 30 days, n (%)	87 (0.8%)	958 (1%)	374 (2%)	39 (2%)	8 (2%)	3 (2%)	**<0.001**

Table 4

Multivariable Cox regression model of impact of dialysis time on graft survival after deceased donor kidney transplantation

	HR (95% C.I.)		
Parameter	**Univariate**	**Demographic Adjustment**	**Full Adjustment**
Dialysis Time			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
<5 years	1.45 (1.42 – 1.39)	1.47 (1.43 – 1.50)	1.37 (1.34 – 1.41)
5–9 years	1.58 (1.54 – 1.62)	1.65 (1.61 – 1.69)	1.57 (1.52 – 1.61)
10–14 years	1.68 (1.61 – 1.76)	1.79 (1.71 – 1.87)	1.76 (1.68 – 1.85)
15–19 years	1.48 (1.35 – 1.63)	1.64 (1.49 – 1.81)	1.62 (1.46 – 1.81)
≥20 years	1.63 (1.41 – 1.88)	1.72 (1.50 – 1.99)	1.60 (1.37 – 1.88)
Male		1.13 (1.11 – 1.14)	1.08 (1.06 – 1.10)
Age			
18–25		1.42 (1.36 – 1.47)	1.64 (1.58 – 1.71)
26–40		1.00 (ref)	1.06 (1.04 −1.09)
41–60		1.06 (1.04 – 1.08)	1.00 (ref)
>60		1.63 (1.60. – 1.66)	1.36 (1.33 – 1.38)
Ethnicity			
White		1.29 (1.27 – 1.31)	1.44 (1.42 – 1.47)
Black		1.54 (1.51 – 1.56)	1.48 (1.45 – 1.51)
Other		1.00 (ref)	1.00 (ref)
PRA			
0–20			1.00 (ref)
21–85			1.05 (1.03 – 1..07)
86–97			1.11 (1.06 – 1.15)
98–100			1.13 (1.07 – 1.19)
Etiology of ESRD			
Diabetes			1.60 (1.55 – 1.67)
Hypertension			1.59 (1.54 – 1.64)
Glomerulonephritis			1.33 (1.28 – 1.38)
Polycystic Kidney Disease			1.00 (ref)
Other			1.40 (1.36 – 1.45)
KDPI			
1–25			1.00 (ref)
26–50			1.17 (1.14 – 1.19)
51–75			1.39 (1.37 – 1.42)
76–99			1.89 (1.85 – 1.92)
Zero HLA Mismatch			0.90 (0.88 – 0.92)
DM			1.27 (1.24 – 1.31)
HCV			1.28 (1.25 – 1.32)

HR: hazard ratio; CI: confidence interval; PRA: panel reactive antibody; KDPI: kidney donor profile index; DM: diabetes mellitus; HCV: hepatitis C virus.