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Practice Patterns and Outcomes in Retransplantation among Pediatric Kidney Transplant Recipients

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Abstract

Background—Over 25% of pediatric kidney transplants are lost within seven years, necessitating dialysis or retransplantation. Retransplantation practices and the outcomes of repeat transplants, particularly among those with early graft loss, are not clear.

Methods—We examined retransplantation practice patterns and outcomes in 14,799 pediatric (<18 years old) patients between 1987–2010. Death-censored graft survival was analyzed using extended Cox models and retransplantation using competing risks regression.

Results—After first graft failure, 50.4% underwent retransplantation and 12.1% died within five years; after second graft failure, 36.1% underwent retransplantation and 15.4% died within five years. A prior pre-emptive transplant and graft loss after five years were associated with increased rates of retransplantation. Graft loss prior to five years, older age, non-Caucasian race, public insurance, and increased PRA were associated with decreased rates of retransplantation. First transplants had lower risk of graft loss compared to second (aHR=0.72, 95% CI: 0.64–0.80; $p<0.001$), third (aHR=0.62, 95% CI: 0.49–0.78; $p<0.001$), and fourth (aHR=0.44, 95% CI: 0.24–0.78; $p=0.005$) transplants. However, among patients receiving 2 transplants (conditioned on having lost a first transplant), second graft median survival was 8.5 years despite a median survival of 4.5 years for the first transplant. Among patients receiving 3 transplants, third graft median survival was 7.7 years despite median survivals of 2.1 and 3.1 years for the first and second transplants.

Conclusions—Among pediatric kidney transplant recipients who experience graft loss, racial and socioeconomic disparities exist with regard to retransplantation, and excellent graft survival can be achieved with retransplantation despite poor survival of previous grafts.

Keywords

pediatric kidney transplantation; practice patterns; outcomes; retransplantation

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INTRODUCTION

Despite transplantation of predominantly high-quality deceased donor (DD) or living donor (LD) kidneys, some pediatric recipients develop graft failure surprisingly early in their post-transplant course. In fact, approximately 25% of LD kidneys and 38% of DD kidneys are lost within seven years of transplantation (1). As a result of these early graft losses, coupled with the longevity of pediatric recipients, repeat transplant candidates comprise approximately 25% of the current pediatric waiting list (2), and half or more of all pediatric kidney recipients can be expected to eventually undergo retransplantation (3).

Knowledge is limited regarding retransplantation outcomes after pediatric kidney transplantation, particularly among those with early loss of their first transplants. In other words, it remains unclear if the underlying mechanism contributing to early loss of the first graft in a pediatric recipient will similarly contribute to early loss of subsequent grafts. In light of the profound organ shortage, this uncertainty raises questions concerning the ethics and utility of allocating organs to patients who develop successive graft failures, and members of the general community have shown a desire to preferentially provide organs to those waiting for a first organ rather than a retransplant (4).

The only way to answer the question of whether patients who experienced early loss of a first kidney might be at future risk for similarly early loss of any subsequent kidneys is through a *conditional probability* approach. In other words, traditional studies have compared survival of a first graft with that of a second graft and have naturally found that first grafts last longer. This finding, however, is not helpful in answering our question of interest, and might even be misleading if extrapolated to suggest that if a first graft had a short survival, then a second graft will have an even shorter survival (since, in general, second grafts have shorter survival than first grafts). The problem with this typical approach is the selection bias inherent in the “second transplant” cohort: to reach a second transplant, these patients necessarily lost a first graft; however, the comparison group (first transplant recipients) was not limited by this selection bias, so the two groups cannot be properly compared. Instead, an approach not previously studied is one where inclusion in the comparison is *conditioned on having lost the first graft*. In this approach, the model is set up to answer exactly the question of interest: among patients who experienced early loss of a first kidney (i.e., conditioned on having lost the first kidney), the model estimates the expected survival of the subsequent transplant and compares it with the fate of the first one.

Using this conditional probability approach, the current study explores the possibility that a certain subset of patients may continue to experience early graft loss with each subsequent transplant. Specifically, the goals of this national study were (1) to examine patient selection and practice patterns in retransplantation and (2) to quantify the outcomes of repeat transplants among pediatric kidney transplant recipients.

RESULTS

Study Population

Of patients receiving their first kidney transplant before age 18 (n=14,799), 11,717 patients (79.2%) received just one transplant, 2634 patients (17.8%) received two transplants, 400 patients (2.7%) received three transplants, 46 patients (0.3%) received four transplants, and two patients (<0.1%) received five transplants. Patients had a diagnosis of FSGS in 9%, other glomerular diseases in 10%, CAKUT in 28%, and other (or missing) diagnoses in the remainder (Table 1A). Among patients receiving multiple transplants, peak panel reactive antibody (PRA) increased substantially with each successive transplant. Repeat transplants

were more frequently performed with DD and zero human leukocyte antigen (HLA)-mismatched kidneys.

Donor Characteristics

Of all primary pediatric kidney transplants (n=14,799), 48.7% were performed with DD kidneys and 51.3% with LD kidneys (Figure 1). Among patients with failure of a primary DD kidney transplant, 74.3% were retransplanted with a DD kidney and 25.7% with a LD kidney; among those with failure of a primary LD transplant, 56.2% were retransplanted with a DD kidney and 43.8% with a LD kidney. Although 67.6% of all third transplants were performed with DD kidneys, 47.1% of patients with failure of two previous LD kidneys were still retransplanted with a third LD kidney.

Donor Characteristics by Race

Caucasian patients were considerably more likely to receive a LD graft among both primary and repeat transplants (Table 1B). For example, in Caucasian patients receiving two or more transplants, 61% of first transplants and 42% of second transplants were LD transplants, compared to 41% of first transplants and 24% of second transplants in non-Caucasians.

Retransplantation Practice Patterns

Among patients whose first kidney transplant failed (n=5772), 50.4% underwent retransplantation and 12.1% died (without first undergoing retransplantation) within five years after graft failure (Figure 2A). Median time to retransplantation after first graft failure was 1.6 years (interquartile range [IQR]: 0.5-3.6). Among patients who were retransplanted and whose second graft also failed (n=1158), 36.1% underwent retransplantation and 15.4% died within five years after graft failure (Figure 2B). Median time to third transplant was 2.0 years (IQR: 0.6-3.9).

Retransplantation Practice Patterns by Race

Caucasian patients were retransplanted more quickly and more frequently compared to non-Caucasian patients after both first and second graft failures. Among Caucasian patients whose first kidney transplant failed, 59.3% underwent retransplantation and 11.7% died within five years after graft failure (Figure 2C). In contrast, among non-Caucasian patients whose first kidney transplant failed, 39.0% underwent retransplantation and 12.5% died within five years after graft failure (Figure 2C). Median time to retransplantation after first graft failure among Caucasian patients was 1.3 years (IQR: 0.3-2.9) compared to 2.3 years (IQR: 0.9-4.6) among non-Caucasian patients.

Among Caucasian patients who were retransplanted and whose second graft also failed, 44.7% underwent retransplantation and 14.6% died within five years after graft failure (Figure 2D). Among non-Caucasian patients who were retransplanted and whose second graft also failed, 22.6% underwent retransplantation and 16.6% died within five years after graft failure (Figure 2D). Median time to third transplant among Caucasian patients was 1.7 years (IQR: 0.6-3.5) compared to 2.8 years (IQR: 1.1-5.8) among non-Caucasian patients.

Patient Selection for Retransplantation: Unadjusted

Patients who underwent retransplantation were younger at the time of their graft failure than those who had not undergone retransplantation (Table 2A). As expected, those who were alive but had not yet undergone retransplantation experienced graft failure more recently than those who had already undergone retransplantation.

Patient Selection for Retransplantation: Adjusted

A prior pre-emptive transplant and later (after five years) graft failure were independently associated with an increased rate of retransplantation after first graft failure (Table 2B, left columns). Older recipient age at the time of graft failure, minority race, public insurance, elevated peak PRA, and earlier (within five years) graft failure were associated with a decreased rate of retransplantation after first graft failure. Similarly, later graft failure was associated with an increased rate of retransplantation after second graft failure (Table 2B, right columns), while older recipient age at the time of graft failure, minority race, and elevated peak PRA were associated with a decreased rate of retransplantation after second graft failure.

Among those experiencing a first graft failure after 2005 (when the Share-35 allocation policy was implemented), African-Americans (aSHR= 0.41, 95% CI: 0.33-0.51; $p<0.001$), Hispanics (aSHR= 0.56, 95% CI: 0.45-0.71; $p<0.001$), and other races (aSHR= 0.53, 95% CI: 0.34-0.82; $p=0.004$) were less likely to undergo retransplantation compared to Caucasians; likewise, among those experiencing a second graft failure after 2005, African-Americans (aSHR= 0.27, 95% CI: 0.14-0.53; $p<0.001$) and Hispanics (aSHR= 0.43, 95% CI: 0.24-0.78; $p=0.005$) were less likely to undergo retransplantation.

Graft Survival: By Transplant Number

The one, five, and ten year graft survival rates were 91.9, 74.8, and 56.1% in first transplants; 89.3, 65.3, and 43.9% in second transplants; 89.6, 62.0, and 39.1% in third transplants; and 84.9, 46.8, and 19.5% in fourth transplants. The median graft survival was 11.6, 8.5, 7.7, and 4.5 years for first, second, third, and fourth transplants, respectively. First transplants had a lower risk of graft loss compared to second (adjusted hazard ratio [aHR]=0.72, 95% CI: 0.64-0.80; $p<0.001$), third (aHR=0.62, 95% CI: 0.49-0.78; $p<0.001$), and fourth (aHR=0.44, 95% CI: 0.24-0.78; $p=0.005$) transplants (SDC, Figure 1A).

Graft Survival: By Most Recent Transplant

Similarly, grafts among patients receiving just one transplant had a lower risk of graft loss compared to the most recent grafts in patients receiving two (aHR=0.68, 95% CI: 0.59-0.78; $p<0.001$), three (aHR=0.54, 95% CI: 0.42-0.70; $p<0.001$), or four (aHR=0.33, 95% CI: 0.19-0.59; $p<0.001$) total transplants (SDC, Figure 1B).

Graft Survival: By Recipient

Among recipients of multiple grafts, initial graft survival was poor, but graft survival significantly improved with subsequent transplants (Table 3). Second graft median survival in recipients of at least two transplants was 8.5 years despite an initial median graft survival of 4.5 years, and the 10-year graft survival of these second grafts was 43.9%. Similarly, third graft median survival in recipients of at least three transplants was 7.7 years despite median graft survivals of just 2.1 and 3.1 years for first and second transplants, and the 10-year graft survival of these third grafts was 39.1%.

These improvements in repeat graft survival among recipients of multiple grafts were seen across a variety of recipient subgroups, including those with theoretically the greatest potential for a repeatedly poor outcome. For example, among patients who had delayed graft function (DGF) in their first transplant and received at least two transplants, second median graft survival was 8.3 years despite an initial median graft survival of <0.1 year. Among patients who had primary non-function (PNF) in their first transplant and received at least two transplants, second median graft survival was 9.1 years despite an initial median graft survival of <0.1 year. In addition, among patients with FSGS who received at least two transplants, second median graft survival was 5.9 years despite an initial median graft

survival of 2.8 years. Finally, among patients who had a peak PRA >80% at their first transplant and received at least two transplants, second median graft survival was 5.8 years despite an initial median graft survival of 3.6 years.

Early Outcomes

The overall rate of DGF among all first transplants was 9% (Table 3). In retransplant recipients who had DGF in their first graft, 28% also had DGF in their second graft. In retransplant recipients who had DGF in both their first and second grafts, 35% experienced DGF in their third graft. The overall rate of PNF among all first transplants was 6%. In retransplant recipients who had PNF in their first graft, 15% also had PNF in their second graft. In retransplant recipients who had PNF in both their first and second grafts, 17% had PNF in their third graft.

DISCUSSION

This national study of retransplantation outcomes after primary pediatric kidney transplantation shows that repeat transplants are not doomed to early failure even if prior graft survival was quite poor. These improvements in repeat graft survival were seen despite an increase in peak PRA with each successive transplant and despite repeat transplants more frequently being performed with DD kidneys. In addition, these improvements were seen even among patients seemingly at highest risk of a repeatedly poor outcome. However, given the considerable number of patients who either died or remain on dialysis after graft loss, promoting the prolonged survival of one's first graft remains crucial.

Importantly, the likelihood of undergoing retransplantation after graft failure varied according to age, race, insurance, timing of graft loss, peak PRA, and having a previous pre-emptive transplant. The increased rate of retransplantation among younger patients is expected and likely due primarily to the age-based priorities included in allocation policies (including the Share-35 policy implemented in 2005). However, some hesitancy to retransplant older patients may also result from the high rate of graft failure seen during late adolescence and early adulthood (5). Interestingly, the primary etiology of renal disease did not independently have a strong impact on the likelihood of retransplantation. For example, even though focal segmental glomerular sclerosis (FSGS) has a considerable risk of recurrence after transplantation (6, 7), recipients with this disease were not less likely to undergo retransplantation.

Racial and socioeconomic disparities have also been found in children's access to primary kidney transplantation and in other areas of pediatric end-stage renal disease (ESRD) care (8-12), consistent with our finding that retransplantation was less likely to occur among minority racial groups and patients with public insurance. These differences are also consistent with decreased access to transplantation in general among minority racial groups (13). We also found that non-Caucasian recipients were less likely to receive LD grafts among both primary and repeat transplants. These findings highlight the need for continued efforts to promote equity and expand the benefits of kidney transplantation to the entire population of children with ESRD.

Interestingly, although implementation of the Share-35 allocation policy appears to have attenuated some racial disparities with regard to primary DD kidney transplantation among pediatric recipients, the shift that occurred from LD to DD kidney transplantation after Share-35 was in fact accentuated among African-Americans and Hispanics compared with Caucasians (15). In addition, the lower rate of retransplantation among minority groups that was identified in this study was consistent even among those experiencing graft failure after Share-35 implementation. These racial differences cannot, however, be attributed entirely to

provider bias or inadequacies in policy and may be due at least in part to biologic constraints. For example, differences in sensitization resulting from prior transplantation may exist across racial groups that contribute to these racial differences in retransplantation rates. In addition, African-Americans may have a lower chance of a zero-mismatch than Caucasians based on the population distributions of HLA (14). These biologic mechanisms would not be accounted for in our analysis, limiting any definitive conclusions regarding the presence of potential biases in pediatric ESRD care.

Previous analyses of the outcomes of retransplantation after pediatric kidney transplantation are inconclusive. A recent single-center study of 173 patients from Spain found no statistically significant difference in DD graft survival between primary and repeat (second and third) transplants in pediatric recipients (16). However, in a previous registry analysis of 3290 primary pediatric transplants and 573 repeat transplants, graft survival of repeat transplants was inferior to those of primary transplants (17).

Our study confirmed previous findings that, in general, repeat transplants do have decreased graft survival compared to primary grafts. However, such traditional comparisons are biased because those receiving a repeat transplant by definition have failed a previous transplant, so comparing a biased cohort with an unbiased cohort is potentially misleading. Our novel analytical approach, drawing on a conditional probability framework, avoids that bias and enables comparison of retransplants to previous transplants specifically among those receiving multiple transplants. In other words, these comparisons allow us to assess whether a patient who rapidly lost a first transplant is predicted to rapidly lose subsequent grafts. However, in avoiding this bias, these comparisons do inevitably introduce a limitation to the generalizability of our findings. Specifically, our findings from the conditional analysis can only be attributed to patients who have already lost a first graft, which is acceptable, however, because those patients are exactly the patient subgroup to which we wish to attribute our findings.

Limitations of this study include selection bias and survivor bias. In other words, the improved graft survival seen among repeat transplants in this study was not found in *all* patients with graft failure, but rather in those patients specifically chosen by centers for retransplantation and in those patients who survived long enough to undergo retransplantation. The conclusion of this study therefore must be stated with the important qualifier that excellent retransplant graft survival was achieved in those who survived and were deemed appropriate by transplant centers for repeat transplantation. That said, the patient selection paradigm used in the past appears to have been successful in identifying patients likely to benefit from retransplantation, and perhaps centers with currently more stringent criteria might even be safe to adopt practices more consistent with national average. Finally, it is also possible that one contributor to improved graft survival in subsequent transplants is an improvement in crossmatch technology.

In selected pediatric recipients with poor initial graft survival, excellent graft survival can be achieved with retransplantation. Given the organ shortage, these results are encouraging and may help mitigate concerns regarding the ethics and utility of retransplantation, particularly given the risks of death and other adverse outcomes associated with prolonged dialysis. If a phenotype of patient that will inevitably continue to experience early graft failure does in fact exist, the patient selection process used thus far appears to have been successful in excluding those patients, on average, from retransplantation. Provided that the careful selection of patients also continues, this study supports the continued practice of retransplantation after loss of primary pediatric kidney transplants and motivates the expansion of this practice across all races and socioeconomic groups.

MATERIALS AND METHODS

Study Population

All kidney-only transplants completed between January 1987 and July 2010 in patients who received their first kidney transplant prior to age 18 were identified using the Scientific Registry of Transplant Recipients (SRTR). Cause of ESRD was categorized as either FSGS, other glomerular diseases, congenital anomalies of the kidney and urinary tract (CAKUT), or other/missing diagnosis, based on precedent set by the SRTR program-specific regression models (available at www.srtr.org) and clinical knowledge.

Outcomes

Death-censored graft survival was defined as the time between transplantation and either graft failure (marked by retransplantation or a return to dialysis) or last date of follow-up with a functioning graft, with censoring for death and administrative end of study. Death ascertainment was supplemented by linkage to the Social Security Death Master File; death and graft loss ascertainment were also supplemented by linkage to data from the Centers for Medicare and Medicaid Services. Other outcomes of interest were the rates of PNF (graft survival less than 90 days) and DGF (need for dialysis within the first week post-transplantation). Timing of graft loss was categorized as PNF, earlier graft loss (within five years, the 25th percentile for first graft survival, but not PNF), and later graft loss (beyond five years after transplantation).

Recipients of Multiple Kidneys

In comparing grafts within multiple transplant recipients, patients receiving one or more transplants were compared with patients receiving two or more transplants and patients receiving three or more transplants. This step was taken to avoid the bias induced when comparing, for example, first grafts among patients receiving *just* one transplant (whose first graft likely did well) to first grafts among patients receiving *exactly* two transplants (whose first graft by definition failed, but whose second graft likely did well). This approach is also more clinically relevant, given that the eventual outcome of a repeat transplant is not known at the time of retransplantation, and therefore it is also unknown at that time whether a repeat transplant will be the patient's last transplant or if the patient could require additional transplants.

Statistical Analysis

Death and retransplantation following graft failure were explored as time-dependent competing events using cumulative incidence functions. Graft survival was compared using Kaplan-Meier survival estimates, log-rank testing, and Cox proportional hazards models that adjusted for recipient and donor characteristics, year of transplantation (to account for potential improvement in graft survival over time), and patient-level clustering (to account for lack of independence of multiple transplants in one patient). Multivariable competing risks models were used to calculate adjusted subhazard ratios (aSHR) of the association of various characteristics with the likelihood for retransplantation after graft failure, while also accounting for the competing risk of death. All tests were two-sided with statistical significance set at $\alpha = 0.05$. Analyses were performed using STATA 12.0/SE (College Station, Texas).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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ABBREVIATIONS

aHR	adjusted hazard ratio
aSHR	adjusted subhazard ratio
CAKUT	congenital anomalies of the kidney and urinary tract
DD	deceased donor
DGF	delayed graft function
ECD	expanded-criteria donor
ESRD	end-stage renal disease
FSGS	focal segmental glomerular sclerosis
HLA	human leukocyte antigen
IQR	interquartile range
LD	living donor
PNF	primary non-function
PRA	panel reactive antibody
SCD	standard-criteria donor
SRTR	Scientific Registry of Transplant Recipients

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Figure 1.
Donor Type in First, Second, and Third Kidney Transplants among Patients with Graft Loss after Primary Pediatric Kidney Transplantation.

Figure 2. Patient Survival and Incidence of Retransplantation after A. First Graft Loss, B. Second Graft Loss, C. First Graft Loss, Stratified by Race, and D. Second Graft Loss, Stratified by Race, among Patients Receiving a Primary Pediatric Kidney Transplant.

Table 1

A. Recipient, Donor, and Transplant Characteristics in Recipients of a Primary Pediatric Kidney Transplant (1987-2010), Stratified by Total Number of Transplants and Graft Number. B. Donor Type in Recipients of a Primary Pediatric Kidney Transplant, Stratified by Recipient Race, Total Number of Transplants, and Graft Number. A.

A.							
	Total Number of Transplants						
	1+Transplants n = 14,799	2+Transplants n = 3082			3+Transplants n = 448		
	Graft Number	Graft Number		Graft Number			
	1	1	2	1	2	3	
Mean Recipient Age (SD)	10.9 (5.1)	11.0 (5.0)	19.0 (6.9)	10.7 (5.2)	15.6 (6.8)	22.9 (7.5)	
Recipient Sex (% Female)	41	43		41			
Recipient Race (%)							
Caucasian	58	64		72			
African-American	19	18		11			
Hispanic	19	14		14			
Other	5	3		3			
Pre-emptive ^a (%)	21	15	13	6	8	14	
Public Insurance ^b (%)	64	76	70	88	77	75	
Etiology of Renal Disease (%)							
FSGS	9	11		13			
Other Glomerular	10	15		19			
CAKUT	28	29		29			
Other/Missing	54	45		39			
Median Peak PRA ^a (%) (IQR)	0 (0-5)	0 (0-7)	46 (6-88)	3 (0-10)	25 (6-70)	80 (27-96)	
Donor Type ^c (%)							
Living	51	54	35	52	29	32	
SCD Deceased	48	45	62	47	67	64	
ECD Deceased	1	1	2	1	4	4	

A.	Total Number of Transplants						
	1+Transplants n = 14,799	2+Transplants n = 3082	3+Transplants n = 448				
	Graft Number	Graft Number	Graft Number	1	2	1	2
	1	1	1	1	2	1	2
Mean Donor Age ^b (SD)	30.1 (12.7)	31.0 (13.9)	31.5 (14.2)	29.9 (14.7)	33.0 (15.2)	32.0 (13.9)	3
Donor Race (%)							
Caucasian	69	74	74	77	79	77	77
African-American	13	13	12	10	12	11	11
Hispanic	16	12	12	11	7	11	11
Other	3	<1	3	2	2	2	2
Zero HLA Mismatch ^a (%)	4	5	15	6	12	29	29
Median Transplant Year	2000	1993	2003	1991	1996	2005	2005

B.	Total Number of Transplants						
	1+Transplants n = 14,799	2+Transplants n = 3082	3+Transplants n = 448				
	Graft Number	Graft Number	Graft Number	1	2	1	2
	1	1	1	1	2	1	2
Caucasian Recipients (%)							
Living	62	61	42	58	33	35	35
SCD Deceased	38	38	56	42	64	61	61
ECD Deceased	<1	1	2	<1	3	4	4
Non-Caucasian Recipients (%)							
Living	37	41	24	39	20	26	26
SCD Deceased	62	57	73	60	74	71	71
ECD Deceased	1	1	3	1	6	3	3

^aMissing in <5% of records

b_p Missing in <1% of records

Table 2

A. Characteristics of Primary Pediatric Kidney Transplant Recipients, Stratified by Outcome after First and Second Graft Failures. B. Association of Recipient and Previous Graft Characteristics with the Likelihood of Retransplantation Following First and Second Graft Failure Among Patients Receiving a Primary Pediatric Kidney Transplant.

A.	Outcome after First Graft Failure (n=5772)			Outcome after Second Graft Failure (n=1158)		
	Retx ^a	Death	Alive without Retx ^a	Retx ^a	Death	Alive without Retx ^a
Mean Age at Graft Failure (SD)	17.0 (6.5)	17.0 (6.0)	19.3 (5.4)	20.3 (7.3)	20.1 (6.2)	23.3 (6.0)
Sex (% Female)	42.8	49.4	41.5	41.1	48.2	43.0
Race (%)						
Caucasian	63.9	53.5	43.1	72.1	59.6	50.3
African-American	18.6	29.0	33.2	11.2	27.5	29.3
Hispanic	14.4	14.1	17.6	13.7	8.3	16.2
Other	3.1	3.4	6.1	2.9	4.6	4.2
Pre-emptive Status of Previous Transplant (%)	14.5	7.8	13.9	7.7	4.6	8.9
Public Insurance (%)	76.3	84.5	71.5	77.0	88.5	77.8
Etiology of Renal Disease (%)						
FSGS	6.8	5.2	13.2	9.2	8.3	14.1
Other Glomerular	8.9	7.2	11.1	13.9	11.5	15.8
CAKUT	16.1	13.3	20.8	19.8	18.4	23.4
Other/Missing	68.2	74.3	54.8	57.1	61.9	46.7
Peak PRA at Previous Transplant (%)						
0-20%	87.4	80.0	87.9	46.3	34.3	31.8
21-80%	10.0	14.3	9.6	35.7	36.6	31.8
81-100%	2.6	5.7	2.5	18.1	29.2	36.5
Timing of Graft Loss (%)						

A.						
Outcome after First Graft Failure (n=5772)				Outcome after Second Graft Failure (n=1158)		
	Retx ^a	Death	Alive without Retx ^a	Retx ^a	Death	Alive without Retx ^a
PNF	18.2	18.0	4.5	19.1	22.0	12.5
Earlier (<5 yrs)	35.6	47.9	45.7	47.0	60.1	57.2
Later (>5 yrs)	46.1	34.1	49.8	33.9	17.9	30.3
Median Yr of Graft Failure	2000	1998	2006	2001	1999	2006

B.					
First Graft Failure (n=5772)			Second Graft Failure (n=1158)		
	aSHR ^a (95% CI)	P-value	aSHR ^a (95% CI)	P-value	
Age at Graft Failure					
0-12	Reference		Reference		
13-17	0.81 (0.73-0.90)	<0.001	0.73 (0.52-1.03)		0.07
>17	0.54 (0.48-0.60)	<0.001	0.48 (0.35-0.66)		<0.001
Female Sex	1.02 (0.94-1.10)	0.6	0.89 (0.73-1.08)		0.2
Race					
Caucasian	Reference		Reference		
African-American	0.54 (0.49-0.59)	<0.001	0.35 (0.26-0.49)		<0.001
Hispanic	0.73 (0.66-0.81)	<0.001	0.77 (0.59-0.99)		0.048
Other	0.63 (0.51-0.78)	<0.001	0.58 (0.33-1.03)		0.06
Pre-emptive Status of Previous Transplant	1.29 (1.15-1.46)	<0.001	1.01 (0.69-1.48)		0.9
Public Insurance	0.86 (0.78-0.95)	0.004	0.94 (0.74-1.19)		0.6
Etiology of Renal Disease					
FSGS	0.93 (0.80-1.08)	0.3	1.03 (0.73-1.44)		0.9
Other Glomerular	1.13 (0.98-1.29)	0.08	1.15 (0.86-1.53)		0.3
CAKUT	0.99 (0.88-1.11)	0.8	0.95 (0.72-1.23)		0.6
Other/Missing	Reference		Reference		

B.				
	First Graft Failure (n=5772)		Second Graft Failure (n=1158)	
	aSHR ^a (95% CI)	P-value	aSHR ^a (95% CI)	P-value
Peak PRA at Previous Transplant				
0-20%	Reference		Reference	
21-80%	0.87 (0.77-0.99)	0.04	0.86 (0.69-1.07)	0.2
81-100%	0.58 (0.45-0.74)	<0.001	0.60 (0.46-0.79)	<0.001
Timing of Graft Loss				
PNF	Reference		Reference	
Earlier (<5 yrs)	0.70 (0.63-0.79)	<0.001	0.99 (0.74-1.33)	0.9
Later (>5 yrs)	1.23 (1.07-1.42)	0.003	1.90 (1.32-2.73)	0.001
Year of Graft Failure	1.00 (0.99-1.01)	0.6	1.02 (0.99-1.05)	0.1

^aRetx = retransplant

^aaSHR: adjusted subhazard ratios of retransplantation from multivariate competing risks regression, showing association of various recipient and graft characteristics with likelihood for retransplantation after graft failure, while accounting for competing risk of death

Kidney Transplant Outcomes among Patients Receiving a Primary Pediatric Kidney Transplant (1987-2010), Stratified by Total Number of Transplants and Graft Number.

Table 3

	Total Number of Transplants						
	1+Transplants n = 14,799	2+Transplants n = 3082			3+Transplants n = 448		
	Graft Number	Graft Number	Graft Number	Graft Number	Graft Number	Graft Number	Graft Number
	1	1	2	1	2	3	
Delayed Graft Function (%)	9	16	18	21	27	21	
Primary Non-function (%)	6	18	7	31	19	7	
Death-Censored Graft Survival (%)							
1-Year	91.9	77.0	89.3	62.1	73.9	89.6	
5-Year	74.8	47.0	65.3	24.6	34.3	62.0	
10-Year	56.1	20.5	43.9	6.5	10.1	39.1	
Median Death-Censored Graft Survival (years)	11.6	4.5	8.5	2.1	3.1	7.7	