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Outcomes of Kidney Transplant Recipients With Percutaneous Ureteral Interventions: A Single-Center Study

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Background. Long-term outcomes of kidney transplantation recipients with percutaneous ureteral management of transplant ureteral complications are not well characterized. **Methods.** Electronic records of 1753 recipients of kidney-alone transplant between January 2000 and December 2008 were reviewed. One hundred thirty-one patients were identified to have undergone percutaneous ureteral management, with placement of percutaneous nephrostomy tube or additional intervention (nephroureteral stenting and/or balloon dilation). Indications for intervention included transplant ureteral stricture or ureteral leak. Kaplan-Meier survival curves and multivariable regression modeling were performed to determine survival outcomes. **Results.** Kaplan-Meier graft survival ($P = 0.04$) was lower in patients with percutaneous ureteral intervention for transplant ureteral complication. Graft survival at 1, 5, and 10 years was 94.3% 78.3%, and 59.1% for no intervention and 97.2%, 72.1%, and 36.2% for intervention cohort. Patient survival ($P = 0.69$) was similar between cohorts. Multivariate analysis demonstrated no association with graft failure (hazard ratio, 1.21; 95% confidence interval, 0.67-2.19; $P = 0.53$) or patient death (hazard ratio, 0.56; 95% confidence interval, 0.22-1.41; $P = 0.22$) in intervention group. The major cause of graft failure was infection for percutaneous ureteral intervention group (20.4%) and chronic rejection for those without intervention (17.3%). **Conclusions.** Kidney transplant recipients with percutaneous ureteral interventions for ureteral complications do not have a significant difference in graft and patient survival outcomes. Therefore, aggressive nonoperative management can be confidently pursued in the appropriate clinical setting.

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Urological complications are a major source of morbidity after renal transplantation. The most common postoperative complication is ureteral stricture at the ureterovesical

anastomosis, with reported incidence rates up to 10%.¹⁻⁹ Strictures often lead to hydronephrosis and risk permanent damage to the renal allograft. Other postoperative urologic complications include ureteral leaks that commonly occur at the surgical anastomosis or less often the renal collecting system, with incidence rates up to 5.4%.^{8,10-12} Leaks may occur due to ischemia, may be associated with concurrent or and subsequent stricture, technical failings, and can lead to infection if not adequately treated. These complications may also be associated with urolithiasis.⁸ Risk factors, such as male recipient and older donor, have been identified as associated with postoperative stricture,¹³ and kidney graft artery multiplicity has also been associated with postoperative urological complications.¹¹ Open-surgery techniques have been used for the correction of postoperative urological complications; however, these procedures have been associated with higher morbidity, delayed convalescence, and may be technically challenging.^{1,7}

This concern has been addressed through the use of percutaneous nephrostomy tubes (PNT) and endourological procedures to manage these complications, both of which have demonstrated favorable outcomes and become primary interventions at many institutions.^{1,7,14-18} Though there is a demonstrated success in treatment of ureteral strictures and leaks with percutaneous ureteral interventions, literature remains

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sparse regarding long-term transplant outcomes. In this single-center retrospective study, we examine long-term graft and patient survival outcomes in transplant recipients with previous percutaneous management of ureteral complications.

MATERIALS AND METHODS

Patient Population

We queried the electronic health records of the University of Michigan Hospital and identified 1753 adult kidney transplant recipients between January 2000 and December 2008. Using the EMERSE search program developed at the University of Michigan, we used specific terms to identify transplant recipients who required PNT placement within 6 months of transplant, and those with additional interventions including nephroureteral stenting (NUS) and balloon dilation therapy. Indications for stenting included ureteral stricture and ureteral leak.

At our institution, we used The Lich Gregoir extravesical ureteral tunneling technique for the transplant ureterovesical anastomosis. Clinically suspected postoperative ureteral stricture and ureteral leak were confirmed by percutaneous nephrostomy with placement of PNT. Strictures were determined by luminal obstruction on antegrade/retrograde ureterography or computed tomography scan, associated with transplant kidney hydronephrosis and progressive serum creatinine elevation. The decision to place NUS or augment with balloon dilation therapy was operator-dependent, with goal of completing therapy within 3 to 6 months; however, interventions remained in place until the stricture or leak resolved, even if greater than the 6-month goal. Ureteral dilation was performed by Interventional Radiology with antegrade Amplatz balloon dilators or Koon Rigid Dilators to greater than 10 French (Fr) diameter. After treatment, 8.5 Fr NUS was placed, and reevaluated every 4 weeks with repeated treatment (restenting). Patency was determined by antegrade pyelogram and/or by computed tomography with contrast, with initial PNT placement and after NUS changes. Those who failed percutaneous management (determined by the clinical assessment of the team based on failure of improvement or severity of the complication radiologically) underwent surgical intervention unless otherwise contraindicated. Interventions included were ureteroneocystostomy, vesicopyloostomy, or ureterourterotomy.

Statistical Analysis

Graft and patient survival were determined for all transplant recipients. Graft failure was defined as graft removal, return to dialysis or death.¹⁹ Follow-up began at the time of transplant and ended at the occurrence of the event of interest, loss to follow-up, or the end of the observation period, December 30, 2010. Graft and patient survival assessment was performed using Kaplan Meier analysis. Comparison of survival curves between patient groups was performed using the Log rank test.

In our multivariate analyses, donor, recipient, and transplant-specific variables known to be associated with graft and patient outcome were obtained from the Scientific Registry of Transplant Recipients. Donor variables included age, sex, ethnicity, weight, cause of death, diabetes, hypertension, kidney pumped, creatinine greater than 1.3, stroke, and expanded criteria donor. Recipient variables included sex, ethnicity, insurance type, weight, BMI, cold ischemia time,

previous organ recipient, diabetes, and donor type. A comparison of risk factors in posttransplant intervention subgroups was performed using contingency table χ^2 analysis for categorical variables, and 1-way analysis of variance for continuous variables. Specific independent risk factors for graft and patient survival were determined using Cox proportional hazard models in univariate analyses. Covariates with *P* less than 0.20 in the univariate analyses were used in the final models to determine hazard ratios between intervention subgroups in multivariate graft and patient survival analyses. Missing data were less than 1% for other variables and were imputed when present. A *P* value less than 0.05 was considered statistically significant. All statistical analyses were performed using STATA (StataCorp, College Station, Texas).

RESULTS

One thousand seven hundred fifty-three kidney transplant recipients were identified in this cohort. Of these, 131 (7.4%) had a percutaneous ureteral intervention within 6 months of transplantation, including PNT only in 11.4% of interventions and PNT with nephroureteral stenting and/or balloon dilation therapy in 88.6%. We identified 58 (44.2%) patients with ureteral stricture and 73 (55.8%) patients with ureteral leak. Of those with a ureteral stricture, 7 had PNT only placed, 39 with PNT and nephroureteral stenting, and 12 with PNT, balloon dilation and stenting. Of those with ureteral leaks, 8 had PNT only, 60 with PNT and nephroureteral stenting, and 5 with PNT, balloon dilation and stenting (Table 1). Long-term clinical success was defined as resolution of stricture or leak. 41 patients (70.6%) had resolution of ureteral stricture with intervention and 60 patients (82.1%) had resolution of ureteral leaks, with an overall long-term clinical success rate of 77% and average of 4.6 treatments. Of the remaining ureteral stricture patients, 8 (14.2%) required surgical revision (all Boari flaps except 2 hernia repairs for incarcerated ureter and 1 open lithotomy), and 2 (3.5%) were PNT dependent as they were sent to hospice. Of those with ureteral leaks, 4 (5.4%) required surgical revision and 1 (1.3%) was PNT dependent (patient passed of cardiovascular event).

Donor and Recipient Variables

Donor, recipient, and transplant-specific variables known to contribute to kidney transplant outcomes were acquired from the Scientific Registry of Transplant Recipients. Donor

TABLE 1.
Indication for intervention categorized by intervention types

Ureteral stricture (n = 58)	N
PNT only	7
PNT and nephroureteral stent	39
PNT and balloon dilation and stent	12
Ureteral leak (n = 73)	N
PNT only	8
PNT and nephroureteral stent	60
PNT and balloon dilation and stent	5

TABLE 2.
Descriptive statistics of patient population

Donor variables	Control (n = 1621)	Intervention (n = 131)	P
Age: mean (SD)	38.9 (14.1)	40.3 (13.5)	0.26
Sex % (n)			
Male	51.7 (838)	50.4 (66)	0.77
Female	48.3 (783)	49.6 (65)	
Ethnicity % (n)			
White	87.1 (1411)	80.2 (105)	0.01
African American	8.7 (140)	15.3 (20)	
Hispanic	3.1 (50)	2.3 (3)	
American Indian	.1 (2)	.8 (1)	
Asian	1.1 (17)	1.5 (2)	
Weight: mean (SD), kg	78.4 (18.5)	80.8 (20.6)	0.16
Cause of death % (n)			
Anoxia	7.3 (118)	4.5 (6)	0.35
Cerebrovascular accident	17.5 (283)	22.9 (30)	
Head trauma	21.9 (355)	23.6 (31)	
Tumor	1.2 (20)	2.3 (3)	
Diabetes, % (n)	1.6 (26)	2.3 (3)	0.44
Hypertension, % (n)	9.1 (147)	13.7 (18)	0.19
Kidney pumped, % (n)	10.6 (172)	6.1 (8)	0.06
Creatinine, >1.3 % (n)	4.1 (67)	7.6 (10)	0.12
Stroke, % (n)	17.9 (290)	23.6 (31)	0.24
Expanded criteria, % (n)	5.9 (92)	6.8 (9)	
Donor type, % (n)			
Deceased	48 (778)	54.2 (71)	0.33
Living related	30.7 (498)	25.2 (33)	
Living unrelated	21.3 (345)	20.6 (27)	
Recipient variables			
Sex % (n)			
Male	59.3 (961)	73.2 (96)	0.002
Female	40.7 (660)	26.7 (35)	
Ethnicity % (n)			
White	78.1 (1266)	67.2 (88)	0.01
African American	16.3 (264)	29.1 (38)	
Hispanic	2.6 (43)	3.8 (5)	
American Indian	.49 (8)	0	
Asian	2.1 (33)	0	
Multiracial	0.3 (5)	0	
Hawaiian	0.1 (1)	0	
Insurance % (n)			
Private	47.8 (776)	41.9 (55)	0.66
Medicaid	1.9 (32)	3.1 (4)	
Medicare	49.9 (810)	54.9 (72)	
Self	0.1 (2)	0	
Weight mean (SD)	84.1 (20.6)	84.6 (22.4)	0.76
BMI mean (SD)	32.1 (13.9)	27.8 (6.1)	0.72
Cold ischemia time (SD), h	8.9 (8.9)	8.6 (7.5)	0.76
Age (SD)	48.6 (19.2)	49.5 (13.4)	0.69
Previous organ % (n)	11.3 (184)	12.2 (16)	0.77
Diabetes % (n)	36.1 (585)	33.5 (44)	0.71

and recipient characteristics are listed in Table 2. These variables were not statistically different between the intervention groups except for donor and recipient ethnicity, and recipient sex ($P = 0.01$, $P = 0.01$. $P = 0.002$ respectively).

Survival Analysis

Kaplan-Meier graft survival at 1, 5 and 10 years was 94.3% 78.3%, and 59.1% for no intervention and 97.2%, 72.1%, and 36.2% for the intervention cohort (Figure 1). Log rank test for graft survival was $P = 0.04$, indicating a statistical difference between the groups. Power for log rank testing in intervention comparison was 0.96, given 2-sided and $P < 0.05$ parameters. A separate Kaplan Meier graft survival was performed to further subdivide intervention group by ureteral stricture versus ureteral leak. Graft survival at 1 and 5 years was 94.3% and 78.3% for no urinary complications, 93.8% and 71.2% for ureteral stricture, and 97.2% and, 74.3% for ureteral leaks. Log rank test for graft survival was $P = 0.09$ (Figure 2).

Kaplan Meier patient survival at 1, 5, and 10 years was 95.4%, 84.4% and 66.2% for no intervention, and 96.1%, 84.4%, and 68.3% for the intervention cohort (Figure 3). Log rank test was $P = 0.69$, indicating no statistical difference in patient survival between the 2 groups. Patient survival for subdivision of intervention group by ureteral stricture versus ureteral leak demonstrated the following results: at 1 and 5 years for urinary complications was 95.4% and 84.4% for no complications, 96.5% and 84.4% for ureteral strictures, and 97.1% and 84.4% for ureteral leaks. Log rank test for patient survival was $P = 0.91$ (Figure 4).

Univariate and Multivariate Analysis

Univariate analysis was performed to determine donor and recipient risk factors associated with graft and patient survival. Recipients with percutaneous ureteral interventions had a higher risk of graft failure but not patient death compared to those without intervention (hazard ratio [HR], 1.38 and 0.91, $P = 0.04$ and 0.69, respectively). Donors older than 50 years, hypertension, kidney pumped, stroke, expanded criteria, and recipients with Medicare, older than 50 years, panel reactive antibody (PRA) greater than 50, and diabetes had a significantly increased risk for both graft failure and death. Other variables and risk assessments are demonstrated in Table 3.

The threshold for inclusion in our final multivariate model was a P value less than 0.2. Based on these criteria, variables

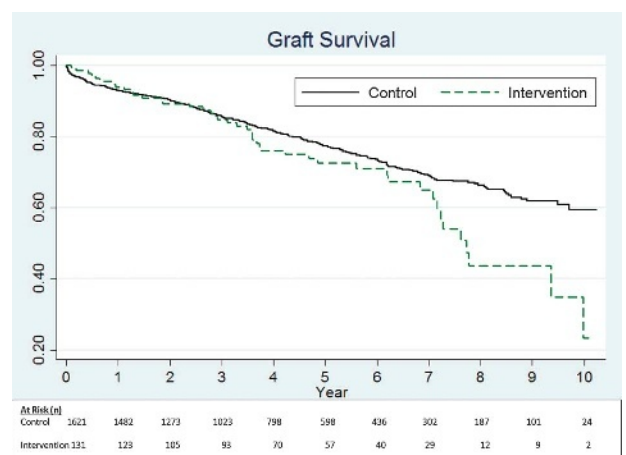


FIGURE 1. Kaplan-Meier survival analysis for graft survival. Graft survival at 1, 5, and 10 years was 94.3% 78.3%, and 59.1% for no intervention and 97.2%, 72.1%, and 36.2% for intervention cohort ($P = 0.04$).

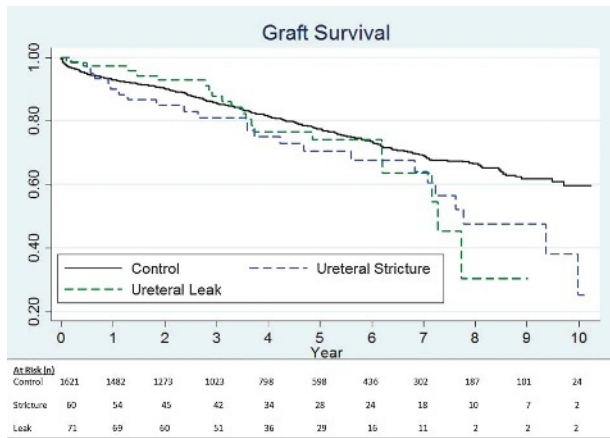


FIGURE 2. Graft survival at 1 and 5 years was 94.3% and 78.3% for no urinary complications, 93.8% and 71.2% for ureteral stricture, and 97.2% and 74.3% for ureteral leaks ($P = 0.09$).

included were percutaneous ureteral intervention, donor age, cause of death, diabetes, hypertension, kidney pumped, stroke, expanded criteria, and recipient ethnicity, PRA, cause of ESRD, age, previous organ transplant, diabetes, and donor type for graft failure. For patient death multivariate analyses, the following variables were used: percutaneous ureteral intervention, donor age, cause of death, hypertension, kidney pumped, creatinine, stroke, expanded criteria, and recipient sex, insurance, PRA, cause of ESRD, age, diabetes, and donor type. Ureteral stricture and leak were not included in these models due to colinearity with PNT. Power for Cox Regression Model in intervention comparison to control was 0.97, given 2-sided and P value less than 0.05 parameters.

The Cox Regression Model for graft survival demonstrated no difference in patients with percutaneous ureteral intervention compared to those without intervention (HR, 1.21, 95% confidence interval, 0.67-2.19, $P = 0.53$). Results for other covariates are listed in Table 4. Significant variables included donor diabetes and recipient insurance and age.

The Cox Regression Model for patient survival also showed no differences between those with percutaneous

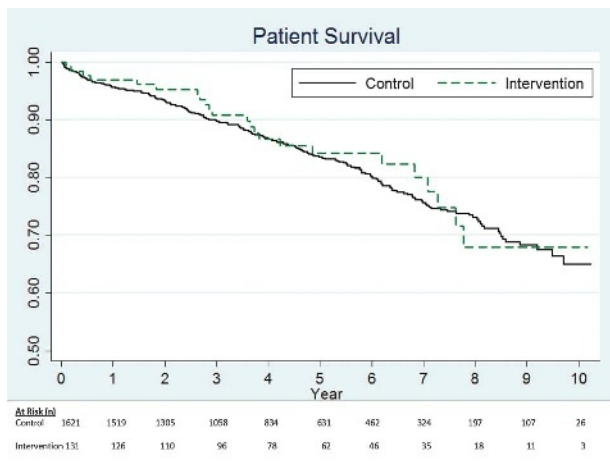


FIGURE 3. Kaplan-Meier analysis for patient survival. Patient survival at 1, 5, and 10 years was 95.4%, 84.4%, and 66.2% for no intervention, and 96.1%, 84.4%, and 68.3% for intervention cohort ($P = 0.69$).

ureteral intervention compared to those without intervention (HR, 0.56 95% confidence interval, 0.22-1.41, $P = 0.22$) (Table 5). As with graft survival, neither ureteral strictures (HR, 0.79) or leaks (HR, 0.63) were associated with patient survival ($P = 0.47$ and $P = 0.15$). Significant variables included donor creatinine and recipient insurance and age.

Cause of Graft Failure

A total of 419 graft failures were seen in this patient population. Causes of graft failure were classified as patient death, acute rejection, chronic rejection, infection, focal segmental glomerulosclerosis, and nephropathy within intervention subgroups (Table 6). The most frequent cause of graft failure in those without intervention was chronic rejection (17.3%), while it was infection in those with percutaneous ureteral intervention (20.4%) ($P = 0.76$). The 2 most isolated bacterial causes were *Escherichia coli* and *Enterococcus*.

DISCUSSION

Urological complications make up a large percentage of surgical complications in renal transplant recipients. Open surgical repair was previously considered first line therapy in urological complication management; however, the introduction of percutaneous ureteral interventions provided an option that held the promise of lower morbidity. Mostafa et al⁷ studied 1402 kidney transplant recipients, of whom 21 required PNT intervention. Kaplan Meier analysis demonstrated no difference in 10-year patient and allograft survival; however, inferences that could be drawn are limited by the small number of patients with PNT. In our cohort, we found no difference in Kaplan-Meier patient survival; however, we did find a statistical difference in graft survival. Our univariate analysis also demonstrated that percutaneous ureteral intervention was associated with graft failure. However, the association did not persist in Cox-Regression analysis indicating that the lower graft survival seen in PNT patients may be a result of factors other than PNT, such as donor and recipient ethnicity that contribute to inferior survival outcomes.

Several groups have shown favorable outcomes after urinary complication management with balloon dilation or other ureteral interventions. Bhayani et al reported outcomes

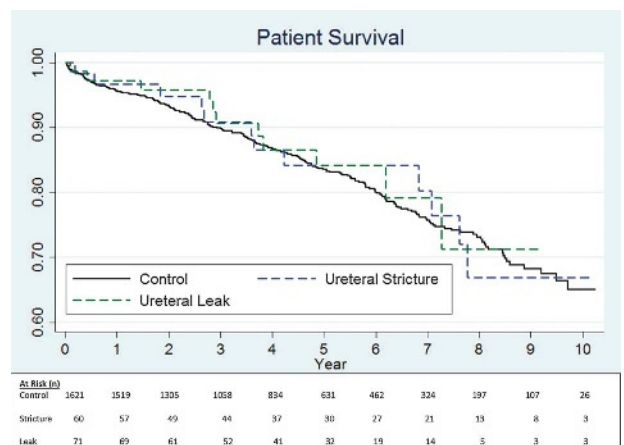


FIGURE 4. Patient survival at 1 and 5 years for urinary complications was 95.4% and 84.4% for no complications, 96.5% and 84.4% for ureteral strictures, and 97.1% and 84.4% for ureteral leaks ($P = 0.91$).

TABLE 3.
Univariate analysis for graft failure and patient death

	HR graft failure	P	HR patient death	P
No intervention	1 (reference)		1 (reference)	
Intervention	1.38 (1.0-1.89)	0.04	0.91 (0.59-1.4)	0.69
Donor variables				
Age, y				
<40	1 (reference)		1 (reference)	
41-50	1.22 (0.97-1.55)	0.08	1.34 (1.02-1.75)	0.03
>50	1.42 (1.12-1.81)	0.004	1.33 (1.01-1.77)	0.05
Sex				
Male	1 (reference)		1 (reference)	
Female	1.05 (0.87-1.28)	0.58	1.04 (0.83-1.31)	0.73
Ethnicity				
White	1 (reference)		1 (reference)	
African American	1.08 (0.78-1.51)	0.61	0.83 (0.54-1.26)	0.39
Hispanic	1.12 (0.67-1.87)	0.67	1.24 (0.69-2.2)	0.48
Asian	1.34 (0.18-9.5)	0.76	1.15 (0.37-3.61)	0.8
Weight, kg				
<70	1 (reference)		1 (reference)	
71-80	0.96 (0.73-1.26)	0.8	0.99 (0.72-1.33)	0.91
>80	1.09 (0.88-1.37)	0.4	1.05 (0.81-1.36)	0.71
Cause of death				
Anoxia	1 (reference)		1 (reference)	
Cerebrovascular accident	1.56 (1.03-2.4)	0.04	1.44 (0.89-2.33)	0.13
Head trauma	.96 (.63-1.48)	0.88	.88 (.54-1.43)	0.62
Tumor	1.17 (0.45-3.05)	0.65	1.55 (0.58-4.12)	0.37
Diabetes	2.25 (1.19-4.25)	0.01	0.99 (0.37-2.69)	0.99
Hypertension	1.55 (1.15-2.09)	0.004	1.57 (1.11-2.19)	0.01
Kidney pumped	1.58 (1.17-2.13)	0.003	1.72 (1.22-2.41)	0.002
Creatinine	1.26 (.81-1.93)	0.29	1.62 (1.03-2.55)	0.04
Stroke	1.62 (1.26-2.08)	0.001	1.59 (1.19-2.11)	0.002
Expanded criteria	2.1 (1.52-2.91)	0.001	2.13 (1.49-3.09)	0.001
Recipient variables				
Sex				
Male	1 (reference)		1 (reference)	
Female	0.89 (0.73-1.09)	0.28	0.85 (0.67-1.07)	0.17
Ethnicity				
White	1 (reference)		1 (reference)	
African American	1.35 (1.05-1.73)	0.02	1.12 (.82-1.51)	0.46
Hispanic	0.87 (0.45-1.69)	0.69	1.05 (.52-2.13)	0.88
Insurance				
Private	1 (reference)		1 (reference)	
Medicaid	2.01 (1.06-3.83)	0.03	1.31 (.53-3.21)	0.55
Medicare	2.00 (1.63-2.45)	0.001	1.91 (1.51-2.41)	0.001
Weight, kg				
<70	1 (reference)		1 (reference)	
71-80	1.07 (0.82-1.42)	0.61	1.02 (0.73-1.42)	0.92
>80	0.96 (0.76-1.21)	0.74	1.05 (0.79-1.39)	0.72
BMI				
<30	1 (reference)		1 (reference)	
>30	1.01 (0.83-1.23)	0.88	1.09 (0.87-1.38)	0.42
PRA				
<25	1 (reference)		1 (reference)	
25-50	0.98 (0.61-1.58)	0.95	0.87 (0.49-1.56)	0.66

Continued next page

TABLE 3. (Continued)

	HR graft failure	P	HR patient death	P
>50	1.42 (1.07-1.91)	0.01	1.31 (0.93-1.84)	0.12
Cause of ESRD				
Glomerulonephritis	1 (reference)		1 (reference)	
Diabetes mellitus	0.99 (0.62-1.57)	0.97	1.14 (0.66-1.98)	0.63
Hypertension	1.05 (0.61-1.81)	0.85	1.05 (0.54-2.02)	0.88
Congenital	0.99 (0.30-3.28)	0.99	0.98 (0.23-4.21)	0.98
Polycystic kidney	0.59 (0.26-1.29)	0.18	0.43 (0.15-1.27)	0.13
Other	1.07 (0.64-1.78)	0.79	1.08 (0.58-2.01)	0.81
Cold ischemia time				
<20	1 (reference)		1 (reference)	
>20	1.10 (0.89-1.37)	0.37	1.17 (0.92-1.49)	0.21
Age				
<40	1 (reference)		1 (reference)	
41-50	1.05 (0.69-1.62)	0.8	1.94 (1.07-3.49)	0.03
>50	2.28 (1.67-3.12)	0.001	4.57 (2.84-7.38)	0.001
Previous organ	1.22 (0.91-1.64)	0.18	0.91 (0.62-1.32)	0.59
Diabetes				
Diabetes	1.47 (1.22-1.79)	0.001	2.07 (1.65-2.59)	0.001
Donor type				
Deceased	1 (reference)		1 (reference)	
Living related	0.44 (0.35-0.56)	0.001	0.42 (0.31-0.56)	0.001
Living unrelated	0.68 (0.52-0.87)	0.003	0.59 (0.43-0.81)	0.001

in 8 patients with ureteral strictures, with 4 undergoing Acucise endoureterotomy and the other 4 balloon dilation.¹ Success rates were 67% and 75% with mean follow-up of 20 months and 23.7 months for Acucise and balloon dilation. A separate study by Fontaine et al evaluated 17 patients with leaks and 44 with obstruction who were treated with percutaneous ureteral therapy; patients underwent percutaneous nephrostomy followed by antegrade placement of nephroureteral stent.¹⁶ Additionally, all patients with obstruction also underwent balloon dilation. Fifty-nine percent of ureteral leak patients were cured after treatment, 62% with early obstruction were cured, and only 16% with late obstruction (>3 months post-op) were cured. In a single-center study by Fonio et al,¹⁵ 146 urological complications were identified in 1,146 renal transplant recipients, consisting of obstruction, leaks and perigraft fluid collections. Seventy-five patients experienced stenosis or obstruction. 36 patients underwent balloon dilation with a long-term clinical success rate of 44.4%. Of the 12 patients who underwent double-J stent, 58% were successfully treated. In our cohort, we identified 58 recipients with ureteral strictures and 73 recipients with ureteral leaks. In our cohort, long-term clinical success rates for ureteral stricture and ureteral leak were 70.6% and 82.1% respectively, with an overall success rate of 77% and mean of 4.6 treatments.

Many of these studies have been limited in their numbers and therefore in their strength of statistical power. Although our study differs in that it is not designed to assess the merits of percutaneous intervention, we identified 131 patients who underwent PNT placement, with 116 patients having further intervention (nephroureteral stenting with or without balloon dilation). Because of our relatively large sample size,

TABLE 4.
Cox regression analysis for graft failure

	HR graft failure	P
No intervention	1 (reference)	
Intervention (PNT)	1.21 (0.67-2.19)	0.53
Donor variables		
Age		
<40	1 (reference)	
41-50	0.79 (0.51-1.22)	0.29
>50	0.69 (0.41-1.17)	0.18
Cause of death		
Anoxia	1 (reference)	
Cerebrovascular accident	0.62 (0.12-2.74)	0.52
Head trauma	1.43 (0.74-2.71)	0.28
Tumor	1.61 (0.94-1.89)	0.89
Diabetes	2.26 (1.03-4.97)	0.04
Hypertension	1.24 (0.74-2.11)	0.41
Kidney pumped	1.26 (0.78-2.05)	0.33
Stroke	2.58 (0.56-11.5)	0.23
Expanded criteria	1.23 (0.57-2.62)	0.61
Recipient variables		
Ethnicity		
White	1 (reference)	
African American	0.95 (0.63-1.45)	0.82
Hispanic	0.51 (0.15-1.66)	0.26
Insurance		
Private	1 (reference)	
Medicaid	1.92 (1.22-7.41)	0.02
Medicare	1.92 (1.27-2.8)	0.01
PRA		
<25	1 (reference)	
25-50	0.89 (0.44-1.81)	0.76
>50	1.05 (0.63-1.76)	0.85
Cause of ESRD		
Glomerulonephritis	1 (reference)	
Diabetes mellitus	0.89 (0.55-1.44)	0.65
Hypertension	0.95 (0.55-1.66)	0.86
Congenital	0.86 (0.26-2.86)	0.81
Polycystic kidney	0.63 (0.29-1.41)	0.26
Other	0.99 (0.59-1.69)	1
Age, y		
<40	1 (reference)	
41-50	1.65 (0.64-4.23)	0.29
>50	3.29 (1.57-6.91)	0.01
Previous organ	1.47 (0.86-2.51)	0.16
Diabetes	1.21 (0.84-1.74)	0.29
Donor type		
Deceased	1 (reference)	
Living related	0.37 (0.29-1.85)	0.21
Living unrelated	0.49 (0.32-1.42)	0.39

we were able to assess the likelihood of graft and patient survival in this population through statistical methods that account for risk factors known to contribute to renal transplant outcomes.

The primary limitation of our study is that it is a single-center retrospective study with a relatively small number of percutaneous ureteral interventions and fewer graft failure and death events. The lack of statistical significance in the multivariate modeling could be a type II error due to low

statistical power. This is a common problem among many retrospective studies as the incidence of urological complications is relatively low. In addition, although the approach to management of ureteral complications has remained consistent throughout the era covered by the study, variability in the indications for intervention and assessment of clinical success cannot be ruled out. Nevertheless, the overall number of events is large enough to accommodate multivariable modeling, and our study is one of the first to perform this and is the largest study to examine the specific impact of

TABLE 5.
Cox regression analysis for patient death

	HR patient death	P
No intervention	1 (reference)	
Intervention (PNT)	0.56 (0.22-1.41)	0.22
Donor variables		
Age		
<40	1 (reference)	
41-50	0.96 (0.57-1.59)	0.88
>50	0.62 (0.31-1.22)	0.17
Cause of death		
Anoxia	1 (reference)	
Cerebrovascular accident	0.78 (0.09-6.22)	0.82
Head trauma	1.41 (0.63-3.13)	0.41
Tumor	2.74 (0.92-3.85)	0.65
Hypertension	1.59 (0.87-2.91)	0.13
Kidney pumped	0.94 (0.54-1.65)	0.83
Creatinine	2.04 (1.08-2.86)	0.03
Stroke	2.25 (0.26-19.4)	0.46
Expanded criteria	1.15 (0.46-2.88)	0.76
Recipient variables		
Sex		
Male	1 (reference)	
Female	0.92 (0.59-1.44)	0.72
Insurance		
Private	1 (reference)	
Medicaid	1.54 (0.37-6.61)	0.56
Medicare	2.11 (1.26-3.51)	0.01
PRA		
<25	1 (reference)	
25-50	0.61 (0.24-1.54)	0.29
>50	1.12 (0.59-2.10)	0.73
Cause of ESRD		
Glomerulonephritis	1 (reference)	
Diabetes Mellitus	1.12 (0.63-1.96)	0.73
Hypertension	0.96 (0.49-1.89)	0.92
Congenital	0.94 (0.22-4.12)	0.94
Polycystic kidney	0.43 (0.14-1.27)	0.13
Other	1.03 (0.54-1.94)	0.94
Age, y		
<40	1 (reference)	
41-50	1.84 (0.45-7.54)	0.39
>50	5.96 (1.85-19.2)	0.01
Diabetes	1.58 (1.02-2.42)	0.04
Donor type		
Deceased	1 (reference)	
Living related	0.97 (0.68-1.08)	0.21
Living unrelated	0.98 (0.42-1.83)	0.69

TABLE 6.
Cause of graft failure ($P = 0.76$)

Cause of graft failure	Intervention (n = 44)	Control (n = 374)
Acute rejection	1 (2.2%)	15 (4.1%)
Chronic rejection	8 (18.1%)	65 (17.3%)
Infection (recurrent UTI, pyelonephritis, glomerulonephritis)	9 (20.4%)	42 (11.2%)
FSGS	3 (6.8%)	11 (2.9%)
Nephropathy	0	4 (1.1%)

FSGS, focal segmental glomerulosclerosis.

percutaneous ureteral intervention in the management of urological complications.

Our findings are of clinical importance as most would predict that patients requiring interventions in the postoperative period are more likely to experience graft failure or patient death. This assumption is reasonable given that if more interventions are needed, there is an inherent implication that urological complications have been present for a longer time. This is likely to lead to adverse events, such as hydronephrosis, pyelonephritis, or urinary tract infections, that could negatively influence graft outcomes or lead to dire septic complications. Indeed, we found that infections were a more frequent cause of graft failure in patients with percutaneous ureteral interventions; however, this did not translate into an increased risk of death or graft failure. Furthermore, our analysis suggests that urological complications can be managed with aggressive percutaneous ureteral interventions if needed in the appropriate clinical setting.

CONCLUSIONS

Kidney transplant recipients with PNT placement do not have significantly worse graft and patient survival outcomes. Therefore, aggressive nonoperative management can be confidently pursued in the appropriate clinical setting.

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