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Native Nephrectomy in Renal Transplant Recipients With Autosomal-Dominant Polycystic Kidney Disease

Fouad T. Chebib, MD,[1] Mikel Prieto, MD,[2] Jung Yeonsoon, MD,[1,3] Maria V. Irazabal, MD,[1] Walter K. Kremers, PhD,[2,4] Patrick G. Dean, MD,[2] David J. Rea, MD,[5] Fernando G. Cosio, MD,[1,2] Vicente E. Torres, MD, PhD,[1] and Ziad M. El-Zoghby, MD[1]

Background. Native nephrectomy (NNx) is often done in patients with autosomal-dominant polycystic kidney disease. Controversy exists concerning the need and timing of nephrectomy in transplant candidates. We hypothesize that posttransplant NNx does not negatively impact patient and graft survival. **Methods.** Among 470 autosomal-dominant polycystic kidney disease transplant recipients included in the study, 114 (24.3%) underwent pretransplant (30.7%) or posttransplant (69.3%) NNx. Clinical data were retrieved from electronic records. Follow-up was until death, graft loss or June 2014. Perioperative complications were compared between the surgical techniques (open or laparoscopic) and between the pretransplant and posttransplant nephrectomy groups. The effect of nephrectomy on graft survival was analyzed as a time-dependent covariate when performed posttransplant. **Results.** Mean age at transplant was 52.4 years, 53.8% were men, 93% white, 70% were from living donors, and 56.8% were preemptive. Nephrectomy was done laparoscopically in 31% and 86% in the pretransplant and posttransplant nephrectomy groups, respectively. Complications were less common in those who underwent nephrectomy posttransplant (26.6% vs 48%, $P = 0.03$) but were similar regardless of surgical technique (open, 33.3% vs laparoscopic, 33%; $P = 0.66$). Patient and graft survivals were similar between those who underwent pretransplant nephrectomy and the rest of the recipients. In the posttransplant nephrectomy group, nephrectomy did not affect patient (hazards ratio, 0.77; 95% confidence interval, 0.38-1.54; $P = 0.45$) or graft survival (hazards ratio, 1.0; 95% confidence interval, 0.57-1.76; $P = 0.1$). **Conclusions.** Nephrectomy does not adversely affect patient or graft survival. Posttransplant nephrectomy is feasible when indicated without compromising long-term graft outcome and has fewer complications than pretransplant nephrectomy.

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Autosomal-dominant polycystic kidney disease (ADPKD) is a common hereditary disorder, estimated to affect more than 10 million people worldwide and approximately 500 000 individuals in the United States.[1,2] Affected individuals develop enlarged kidneys with cysts of various sizes throughout the renal parenchyma. The progression of renal cystic disease is variable, but approximately 50% of patients with ADPKD develop end-stage renal disease by the age of 55 years.[1] Currently, ADPKD accounts for 5% to 10% of cases of end-stage renal disease in the United States and Europe.[3,4] Continued cyst growth leads to massive kidney size and multiple local and systemic complications, such as pain,

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[1] *Department of Internal Medicine, Division of Nephrology and Hypertension, Mayo Clinic, Rochester, MN.*

[2] *William von Liebig Transplant Center, Mayo Clinic, Rochester, MN.*

[3] *Kosin University College of Medicine, Busan, South Korea.*

[4] *Department of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, MN.*

[5] *Department of Surgery, Southern Illinois University, Springfield, IL.*

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Correspondence: Ziad M El-Zoghby, MD, Division of Nephrology and Hypertension Mayo Clinic College of Medicine, 200 First St., SW Rochester, MN 55905. (zoghby.ziad@mayo.edu).

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early satiety, abdominal fullness, bloating, and gastroesophageal reflux. Additionally, the cysts can become infected or may hemorrhage, causing additional pain or gross hematuria. When conservative management fails to control symptoms, native nephrectomy (NNx) might be indicated. Controversy exists concerning the need, indication, timing, and approach for NNx in patients with ADPKD who develop stages 4 and 5 chronic kidney disease, especially those who are candidates for kidney transplantation.[5-8] Nephrectomy before, concomitant with, or after transplant has various advantages and disadvantages (**Table S1, SDC**, http://links.lww.com/TXD/A20). There are no clear guidelines for the best approach, and the decision usually relies on individual centers and surgeons' expertise. In general, our practice has been to remove symptomatic native kidneys either before or after kidney transplantation to avoid potential negative consequences of concomitant NNx on the outcome of the kidney graft. Over the last decade, our practice has shifted from open nephrectomy to hand-assisted laparoscopic nephrectomy with the majority performed after transplant. The shift to posttransplant nephrectomy in our center was mainly triggered by an event involving a transplant candidate who required blood transfusion after nephrectomy. Subsequently, he developed high titers of anti-HLA antibodies compromising his transplant eligibility because all his potential living donors became nonsuitable donors. Whether this practice shift affected outcomes of ADPKD transplant recipients is not clear.

The aim of this study is to report our experience with the indications, timing, and postoperative complications of nephrectomy in ADPKD and determine the effect of NNx on patient and graft survival in kidney transplant recipients. We hypothesize that posttransplant NNx does not negatively impact patient and graft survivals.

MATERIALS AND METHODS

The institutional review board approved this study. Between January 1984 and March 2014, 4213 kidney transplant were performed at Mayo Clinic in Rochester, MN and among the recipients, 472 (11%) had ADPKD. We excluded 2 recipients who had NNx at the time of transplant, thus a total of 470 patients were included in this study. Demographics and clinical data were retrieved from the patients' electronic records. Information collected included type and indications of nephrectomy as well as complications after surgery. In addition, we collected the total kidney volume (TKV) measured from axial/coronal computed tomography or magnetic resonance imaging using Analyze software (Analyze 120.0; Biomedical Image Resource, Mayo Clinic, Rochester, MN) when available within 1 year before transplantation (n = 92, 19.6%). Follow-up time was until death, graft loss, or June 1, 2014. For 3 patients who had bilateral nephrectomies in a staged fashion (2 surgeries on different days), only the first nephrectomy procedure was considered in the analysis.

Statistical Analysis

Data are reported as mean ± standard deviation or median and interquartile range (IQR). Continuous data were analyzed using Student's *t* test or Wilcoxon Rank Sum test as appropriate. Comparisons between more than 2 groups were done by analysis of variance for normally distributed and by Kruskall-Wallis test for skewed data. Proportions were compared by χ^2. Patient and graft survivals were calculated by the Kaplan-Meier method, censored at the date of last follow-up. Univariate and multivariate Cox Regression analyses were performed to assess the association between various covariates and the outcomes of interest (patient and graft survivals). For evaluation of posttransplant nephrectomy, nephrectomy was analyzed as a time-dependent covariate. Other covariates that were adjusted for included age, sex, transplant year, donor type, dialysis status, diabetes, and atherosclerotic cardiovascular disease (coronary artery, stroke, or peripheral vascular disease [PVD]) pretransplant. We also accounted for timing of the posttransplant nephrectomy being less or more than 1 year after transplant (early vs late nephrectomy, respectively). *P* values less than 0.05 were considered statistically significant.

The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the "Declaration of Istanbul on Organ Trafficking and Transplant Tourism."

RESULTS

Among the 470 ADPKD patients included in the study, 114 (24.3%) underwent nephrectomy: 35 (31%) pretransplant and 79 (69%) posttransplant. Our practice has shifted over the years from doing nephrectomy predominantly pretransplant to posttransplant such that after 2008, all nephrectomies were done posttransplant. Similarly, the surgical technique shifted in 2003 from an open nephrectomy to a hand-assisted laparoscopic procedure in the large majority of cases. The nephrectomies were performed between 1990 and 2014. The type and timing of nephrectomies according to the nephrectomy and transplant years are shown in Supplementary **Figures S1**, and **S2** (**SDC**, http://links.lww.com/TXD/A20). All the open nephrectomies were done through a transperitoneal approach by 8 different surgeons (each performing between 2 and 10 procedures), whereas over 90% of the laparoscopic procedures were done by the same surgeon and all through a hand-assisted technique.

Mean age at transplant was 52.5 ± 11.4, 53.8% were men, 93% white, and 70% received a kidney from a live donor. Overall, 5.5% had diabetes before transplantation, 12.6% cardiovascular diseases (coronary artery disease, stroke, or PVD), 43.2% were on dialysis (peritoneal or hemodialyis) before transplantation for a median of 15.6 months (IQR, 6-33) and median TKV was 3270 mL (2219-4630) (Table 1). Compared with recipients who did not have a nephrectomy, those who underwent nephrectomy posttransplant were younger (50.6 vs 53.1; $P = 0.027$), more likely to be white (97.7% vs. 91.2%; $P = 0.007$) and to receive a living donor kidney transplant (79.8% vs 67.3%; $P = 0.031$). Compared with recipients who did have a nephrectomy posttransplant, those who underwent nephrectomy pretransplant were younger at time of nephrectomy (49.6 vs 54.1; $P = 0.01$) (with similar age at transplant) and as expected more likely to require dialysis before transplant. Of note, among those with nephrectomy pretransplant, 58% were on dialysis at the time of nephrectomy. Median TKV was larger in those with nephrectomy pretransplant compared to those with nephrectomy posttransplant or no nephrectomy (5494 mL vs 3714 vs 3052, respectively; $P = 0.0017$).

TABLE 1.

Patients characteristics

Variables	All (n = 470)	Nx Pre-Tx (n = 35)	Nx Post-Tx (n = 79)	No Nx (n = 356)	p^1	p^2	p^3
Age at Tx	52.5 ± 11.4	50.3 ± 9.1	50.6 ± 9	53.1 ± 12	0.08	0.027	0.015
Age at Nx	—	49.6 ± 9.3*	54.1 ± 10.4*	—	0.03		
Male, %	53.8%	62.9%	52.4%	57.5%	0.22	0.41	0.23
Caucasians	93%	97.1%	97.7%	91.2%	0.01	0.007	0.24
Living donor	70%	74.3%	79.8%	67.3%	0.08	0.031	0.41
DM at Tx	25 (5.5%)	5.9%	3.9%	5.8%	0.8	0.51	0.98
CAD	37 (8.1%)	5.9%	7.7%	8.5%	0.87	0.85	0.61
Stroke	17 (3.7%)	0	3.8%	4.1%	0.49	0.93	0.23
PVD	10 (2.2%)	0	2.5%	2.3%	0.66	0.90	0.37
Dialysis pre-Tx	203 (43.2%)	91%†	33.8%†	41.4%	<0.001	0.17	<0.001
Dialysis, mo	15.6 (6-33)	2.6 (1.5-22)‡	13.8 (6-26)‡	17 (7-37)	<0.001	0.12	<0.001
Retransplant	7%	11.4%	2.5%	7.6%	0.17	0.11	0.42
Follow-up, mo (IQR)	79.8 (38-128)	98.4 (61-157)	79.9 (39-140)	76.3 (35-122)	0.09	0.29	0.047
TKV, mL	3270 (2219-4630)	5494 (3617-9909)	3714 (2702-4756)	2758 (1901-3834)	0.0017	0.005	0.003
Time Tx-Nx, mo		–2.6 (–20 to 1.4)	19.9 (8-72)		—	—	—
Graft loss	132 (28.1%)	12 (34.2%)	14 (17.7%)	106 (29.9%)	—	—	0.57
Death-censored graft loss	54 (11.5%)	6 (17.1%)	7 (8.9%)	41 (11.6%)	—	—	0.41
Total death	96 (20%)	8 (23%)	9 (11.4%)	79 (22.2%)	—	—	0.97

TKV, reported in 92 recipients who had it measured within 1 year pretransplant; No Nx, recipients who did not have a nephrectomy; Nx pre-Tx, recipients who had a nephrectomy pretransplant; Nx post-Tx, recipients who had a nephrectomy post-transplant; p^1, comparing all 3 groups; p^2, comparison between Nx post-Tx and No Nx; p^3, comparison between Nx pre-Tx and No Nx.

*$P = 0.02$, †$P < 0.001$, ‡$P = 0.018$, for the comparison between Nx pre- and post-Tx.

Nx, nephrectomy; Tx, transplant; DM, diabetes mellitus; CAD, coronary artery disease; PVD, peripheral vascular disease; TKV, total kidney volume.

In the posttransplant nephrectomy group, 86% of the surgeries were performed by a hand-assisted laparoscopic procedure, but after 2003, only 2 cases were done by open procedure (one was conversion from laparoscopy during surgery). As shown in Table 2, the most common indications for pretransplant nephrectomy were recurrent symptomatic hematuria (28.6), lack of space (25.2%), and back pain (22.9%), significant enough to affect quality of life. It is important to note, however, that lack of space has not been an indication for nephrectomy since 2004. In the posttransplant nephrectomy group, the most common indications were back pain (39.2%), abdominal pain (22.8%), and recurrent symptomatic hematuria (21.5%).

TABLE 2.

Indications for nephrectomy[a]

Indications	Nx Pretransplant (n = 35)[b]	Nx Posttransplant (n = 79)[b]
Lack of space[c]	9 (25.2)	n/a
Back pain	8 (22.9)	31 (39.2)
Abdominal pain	7 (20)	18 (22.8)
Recurrent symptomatic hematuria	10 (28.6)	17 (21.5)
Recurrent cyst infection	4 (11.4)	12 (15.2)
Nonspecific pain	—	10 (12.7)
Kidney mass	—	8 (10.1)
Gastric fullness	4 (11.4)	5 (6.3)
Dyspnea	—	5 (6.3)

[a] Each recipient could have one or more indications such that the total percent exceeds 100% in each column. Any of the pain symptoms was considered an indication for nephrectomy if reported to be severe by the patient and affecting their quality of life.

[b] Information was missing on 2 of the 35 patients with pretransplant nephrectomy and 1 of the 79 with posttransplant nephrectomy.

[c] Lack of space has not been an indication for nephrectomy since 2004.

Complications After Nephrectomy

The complications after nephrectomy according to transplant timing (pretransplant or posttransplant) or surgical technique are reported in Tables 3A and 3B, respectively. Overall, the complication rate was lower in those who underwent nephrectomy posttransplant compared with those with nephrectomy pretransplant (26.6% vs 48%; $P = 0.03$); however, the rate was similar regardless of the surgical technique (open nephrectomy, 33.3% vs laparoscopic, 33%; $P = 0.66$). Patients with posttransplant nephrectomy had a shorter median length of stay in the hospital compared to those with pretransplant nephrectomy (4 vs 6 days; $P < 0.001$), likely reflecting the higher proportion of laparoscopic procedures in the posttransplant group. Similarly, fewer patients received blood transfusion in the posttransplant nephrectomy group compared with the pretransplant nephrectomy group (11.4% vs 42.4%; $P < 0.001$) and in those who underwent nephrectomy by laparoscopic technique (12.7% vs 39.4%; $P = 0.004$). The hemoglobin was lower in the pretransplant nephrectomy group after nephrectomy (7.9 vs 10.7; $P < 0.001$), and although it was lower at baseline, it dropped more after surgery (3.5 vs 2.7; $P = 0.006$). The median units of red cells transfused were 2 and similar in all groups. Among the 23 patients who required transfusions, only 6 had postoperative hemoglobin above 8 g/dL and among those, the hemoglobin dropped by at least 3.5 g/dL which may have prompted the transfusion. The proportion of patients who required admission to the intensive care unit and those who required perioperative vasopressors were similar in the pretransplant and posttransplant nephrectomy groups and in those who underwent an open or a laparoscopic procedure. We examined in more detail the complications in patients who underwent a posttransplant nephrectomy because of the concern that the NNx procedure could have an undesirable

TABLE 3A.

Nephrectomy type and perioperative complications according to transplant timing[a]

Outcome	Pretransplant Nephrectomy (n = 33)[b]	Posttransplant Nephrectomy (n = 79)	*P*
Laparoscopic nephrectomy, %	11 (33.3%)	68 (86.1%)	<0.001
Median length of stay (range), d	6 (3-14)	4 (1-14)	<0.001
Patients receiving PRBC	14 (42.4%)	9 (11.4%)	<0.001
PRBC transfused, median units (range)	2 (2-11)	2 (1-5)	0.31
Hemoglobin before nephrectomy	11.5 ± 1.7	13.4 ± 1.8	<0.001
Hemoglobin after nephrectomy	7.9 ± 1.5	10.7 ± 1.8	<0.001
Hemoglobin change	3.5 ± 1.7	2.7 ± 1.2	0.006
ICU admission	5 (15.2%)	5 (6.3%)	0.16
Vasopressors	2 (6.1%)	2 (2.5%)	0.58
Complications rate[c]	16 (48%)	21 (26.6%)	0.03

[a] Each patient could have 1 or more complications.

[b] Information on 2 of the 35 patients with pretransplant nephrectomy were missing.

[c] Complications include: ileus (n = 10), arrhythmia (3), wound infection (3), acute kidney allograft injury (2), apnea/atelectasis (2), acute gout (2), surgical reintervention (2), arteriovenous fistula thrombosis (1), adrenal hemorrhage (1), pneumothorax (1), clostridium difficile colitis (1), acute respiratory distress syndrome (1), disseminated intravascular coagulation (1), non-ST elevation myocardial infarction (1), and hyperkalemia (1).

PRBC, packed red blood cell; ICU, intensive care unit.

consequence on the kidney allograft. The single most common complication was ileus (n = 8, 10.1%). Overall, 2 patients (2.5%) had an acute allograft injury, the first in the setting of aspiration complicated by an acute respiratory distress syndrome and the second after adrenal hemorrhage. In both cases, the allograft function recovered with serum creatinine returning to baseline.

Patient and Graft Survivals

During a median patient follow-up time of 79.7 months (IQR, 38-128), 96 (20%) recipients with ADPKD died, 132 (28.1%) grafts were lost and among those 54 (11.5%) were death-censored losses (Table 1). The causes of death were known in 42 (44%) patients and include: malignancy (31%), cardiovascular (21.4%), infectious (16.7%), kidney graft failure (9.5%), motor vehicle accident (4.7%), and other causes (16.7%).

Pretransplant Nephrectomy Versus No-Pretransplant Nephrectomy

Patient and graft survivals between those with pretransplant nephrectomy (n = 35) and the remaining ADPKD recipients (n = 435) were similar. At 1, 5, and 10 years, patient survival was 97.1%, 94%, and 86%, respectively for the pretransplant nephrectomy group and 98.8%, 94.1%, and 80% for those without pretransplant nephrectomy ($P = 0.47$, log-rank). Similarly, death-censored graft survival was 93.9%, 90.7%, and 86.8% for the pretransplant nephrectomy group and 97.4%, 94.7%, and 86.9% for those without pretransplant nephrectomy (Figure 1). Of note, 6 patients not included in the study underwent nephrectomy and were candidate for transplant. Three of them remain on the waiting list at the end of the follow-up, one was transplanted at another center, and 2 died. One of the patients who died was scheduled to undergo transplant from a living donor but developed a septic shock with multiorgan failure after the nephrectomy.

TABLE 3B.

Timing of nephrectomy and perioperative complications according to surgical technique[a]

Outcome	Open Nephrectomy[b] (n = 33)	Laparoscopic Nephrectomy (n = 79)	*P*
Posttransplant nephrectomy (%)	11 (33.3%)	68 (86.1%)	<0.001
Median length of stay (range), d	6.5 (3-14)	4 (1-14)	<0.001
Patients receiving PRBC	13 (39.4%)	10 (12.7%)	0.004
PRBC transfused, median units (range)	2 (2-11)	2 (1-4)	0.54
Hemoglobin before nephrectomy	12 ± 2.1	13.2 ± 1.8	0.004
Hemoglobin after nephrectomy	8.7 ± 1.9	10.5 ± 2	<0.001
Hemoglobin change	3.3 ± 1.3	2.8 ± 1.5	0.11
ICU admission	5 (15.2%)	5 (6.3%)	0.16
Vasopressors	1 (3%)	3 (3.8%)	1
Complications rate[c]	11 (33.3%)	26 (33%)	0.66

[a] Each patient could have 1 or more complications.

[b] Information on 2 of the 35 patients with open nephrectomy were missing.

[c] Complications include: ileus (n = 10), arrhythmia (3), wound infection (3), acute kidney allograft injury (2), apnea/atelectasis (2), acute gout (2), surgical reintervention (2), arteriovenous fistula thrombosis (1), adrenal hemorrhage (1), pneumothorax (1), clostridium difficile colitis (1), acute respiratory distress syndrome (1), disseminated intravascular coagulation (1), non-ST elevation myocardial infarction (1) and hyperkalemia (1).

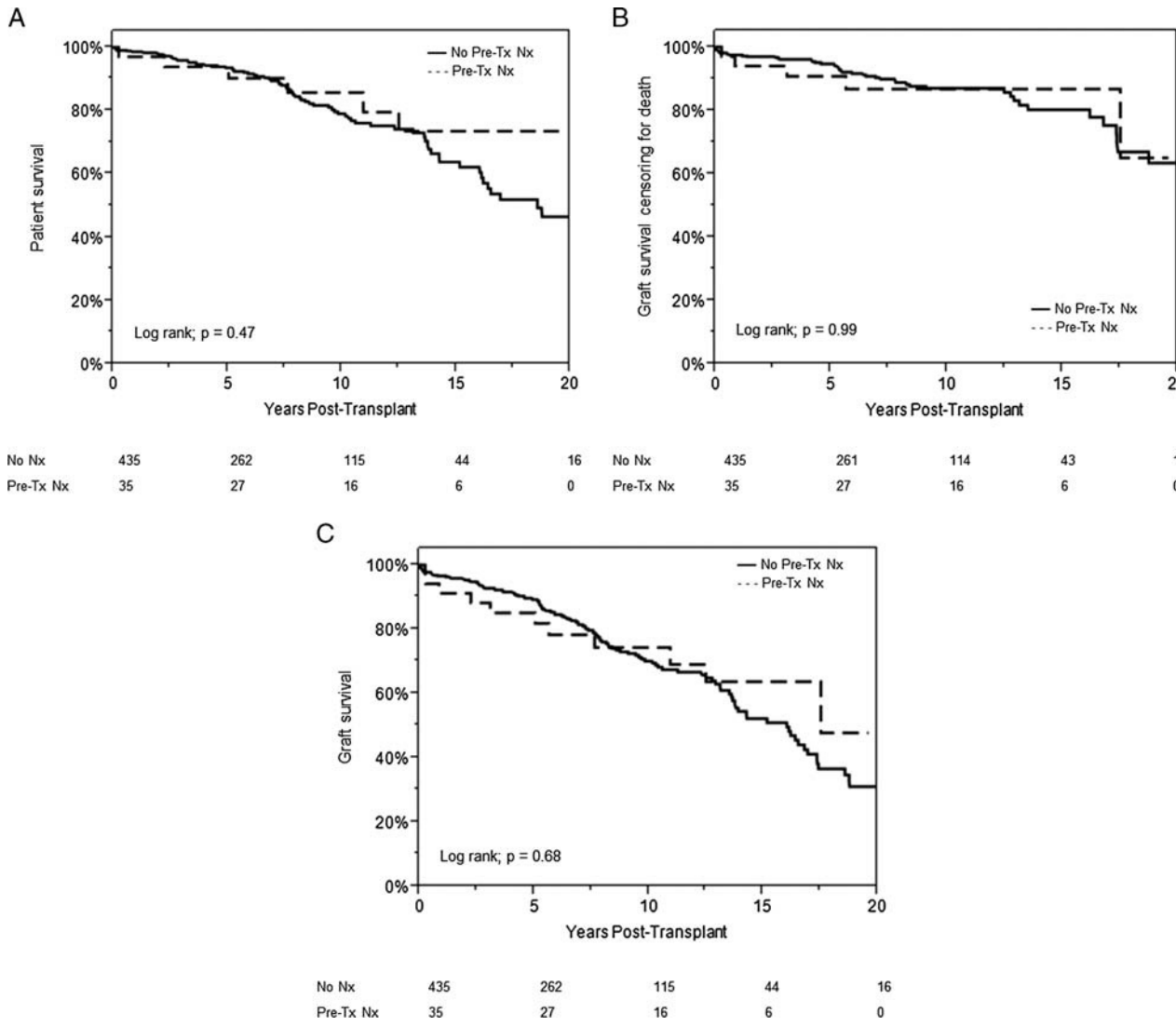

FIGURE 1. Patient and graft survival in those with or without pretransplant nephrectomy. A, patient survival; B, graft survival censoring for death; C, overall graft survival.

Posttransplant Nephrectomy Versus No Nephrectomy

In this analysis, we excluded recipients with pretransplant nephrectomy and compared recipients without nephrectomy to those with posttransplant nephrectomy. On univariate analysis, age, deceased donor, dialysis pretransplant, and PVD were associated with patient and graft survivals, whereas sex, diabetes status, nephrectomy, and transplant year were not (Table 4). Nephrectomy was not associated with patient survival (hazards ratio [HR], 0.77; 95% confidence interval [95% CI], 0.38-1.54; $P = 0.45$), death-censored graft survival (HR, 1.5; 95% CI, 0.66-3.41; $P = 0.34$), or overall graft survival (HR, 1.0; 95% CI, 0.57-1.76; $P = 0.1$) on univariate analysis and after multivariate adjustment (Table 4). Interestingly, compared with recipients without nephrectomy, those who underwent open nephrectomy had a higher risk of death-censored graft loss (HR, 3.93; 95% CI, 1.29-11.9; $P = 0.016$) but this was not the case for those who underwent laparoscopic nephrectomy (HR, 0.9; 95% CI, 0.27-2.97; $P = 0.86$) (Table 4B). Upon detailed review of the causes of death-censored graft loss in those with posttransplant nephrectomy, we did not find a direct effect of the nephrectomy procedure on graft loss. The graft losses occurred between 2.1 and 13.4 years after nephrectomy from the following causes: interstitial fibrosis/tubular atrophy from poor quality deceased donor graft; severe interstitial fibrosis/tubular atrophy from recurrent cellular rejections; immune complex glomerulonephritis; severe arterial hyalinosis and transplant glomerulopathy; secondary focal segmental glomerulosclerosis associated with severe vascular disease and acute humoral rejection). We did not find an association between nephrectomy done early (<1 year after transplant, n = 29) or late (≥1 year after transplant, n = 50) and graft loss.

DISCUSSION

In this study, almost a quarter (24.3%) of ADPKD patients underwent nephrectomy either pretransplant or posttransplant. Patient and graft survivals were similar between those with or without pretransplant nephrectomy. Similarly, nephrectomy posttransplant was not associated with different patient and graft outcomes even after multivariate adjustment.

TABLE 4.

Association between various variables and patient (A), death-censored graft (B) and overall graft (C) survival

	Univariate Analysis			Multivariate Analysis		
	HR	95% CI	P	HR	95% CI	P
(A) Patient Survival						
Age at Tx (per year)	1.07	1.04-1.10	<0.001	1.08	1.05-1.11	<0.001
Gender (male)	1.30	0.85-1.99	0.23			
Deceased donor	2.40	1.53-3.75	<0.001	1.68	1.04-2.72	0.034
Dialysis	1.57	1.03-2.41	0.038			
Diabetes	1.81	0.73-4.49	0.2			
Stroke	1.72	0.63-4.72	0.29			
CAD	1.51	0.75-3.05	0.25			
PVD	5.66	2.26-14.1	<0.001	4.15	1.65-10.4	0.003
CVD	2.02	1.16-3.52	0.013			
Transplant year	0.97	0.94-1.00	0.09			
Nephrectomy	0.77	0.38-1.54	0.45			
Nephrectomy year	1.01	0.92-1.11	0.84			
Open nephrectomy	1.35	0.54-3.39	0.52	1.29	0.46-3.60	0.63
Lap nephrectomy	0.50	0.18-1.37	0.18	0.74	0.26-2.06	0.56
Early nephrectomy	1.02	0.37-2.82	0.96			
Late nephrectomy	0.63	0.25-1.59	0.33			
(B) Graft Loss Censoring for Death						
Age at Tx (per year)	0.98	0.96-1.01	0.15	0.98	0.95-0.99	0.046
Sex (male)	0.86	0.49-1.51	0.6	0.74	0.41-1.33	0.32
Deceased donor	1.59	0.89-2.84	0.11	1.48	0.78-2.81	0.23
Dialysis	1.59	0.90-2.81	0.11	1.42	0.76-2.65	0.27
Diabetes	1.58	0.49-5.12	0.44			
CVD	0.68	0.24-1.9	0.46			
Transplant year	1.01	0.96-1.05	0.85			
Nephrectomy	1.50	0.66-3.41	0.34			
Nephrectomy year	0.91	0.82-0.99	0.049			
Open nephrectomy	3.75	1.29-10.9	0.015	3.93	1.29-11.9	0.016
Lap nephrectomy	0.84	0.26-2.74	0.77	0.90	0.27-2.97	0.86
Early nephrectomy	1.63	0.49-5.39	0.42			
Late nephrectomy	1.41	0.48-4.09	0.53			
(C) Graft Loss Including Loss Due to Death						
Age at Tx (per year)	1.03	1.01-1.05	0.0049	1.03	1-1.05	0.022
Sex (male)	1.19	0.83-1.71	0.36	1.1	0.74-1.63	0.64
Deceased donor	2.0	1.38-2.9	<0.001	1.69	1.14-2.51	0.009
Dialysis	1.52	1.06-2.18	0.02			
Diabetes	1.94	0.94-3.99	0.07			
PVD	3.45	1.4-8.5	0.007	2.87	1.14-7.23	0.026
CVD	1.44	0.86-2.39	0.16			
Transplant year	0.99	0.96-1.01	0.32			
Nephrectomy	1.0	0.57-1.76	0.99			
Nephrectomy year	0.97	0.90-1.05	0.49			
Open nephrectomy	1.97	0.90-4.3	0.089	1.6	0.68-3.78	0.28
Lap nephrectomy	0.67	0.31-1.45	0.31	0.87	0.40-1.89	0.72
Early nephrectomy	1.20	0.52-2.75	0.68			
Late nephrectomy	0.89	0.42-1.86	0.75			

Tx, transplant; CAD, coronary artery disease; PVD, peripheral vascular disease; CVD, cardio-vascular disease (includes any of CAD, PVD or stroke). Early and late nephrectomy, refer to nephrectomy performed less or more than 1 year after transplant, respectively, regardless of the transplant date.

The overall postoperative complication rate was lower in the posttransplant nephrectomy group compared with the pretransplant nephrectomy group (26.6% vs 48%, $P = 0.03$). The need for blood transfusion was also less significant in the posttransplant nephrectomy group compared with the pretransplant nephrectomy group (11.4% vs 42.4%, $P < 0.001$). Before surgery, baseline hemoglobin was lower in the pretransplant nephrectomy group (11.5 vs 13.4), which could explain the difference in transfusion requirements but the hemoglobin drop after surgery was on average more significant in the pretransplant nephrectomy group (3.5 vs 2.7, $P = 0.006$). It is possible that the hemostasis disorder state (platelets dysfunction) in chronic kidney disease contribute to this difference in patients who had pretransplant nephrectomy. However, interpretation of these results should be done with caution. A direct comparison between the timing of nephrectomy in relationship to transplant in this study is difficult and limited by potential biases because the majority of posttransplant nephrectomies were done in the more recent era and with different surgical technique compared with the pretransplant nephrectomies.

Many perioperative comorbidities occurred in the post-nephrectomy group in our study. Approximately, 26% of the patients had at least 1 complication (some of which are significant, such as severe adrenal hemorrhage, disseminated intravascular coagulation and acute respiratory distress syndrome), which is consistent with prior studies.[8,9] In one study, complications were much more common (>60%) and similar after pretransplant and posttransplant nephrectomies. However, details regarding the severity of these complications were not reported in that series.[10] Nonetheless, despite these potential complications, nephrectomy posttransplant is feasible and does not affect long-term patient and graft survival.

Pretransplant nephrectomy is advocated by some because of improved kidney graft survival and lower risk of infection and hematuria compared with patients who retain the native kidneys but others reported more complications with this approach.[8,11,12] Based on the recently published Kidney Disease Improving Global Outcomes controversies conference, the current consensus is that routine pretransplant NNx for ADPKD is not indicated.[13] Our study supports this recommendation because we did not observe a difference in patient or graft survival between recipients who underwent pretransplant nephrectomy and those who did not. At some transplant centers, nephrectomy is done before or at the time of transplant routinely to provide space for the kidney allograft. At our center, this has been a rare indication for nephrectomy (none were performed since 2004 for this indication), likely reflecting a different threshold used by the surgeons in regard to the native kidneys size acceptable to proceed with transplantation. It could also reflect that in our practice, native kidneys have not become massive in size because a significant proportion of recipients undergo preemptive transplant (57%). Indeed, median TKV was significantly lower in those who underwent preemptive transplant (3211 vs 4197, $P = 0.045$). Based on recent evidence showing that the volume of native kidneys decrease after transplantation, especially during the first year, resection might be unnecessary in the absence of concern for malignancy, recurrent infection, or bleeding if a space for the kidney graft can be secured.[14,15] Another potential problem with pretransplant nephrectomy is the risk of sensitization if blood transfusion is needed, and in this study, 42.4% of patients with pretransplant nephrectomy required transfusion. Sensitization can delay or even compromise the possibility of kidney

transplant. However, we did not evaluate the degree of sensitization in patients with or without nephrectomy pretransplant to determine whether this affected the waiting time on the transplant list.

There was no difference in the complication rate between the open and laparoscopic nephrectomy groups (33.3% vs 33%, respectively) but the need for blood transfusion was more significant with open nephrectomy (39.4% vs 12.7%, $P = 0.004$), and the median duration of hospitalization was 2 days shorter for those who underwent a laparoscopic procedure. This is consistent with previous studies reporting similar complication rate between the 2 techniques although in the study by Verhoest et al,[16,17] severe complications were more significant after open nephrectomy (37% vs 9.5%, $P = 0.04$). These results suggest that laparoscopic nephrectomy can be done regardless of native kidney size, is at least as safe as open nephrectomy, and require a shorter hospitalization. Because posttransplant nephrectomy is associated with fewer complications compared with pretransplant nephrectomy and most were done laparoscopically but complication rate was similar regardless of the surgical technique, it is possible that this reflect a learning curve of the new technique. The rate of complications was indeed numerically higher in the first 3 years after introduction of the laparoscopic technique in our center compared with those done after 2010; however, the difference was not statistically significant.

Our study does not include recipients with concomitant nephrectomy at the time of transplant. This strategy has been reported by several groups as safe and not affecting patient and graft survivals although the published studies are small, and nephrectomy was associated with significant perioperative morbidities in some of them.[5,7,16,18,19] The larger series to date include 100 consecutive kidney transplants with simultaneous unilateral nephrectomy.[20] In that study, unilateral nephrectomy was performed regardless of whether it is indicated or not. The surgical complication rate requiring reoperation was 19% although only 12% were possibly associated with the simultaneous nephrectomy. Because over half of patients do not require posttransplant nephrectomy, any complication after a simultaneous nephrectomy done routinely could be considered excessive if nephrectomy is not indicated. Another limitation of the current study is that it included nephrectomies performed over a long period and the timing in relation to transplant varied significantly. In addition, there was no specific written protocol in regard to the indications and patients eligible for surgery but rather the decision to proceed with nephrectomy was a joint decision between the nephrologist and transplant surgeon based on clinical judgement.

CONCLUSIONS

Native nephrectomy in ADPKD transplant recipients was performed pretransplant and posttransplant in 7.4% and 16.8%, respectively. Overall, the complications rate after nephrectomy was similar with open or laparoscopic procedure, but duration of hospitalization was shorter after laparoscopic nephrectomy. Nephrectomy does not adversely affect patient or graft survival, and posttransplant laparoscopic nephrectomy is feasible when indicated without compromising long-term graft outcome and has fewer complications and transfusion requirements than pretransplant nephrectomy.

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