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Pediatric Recipients of Adult Laparoscopic Donor Nephrectomy: A Single-Institution Outcome Analysis

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ABSTRACT

Introduction: For more than a decade, adult laparoscopic donor nephrectomy (LDN) has been offered as a minimally invasive organ procurement modality for pediatric patients with end-stage renal disease. There is a paucity of literature reflecting pediatric recipient outcomes of adult LDN kidneys, and the objective of this study was to evaluate our institutional experience.

Methods: Thirty-six pediatric patients were identified as recipients of adult LDN from 2000 to 2009 at our institution.

Results: The most common renal disease was dysplasia (N = 6) for those 0 to 5 years of age and nephronophthisis (N = 7) for those 6 to 18 years if age. The mean operative time for those 0 to 5 years of age was 262 ± 38 min and 216 ± 69 min for those 6 to 18 years ($P < 0.04$). Perioperative complications were more common in those 0 to 5 years of age (73 vs 24%, $P < 0.01$) and the length of stay (19.3 ± 20.8 days vs 4.8 ± 2.7 days, $P < 0.001$) was longer compared with those 6 to 18 years.

Conclusion: Pediatric recipients of adult LDN kidneys present unique surgical and hemodynamic challenges. Although renal transplants in pediatric patients are associated with postoperative morbidity, graft survival is comparable to adult LDN recipients.

INTRODUCTION

More than 85 000 people remain on the Organ Procurement and Transplantation Network's (OPTN) list awaiting a kidney donor, including nearly 1 000 patients less than 17 years of age [1]. Following the first laparoscopic donor nephrectomy in 1995 [2], the United Network for Organ Sharing (UNOS) has reported an increase in living kidney donors, culminating in 2001 with the number of living donors exceeding the number of cadaveric kidneys used for transplantation [3]. The pediatric population (≦ 18 years of age) represents a unique subset of patients awaiting a kidney donor. Within the first few years of life, pediatric patients with nephronophthisis, congenital dysplasia, and obstructive and reflux nephropathy suffering from end-stage renal disease (ESRD) often require kidney transplantation or hemodialysis.

A number of studies have suggested that pediatric recipients of laparoscopically procured kidneys achieve favorable post-transplant outcomes similar to adult recipients [4-10]. However, more recently, Troppmann et al. [11] reported a large study by UNOS in which higher rates of delayed graft function (DGF) and acute rejection (AR) were reported for pediatric recipients of laparoscopically procured kidneys compared to open controls. These authors postulated that challenging intraoperative factors, hemodynamic changes at the time of graft reperfusion, and increased immune reactivity in the pediatric patient accounted for adverse outcomes [11].

Given the paucity of published data on outcomes of pediatric recipients of adult LDN-procured kidneys, we sought to review our own experience. Thirty-six patients ≦ 18 years of age who received kidneys via LDN formed the study cohort and were

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analyzed for demographic and perioperative parameters, and they were compared to previously published results.

METHODS

Between 2000 and 2009 nearly 1 000 patients underwent LDN at the Saint Barnabas Medical Center, Livingston, New Jersey. Among these patients, 36 patients (males 44% [N = 16), and females 56% [N = 20]) were identified as kidney donors for pediatric recipients (≦ 18 years of age). Our technique for LDN kidney procurement has been previously described [12].

Briefly, the recipient surgical procedure for infants and small children was as follows: The patient was positioned supine and a standard midline incision was made. The right colon and small bowel were mobilized by the Cattell-Braasch maneuver and were reflected superiorly and medially to expose the aorta and vena cava, which were subsequently and partially occluded with vascular clamps. Appropriate retraction of the bowel was obtained to allow space for the transplant kidney to be positioned in the right side of the abdomen. The donor kidney was benched with cold Ringer's lactate and an albumin solution, and it was irrigated until the returning solution was clear. Subsequently, the renal vessels were mobilized, all side branches were ligated, the ureter was preserved, and all remaining perinephric fat was removed. The renal artery and vein were anastomosed with 6-0 PROLENE™ sutures to the aorta or iliac artery and vena cava, respectively. Vascular control was removed, flow was restored to the kidney, and hemostasis was obtained. Each recipient transplant procedure involved a transplant urologist who performed the ureteroneocystostomy and closure of the abdomen. For children > 5 years of age and adolescents, a standard right lower quadrant renal transplant incision was made to allow dissection of the retroperitoneum and mobilization of the common iliac artery and vein or external iliac artery and vein for subsequent vascular anastomosis.

Pediatric recipient patients of LDN-procured kidneys were retrospectively analyzed, and data was entered into a Microsoft Excel database. The data was arranged into 2 patient cohorts that included those 0 to 5 years of age and 6 to 18 years of age. The demographic parameters analyzed included: mean age, gender, body mass index (BMI), relationship of the donor to recipient, primary renal disease, and dialysis status at the time of transplantation. Perioperative parameters reviewed included: mean preoperative creatinine, comorbidities, single or multiple renal arteries for the donor kidney, the site of renal artery anastomosis, mean operative time, mean EBL, mean cold ischemic time (CIT), mean postoperative creatinine, postoperative complications, mean length of stay (LOS), and graft loss. Complications were graded using the Clavien Classification of Surgical Complications [13].

Statistical analysis for donor and recipient data included the Fisher's exact test for nonparametric data between 2 groups and a 2-tailed Student *t* test for comparison of parametric data between 2 groups. Statistical significance was defined as $P < 0.05$.

RESULTS

Demographic Data for 36 Pediatric Recipient Patients (Table 1)

Eleven patients in the 0 to 5 years of age cohort (mean age: 2.3 ± 2.0 years, 6 males and 5 females) and 25 patients in the 6 to 18 years of age cohort (mean age: 14.2 ± 3.9 years, 15 males and 10 females) were the recipients of adult-procured LDN kidneys. The mean BMI for the 0 to 5 years of age patients was 17.9 ± 2.1 while it was 21.8 ± 6.7 for those 6 to 18 years of age ($P = 0.07$). All donors for the 0 to 5 years of age cohort were related to the recipients. Similarly, 22 of 25 patients in the 6 to 18 years of age cohort were related to the recipients ($P = 0.54$). ESRD in the 0 to 5 years of age cohort resulted from: dysplasia in 6 patients (55%), obstructive nephropathy in 2 patients (18%), and single cases of focal segmental glomerular sclerosis (FSGS), Denys-Drash syndrome leading to infantile nephrotic syndrome, and hemolytic uremic syndrome due to streptococcal meningitis. ESRD in the 6 to 18 years of age cohort was due to nephronophthisis in 7 patients (28%); FSGS in 5 patients (20%); 3 patients with other congenital diseases (congenital nephritis, congenital nephrosis, and Alport syndrome) (12%); 3 patients with other diseases (systemic lupus erythematosus, neurogenic bladder, and steroid-resistant nephrotic syndrome) (12%); 2 patients with obstructive uropathy (8%); 2 patients with reflux nephropathy (8%); and one patient (4%) each with dysplasia, glomerulonephritis, and membranous nephropathy. Dysplasia was the only etiologic factor significantly different between the 2 groups ($P < 0.001$). Among patients 0 to 5 years of age, 8 patients were on peritoneal dialysis (73%) and 3 patients were not on dialysis (27%). In the 6 to 18 years of age cohort, 9 patients were on peritoneal dialysis (36%), 9 patients were not on dialysis (36%), and 7 patients were on hemodialysis (28%).

Perioperative Outcomes for 36 Pediatric Patients (Table 2)

Eight patients (73%) in the 0 to 5 years of age cohort and 15 patients (60%) in the 6 to 18 years of age cohort had comorbidities in addition to their ESRD ($P = 0.71$). Mean preoperative creatinine for those 0 to 5 years of age was 5.14 ± 1.71 mg/dL, while it was 7.07 ± 3.40 mg/dL for those 6 to 18 years of age ($P = 0.08$). Renal artery anastomosis sites for those 0 to 5 years of age included 10 patients (91%) with anastomosis to the aorta and 1 patient (9%) with anastomosis to the common iliac artery. Renal artery anastomosis sites for those 6 to 18 years of age included 18 patients (72%) with anastomosis to the common iliac artery, 5 patients (20%) with anastomosis to the external iliac artery, and 2 patients (8%) with anastomosis to the aorta. A statistical significance between the 2 groups was

Table 1. Demographic data for 36 pediatric patients (11 patients, 0 to 5 years of age; 25 patients 6 to 18 years of age) receiving a laparoscopic donor nephrectomy (LDN) procured adult kidney transplantation.

	0 to 5 Years of Age	6 to 18 Years of Age	*P* Value
patients, N = (%)	11 (31)	25 (69)	
age, years (mean ± SD)	2.3 ± 2	14.2 ± 3.9	
male/female	6/5	15/10	1
BMI, kg/m^2 (mean ± SD)	17.9 ± 2.1	21.8 ± 6.7	0.07
donor related/unrelated	11/0	22/3	0.54
underlying renal disease			
nephronophthisis, N = (%)	0	7 (28)	0.08
dysplasia, N = (%)	6 (55)	1 (4)	*0.001
FSGS, N = (%)	1 (9)	5 (20)	0.64
obstructive uropathy , N = (%)	2 (18)	2 (8)	0.57
reflux nephropathy, N = (%)	0	2 (8)	1
glomerulonephritis, N = (%)	0	1 (4)	1
membranous nephropathy, N = (%)	0	1 (4)	1
other congenital, N = (%)	1 (9)	3 (12)	1
other, N = (%)	1 (9)	3 (12)	1
dialysis status			
peritoneal, N = (%)	8 (73)	9 (36)	0.07
hemodialysis, N = (%)	0	7 (28)	0.08
no dialysis, N = (%)	3 (27)	9 (36)	0.71

Abbreviations: M/F = male/female; BMI = body mass index; FSGS = focal segmental glomerular sclerosis
*statistically significant to $P < 5$

noted for renal artery anastomosis to the aorta (P < 0.0001) and common iliac artery ($P < 0.0008$). Mean operative times, EBL, and CIT for those 0 to 5 years of age and 6 to 18 years of age was 262 ± 38 minutes vs 216 ± 69 minutes ($P < 0.04$), 42 ± 39 mL vs 118 ± 241 mL ($P = 0.31$), and 49 ± 10 minutes vs 45 ± 13 minutes ($P = 0.37$), respectively. Mean postoperative creatinine and LOS for those 0 to 5 years of age and 6 to 18 years of age was 0.98 ± 0.74 mg/dL vs 2.91 ± 2.48 ($P < 0.02$) and 19.3 ± 20.8 days vs 4.8 ± 2.7 days ($P < 0.001$), respectively. There were 8 (73%) perioperative complications among those 0 to 5 years of age (2 Clavien grade III [25%], 6 Clavien grade IV [75%]) and 6 complications (24%) among those 6 to 18 years of age (4 Clavien grade II [67%], 1 Clavien grade III [17%], 1 Clavien grade IV [17%]) ($P < 0.01$).

DISCUSSION

The advent of laparoscopic donor nephrectomy in the mid-1990s [2] and its popularization in the early part of the 21st century has propelled kidney transplantation into a new era and increased the pool of live organs. Although LDN is accepted as the new gold standard for kidney procurement for adult patients with ESRD, Nogueira et al. [14] recently suggested that laparoscopic procurement of kidneys confers poor early graft function. The authors reported that in 946 consecutive LDN donors/recipients at their institution there was a 16.3% incidence of poor early graft function, defined as patients receiving hemodialysis on postoperative day 1 through 7 or serum creatinine ≥ 3.0 mg/dL at postoperative day 5. Data pertaining to pediatric recipients of LDN is less prevalent. In the past 40 years, live donor kidney transplantation has become the treatment of choice for children suffering from ESRD [15]. However, pediatric patients present a unique set of perioperative challenges for laparoscopically procured kidneys that is not encountered with adult patients. Due to an overall lower systemic blood volume, infants and small children face significant hemodynamic effects when the adult donor kidney is initially perfused [11]. These patients may also have increased immune reactivity [15,16] leading to increased acute and chronic rejection, particularly if there is a procurement injury to the donor kidney.

Table 2. Perioperative outcome data for 36 pediatric patients (11 patients, 0 to 5 years of age; 25 patients 6 to 18 years of age) receiving a laparoscopic donor nephrectomy (LDN) procured adult kidney transplantation.

	0 to 5 Years of Age	6 to 18 Years of Age	*P* Value
patients, N = (%)	11 (31)	25 (69)	
preoperative cr, mg/dL (mean ± SD)	5.14 ± 1.71	7.07 ± 3.40	0.08
comorbidities, N = (%)	8 (73)	15 (60)	0.71
renal artery anastomosis site			
aorta, N = (%)	10 (91)	2 (8)	*0.0001
common iliac artery, N = (%)	1 (9)	18 (72)	*0.0008
external iliac artery, N = (%)	0	5 (20)	0.30
operative time, min (mean ± SD)	262 ± 38	216 ± 69	*0.04
EBL, mL (mean ± SD)	42 ± 39	118 ± 241	0.31
CIT, min (mean ± SD)	49 ± 10	45 ± 13	0.37
postoperative cr, mg/dL (mean ± SD)	0.98 ± 0.74	2.91 ± 2.48	*0.02
perioperative complication, N = (%)	8 (73)	6 (24)	*0.01
LOS, days (mean ± SD)	19.3 ± 20.8	4.8 ± 2.7	*0.001

Abbreviations: cr = creatinine; EBL = estimated blood loss; CIT = cold ischemic time; LOS = length of stay
*statistically significant to $P < 5$

A number of pediatric-specific perioperative initiatives have been instituted in an attempt to decrease morbidity in the pediatric LDN recipient. Aggressive intravenous hydration the day before surgery and intraoperatively has been suggested as a means to alleviate hemodynamic changes when the adult kidney is anastomosed to the native vessel [10]. Vigilant maintenance of systolic blood pressure over 120 mmHg and central venous pressure of 12 to 14 cm H2O are important to maintain overall hemodynamic stability during surgery [10]. Traditionally, pneumoperitoneum pressure for laparoscopic procedures is set at 15 mmHg in order to maintain renal blood flow and urine output; however, many nephrologists believe that a lower pneumoperitoneum pressure of 10 mmHg results in less adverse effects on renal physiology [17]. Singer et al. [10] have also published that maintaining a pneumoperitoneum of only 10 mmHg during LDN for pediatric transplantation allows additional renal-protective measures.

Two previous studies have reported results for pediatric recipients using 0- to 5-year-old and 6- to 18-year-old cohorts [10,11]. Troppmann et al. [11] analyzed recipients of 995 pediatric live donor transplants from the UNOS database between January 2000 and June 2002, which included 212 patients in the 0 to 5 age group (94 LDN recipients) and 783 patients in the 6 to 18 age group (389 LDN recipients). For both patient cohorts, DGF rates were higher for LDN patients compared to open patients; in addition, there were higher rates of acute rejection in LDN patients at 6 months in both 0- to 5- and 6- to 18-year-old cohorts and at 1 year in the 0 to 5 years of age cohort [11]. Singer et al. [10] retrospectively analyzed 34 LDN and 26 open donor nephrectomy (ODN) patients between 2000 and 2004. In the 34 LDN patients group, there were 9 patients less than 5 years of age and 25 patients older than 5 years of age. The postoperative creatinine level was the only factor significantly different between the 2 groups (0.5 ± 0.2 vs 1.1 ± 0.3) [10].

The current study represents the largest single-institution study analyzing the outcomes of pediatric recipients of adult LDN procured kidneys. The current study cohort is comparable to that of Troppmann et al. [11] in regards to the ratio of patients on pre-transplant dialysis to those not on dialysis (8/3 vs 71/23) and a mean LOS (19.3 ± 20.8 vs 16.6 ± 28.6 days). Similar to the Troppmann et al. [11] and Singer et al. studies [10], the current study reports that the majority of donors were relatives of the recipient (11/0 vs 89/5 vs 9/0), with the current study having a slightly higher percentage of patients surviving

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allograft rejection (18% vs 11% vs 0%). Data for the 6 to 18 years of age cohort (Table 3) confirms a similar incidence of pre-dialysis/no dialysis to that of Troppmann et al. [11] but notes an asymmetrically decreased mean LOS (4.8 ± 2.7 vs 8.5 ± 7.3). All 3 studies have reported comparable graft loss for this age group (7 to 12%) [10,11].

The current literature for pediatric recipients of adult LDN kidneys (Table 4) demonstrates a predominance of male patients requiring kidney transplant (N = 477, 59%), with a considerable number of patients receiving dialysis prior to transplantation (N = 377, 63%). The increased vessel length provided by the procurement of a left-sided kidney has resulted in almost universal left-sided procurement at most centers (N = 142, 95%). Pediatric renal transplant continues to be a prolonged operation with all studies reporting operative times approaching 4 hours. Furthermore, the length of stay is prolonged (range: 6 to 10 days) and postoperative complications are not infrequent (range: 8 to 67%).

CONCLUSION

Renal transplantation continues to offer pediatric patients with ESRD an opportunity for improved growth, a better quality of life, and longer survival [18]. Although the operation may have significant complications and prolonged hospitalization, transplantation remains the gold-standard treatment for these patients. Adult LDN is now routinely performed at all major transplant centers in the United States and may be safely utilized as a source of organs for pediatric recipients suffering from ESRD.

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Table 3. Published studies comparing demographic and perioperative outcomes for patients ≤ 5 years of age and > 5 years of age receiving a laparoscopic donor nephrectomy (LDN) procured adult kidney transplantation.

	≤ 5 Years of Age			> 5 Years of Age		
	current study	Troppmann et al. [11]	Singer et al. [10]	current study	Troppmann et al. [11]	Singer et al. [10]
patients, N = (%)	11	94	9	25	389	25
male/female	6/5	67/27	6/3	15/10	226/163	11/14
age, years (mean ± SD)	2.3 ± 2	2.4 ± 1.4	3 ± 1.1	14.2 ± 3.9	13.5 ± 3.5	15 ± 3.7
pre-dialysis/no dialysis	8/3	71/23	NR	16/9	233/156	NR
L/R nephrectomy	10/1	NR	9/0	22/3	NR	25/0
single/multiple RA	11/0	NR	NR	22/3	NR	NR
donor related/unrelated	11/0	89/5	9/0	22/3	346/43	25/0
operative time, min (mean ± SD)	262 ± 38	NR	NR	216 ± 69	NR	NR
complications, N = (%)	8 (73)	NR	NR	6 (24)	NR	NR
LOS, days (mean ± SD)	19.3 ± 20.8	16.6 ± 28.6	NR	4.8 ± 2.7	8.5 ± 7.3	NR
graft loss, N = (%)	2 (18)	10 (11)	0	2 (8)	28 (7)	3 (12)

Abbreviations: M/F = male/female; L/R = left/right; RA = renal artery(ies); LOS = length of stay; NR = not reported

Table 4. All published studies of pediatric patients receiving a laparoscopic donor nephrectomy (LDN) procured adult kidney transplantation.

	Current Study	Troppmann et al. [11]	Mamode et al. [20]	Chandak et al. [21]	Singer et al. [10]	Basiri et al. [19]	Abrahams et al. [9]	Mishra et al. [4]	Kayler et al. [7]	Troppmann et al. [6]	Bergman et al. [5]	Hsu et al. [8]
Patients, N =	36	483	119	46	34	20	20	15	13	11	10	7
male/female	21/15	293/190	75/44	25/21	17/17	9/11	12/8	4/11	7/6	7/4	5/5	2/5
mean age, years	10.5	11.3	10.7	9	12	12.1	12.8	14.8	9.8	11.9	10.5	9.5
pre-dialysis/no dialysis	24/12	304/179	NR	27/19	NR	NR	NR	10/5	5/8	7/4	9/1	NR
underlying renal disease												
nephronophthisis, N =	7	NR	NR	0	0	NR	NR	NR	NR	0	0	0
obstructive uropathy, N =	4	NR	NR	0	5	NR	NR	NR	NR	0	0	2
dysplasia, N =	7	NR	NR	0	7	NR	NR	NR	NR	3	1	1
FSGS, N =	6	NR	NR	2	0	NR	NR	NR	NR	3	1	1
reflux nephropathy, N =	2	NR	NR	0	1	NR	NR	NR	NR	2	0	0
glomerulonephritis, N =	1	NR	NR	0	8	NR	NR	NR	NR	0	0	0
other causes, N =	8	NR	NR	44	10	NR	NR	NR	NR	2	8	0
unknown, N =	0	NR	NR	0	3	NR	NR	NR	NR	2	0	3
SLE, N =	1	NR	NR	0	0	NR	NR	NR	NR	0	0	1
L/R nephrectomy	32/4	NR	NR	NR	34/0	20/0	19/1	15/0	13/0	9/2	10/0	7/0
single/multiple RA	33/3	NR	NR	NR	20/14	20/0	16/4	13/2	10/3	7/4	8/2	NR
donor related/unrelated	33/3	435/48	NR	NR	34/0	NR	19/1	3/12	NR	9/2	NR	5/2
operative time (min)	230	NR	NR	NR	233	NR	234	NR	NR	NR	248	NR
complications, N = (%)	14 (39)	NR	NR	27 (59)	NR	0	6 (30)	10 (67)	1 (8)	5 (45)	3 (30)	1 (14)
mean LOS (days)	9.3	10.1	NR	N/A	NR	NR	6	NR	NR	NR	15	NR
overall graft loss, N = (%)	4 (11)	38 (8)	1 (0.8)	0	3 (9)	0	0	1 (7)	0	1 (9)	0	0

Abbreviations: FSGS = focal segmental glomerular sclerosis; SLE = systemic lupus erythematosus; RA = renal artery(ies); LOS = length of stay; NR = not reported

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