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Dual and Pediatric En-Bloc Compared to Living Donor Kidney Transplant: A Single Center Retrospective Review

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Abstract: Safely expanding the use of extended-criteria organ donors is critical to increase access to kidney transplantation and reduce wait list mortality. We performed a retrospective analysis of 24 pediatric en-bloc (PEB) compared to 13 dual-kidney transplantations (DKT) and 39 living donor kidney transplants (LDKT) at the University of Virginia hospital, performed between 2011 and 2019. All living donor kidney transplants were performed in 2017. This year was chosen so that 5-year outcomes data would be available. Primary outcomes were glomerular filtration rate and serum creatinine at 12 and 24 months postoperatively. Secondary outcomes were patient and graft survival. The 1-year creatinine levels (mL/min/1.73 m^2) were lower in the PEB group (median 0.9, IQR 0.8–1.4) when compared to the DKT (median 1.4, IQR 1.2–1.5) and LDKT (median 1.3, IQR 1.1–1.5) groups ($p < 0.001$). The 2-year creatinine levels (mL/min/1.73 m^2) were also lower in the PEB group (median 0.8, IQR 0.7–1.08) compared to the DKT (median 1.3, IQR 1.1–1.5) and LDKT (median 1.3, IQR 1.0–1.5) groups ($p < 0.001$). The glomerular filtration rates demonstrated similar results. Graft survival at 1, 3, and 5 years was 100/100/90, 100/92/69, and 96/96/91 for LDKT, DKT, and PEB, respectively ($p = 0.27$). Patient survival at 1, 3, and 5 years was 100/100/90, 100/100/88 and 100/100/95 for LDKT, DKT, and PEB, respectively ($p = 0.78$). Dual KT and PEB transplantation are two alternative techniques to safely expand the donor pool. PEB kidney transplantation, though technically more demanding, provides the best long-term graft function.

Keywords: dual-kidney transplantation; pediatric en-bloc transplantation; single-kidney transplantation; serum creatinine; GFR; graft survival; patient survival

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1. Introduction

The demand for organ transplantation exceeds the availability of donated organs. From 2006 to 2014, the kidney transplant wait list in the US increased from approximately 68,000 to over 100,000 patients, and subsequently stabilized [1]. This number saw a decline due to the COVID-19 pandemic; however, this has since rebounded, and the number of waitlisted patients exceeded 139,000 in 2021. Despite the high demand for kidneys, one in four donated kidneys is not utilized, and fewer patients are willing to accept high-kidney donor profile index (KDPI) kidneys [2].

DKT from extended criteria (ECD) as well as PEB kidney transplants from infants could potentially safely increase organ utilization [3–13]. Specifically, for PEB kidney transplantations, superior long-term kidney function compared to single-kidney transplants has been observed [14–18]. However, PEB kidney transplantation has been mostly limited

to larger infants with a body weight above 10 to 15 kg, and a large number of small pediatric kidneys are not utilized [19,20]. The increased technical difficulty with very small donors may increase the risk of early graft thrombosis, insufficient renal mass, and hyperfiltration [17,21–25], and a major reason for the non-utilization of pediatric kidneys is the reduced organ weight in donors < 10 kg [19,20]. Similarly, the results of DKT in high-KDPI donors that would have otherwise not been utilized have shown comparable outcomes in kidney function, as well as decreased wait times [12,26] and waitlist mortality [27].

The aim of this study was to provide modern data on PEB, with the new addition of the use of infants below 10 kg and a newly initiated DKT program for high-KDPI kidneys to understand its value in safely increasing organ utilization.

2. Materials and Methods

2.1. Study Design

We performed a retrospective chart review of all DKT and PEB transplants performed at the University of Virginia from 2011 to 2019. This was performed under approval by the institutional review board (IRB). In total, 24 PEB and 13 DKT were performed during the study period. Out of the 24 PEB donors, 9 were $\leq$10 kg. Data from a control group of 39 patients who underwent LDKT were collected (all transplants occurred in 2017). This year was chosen so that 5-year outcomes data would be available for these recipients. Primary outcomes were glomerular filtration rate (GFR) and serum creatinine at 1 and 2 years postoperatively. Secondary outcomes were patient and graft survival. We compared recipient and donor baseline characteristics, as well as length of stay (LOS), dialysis duration, freedom from dialysis post-transplant, and readmissions in the first year in the recipients.

2.2. Selection Criteria

Selection criteria for PEB included donor weight $\leq$ 10 kg and donor age $\leq$ 3 years. The recipient criteria for PEB were BMI < 25 kg/m^2 and mild or no arterial calcifications, although the BMI was flexible based on recipient body habitus and weight distribution. Selection criteria for DKT were KDPI > 85%, grafts with suitable arterial anatomy to safely perform an anastomosis, donor age > 60 years, allograft biopsy demonstrating glomerulosclerosis > 15%, and donor hypertension and diabetes mellitus. Exclusion criteria were recipients with severe vascular calcifications and/or BMI > 31 kg/m^2. All recipients consented appropriately.

2.3. Operative Procedure

For DKT, the surgical approach may consist of bilateral Gibson incisions with an allograft on each side, unilateral Gibson incision with placement of both allografts in the same iliac fossa, or a midline intraperitoneal approach. The vessels are anastomosed end-to-side, preferentially to the external iliac vessels of the recipient. Extra-vesical uretero-neocystostomy is performed individually for each ureter according to the Lich–Gregoir technique.

For PEB, the kidneys are recovered en-bloc at the donor center. The kidneys are prepared for implantation on the backtable, with care taken to ligate the small aortic and inferior vena cava lumbar branches. The supra-renal aorta and vena cava are closed individually with 5-0 or 6-0 Prolene. Implantation proceeds via standard Gibson incision, preferentially on the right side. The caudal ends of the aorta and vena cava are anastomosed to the iliac vessels using 6-0 or 7-0 Prolene. The ureters are either sutured together using 6-0 polydioxanone suture and then transplanted into the urinary bladder by use of an extra-vesicular method, or individually sutured to the bladder using the Lich–Gregoir technique. Here, the bladder patch technique was not used. The kidneys are carefully positioned to prevent torsion or kinking of the vessels.

2.4. Immunosuppression

All patients received a single dose of pre-operative antibiotic prophylaxis, methylprednisolone, and thymoglobulin for induction (3–6 mg/kg). Immunosuppression was administered based on our center's protocol with maintenance immunosuppression consisting of tacrolimus, mycophenolate mofetil, and prednisone, with dose adjustment to achieve therapeutic effects on an individual basis.

2.5. Statistical Analysis

Continuous variables are presented as median (interquartile range) or mean (SD) based on the distribution of the data. Categorical data are presented as count (percentages). Continuous variables were compared using the independent two-sample *t*-test, Mann–Whitney U-test or one-way analysis of variance (ANOVA) according to the normality of the data distribution and number of groups to compare. Post-hoc tests were conducted using Bonferroni correction and Tukey's HSD test procedures, as appropriate, to perform pairwise comparisons between groups when the *p*-value was $\leq$0.05. For categorical data, the Pearson Chi-Square test or Fisher's exact test were used as appropriate. The Kaplan–Meier method was used to analyze the actuarial graft and patient survival between study groups, and the groups were compared using a log-rank test. Event (yes/no) for graft survival was defined as per OPTN definition (time between transplant and any of the following events: a recipient's transplanted organ is removed, a recipient dies, a recipient is placed on chronic allograft support system). For all analyses, two-tailed *p*-values $\leq$ 0.05 were considered statistically significant. All analyses were performed using IBM SPSS Statistics Version 28.

3. Results

3.1. Donor Characteristics

The baseline characteristics of all donors are summarized in Table 1. Donors in the PEB group were significantly younger, with a median age of 1 (median interquartile range [IQR] 1–2), compared to the LDKT (median 45 years, IQR 38–51) and DKT (median 58 years, IQR 55–67) ($p < 0.001$). There were more female donors in the LDKT group (74.4%, $n = 29$) compared to the DKT (53.8%, $n = 7$) and PEB (45.8%, $n = 11$) groups ($p = 0.026$). Terminal creatinine (mL/min/1.73 m^2) was lower in the PEB group (median 0.3, IQR 0.2–0.47) compared to the DKT group (median 1.10, IQR 0.77–1.77) ($p < 0.001$). Donor weight (kg) was lower in the PEB group (median 13, IQR 9.2–15) compared to the DKT (median 74, IQR 65–116.5) and LDKT (median 80, IQR 69–89) groups ($p < 0.001$). Cold ischemia time (min) was expectedly shorter in the LDKT group (median 38, IQR 27–69) compared to DKT (median 1369, IQR 1174–2014) and PEB (median 1282, IQR 1086–1509) ($p < 0.001$). There was no difference in warm ischemia time between groups. In total, 15 living donors were related to the recipients, while 24 were unrelated. Of the donors that were related, four donated to a parent, two donated to a child, six donated to a sibling, and three donated to a cousin, nephew, and aunt, respectively.

Table 1. Donor characteristics. IQR, interquartile range. BMI, body mass index. DBD, donation after brain death. DCD, donation after cardiac death. KDPI, kidney donor profile index.

Donor Characteristics	Living (n = 39)	Dual Kidney (n = 13)	En-Bloc (n = 24)	p Value	Post Hoc Tests
Age in years (Median IQR)	45 (3–51)	58 (55–67)	1 (1–2)	<0.001	Pairwise comparisons (Bonferroni correction): En-bloc vs. Living $p \leq 0.001$; En-Bloc vs. Dual $p \leq 0.001$; Living vs. Dual $p = 0.094$

Table 1. *Cont.*

Donor Characteristics	Living (n = 39)	Dual Kidney (n = 13)	En-Bloc (n = 24)	p Value	Post Hoc Tests
Gender (female)	29 (74.4)	7 (53.8)	11 (45.8)	0.026	
Ethnicity					
White/Caucasian	32 (82.1)	10 (76.9)	17 (70.8)	0.11	
Other	3 (7.7)	3 (23.1)	7 (29.2)		
Donor Terminal Creatinine, mg/dL (Median IQR)	NA	1.10 (0.77–1.77)	0.30 (0.20–0.47)	<0.001	
Donor BMI (Median IQR)	28.0 (24.0–31.0)	26.0 (24.5–37.5)	18 (16–19)	<0.001	Pairwise comparisons (Bonferroni correction): En-bloc vs. dual $p \leq 0.001$; En-bloc vs. Living $p \leq 0.001$; Dual vs. Living p =1.00
Donor Weight (kg) (Median IQR)	80 (69–89)	74 (65–116.5)	13 (9.2–15.0)	<0.001	Pairwise comparisons (Bonferroni correction): En-bloc vs. dual $p \leq 0.001$; En-bloc vs. Living $p \leq 0.001$; Dual vs. Living p = 1.00
Pumped (yes)	NA	6 (46.2)	0	<0.001	
Donor type					
DBD	NA	8 (61.5)	21 (87.5)	0.81	
DCD	NA	5 (38.5)	3 (12.5)		
Donor KDPI (mean SD)	NA	88.2 (±13.4)	71.6 (±8.8)	<0.001	
Warm ischemia time (min) (Median IQR)	36 (32–47)	41 (27–52)	32.5 (27.2–44.7)	0.25	
Cold ischemia time (min) (Median IQR)	38 (27–69)	1369 (1174–2014)	1282 (1086–1509)	<0.001	Pairwise comparisons (Bonferroni correction): Dual vs. Living $p \leq 0.001$; Dual vs. En-bloc p = 1.0, Living vs. En-bloc $p \leq 0.001$

3.2. Recipient Characteristics

The baseline characteristics of recipients are summarized in Table 2. Recipients in the DKT group were significantly older (mean 65.2, SD 7.4) compared to the LDKT (mean 50, SD 13.9) and PEB (mean 46.7, SD 11.7) ($p < 0.001$). There was a higher percentage of male recipients in the LDKT group (74.4%, n = 29) compared to the DKT (46.2%, n = 6) and PEB (33.3%, n = 8) groups (p = 0.004). There was a higher percentage of white/Caucasian recipients in the LDKT group (79.5%, n = 31) compared to DKT (53.8, n = 7) and PEB groups (29.2%, n = 7) ($p < 0.001$), likely related to the availability of suitable recipients in each group based on selection criteria previously outlined above. Weight (kg) was lower in the PEB group (median 71.7, IQR 59.9–75.6) compared to DKT (median 75, IQR 58.7–83.6) and LDKT (median 79, IQR 68–95). There were no differences in recipient BMI or etiology of renal failure (with hypertension and diabetes being the two most common causes across groups). The wait time (days) was longer in the PEB group (median 1019, IQR 533–1396) than in the LDKT (median 507, IQR 291–953) and DKT (median 465, IQR 162–1059) groups (p = 0.02).

Table 2. Recipient characteristics. SD, standard deviation. IQR, interquartile range. BMI, body mass index. DM, diabetes mellitus.

Recipient Characteristics	Living (n = 39)	Dual Kidney (n = 13)	En-Bloc (n = 24)	p Value	Post Hoc Tests
Recipient age (mean SD)	50 (±13.9)	65.2 (±7.4)	46.7 (±11.7)	<0.001	One-way ANOVA (F(2,73) = 9.95, $p \leq 0.001$). Tukey post hoc: Living vs. En-bloc $p = 0.57$; Living vs. Dual $p \leq 0.001$; En-bloc vs. Dual $p \leq 0.001$
Gender (male)	29 (74.4)	6 (46.2)	8 (33.3)	0.004	
Ethnicity					
White/Caucasian	31 (79.5)	7 (53.8)	7 (29.2)	<0.001	
Other	8 (20.5)	6 (46.2)	17 (70.8)		
Recipient weight (Median IQR)	79 (68–95)	75.0 (58.7–83.6)	71.7 (59.9–75.6)	0.049	Pairwise comparisons (Bonferroni correction): En-bloc vs. Dual $p = 1.0$; En-bloc vs. living $p = 0.053$; Dual vs. Living $p = 0.55$
Recipient BMI (mean SD)	27.3 (±5.7)	27.6 (±4.3)	27.0 (±4.4)	0.94	
Primary organ failure:				0.46	
HTN	9 (23.1)	5 (38.5)	5 (20.8)		
Diabetic nephropathy (DM1, DM2)	8 (20.5)	2 (15.4)	6 (25)		
Other	22 (56.4)	6 (46.1)	13 (54.2)		
Wait time (Median IQR)	507 (291–953)	465 (162–1059)	1019 (533–1396)	0.02	Pairwise comparisons (Bonferroni correction): Dual vs. Living $p = 1.0$; Dual vs. En-bloc $p = 0.06$; Living vs. En-bloc $p = 0.049$

3.3. Transplant Outcomes

Recipient outcomes are summarized in Table 3. The LOS (days) differed between groups: PEB had a median LOS of 4 days (IQR 3–4), DKT had a median of 5 days (IQR 4–7), and LDKT had a median of 3 days (IQR 3–3) ($p < 0.001$). Concomitant with wait times, the duration of dialysis (days) differed between groups, with a median duration in the LDKT group of 178 days (IQR 0–660), in the DKT group of 635 days (IQR 337–1179), and in the PEB group of 1471 days (IQR 777–1781) ($p < 0.001$). Readmissions in the first year were similar across groups. The 1-year creatinine levels (mL/min/1.73 m^2) were lower in the PEB group (median 0.9, IQR 0.8–1.4) when compared to the DKT (median 1.4, IQR 1.2–1.5) and LDKT (median 1.3, IQR 1.1–1.5) groups ($p < 0.001$). The 2-year creatinine levels (mL/min/1.73 m^2) were also lower in the PEB group (median 0.8, IQR 0.7–1.08) compared to the DKT (median 1.3, IQR 1.1–1.5) and LDKT (median 1.3, IQR 1.0–1.5) groups ($p < 0.001$). Glomerular filtration rates demonstrated similar results. Death-censored graft survival (Figure 1) at 1, 3, and 5 years was 100/100/90, 100/92/69, and 96/96/91 for LDKT, DKT, and PEB, respectively ($p = 0.27$). Patient survival (Figure 2) at 1, 3, and 5 years was 100/100/90, 100/100/88 and 100/100/95 for LDKT, DKT, and PEB, respectively ($p = 0.78$).

Table 3. Outcomes. IQR, interquartile range. GFR, glomerular filtration rate. DGF, delayed graft function.

Outcomes	Living (n = 39)	Dual Kidney (n = 13)	En-Bloc (n = 24)	p Value	Post Hoc Tests
Length of stay, days (Median IQR)	3 (3–3)	5 (4–7)	4 (3–4)	<0.001	Pairwise comparisons (Bonferroni correction): Living vs. En-bloc $p = 0.003$; Living vs. Dual < 0.001; En-bloc vs. Dual: $p = 0.13$
Dialysis duration days (Median IQR)	178 (0–660)	635 (337–1179)	1471 (777–1781)	<0.001	Pairwise comparisons (Bonferroni correction): Living vs. Dual $p = 0.22$; Living vs. En-bloc $p \leq 0.001$; Dual vs. En-bloc $p = 0.15$
Dialysis-free	39 (100)	11 (84.6)	23 (95.8)	0.048	
Number of readmissions in 1st year (Median IQR)	0 (0–2)	1 (0–2)	0.5 (0–1)	0.59	
Readmissions in 1st year (yes)	15 (38.5)	8 (61.5)	12 (50)	0.31	
1-year creatinine, mg/dL (Median IQR)	1.3 (1.1–1.5)	1.4 (1.2–1.5)	0.9 (0.8–1.14)	<0.001	Pairwise comparisons (Bonferroni correction): Enbloc vs. Living $p = 0.004$; En-bloc vs. Dual $p = 0.002$; Living vs. Dual $p = 0.87$
2-year creatinine, mg/dL (Median IQR)	1.3 (1.0–1.5)	1.3 (1.1–1.5)	0.8 (0.7–1.08)	<0.001	Pairwise comparisons (Bonferroni correction): En-bloc vs. Living $p = 0.001$; En-bloc vs. Dual $p = 0.002$; Living vs. Dual $p = 1.0$
1-year GFR, mL/min/1.73 m^2 (Median IQR)	60 (49–67)	43.0 (35.5–51.5)	78 (61–97)	<0.001	Pairwise comparisons (Bonferroni correction): Dual vs. Living $p = 0.06$; Dual vs. En-bloc $p \leq 0.001$; Living vs. En-bloc $p = 0.01$
2-year GFR, mL/min/1.73 m^2 (Median IQR)	59 (48–73)	51 (40–62)	89 (67–109)	<0.001	Pairwise comparisons (Bonferroni correction): Dual vs. Living $p = 0.52$; Dual vs. En-bloc $p \leq 0.001$; Living vs. En-bloc $p \leq 0.001$
DGF	0	6 (46.2)	5 (20.8)		
Graft survival, 1-, 3- and 5-year (death-censored)	100/100/90	100/92/69	96/96/91	0.27	
Patient survival, 1-, 3- and 5-year	100/100/90	100/100/88	100/100/95	0.78	

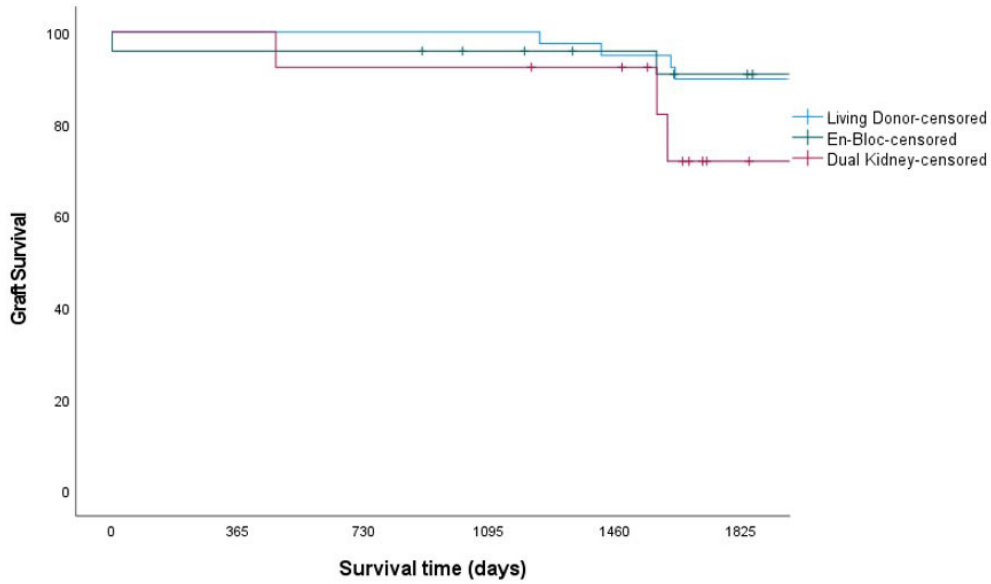

Figure 1. Graft survival (death censored).

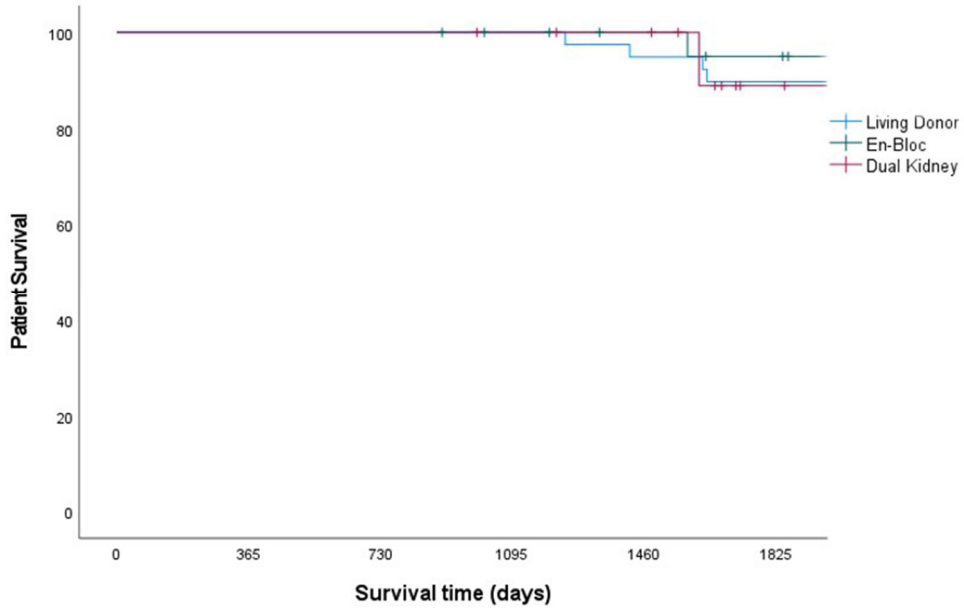

Figure 2. Recipient survival.

3.4. Complications

The post-operative complications are summarized in Table 4. These were graded based on the Clavien–Dindo classification [28]. The majority of complications were minor (grade 1 and 2). The DKT group experienced the highest proportion of grade 3a and above complications. No grafts were lost in the LD group. The reasons for graft loss in the DKT group included one case of chronic allograft nephropathy and one case of chronic rejection. In the PEB group, reasons for graft loss included one case of vascular thrombosis on post-operative day 1 and one patient with chronic interstitial fibrosis and tubular atrophy. In the LD group, four patients died with a functioning graft; in the DKT group, this was one patient, and in the PEB group it was two patients, with another patient in the PEB group dying without a functioning graft.

Table 4. Complications.

Grade [28]	Living (*n* = 39)	Dual Kidney (*n* = 13)	En-Bloc (*n* = 24)
1	9 (23%)	3 (23%)	6 (25%)
	Tacrolimus toxicity, urinary retention (2), traumatic foley insertion, hematuria, atrial fibrillation, fluid retention (diuresis) (2), thigh numbness	Hyperglycemia, prolonged Jackson–Pratt drain, drainage from prior drain site	Urinary retention, atrial fibrillation, fever (2), fluid retention (diuresis), nausea/vomiting
2	7 (18%)	3 (23%)	8 (33%)
	Blood transfusion, deep venous thrombosis, rejection (3), UTI, bacteremia	Delayed graft function (2), pancreatitis	Blood transfusion (3), delayed graft function (2), superficial surgical site infection, rejection, UTI
3a	4 (10%)	3 (23%)	2 (8%)
	Seroma drained (2), lymphocele drained, hematoma aspirated	Common iliac artery stenosis (clamp injury) requiring stenting (2), renal artery pseudoaneurysm requiring coiling	Seroma (drained) (2)
3b	None	3 (23%)	3 (13%)
		Incarcerated incisional hernia requiring bowel resection, acute limb ischemia requiring femoral endarterectomy and fasciotomy, cholecystitis requiring cholecystectomy	Distal ureteral necrosis (revision with percutaneous nephrostomy), intra-operative thrombosis salvaged with explant/flush/anticoagulation, post-operative thrombosis and graft explantation
4a	1 (3%)	5 (38%)	3 (13%)
	Hypotension requiring vasopressors	Unable to extubate in OR, hypotension requiring vasopressors (2), pyelonephritis, volume overload requiring emergent hemodialysis	Vasovagal syncope requiring cardiopulmonary resuscitation, non-ST elevated myocardial infarction, pseudomonas pneumonia
4b	1 (3%)	none	none
	Bacteremia and sepsis/hyperkalemia requiring hemodialysis		

4. Discussion

The demand for kidneys far outpaces the available organs in the deceased donor pool. The 5-year life expectancy on dialysis is approximately 50%, whereas with transplant it is well over 80% [29]. Kidney transplantation is extending the life expectancy of patients with end-stage renal disease. As such, it is important to limit organ non-utilization, and we demonstrate here that PEB and DKT show results comparable to those of LDKT.

Overall, PEB transplants show significantly better 1- and 2-year serum creatinine and GFR compared to LDKT and DKT, which is consistent and comparable to already-published data [3,9,12,17]. While no statistical difference in graft survival is noted in our series, this is a low-powered study, and the results highlight the expectedly higher quality of living donor kidneys (numerically improved graft survival), while also indicating lower graft survival for high-KDPI kidneys. The technical pitfalls of accepting PEB kidneys are illustrated in our series, as the graft loss experienced by one of the recipients was the result of venous thrombosis and outflow obstruction, a well-described complication of this operation. PEB has a higher rate of graft failure reported in the literature (mostly early), with surgical complication and early graft thrombosis accounting for this result [17,21–24]. We consider the initiation of early anticoagulation (it is our center's practice to use low-dose intravenous

heparin infusion for the first several days, typically 300–500 units/hour). These allografts require a technical expertise: the backtable preparation is typically an hours-long process, and requires meticulous dissection and careful preservation of the tiny renal veins and arteries during ligation of the lumbar arteries and veins, and the oversewing of the aorta and vena cava. We also typically lay the allografts so that the vessels lie parallel to the external iliac vessels. It is crucial to individualize the approach to best suit the recipient. Given prior published data indicating that PEB have better graft survival compared to ideal (e.g., living donors) donors, these grafts should preferentially be utilized in younger recipients with higher expected post-transplant survival (EPTS) [19]. We prefer to implant these into leaner recipients, to limit the technical difficulty of implantation in an otherwise highly technical procedure.

For elderly and borderline frail patients in particular, a longer time on the waitlist correlates with a higher rate of mortality and morbidity [12,27]. It has been estimated that 46% of the waitlisted patients over 60 years may die waiting for a transplant [30]. It is imperative to provide a pathway to transplant these patients in a timely fashion. One such pathway is to use extended-criteria kidneys, including from donors with >85% KDPI. A high KDPI can correlate with reduced nephron mass, high immunogenicity and reduced repair capacity [12]. Some high-KDPI kidneys show inferior graft survival when compared to standard criteria donors with lower KDPI, but well-selected high-KDPI kidneys can have similar outcomes [31]. KDPI interpretation in DKT is difficult. In fact, past investigations have shown that high-KDPI DKT transplantations have lower overall allograft failure rates and better patient survival rates than ECD single-kidney transplants [32–34]. Still, kidneys with a KDPI > 90% still have much higher discard rates than those with a KDPI < 80%, even though they could be used for DKT [32]. There is room for improvement to decrease the rate of non-utilization in these kidneys.

Our analysis demonstrates that DKT allows for a shorter time on the waitlist, especially in the elderly (the median age at transplant for DKT recipients in our series was 65 years). Our practice with marginal kidneys (criteria described above) is to decline a single kidney, but accept if the organ procurement organization is willing to allocate both kidneys. We will oftentimes advocate for open offers and find the next suitable candidate from our waitlist that meets the previously described criteria. This can be labor-intensive, but careful recipient selection can still lead to a good transplant outcome with favorable outcomes when compared to remaining on dialysis. By transplanting two marginal-quality kidneys in DKT, comparable 5-year graft outcomes can be achieved.

Overall, both procedures increase the kidney donor pool and decrease not only waiting time, but also the number of patients on the waitlist, which again lowers mortality and morbidity in ESRD patients. However, each approach has its limitations. Efforts should be focused on limiting technical complications and adhering to defined graft and recipient selection criteria.

Our study has several limitations. Retrospective data analysis is non-randomized, and therefore subject to inherent bias. The sample size of our population limits the statistical analysis in many ways; however, statistical significance was demonstrated in several instances. The length of time across the study may contribute to bias, as well as differences in technique between the surgeons performing the implantation (four surgeons performed the transplants). We had a large proportion of white male LDKT recipients (80%) and white female living kidney donors (74%), and as such our results may not be generalizable to more diverse populations. This exposes the larger problem of poor access to transplantation among minorities, and we have focused our efforts over the last several years on improving this situation at our center. In addition, we prefer to place DKTs on pump; however, only 6 of the 13 (46.2) DKTs performed during the study period were pumped. We did not control for this, and therefore this confounds some of the results of the DKT group.

5. Conclusions

Renal function at 1 and 2 years post-transplant showed a statistically significant difference favoring the PEB compared to the DKT and LDKT. When compared to LDKT, DKT and PEB are feasible options for kidney transplantation and should be implemented in appropriately selected recipients. Further research on the outcome of these techniques is essential to improving the selection criteria for each method.

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Abbreviations

BMI	Body mass index
cPRA	Calculated panel of reactive antibodies
DKT	Dual-kidney transplant
DM	Diabetes mellitus
ECD	Extended-criteria donor
GFR	Glomerular filtration rate
KDPI	Kidney donor profile index
LDKT	Living donor kidney transplant
LOS	Length of stay
PCKD	Polycystic kidney disease
PEB	Pediatric en-bloc
SD	Standard deviation

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