

Living Donor Kidney Transplantation With Multiple Arteries

Recent Increase in Modern Era of Laparoscopic Donor Nephrectomy

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Objective: To compare the outcome of living donor kidney transplantation using allografts with a single artery with that observed in recipients of allografts with multiple arteries.

Design: Retrospective analysis.

Setting: Tertiary center.

Patients: Three hundred fifty patients who underwent living donor kidney transplantation from January 2000 to March 2007.

Interventions: Living donor kidney transplantation.

Main Outcome Measures: Surgical complications and allograft survival.

Results: Three hundred nineteen allografts (91.1%) had a single artery (group 1) and 31 (8.9%) had multiple arteries (group 2), including 2 arteries in 21 grafts (67.8%), 3 arteries in 6 (19.3%), and 4 arteries in 4 grafts (12.9%). The operative time was shorter in group 1 compared with group 2 (mean [SD], 173 [35] vs 259 [48] minutes;

$P < .001$). The overall surgical complication rate in groups 1 and 2 was comparable (9.6% vs 9.7%; vascular, 2.8% vs 3.2%; urological, 1.6% vs 3.2%; symptomatic lymphocele, 2.8% vs 3.2%; and wound infections, 2.8% vs 3.2%). The actuarial 1- and 5-year allograft survival rates were comparable in both groups (98.4% and 91.5% in group 1 and 96.8% and 87.1% in group 2). A significant increased use of allografts with multiple arteries has been observed in recent years: 7.8% ($n=10$) in grafts that were procured by open technique ($n=127$), 4.1% ($n=5$) during our initial experience with laparoscopic nephrectomy ($n=123$), and 16% ($n=16$) in the most recent 100 cases ($P < .01$).

Conclusions: Living donor kidney transplantation in the presence of multiple renal arteries is feasible and safe. Additionally, graft survival and graft function are not adversely affected by the presence of multiple renal arteries in grafts procured laparoscopically. Recently, there has been an increased use of kidneys with multiple arteries with excellent results.

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KIDNEY TRANSPLANTATION IS the treatment of choice for patients with end-stage renal disease. The technical aspects of the procedure are well established and are typically accomplished without complications when the



Video available online at www.archsurg.com

kidney allograft has a single renal artery. Autopsy studies have documented an 18% to 30% prevalence rate of multiple renal arteries, with 15% being bilateral.¹ The need to use such kidneys is not uncommon.

Since the initial report by Ratner et al² in 1995, laparoscopic donor nephrectomy (LDN) has gained in worldwide

popularity. In addition to minimizing donor morbidity, hospital stay, and convalescence, LDN has also been shown to provide equivalent short- and long-term renal allograft functional outcomes compared with open surgery. Although initially kidneys with multiple arteries were considered inappropriate for laparoscopic removal, with increasing experience, LDN has now been extended to donors with multiple renal arteries. This is technically challenging, and concerns regarding prolonged warm ischemia time, increased risk of complications, and poor outcome persist.

Allografts with multiple arteries have been reported to be associated with increased complication rates in the past.^{1,3,4} In this study, we retrospectively reviewed our experience of living donor kid-

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ney transplantation (LDKT) with multiple arteries vs a single artery and compared both short- and long-term outcomes.

METHODS

Between January 2000 to March 2007, 350 patients underwent LDKT at our institution. The techniques of the laparoscopic and open nephrectomy have been previously described.^{2,5} During the preoperative donor evaluation, medical, surgical, and psychosocial suitability for live donation were assessed. Detailed informed consent was obtained. The arterial anatomy was delineated by selective renal angiography or computed tomography angiogram in all cases. All donor-recipient pairs were T-cell cross-matched and ABO blood type compatible.

During this time, 223 underwent LDN and 127 had open donor nephrectomy. All LDN procedures were done using a hand-assisted device. The renal artery and vein were divided using an endovascular TA stapler (US Surgical, Norwalk, Connecticut) in the LDN group. The retrieved graft was perfused with cold perfusate until the efflux was clear.

The recipient procedure was performed using the standard extraperitoneal approach with end-to-side anastomoses of the renal vessels to the recipient iliac vessels. In kidneys involving 2 or more renal arteries, revascularization was performed for all vessels that supplied more than 5% to 10% of the renal parenchyma, as estimated by the preoperative imaging and intraoperative in situ and back-table evaluations. To minimize warm ischemia time, ex vivo end-to-side accessory artery-to-main renal artery anastomosis or side-to-side conjoint artery-

to-artery anastomosis using 8-0 polypropylene continuous sutures was usually carried out while the kidney remained in cold preservation solution. Side-to-side spatulated anastomoses have been our preferred method (71%) because of the creation of a wide lumen for anastomosis in the recipient (Video, <http://www.archsurg.com>). All the patients in group 2 received low-molecular weight dextran postoperatively for 5 days and low-dose aspirin indefinitely.

Statistical analysis was performed with the *t* test. The graft outcome was evaluated by Kaplan-Meier survival probability.

RESULTS

Of the 350 consecutive LDKTs, 319 renal allografts (91.1%) had a single renal artery (group 1) and 31 allografts (8.9%) had multiple arteries (group 2). There were 2 arteries in 21 grafts (67.8%), 3 arteries in 6 (19.3%), and 4 arteries in 4 grafts (12.9%).

The donor operation time was comparable in both groups (mean [SD], 227.6 [67.7] minutes in group 1 vs 248 [60.8] minutes in group 2; *P* = .42), as most of the procedures with laparoscopically procured kidneys with multiple arteries were done after our team had gained experience in LDN.

The recipients' operative time was longer in group 2 compared with group 1 (mean [SD], 259 [48] vs 173 [35] minutes; *P* < .001) because of time needed for back-table reconstruction. The creatinine and rejection rates were comparable in both groups (**Table 1**).

The overall surgical complication rate in groups 1 and 2 was comparable (9.6% vs 9.7%; vascular, 2.8% vs 3.2%; urological, 1.6% vs 3.2%; symptomatic lymphocele, 2.8% vs 3.2%; and wound infections, 2.8% vs 3.2%) (**Table 2**). The actuarial 1- and 5-year allograft survival rates were also comparable in both groups (96.8% and 87.1% in group 2 and 98.4% and 91.5% in group 1) (**Figure**).

The use of allografts with multiple arteries has dramatically increased in recent years: 7.8% (*n* = 10) in grafts that were procured by open technique (*n* = 127), 4.1% (*n* = 5) during our initial experience with laparoscopic nephrectomy (*n* = 123), and 16% (*n* = 16) in the most recent 100 cases (*P* < .01).

COMMENT

Kidney transplantation is the treatment of choice for patients with end-stage renal disease. Advances in sur-

Table 1. Group Characteristics

	Group 1: Single Artery (n=319)	Group 2: Multiple Artery (n=31)
M/F, No.	178/141	17/14
Operative time, min, mean (SD)	173 (35) ^a	259 (48)
Creatinine level, mg/dL, mean		
1 y	1.59	1.56
3 y	1.68	1.65
5 y	1.72	1.69
Rejection at 1 y, No. (%)	3 (9.6)	38 (11.9)
Graft survival, %		
1 y	98.4	96.8
5 y	91.5	87.1

SI conversion factor: To convert creatinine to micromoles per liter, multiply by 88.4.

^a*P* < .001.

Table 2. Complication Rates by Group

Complication	No. (%)	
	Group 1: Single Artery	Group 2: Multiple Artery
Vascular	9 (2.8) Anastomotic bleeding (<i>n</i> = 8) Renal vein thrombosis (<i>n</i> = 1)	1 (3.2) Anastomotic bleeding
Urological	5 (1.6) Leak (<i>n</i> = 1) Obstruction (<i>n</i> = 1) Stricture (<i>n</i> = 3)	1 (3.2) Stricture
Symptomatic lymphocele	9 (2.8)	1 (3.2)
Wound infection	9 (2.8)	1 (3.2)

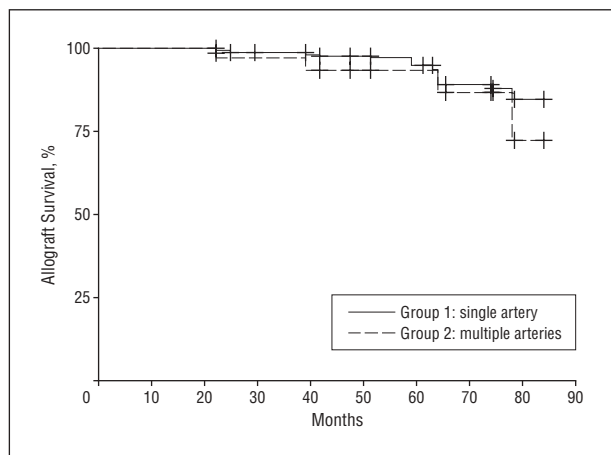


Figure. Kaplan-Meier analysis showed comparable allograft survival in both groups ($P=.44$).

gical techniques, immunosuppressive therapies, and posttransplant monitoring have led to an impressive increase in patient and allograft survival. However, donor organ shortage has become one of the problems preventing the wider application of this treatment. Therefore, every organ must be used in a maximal favorable condition. Theoretically, transplanting a kidney with multiple arteries has several drawbacks, such as prolonged warm ischemia time; an increased incidence of acute tubular necrosis, which can increase the likelihood of acute rejection episodes^{1,3,4}; prolonged hospitalization; and decreased graft function. In deceased donor kidney allografts, use of the Carrel aortic patch incorporating the multiple renal artery ostia represents a good method for revascularizing the graft. However, this technique is not applicable to live donor transplantation.

Multiplicity of the renal arteries had no negative impact on graft survival in our study, as well as in others.⁶⁻¹⁰ Some investigators have concluded that grafts with multiple arteries are associated with a higher incidence of vascular complications than that observed in those with single arteries.^{1,3,4,11} In our study, as well as in others,⁷⁻⁹ there was no association between multiplicity of the renal artery and an increased risk of vascular complications. Although an increased incidence of urological complications was reported in association with this group of patients undergoing renal transplant in earlier studies,^{3,4,11} Roza et al¹ reported on 42 living donor open nephrectomies with multiple renal arteries, in which 8 urological complications (19%) (including 5 leaks and 3 obstructions) and 3 vascular complications (7%) were observed. These complications may be related to the absence of a Carrell patch, which facilitates reimplantation of vessels in cadaveric organs, and the smaller diameter of accessory arteries, making them more susceptible to thrombosis and technical errors. In our study, the rate of vascular and urological complications was comparable in both groups. This could be because of our meticulous *ex vivo* microsurgical technique to create a wide lumen by performing side-to-side anastomosis (Video) and routine use of low-molecular weight dextran with aspirin. Moreover, all efforts were made to ensure

the ureter had adequate vascular supply and that redundant length of the ureter was trimmed accordingly to maintain excellent vascular viability for the ureteroneocystostomy or ureteropyelostomy anastomoses.

Laparoscopic donor nephrectomy has been shown to be less morbid than open donor nephrectomy.^{12,13} As a result of reduced morbidity and improved cosmesis, the proportion of voluntary kidney donors is expected to increase. Because of the ability to rapidly control hemorrhage and because of the overall reduction in the incidence of vascular complications, LDN is now being extended to those with multiple vessels. Even obese donors are no longer contraindicated for LDN.¹⁴

Presently available imaging techniques have a sensitivity of 98% in identifying the number of vessels preoperatively.¹⁵ Rarely, the surgeon faces unexpected hilar vascular anomalies. In our experience, we had one instance of a donor whose preoperative imaging suggested 2 renal arteries but intraoperatively was found to have 4. Retrospectively, this was due to the superimposed visual images of the adjacent renal arteries giving a reconstituted image that did not distinguish the multiplicity of the vessels. Recently, LDN has significantly increased the number of grafts with multiple arteries in our experience because of improved surgical techniques and better preoperative planning by using computed tomography angiogram. This change in practice is safe for both donor and recipient. Short-term and long-term graft functioning are comparable, without evidence for functional or immunological sequelae.

In a retrospective review of 124 LDNs, Kuo et al¹⁶ identified 83 cases involving 1 renal artery, 33 cases involving 2 arteries, and 8 cases involving 3 arteries. In their report, the 1-year graft survival rates were 96.1%, 90.9%, and 90.0% for allografts with 1 renal artery, 2 renal arteries, and 3 renal arteries, respectively, and the differences were not statistically significant. The presence of multiple arteries was associated with longer operative time and allograft warm ischemia time, but the associations were not statistically significant. No relationship was found between the number of renal arteries and intraoperative blood loss, complication rate, or length of hospitalization. Furthermore, our results demonstrate that the presence of multiple arteries did not have a statistically significant impact on the overall complication rate or allograft function at short-term and long-term follow-up.

In conclusion, multiplicity of renal arteries in LDKT does not adversely affect allograft survival compared with the single renal artery group when our techniques of vascular reconstruction and urological implantation were used. We standardized our approach to these operative cases so that, even with different surgeons, these techniques can be easily duplicated in each instance. Multiplicity of the renal arteries in LDKT is not associated with a higher rate of complications than in the single artery group given the extra precautions that we have taken. Improvement in surgical techniques and laparoscopic equipment has made recovery of renal allografts with multiple arteries safe and feasible and, therefore, a more common practice recently.

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