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ORIGINAL ARTICLE

Multiple renal arteries challenge in laparoscopic donor nephrectomy: how far can we go?

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Purpose: Living donor kidneys with multiple arteries are routinely procured laparoscopically. We aim to present our experience with laparoscopic donor nephrectomy (LDN) and to compare the graft function and outcome between cases with single versus multiple arteries. **Methods:** We compared the demographic data, operation time, warm ischemia time, rejection rate, and graft function between LDN kidneys with single artery and those with multiple arteries. **Results:** Seventy-three cases with 1 renal artery (group LDN-1), 8 cases with 2 renal arteries (group LDN-2) and 5 cases with 3 or more renal arteries (group LDN-3) were included in the study. The mean operative time was significantly higher in groups LDN-2 (100.3 ± 9.5 minutes) and LDN-3 (120.6 ± 10.3 minutes) compared to group LDN-1 (75.7 ± 10 minutes, $P < 0.001$). Similar results were detected with respect to the warm ischemia time. There were no statistically significant differences related to graft function and outcome among these groups. **Conclusion:** Multiple renal arteries present a special challenge in both donor nephrectomy and renal transplantation. However, laparoscopic procurement of a kidney with multiple renal arteries, regardless of the number, is reliable and has no significant impact on the graft outcome.

Key Words: Laparoscopic, Nephrectomy, Graft rejection, Multiple, Renal artery

INTRODUCTION

Laparoscopic donor nephrectomy (LDN) has become the gold standard in many kidney transplant centers. The shortfall of available organs for patients awaiting kidney transplant grows continuously. LDN may increase the number of kidneys available for transplantation while minimizing the morbidity and expediting the recovery of potential donors.

Since the first report of laparoscopic live donor nephrectomy in 1995 [1], graft outcome has been the primary theme in research literature. On the other hand, to maximize the available donor pool, organs with multiple arteries were included in the scenario with the expectation of similar graft outcome in comparison to single artery organs. In the present study, we aim to present our experience with LDN and to compare the outcomes when procuring kidneys with single versus multiple renal arteries.

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METHODS

Eighty-six LDNs performed between December 2005 and June 2009 were included in this study. Exclusion criteria were hand assisted technique and defective follow up period. All LDN subjects who underwent procedures by the same senior transplant surgeon (SMH) at the Ankara University Hospital and conversion to open surgery did not occur in any LDN donors.

Surgical procedures

Before placing the patient in the lateral decubitus position, the Pfannenstiel incision site was marked. A 10-mm trocar for camera placement was inserted directly in the periumbilical region. Two 5-mm trocars were then placed in the subcostal area. On the right side, a third 5-mm trocar for liver retraction was placed in the subxiphoid region. Dissection for kidney exposure was performed with harmonic scalpel (Ultracision ACE36P, Ethicon Endo-Surgery Inc., Cincinnati, OH, USA). The gonadal vein on the left side was dissected up to the renal vein together with the ureter. Adrenal and lumbar veins were divided with a harmonic scalpel. The renal artery and vein were skeletonized. The ureter with surrounding tissue was dissected down to the iliac vessels and divided by using 10-mm titanium clips (Ethicon Endo-Surgery). After completing all dissection procedures, the Pfannenstiel incision was performed and a 12-mm trocar was placed in this area for the stapler entrance. Renal artery and renal vein were divided with one angle laparoscopic stapling device (Endo GIA Roticulator; Tyco Healthcare, Hampshire, UK). Thereafter, the peritoneum was transected and the kidney was extracted quickly by hand.

Total operative time of donors was measured as from first incision to last skin suture. Warm ischemia time (WIT) was defined as the time from clamping of renal artery/arteries and renal vein/veins with stapler to commencement of cold flushing. If the graft had 2 or more renal arteries, the point of commencement of cold flushing was accepted after the cannulation and perfusion of all arteries.

Donors were divided into three subgroups according to: 1 renal artery (LDN-1), 2 renal arteries (LDN-2), and 3 or more renal arteries (LDN-3). Patient demographics, total operative times, WITs, serum creatinine level at various time points, rejection rate, arterial and venous complications, and graft and patient survival rates were compared among these three groups.

Statistical analysis

Statistical analyses were performed using SPSS ver. 11.5 (SPSS Inc., Chicago, IL, USA). Data were expressed as mean ± standard deviation for metric variables and as fre-

Table 1. Demographic data of the three groups

	Group LDN-1 (n = 73)	Group LDN-2 (n = 8)	Group LDN-3 (n = 5)	P-value
Donor age in years (mean, range)	44.3 (21-71)	50 (32-62)	41.6 (27-56)	NS
Recipient age in years (mean, range)	33.7 (3-63)	39.2 (22-53)	46.4 (34-54)	NS
Sex donor (M:F)	22:51	2:6	1:4	NS
Sex recipient (M:F)	57:16	7:1	5:0	NS
Donor BMI at surgery, kg/m^2 (mean, range)	25.5 (18.4-36.3)	24.9 (21.1-29.7)	27.1 (21.7-36.6)	NS
Conversion to ODN	0	0	0	
Kidney removed (left:right)	65:8	8:0	4:1	NS
Renal veins				NS
Single	71	7	5	
Double	2	1	0	
Recipient native kidney disease				NS
Nephrologic cause	65	8	5	
Urologic cause	8	0	0	

LDN, laparoscopic donor nephrectomy; LDN-1, cases with single renal arteries; LDN-2, cases with two renal arteries; LDN-3, cases with three or more renalarteries; BMI, body mass index; ODN, open donor nephrectomy; NS, not significant.

quency (percentage) for categorical variables. In order to compare the three groups in terms of metric variables, Kruskal-Wallis variance analysis was used, and for categorical variables, chi-square test was used. If significant differences were found, the multiple comparison test was used to determine which groups were different. A value of $P < 0.05$ was accepted as statistically significant.

RESULTS

Seventy-three cases with 1 renal artery (group LDN-1), 8 cases with 2 renal arteries (group LDN-2) and 5 cases with 3 or more renal arteries (group LDN-3, four cases with 3 renal arteries and one case with 4 renal arteries) were included in this study. Demographic data with respect to the three groups are shown in Table 1. The mean ages of LDN-1, LDN-2, and LDN-3 donors were 44.3 years (range, 21 to 71 years), 50 years (range, 32 to 62 years), and 41.6 years (range, 27 to 56 years), respectively. The mean age of recipients was 33.7 years (range, 3 to 63 years) in LDN-1, 39.2 years (range, 22 to 53 years) in LDN-2, and 46.4 years (range, 34 to 54 years) in LDN-3. The gender distribution was similar among groups. Body mass index was similar in LDN-1, LDN-2, and LDN-3 donor groups (P = 0.59). Conversion to open surgery was not necessary in any of the LDN subjects. Right-sided nephrectomy was performed in 8 donors in the LDN-1 group and in 1 donor in the LDN-3 group. Recipient native kidney diseases were similar among groups.

The operative data, postoperative renal outcome and complications are given in Table 2. The mean total operative time was shorter for the procurement of organs with single arteries (75.7 minutes; range, 60 to 90 minutes) than for organs with 2 arteries (100.2 minutes; range, 82 to 112 minutes) and organs with 3 or more arteries (120.6 minutes; range, 112 to 138 minutes; $P < 0.001$). Furthermore, the mean WIT was significantly shorter for organs with single arteries (28.62 seconds; range, 22 to 34 seconds) than for organs with 2 arteries (46.5 seconds; range, 36 to 61 seconds) and organs with 3 or more arteries (93 seconds; range, 78 to 126 seconds; $P < 0.001$). Eleven percent of the LDN-1 group, 12.5% of the LDN-2 group and 20% of the LDN-3 group had an episode of acute rejection within the follow-up period. Lymphocele was detected in one LDN-1 recipient and was treated with surgical intervention. Renovascular hypertension and partial perfusion defect after transplantation was not seen in any patients. Graft artery stenosis in one LDN-1 recipient was treated with percutaneous transluminal balloon angioplasty. The cause of the one graft loss in the LDN-1 group was due to graft artery thrombosis, but there were no significant differences identified among these three groups with respect to graft and patient survivals.

Serum creatinine levels were not statistically significant among these three groups in the preoperative period (P = 0.81) or at postoperative day 1 (P = 0.82), day 2 (P = 0.42), day 5 (P = 0.51), 1 month (P = 0.74), 3 months (P = 0.29), 6

Table 2. Operative data and postoperative outcomes

	Group LDN-1 (n = 73)	Group LDN-2 (n = 8)	Group LDN-3 (n = 5)	P-value
Total operative time (min)	75.7 ± 10	100.3 ± 9.5	120.6 ± 10.3	<0.001[a]
Warm ischemia time (min)	28.6 ± 2.4	46.5 ± 8.4	93.0 ± 19.2	<0.001[b]
Rejection rates during follow-up period	8 (11.0)	1 (12.5)	1 (20.0)	
Graft artery stenosis	1	0	0	
Lymphocele	1	0	0	
Graft survival during follow-up period	72 (98.6)	8 (100.0)	5 (100.0)	NS
Patient survival during follow-up period	73 (100.0)	8 (100.0)	5 (100.0)	NS

Values are presented as mean ± SD or number (%).
LDN, laparoscopic donor nephrectomy; LDN-1, cases with single renal arteries; LDN-2, cases with two renal arteries; LDN-3, cases with three or more renal arteries; NS, not significant.
[a]Multiple comparison tests for all pairwise comparisons. [b]Multiple comparison tests for pairwise comparisons except group LDN-2 vs. group LDN-3.

months (P = 0.10), and 12 months (P = 0.09) (Table 3).

DISCUSSION

LDN was associated with a significant improvement in postoperative pain control, better postoperative respiratory function, a reduction in hospital stay, earlier return to normal activities, and improved wound cosmesis. Furthermore, this operation technique resulted in similar graft survival and donor safety compared with open donor nephrectomy [2]. This technique is technically challenging related to various vascular abnormalities. Hence, an exact knowledge of the vascular anatomy and collecting system are mandatory before operation. We used multidetector renal computed tomography angiography (MDCTA) for evaluation of the renal arteries preoperatively. MDCTA has sensitivity ranging between 86-88%, specificity between 98-100% and accuracy between 93-98% for arterial anatomy [3-5]. In our study, 15.1% of the donor organs had multiple arteries, and CT evaluation of renal artery anatomy in these donors was sufficiently accurate for correctly identifying renal arteries and veins. No false-positive accessory artery was detected but in one patient, a 2-mm accessory artery was missed on preoperative CT angiography. We identified this accessory artery during surgical dissection and it was undamaged.

Living donor kidneys with multiple arteries are also routinely procured laparoscopically. While there have been many studies related with the effects of laparoscopic versus open technique on graft function, there are only a limited number of studies in the literature including the effect of multiple renal arteries on graft function (Table 4).

While some studies reported a higher rate of surgical and medical complications after transplant with multiple arteries grafts [6-8], other reports suggested no difference related to rejection rate and patient and graft survival be-

Table 3. Serum creatinine (mg/dL) levels (preoperative and postoperative at various time points)

	Group LDN-1	Group LDN-2	Group LDN-3	P-value
Day PO	8.16 ± 3.25	7.65 ± 1.88	8.56 ± 4.88	0.81
Day 1	3.97 ± 1.91	3.48 ± 1.22	3.12 ± 1.41	0.82
Day 2	2.05 ± 1.08	1.73 ± 0.65	1.56 ± 0.31	0.42
Day 5	1.37 ± 0.53	1.35 ± 0.65	1.14 ± 0.29	0.51
1 month	1.21 ± 0.31	1.16 ± 0.36	1.16 ± 0.20	0.74
3 months	1.25 ± 0.36	1.07 ± 0.27	1.11 ± 0.27	0.29
6 months	1.25 ± 0.31	1.02 ± 0.13	1.61 ± 1.05	0.10
12 months	1.24 ± 0.35	0.97 ± 0.13	1.18 ± 0.22	0.09

Values are presented as mean ± SD.
LDN, Laparoscopic donor nephrectomy; LDN-1, cases with single renal arteries; LDN-2, cases with two renal arteries; LDN-3, cases with three or more renal arteries; PO, pre-operative.

Table 4. Literature review regarding series of multiple renal arteries (RA) in laparoscopic donor nephrectomy

First author	Year	No. of cases / mean OT / mean WIT	
		Single RA	Multiple RA
Carter [6]	2005	312 / 203 min / 35.3 min	49 / 202 min / 29.2 min
Kadotani [7]	2005	292 / ND / 46.6 min	48 / ND / 73.1 min[b]
Paramesh [8]	2009	218 / 1.7 hr / 26.5 min	60 / 1.9 hr / 28.6 min
Kuo [9]	1998	83 / ND / ND	41/ ND / ND
Hsu [10]	2003	277 / 253.5 min / 289.3 sec	76 / 280.8 min / 300 sec
Gürkan [11][a]	2004	23 / ND / ND	8 / 247 min / 43
Husted [12]	2005	203 / ND / 3.13 min	37 / ND / 4.20 min
Desai [13]	2007	276 / 147.6 min / 5.6 min	27 / 166.3 min / 7.2 min
Kok [14]	2008	208 / 161 min / 2.9 min	60 / 174 min / 4.5 min
Fettouh [15]	2008	321 / 131 min / 2.4 min	79[c] / 161 min / 2.6 min

OT, operation time; WIT, warm ischemia time; ND, no data.
[a]In this study, cases with multiple arteries in laparoscopic donor nephrectomy were only compared with cases with multiple arteries in open donor nephrectomy and were not compared to cases with single arteries. [b]Results in the article were defined as total ischemia time. [c]Sum of the cases with multiple renal arteries (n = 59) and cases with venous anomalies and/or multiple veins (n = 20).

tween cases with multiple and single arteries [9-15]. In this study, we aim to present our experience with LDN and to compare the graft function and outcome between cases with single versus multiple arteries.

Multiple renal arteries in LDN present potential disadvantages. Prolonged pneumoperitoneum related to increased operation time and increased WIT generally occurs. The pneumoperitoneum that is created during laparoscopy is known to be associated with adverse renal hemodynamic effects and acutely decreased urine output of native kidneys [16,17]. However, multiple studies including comparison of laparoscopic versus open donor nephrectomy showed that this situation did not affect the long-term graft outcome [18-20]. Delayed graft function (DGF) is defined as hemodialysis requirement within one week of transplantation. The effect of WIT on DGF is controversial according to the literature. Jacobs et al. [21] compared WIT $\leq$ 3 minutes vs. $\geq$ 3 minutes and WIT $\leq$ 5 minutes, 5-10 minutes, and $\geq$ 10 minutes, and showed that prolonged WIT did not affect graft function. Similarly, another study by Simforoosh et al. [22] compared three groups with WIT in the ranges of 4-6 minutes, 6-10 minutes, and $>$ 10 minutes, and no significant difference in graft function was detected among these groups. In contrast, in a series reported by Sasaki et al. [23], a WIT of > 10 minutes was associated with acute tubular necrosis and an elevated serum creatinine concentration at 7 days post-transplantation. The WITs in this study are shorter than in other reports [6-15], because we used only one angle stapler and, thus, the kidney could be quickly extracted by hand. No time was lost with single-division of artery and vein and extraction bag. Nevertheless, we prepared the cold perfusion table equipment in concordance with the number of renal arteries for the duration of surgery. Although we detected significantly longer WIT in the LDN-2 and LDN-3 groups than LDN-1 group, no significant difference was identified among these three groups with respect to graft outcome, including creatinine level, rejection rate and graft survival.

In conclusion, multiple renal arteries present a special challenge in both donor nephrectomy and renal transplantation. However, laparoscopic procurement of a kidney with multiple arteries, regardless of the number, is reliable and has no significant impact on the graft outcome.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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