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IMPACT OF RENAL ARTERY MULTIPLICITY ON OUTCOMES OF RENAL DONORS AND RECIPIENTS IN LAPAROSCOPIC DONOR NEPHRECTOMY

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ABSTRACT

Objectives. To review our laparoscopic donor nephrectomy experience to determine the impact of multiple renal arteries on renal donor and recipient outcomes. Multiple renal arteries can present a challenge during live laparoscopic donor nephrectomy.

Methods. During a 6-year period, 353 patients underwent laparoscopic donor nephrectomy and an equal number of patients underwent living-related renal transplantation. A retrospective chart review was performed to evaluate the renal donors and recipients associated with the laparoscopic procedure.

Results. Laparoscopic donor nephrectomies were associated with one renal artery in 277 cases (78.5%), two renal arteries in 71 cases (20.1%), and three renal arteries in 5 cases (1.4%). A left-sided procedure was most commonly performed in all three groups. The operative and renal allograft warm ischemia times increased with the number of renal arteries, but the differences were not statistically significant. The renal artery anatomy did not have a significant association with intraoperative blood loss, postoperative hospital stay, or complication rate in the donor group. Regarding the transplant recipients, renal artery multiplicity had no significant association with the complication rate, 1-year graft survival, or creatinine clearance levels at 1, 2, or 3 days or at 3, 6, or 12 months postoperatively.

Conclusions. With meticulous procurement and reconstructive transplantation techniques, the presence of multiple renal arteries in laparoscopic donor nephrectomy does not have a significant impact on the outcomes of the renal donors or recipients. UROLOGY **61:** 323–327, 2003. © 2003, Elsevier Science Inc.

Since the initial report in 1995, laparoscopic donor nephrectomy has evolved as an acceptable, safe alternative to open donor nephrectomy.[1–3] At present, it is performed at various institutions worldwide.[4] Successful laparoscopic donor nephrectomy involves meticulous procurement techniques, and the presence of multiple renal arteries presents a special challenge, because it may jeopardize not only the safety of the donor but also the survival and outcome of the allograft. The issue of renal artery multiplicity has become increasingly more important because the number of left-sided kidneys harvested has increased to greater than 90% of all live renal donor cases in the laparoscopic era compared with approximately 70% to 80% in the historical open series.[5] The aim of this initial report was to review our laparoscopic donor nephrectomy experience with respect to multiple renal arteries and their relationship to renal donor and recipient outcomes.

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MATERIAL AND METHODS

From February 1995 to August 2001, 353 patients (144 men and 209 women) underwent laparoscopic donor nephrectomy for living-related renal transplantation at our institution. The techniques of the laparoscopic procedure have been previously described.[6,7] After the renal allograft procurement, the recipients underwent the transplantation procedure, which was performed using the standard extraperitoneal approach, end-to-side anastomoses of the renal vessels to the recipient iliac vessels, and creation of a ureteroneocystostomy. In the cases involving two 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 computed tomography, angiography, and intraoperative in situ and back table evaluations. End-to-side accessory

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artery-to-main renal artery anastomosis and side-to-side conjoint artery-to-artery anastomosis were commonly used as reconstructive techniques before implantation to the recipient vessels.

A retrospective chart review was performed to identify and evaluate all laparoscopic donors and recipients (n = 706). All renal donors and recipients were categorized into three main groups according to the number of the renal arteries associated with the respective renal allografts (range 1 to 3). A comparison of these three groups was then performed in a pairwise manner with respect to various preoperative, intraoperative, and postoperative parameters. Statistical analysis was done using the two-tailed Student *t* test for quantitative data and Fisher's exact test for categorical data.

RESULTS

Of the 353 laparoscopic donor nephrectomies, renal allografts were found to be associated with one renal artery in 277 (78.5%), two renal arteries in 71 (20.1%), and three renal arteries in 5 cases (1.4%). None of the renal allografts from laparoscopic donor nephrectomy had four or more renal arteries.

Table I illustrates the demographic characteristics and various intraoperative and postoperative data of the laparoscopic renal donors. Most patients were young (between 30 and 40 years of age). Donors with three renal arteries were significantly younger than those with one or two arteries ($P = 0.02$ and 0.04, respectively). The left-sided procedure was most commonly performed in all three groups. The operative and renal allograft warm ischemia times increased with the number of renal arteries, but the differences among the three groups with different numbers of renal arteries were not statistically significant from one another. Moreover, the differences among the three groups with respect to intraoperative blood loss, postoperative hospital stay, and complication rates were not statistically significant.

Complications occurred in 35 (12.6%) of 277 renal donors with one renal artery, of which 11 (3.9%) were intraoperative and 24 (8.7%) were postoperative. Intraoperative complications included renal artery injury (2 patients), renal vein injury (2 patients), vascular stapling device failure or clip dislodgement (2 patients), bowel injury (4 patients), and splenic capsule tear (1 patient). Postoperative complications included neuromuscular injury (4 patients), incisional hernia (1 patient), thrombophlebitis (1 patient), orchalgia (3 patients), epididymitis (4 patients), testicular infarction (2 patients), pneumothorax (1 patient), pneumonia (1 patient), superficial wound infection (4 patients), epigastric artery injury requiring reoperative ligation (1 patient), and retroperitoneal bleeding without reoperation (2 patients). Among the renal donors with two renal arteries, complications occurred in 9 (12.7%) of 71 cases. Intraoperative complications occurred in 7 patients (9.9%) and included vascular stapling device failure (2 patients), splenic laceration (1 patient), enterotomy (1 patient), cystotomy (1 patient), and superficial adrenal vein laceration (2 patients). Postoperative complications occurred in 2 patients (2.8%): transient thigh numbness in 1 and superficial wound hematoma in 1 patient. No intraoperative or postoperative complications occurred in the renal donors with three renal arteries.

Table II illustrates the demographic characteristics and various intraoperative and postoperative outcomes with respect to the patients receiving renal transplants from the 353 laparoscopic donors. The renal recipients were likewise stratified into three groups on the basis of the number of renal arteries associated with their respective renal grafts (range 1 to 3). The three groups of recipients did not differ significantly from one another with respect to mean age, complication rate, 1-year graft loss, and creatinine clearance levels at 1, 2, or 3 days or 3, 6, or 12 months postoperatively. The mean follow-up time of the recipients with three renal arteries in their allografts (13.4 months) was significantly shorter than those of recipients with one or two renal arteries (29.0 and 28.6 months, $P = 0.04$ and 0.02, respectively).

No intraoperative complications occurred in any of the recipient groups. Postoperatively, complications occurred in 25 (9.0%) of 277 patients with one renal artery associated with their renal allograft, of which 6 (2.2%) were medical and 19 (6.9%) were surgical. The medical complications were cryptococcal sepsis (1 case), delayed graft failure (1 case), FK506 renal toxicity (3 cases), and early graft failure due to recurrent focal segmental glomerulosclerosis (1 case). The surgical complications included renal artery thrombosis (1 patient), urine leak/distal ureteral stricture requiring percutaneous urinary diversion or reoperative ureteral reimplantation (16 patients), superficial wound infection (1 patient), and testicular infarction (1 patient). Among the renal transplant recipients with an allograft with two renal arteries, postoperative complications occurred in 8 (11.3%) of 71 patients, of which two (2.8%) were medical and six (8.5%) were surgical. The medical complications were FK506 renal toxicity in 1 and cyclosporine toxicity in 1 patient. The surgical complications were urinary leak/distal ureteral stricture requiring reoperation (4 cases), renal vein thrombosis (1 case), and renal artery thrombosis (1 case). Among the 5 patients receiving renal allografts with three renal arteries, a postoperative complication occurred in 1 patient (distal ureteral stricture requiring ureteroureterostomy).

TABLE I. *Number of renal arteries and outcome of renal donors in laparoscopic donor nephrectomy*

	Donors with 1 Ipsilateral Renal Artery (n = 277)	Donors with 2 Ipsilateral Renal Arteries (n = 71)	Donors with 3 Ipsilateral Renal Arteries (n = 5)	*P* Value		
				Comparison of Donors with 1 and 2 Ipsilateral Renal Arteries	Comparison of Donors with 1 and 3 Ipsilateral Renal Arteries	Comparison of Donors with 2 and 3 Ipsilateral Renal Arteries
Mean age (yr)	41.4 (17–74)	40.8 (18–69)	30 (19–39)	0.67	0.02*	0.04*
Male (%)	113 (40.8)	28 (39.4)	4 (80)	0.80	0.35	0.39
Left-sided donor nephrectomy (%)	258 (92.8)	70 (98.6)	5 (100)	0.12	0.57	0.79
Mean total operative time (min)	253.5 (135–450)	266.4 (166–526)	295.3 (141–526)	0.14	0.65	0.74
Mean renal allograft warm ischemia time (s)	289.3 (120–3600)	293.4 (180–465)	306.6 (186–406)	0.82	0.87	0.66
Mean estimated blood loss (mL)	343.5 (50–12,000)	333.3 (100–2700)	250 (150–350)	0.88	0.19	0.23
Complications (%)	35 (12.6)	9 (12.7)	0 (0)	0.93	0.40	0.39
Intraoperative	11 (3.9)	7 (9.9)	0 (0)			
Postoperative	24 (8.7)	2 (2.8)	0 (0)			
Mean length of hospitalization (days)	3.4 (1–84)	3 (1–7)	2.5 (2–4)	0.32	0.19	0.28

Numbers in parentheses are the range, unless noted otherwise.
**Statistically significant difference.*

TABLE II. *Number of renal arteries and outcome of renal transplant recipients in laparoscopic donor nephrectomy*

	Recipients of Renal Allograft with 1 Renal Artery (n = 277)	Recipients of Renal Allograft with 2 Renal Arteries (n = 71)	Recipients of Renal Allograft with 3 Renal Arteries (n = 5)	*P* Value		
				Comparison of Recipients with 1 and 2 Allograft Renal Arteries	Comparison of Recipients with 1 and 3 Allograft Renal Arteries	Comparison of Recipients with 2 and 3 Allograft Renal Arteries
Mean age (yr)	43.1 (2–76)	42.6 (2–72)	52.6 (31–68)	0.80	0.17	0.15
Intraoperative complications (%)	0 (0)	0 (0)	0 (0)	1.0	1.0	1.0
Postoperative complications (%)	25 (9)	8 (11.3)	1 (20)	0.52	0.40	0.58
Medical	6 (2.2)	2 (2.8)	0 (0)			
Surgical	19 (6.8)	6 (8.5)	1 (20)			
Mean postoperative creatinine at 1 day (mg/dL)	4.8 (0.2–16.2)	5.1 (0.7–12.9)	4.1 (2.0–9.4)	0.43	0.56	0.43
Mean postoperative creatinine at 2 days (mg/dL)	2.8 (0.1–14.1)	3.0 (0.3–10.8)	1.7 (0.6–3.8)	0.47	0.34	0.22
Mean postoperative creatinine at 3 days (mg/dL)	2.5 (0.2–13.1)	2.6 (0.1–11.3)	1.4 (0.7–2.3)	0.67	0.30	0.26
Mean postoperative creatinine clearance at 3 mo (mL/min)	73.6 (8.2–178.8)	76.1 (33.0–143.6)	77.5 (53.5–142.8)	0.53	0.79	0.92
Mean postoperative creatinine clearance at 6 mo (mL/min)	71.2 (3.0–163.2)	74.4 (14.0–136)	63.7 (48.1–93.0)	0.33	0.57	0.39
Mean postoperative creatinine clearance at 12 mo (mL/min)	68.1 (3.0–68.9)	72.1 (31.0–133.8)	57.6 (52.9–62.2)	0.35	0.57	0.41
Mean postoperative follow-up (mo)	29.0 (1–73)	28.6 (2–60)	13.4 (3–30)	0.87	0.04*	0.02*
Graft loss at 1 yr (%)	14 (5.1)	5 (7.0)	0 (0)	0.48	0.61	0.53

Numbers in parentheses are the range, unless noted otherwise.
**Statistically significant difference.*

COMMENT

Laparoscopic donor nephrectomy has been shown by multiple investigators to be safe and effective, providing kidney donor and allograft outcomes comparable to those of open surgery.[2–4,8–10] However, the issue of multiple renal arteries in laparoscopic donor nephrectomy has not previously received much attention. The presence of multiple renal arteries is not an uncommon clinical problem and presents a special challenge in both donor nephrectomy and renal transplantation, because it often requires more complex procurement and reconstruction strategies and has a higher risk of longer renal warm ischemia time and less optimal allograft outcome.

To date, only one study has been reported addressing the issue of multiple renal arteries in laparoscopic donor nephrectomy.[11] In a retrospective review of 124 laparoscopic donor nephrectomies, Kuo *et al.*[11] identified 83 cases involving one renal artery, 33 cases involving two arteries, and 8 cases involving three arteries. In their report, the 1-year graft survival rate was 96.1%, 90.9%, and 90.0% for one renal artery, two renal artery, and three renal artery allografts, respectively, and the differences were not statistically significant. Moreover, the investigators reported that the number of renal arteries did not correlate with recipient ureteral complication. The impact of the multiple arteries on the laparoscopic renal donors, including intraoperative renal warm ischemia time, was not addressed, nor was the overall complication profile associated with the transplant recipients fully characterized.

In the present study of 353 laparoscopic renal donors, 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. Similar to the data reported by Kuo *et al.*,[11] the 1-year graft survival rates with respect to the different numbers of graft renal arteries in this series were equivalent, all greater than 90%. 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 intermediate-term follow-up. The individual types of complications associated with the donors and recipients in this series are similar to those previously reported.[3,4,9–13]

The equivalent renal donor and recipient outcomes with respect to the different numbers of renal arteries in laparoscopic donor nephrectomy from this report should be interpreted with caution. Successful outcomes in the presence of multiple renal arteries require two key components: meticulous procurement techniques by an experienced laparoscopic surgeon and precise reconstructive techniques by an experienced transplant surgeon. A breach in any part of the collaborative efforts is likely to lead to suboptimal outcomes.

CONCLUSIONS

The presence of multiple renal arteries presents a special challenge in both donor nephrectomy and renal transplantation. However, with meticulous surgical techniques, renal artery multiplicity in laparoscopic donor nephrectomy does not have a significant impact on the outcomes of renal donors or recipients.

REFERENCES

1. Ratner LE, Ciseck LJ, Moore RG, *et al:* Laparoscopic live donor nephrectomy. Transplantation **60:** 1047–1049, 1995.
2. Fabrizio MD, Ratner LF, and Kavoussi LR: Laparoscopic live donor nephrectomy: pro. Urology **53:** 665–667, 1999.
3. Flowers JL, Jacobs S, Cho E, *et al:* Comparison of open and laparoscopic live donor nephrectomy. Ann Surg **226:** 483–489, 1997.
4. Novotny MJ: Laparoscopic live donor nephrectomy. Urol Clin North Am **28:** 127–135, 2001.
5. Goldfarb DA: Are concerns over right laparoscopic donor nephrectomy unwarranted? J Urol **166:** 2558–2559, 2001.
6. Fabrizio MD, Ratner LE, Montgomery RA, *et al:* Laparoscopic live donor nephrectomy. Urol Clin North Am **26:** 247–256, 1999.
7. Ratner LE, Hiller J, Sroka M, *et al:* Laparoscopic live donor nephrectomy removes disincentives to live donation. Transplant Proc **29:** 3402–3403, 1997.
8. Lee BR, Chow GK, Ratner LE, *et al:* Laparoscopic live donor nephrectomy: outcomes equivalent to open surgery. J Endourol **14:** 811–819, 2000.
9. Brown SL, Biehl TR, Rawlins MC, *et al:* Laparoscopic live donor nephrectomy: a comparison with the conventional open approach. J Urol **165:** 766–769, 2001.
10. Jacobs SC, Cho E, Dunkin BJ, *et al:* Laparoscopic live donor nephrectomy: the University of Maryland 3-year experience. J Urol **164:** 1494–1499, 2000.
11. Kuo PC, Cho ES, Flowers JL, *et al:* Laparoscopic living donor nephrectomy and multiple renal arteries. Am J Surg **176:** 559–563, 1998.
12. Leventhal JR, Deeik RK, Joehl RJ, *et al:* Laparoscopic live donor nephrectomy—is it safe? Transplantation **70:** 602–606, 2000.
13. Hawasli A, Boutt A, Cousins G, *et al:* Laparoscopic versus conventional live donor nephrectomy: experience in a community transplant program. Am Surg **67:** 342–345, 2001.