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A Case-Matched Comparative Analysis of a Laparoscopic Donor Nephrectomy in Single and Multiple Renal Arteries

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ABSTRACT

Introduction: Laparoscopic live donor nephrectomy (LLDN), in cases with multiple renal arteries, has not been universally practiced worldwide. This paper demonstrates LLDN experience in donors with multiple arteries and compares the results with single artery donors on a case-matched basis.

Methods: Of 553 LLDN surgeries performed between December 1999 and November 2009, 132 cases were performed for multiple renal arteries. One hundred cases were selected. Detailed demographic profiles, operative profiles, and renal function tests in the immediate postoperative period and up to 1 year post transplantation were recorded. A matched comparison was made with 100 cases of LLDN in single arteries.

Results: Ninety-two cases had double arteries, 7 had triple arteries, and 1 revealed quadruple arteries prior to vascular disconnection. One accidental creation of 5 arterial branches was encountered. Warm ischemia time (WIT), total ischemia time (TIT), operative duration, blood loss, analgesic need, and hospital stay were significantly different between 2 groups ($p < 0.05$). No significant difference was observed in operative complications, renal function at 5 days, time to normalization of creatinine, or creatinine at 1 month, 3 months, and 1 year. Two patients in multiple artery groups required dialysis in the first postoperative week.

Conclusions: LLDN is equally feasible in the scenario of multiple renal arteries.

KEYWORDS: Laparoscopy, donor nephrectomy

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Acronyms and Abbreviations

ESRD: end stage renal disease
LLDN: laparoscopic live donor nephrectomy
USG: ultrasound
VCUG: voiding cystourethrogram 3D
CTA: three-dimensional spiral computed tomography angiogram
CTU: computed tomography urogram
MM: millimeter
GRT: Graft retrieval time (minutes)
WIT: Warm ischemia time (minutes)
GRT25, **WIT25**: GRT, WIT 25 cases, terminal and assisted approach
GRT75, WIT75: GRT, WIT 75 cases, total laparoscopic approach
CIT: cold ischemia time (minutes)
TIT: total ischemia time (minutes) RI= resistive index
AT: acceleration time
BMI: body mass index (kg/m2)
BL: blood loss (milliliters)
HS: hospital stay (days)
OD: operation duration (minutes)
OT: time to tolerance of orals (hours)
A: analgesic need (grams of paracetamol)
CNT: serum creatinine normalisation time (days)
Cr5d, **Cr1m**, **Cr3m**, **Cr6m**, **Cr1y**: serum creatinine at fifth postoperative day, 1 month, 3 months, 6 months, and 1 year post-transplantation (mg/dl)

INTRODUCTION

With the ever growing pool of sufferers with ESRD around the world [1], renal transplantation is an important tool for the practicing urologist. Since its evolution in animal models [2] and humans [3], LLDN has gained widespread acceptance as the procedure of choice for procuring donor renal allografts. Although the literature is enriched with LLDN experience in single renal arteries [4-7], data regarding LLDN for harvesting units harboring multiple renal arteries is scarce [8]. This paper presents laparoscopic harvesting of kidneys with single and multiple arteries by a single surgeon at 2 different centers, and it demonstrates comparisons on a case-matched basis.

PATIENTS AND METHODS

Renal transplantation has been performed at this center since 1989 where doctors initially harvested kidneys by flank

Figure 1. Port positions and extraction site for terminal hand-assisted (A) and total laparoscopic (B) left donor nephrectomy.
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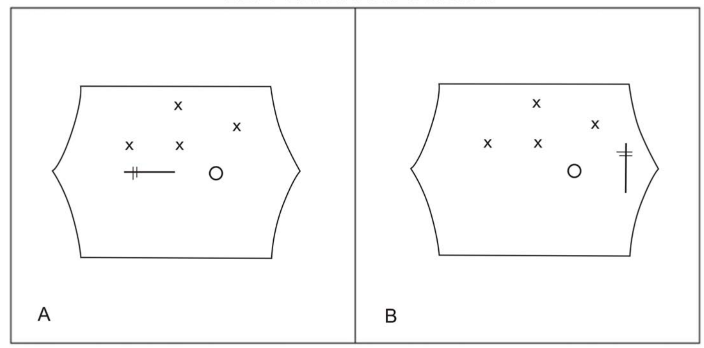

incisions. Since 1998, the laparoscopic approach was employed for harvesting kidneys. Patients undergoing LLDN with venous anomalies were excluded from the analysis.

PREOPERATIVE WORKUP

All donors were selected after complete evaluation, including detailed medical, surgical, psychological, and immunological evaluation. Imaging protocol included USG, 3D spiral CTA and CTU, and diuretic renogram. Recipients were evaluated thoroughly by the nephrology team, and a USG and a VCUG were included in their baseline workup. Recipients requiring native nephrectomy underwent laparoscopic left nephrectomy prior to renal transplantation, followed by right nephrectomy during transplant bed preparation via cranial extension of the incision for renal placement. Donors underwent bowel preparation the previous evening. All procedures were conducted under general anaesthesia. Intravenous antibiotics were administered at induction. One hundred ml of 20% mannitol were infused at the start of the procedure.

Operative exercise: Left LLDN

Patients were positioned in lateral decubitus with compression stockings and padded pressure points. Pneumoperitoneum was established by the Hasson technique. A transperitoneal approach was followed. Irrespective of vascular anatomy, 4 ports were employed for renal mobilization: 3 mm to 10 mm ports and 1 mm to 5 mm ports (Figure 1). The renal unit was

Figure 2. Insertion of fifth port (5 mm) through pfannenstiel incision prior to vascular disconnection during left donor nephrectomy.
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Figure 3. Port positions (A) and incision for graft retrieval (B) in right lap donor nephrectomy.
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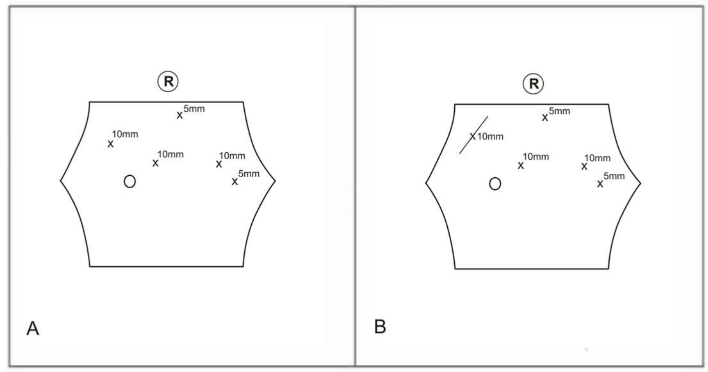

mobilized, following the plane between the renal capsule and the Gerota fascia. The gonadal vessels were clipped and divided. The lumbar and adrenal veins were similarly treated. Few attachments in the upper pole were preserved until vascular disconnection to avoid rotation of the renal unit and vascular torsion. After mobilization, 2 small gauze pieces fully soaked with papaverine (2 ml, 30 mg/ml) were applied around the renal artery. The pneumoperitoneum was released and 3 liters of normal saline were intravenously administered, along with 20 mg of frusemide. We waited for 15 minutes to allow for the complete action of papaverine on the renal artery. Thereafter, the pneumoperitoneum was re-established and preparation was made for the procurement of the kidneys.

Ureteric vascular disconnection and organ procurement: Terminal hand-assisted approach (left LLDN)

In the initial series (to January 2006), a terminal hand-assisted approach was practiced. An incision was made in the midline supraumbilically of just sufficient length for hand insertion (Figure 1). The left hand of the operating surgeon was introduced intraperitoneally after wrapping a piece of bandage at the level of the left wrist to ensure a snug fit and to prevent air leakage during insertion. No special hand port was employed. The ureter was divided after ensuring adequate length below the pelvis. Under hand control, the renal artery and vein were sequentially divided after applying 2 10 mm Hem-o-lok (Weck Closure Systems, Teleflex Medical) clips on the renal artery and vein. Clips were flush to the aorta and vena cava, ensuring the maximum length of the harvested vessels. The renal unit was procured through the same incision.

Ureteric, vascular disconnection and organ procurement: Total laparoscopic approach (left LLDN)

Since 2006, total laparoscopic mobilization and vascular disconnection were practiced. In this exercise, after complete mobilization and papaverine application, a Pfannenstiel incision was made, exposing the extraperitoneal layer (Figure 1). The length was just adequate enough to insert the hand. In addition, a 5 mm port (fifth port) was inserted through the midpart of this incision (Figure 2) and a retractor was placed through this port for additional retraction at the level of hilum. The ureter and the renal pedicle were dealt with in an identical fashion. In case of multiple arteries, the most accessible artery was secured first, irrespective of size, followed by the further arteries. Smaller arteries were secured using 5 mm Hem-o-lok clips or titanium clips (as deemed necessary) and larger arteries were secured with 10 mm Hem-o-lok clips. After the division of all arteries, the renal vein was held with a nontraumatic grasper, stretched optimally to ensure maximum procurable length, and divided. After division of the renal pedicle, the fifth port was removed and the peritoneal entry point was promptly extended along the line of the incision. The right hand of the operating surgeon was inserted and the disconnected kidney was procured and kept in ice slush.

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Right LLDN

The five ports employed for the right LLDN are depicted in Figure 3. The additional 5 mm port at the epigastrium was utilized for liver retraction. Renal mobilization and papaverine application were carried out in an identical fashion. After attaining satisfactory turgidity, an incision was made, centering the caudal 10 mm port (Figure 3). The left hand was inserted through this port and the division of the ureter and renal pedicle were carried out under hand control. The artery (arteries) was occluded first by the application of Hem-o-lok clips, followed by division of the same. The vein was then divided after applying 1 10 mm Hem-o-lok clip and 1 long titanium clip flush to the inferior vena cava. Renal extraction was performed by the already placed left hand through the same incision.

Figure 4. Vascular anastomosis for 4 donor renal arteries (A) and 3 donor renal arteries (B).

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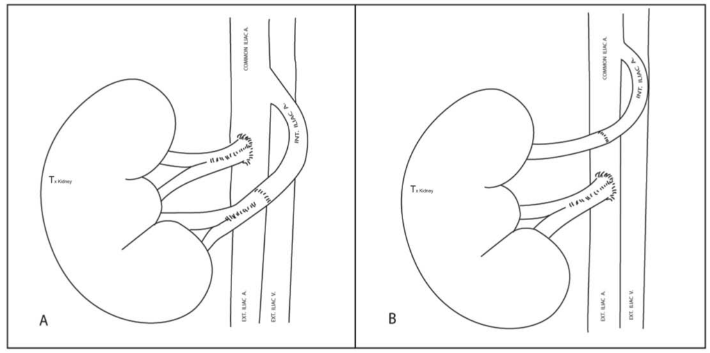

Procedure completion, postoperative course, and follow-up

After attaining satisfactory hemostasis, a drain was placed, and the ports and retrieval site were closed. Drain and catheter pullouts were scheduled as necessary. Subjects were sent home once fully ambulatory with satisfactory oral intake. They were recalled at 1 week, 1 month, and 1 year, postprocedure.

Bench preparation

Cold perfusant was instilled into the harvested renal unit followed by suture ligation of the venous tributaries. In the case of double arteries, double barrelling was performed in a side-to-side fashion, with 6/0 polypropelene sutures. In the cases of 3 arteries (Figure 4), 2 arteries were anastomosed side to side and the common stem was rejoined to the recipient's external iliac artery end to side, and the third artery anastomosed to the recipient's internal iliac artery in an end-to-end fashion. In cases with 4 arteries, 2 were joined together to the external iliac artery and 2 were joined together to the internal iliac artery (Figure 4). If the donor artery was supplying less than 5% of the renal surface area, it was simply ligated. If the internal iliac artery of the recipient was extremely small in caliber, all the donor arteries were anastomosed to the recipient's external iliac artery (1 case). Neoureterocystostomy was created obeying a modified Lich-Gregoir principle, with the placement of a 6/16 Fr double J stent.

Operative and postoperative parameters

Operative parameters like blood loss, operation duration, and intraoperative complications were noted. GRT was defined as the interval between first clip application on the renal artery until the procurement of the kidney and placement in ice slush. WIT was defined as GRT plus the time until clear effluent was obtained, following cold perfusant instillation. CIT was defined as the interval from clear effluent until the establishment of vascular continuity in the recipient. TIT was defined as WIT plus CIT. Postoperative events, such as the start of orals, analgesic requirement, and the duration of a hospital stay, were also recorded. The records of renal allograft recipients were recorded in terms of serum creatinine at the fifth postoperative day, the time to normalization of serum creatinine, dialysis need in the first postoperative week, and serum creatinine at 3 months, 6 months, and 1 year after transplantation. Ultrasound/Doppler examination of the transplant kidney was performed at 1 week, 3 months, 6 months, and 1 year posttransplant. RI ([peak systolic velocity – end diastolic velocity] / peak systolic velocity, normal 0.60 ± 0.019) and AT ([elapsed time in milliseconds from the beginning of systole to early systolic peak], normal < 70 msec 10) were compared.

Case matching

Case matching was done in terms of age (close match up to 2 years), BMI (close match within 2 points), laterality (left or right), and operative approach (terminal hand assistance or total laparoscopic). Also, all procedures (laparoscopic harvesting, bench preparation, and vascular anastomosis) were performed by a single surgeon, and bias due to interindividual surgical skill variability was eliminated.

Statistical analysis

Figure 5. Follow-up CT Angiogram (after 4 years of transplant) in a patient with accidental creation of 5 branches following division near the branch point during laparoscopic donor nephrectomy; 4 branches anastomosed to recipient and 1 branch ligated. Follow-up serum creatinine was 1.1 mg/dl.
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Statistical analysis was carried out employing the Mann-Whitney U test for all continuous variables (nonparametric). A p value < 0.05 was considered statistically significant.

RESULTS

Overall, 553 laparoscopic live donor nephrectomies were performed over 10 years by a single surgeon (GPA) at 2 different centers. One hundred and thirty-two cases were performed in multiple renal arteries, and 421 cases were performed in single renal arteries. Two hundred and three laparoscopic donor nephrectomies were performed using the terminal hand-assisted approach, and 350 laparoscopic donor nephrectomies were performed through total laparoscopic approach.

Demography/preoperative profile

Of the case-matched pool, 108 renal donors were males and 92 were females. No donors had any significant comorbidity. Prior surgical exposure in the form of tubal ligation was reported by 2 donors in a single artery group. The age profile (mean age ± SD 34.79 ± 5.9 years [range 21-52 years] for a single artery [Group I] versus 34.8 ± 6.8 years [range 22-51 years] for multiple arteries [Group II]) and BMI (mean BMI ± SD 25.1± 0.8 kg/m^2 [range 22.8-26.2 kg/m^2] for Group I versus 24.8 ± 1.1 kg/m^2 [range 22.2-26.8 kg/m^2] for Group II) was comparable in these 2 groups.

The age profile of allograft recipients was also similar between the 2 groups (mean age ± SD 37.39 ± 3.8 years [range 25-55 years] for Group I versus 37.8 ± 4.1 years [range 27-57 years] for Group II). The preoperative mean serum creatinine ± SD was 0.9 ± 0.15 mg/dl (range 0.6-1.2 mg/dl) for Group I and 0.8 ± 0.17 mg/dl (range 0.6-1.1 mg/dl) for Group II, and the preoperative mean GFR ± SD of the harvested kidney was 48 ± 3.15 ml/min (range 42.2-56.6 ml/min) for Group I and 49.89 ± 3.67 ml/min (range 43.4-58.1 ml/min) for Group II.

Preoperative imaging

The preoperative imaging for the delineation of the vascular anatomy also changed with time. A conventional CT angiogram was performed in 63 cases and a spiral CT angiogram was performed in 137 cases. In the multiple arteries group, laparoscopic donor nephrectomy was performed for 2 renal arteries in 92 cases (92%), 3 renal arteries in 7 cases (7%), and 4 renal arteries in 1 case (1%). In 71 cases in this group (69 double arteries, 2 triple arteries), a preoperative CT scan was correctly predictive of the vascular anatomy. In the remaining 29 cases, unprecedented multiple arteries were encountered during laparoscopic renal harvesting (23 double arteries, 5 triple arteries, and 1 quadruple artery). Disparity in the number of arteries delineated at preoperative imaging, and those actually perceived intraoperatively, was more frequently encountered in the prespiral CT angiogram era (26 versus 3 occasions).

Operative profile

All patients underwent LLDN successfully with no conversion to an open procedure. Twenty-five cases in each group underwent the terminal hand-assisted approach and 75 underwent the total laparoscopic approach. Eighty-five procedures were conducted on the left renal unit and 15 on the right renal unit in each group. In 1 case of single artery laparoscopic donor nephrectomy (after division near the branch point), 5 different arterial branches were created and 4 branches were anastomosed to the recipient external iliac artery after creating 2 common stems. One very small branch was ligated. At the 4-year follow-up, satisfactory function of the renal unit was obtained with a preserved renal profile in the recipient (Figure 5).

Operative/postoperative complications

Operative complications encountered in 2 groups were almost similar (4 in each group). Two patients sustained sutured bowel injury. Significant vascular complications were experienced on 5 occasions (1 arterial clip slippage, 1 avulsion of the right renal vein, and 3 lumbar vein disruptions, all on the left side). Unaccustomed bleeding from the ureteral stump was encountered in 1 case that presented 3 weeks following the donor nephrectomy, with significant intraperitoneal hematoma. The hematoma was evacuated through the laparoscopic approach. Seven patients (3.5%) experienced delayed graft function (4 patients in Group I: 2 had hyperacute rejection and 2 had acute tubular necrosis, and 3 patients in Group II: 3 had acute tubular necrosis). All others revealed satisfactory graft function immediately after the establishment of vascular continuity. Other noteworthy complications in the allograft recipients included graft thrombosis (2 cases), sloughing of the ureteric stump (2 cases), lymphocele (3 cases, 2 in Group I and 1 in Group II, laparoscopic marsupialization done in all), forgotten ureteral stent (1 case), and calf vein thrombosis (2 cases). Two patients experienced hyperacute rejection that was managed by plasmapheresis and antithymocyte globulin. Five patients experienced acute tubular necrosis in the immediate postoperative period (2 in Group I and 3 in Group II) that recovered on conservative management. Three recipients in Group I and 2 recipients in Group II required supportive dialysis in the first postoperative week. Graft nephrectomy was required in 2 cases. Both patients belonged to a single artery group. Both patients exhibited vascular thrombosis. No patients revealed stenosis of the graft artery.

Comparative analysis

The comparison of operative parameters, postoperative events, and follow-up serum creatinine levels are depicted in Table 1. The mean ± SD serum creatinine of the donor at 1 month postprocedure was 1 ± 0.1 mg/dl (range 0.6 to 1.4 mg/dl) for Group I and 1.1 ± 0.1 mg/dl (range 0.5 to 1.2 mg/dl) for Group II. Graft survival rates were 97% in Group I and 96% in Group II.

Statistical interpretation

A significant difference was noted in terms of WIT, TIT, blood loss, operation duration, and hospital stay between the 2 groups. The time to oral tolerance and analgesic need for the donor, time taken to normalization of serum creatinine, and acceleration time intervals at posttransplantation renal Doppler for the recipient were also significantly less in the single artery group. However, the difference in RI between the recipients of the 2 groups did not reach any statistical significance. The difference in serum creatinine levels of the transplant recipients at the fifth postoperative day and at 3 monthly intervals up to 1 year did not achieve statistical significance.

DISCUSSION

With the ever-growing pool of ESRD sufferers, the demand for renal transplantation is constantly on the rise worldwide. Crossing more than a decade since its evolution, the laparoscopic approach for renal harvest has clearly surpassed the traditional open approach in terms of a morbidity profile and patient satisfaction, and it may well be considered the gold standard procedure for renal procurement [2-7,11-14]. Donor vascular anatomy plays a pivotal role in decision making for a LLDN. Due to technical issues, a renal unit harboring a solitary renal artery is preferred than one with multiple arteries. Additionally, the left kidney is preferred for laparoscopic harvesting in view of the longer procurable length of the left renal vein in comparison to its right counterpart. However, in 18 to 30% of cases, one may be met with multiple unilateral donor renal arteries [15,16], and in 2 to 15% of cases, bilateral multiple arteries may result [17,18]. In these scenarios, the donor is often denied organ donation or the renal unit is harvested through an incisional approach.

Occasionally, during the performance of LLDN for a single artery, one may be faced with unprecedented multiple arteries that may have been missed in preoperative imaging. This accidental finding has often culminated in conversion from a minimally invasive approach to incisional access. Thus a significant patient pool may be bereft of the benefits of a procedure with low morbidity. To date, few centers worldwide have proclaimed successful performances of laparoscopic donor nephrectomies

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Table 1. Mann Whitney U analysis of operative, postoperative, and outcome parameters between Groups I and II.
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Variable	Group I median	95% LCL-UCL Group I		Group II median	95% LCL-UCL Group II		Z value	p
GRT_{25}	1.4	1.3	2	2.2	2	2.4	4.8901	$p < 0.05$
GRT_{75}	3.0	2.5	3.1	3.4	3.4	3.4	6.7897	$p < 0.05$
WIT_{25}	3.3	3.1	3.4	4	3.5	4.3	5.7501	$p < 0.05$
WIT_{75}	4.2	3.8	4	5.5	5	5.5	7.4317	$p < 0.05$
TIT	85	83	88	110	108	115	11.36	$p < 0.05$
BL	120	115	125	140	130	200	6.067	$p <0.05$
OD	90	85	95	100	115	130	10.803	$p < 0.05$
OT	22	20	24	24	22	24	3.65	$p < 0.05$
HS	3	3	3	4	4	4	4.307	$p < 0.05$
A	2500	2000	2500	3000	2500	3000	5.219	$p < 0.05$
CNT	90	80	100	100	100	110	4.923	$p < 0.05$
RI	0.6	0.59	0.61	0.63	0.61	0.64	1.52	0.0647
AT	40	35	45	52.5	47.5	57.5	6.43	$p < 0.05$
Cr_{5d}	1.4	1.4	1.4	1.6	1.6	1.6	-5.283	1
Cr_{1m}	1.4	1.4	1.5	1.5	1.4	1.5	-1.200	0.8849
Cr_{3m}	1.5	1.5	1.5	1.4	1.4	1.4	9.1017	$p < 0.05$
Cr_{6m}	1.4	1.4	1.6	1.3	1.3	1.4	3.9112	$p < 0.05$
Cr_{1y}	1.4	1.4	1.6	1.6	1.3	1.9	1.0743	0.1413

in multiple arteries in sufficient volumes [18-20].

Over the last 10 years, LLDN for single as well as multiple renal arteries has been regularly conducted by the same surgical team and no harvesting has been undertaken through incisional approaches during this timeframe. The incidence of multiple renal arteries in various reported series of left LLDN ranges from 9 to 30% [19,21,22]. In our series, the left renal unit harbored multiple arteries in 18.44% of cases (102/553) and the right renal unit in 5.42% of cases (30/553). Preoperative delineation of renal vascular anatomy plays a crucial role in decision making for laparoscopic harvesting. Current imaging modalities claim high accuracy in predicting renal vascular anatomy [23]. CTA is the most popular investigation modality for this purpose and our experience supports the same.

In the prespiral CTA era in our patient pool, intraoperative unprecedented detection of additional arteries was encountered on 26 occasions (41.27%). By contrast, since the incorporation of spiral CTA, such happenings were experienced on 3 occasions only (2.19%). This establishes the importance of inclusion of a 3D spiral CTA in donor imaging protocol. The technical challenges for laparoscopic harvesting in multiple arteries are multipronged. During the dissection of individual renal arteries, the risk of inciting vascular injury or precipitating arterial spasm, especially in small sized arteries, is high. Gentle handling of the arteries is mandatory. Division of the main renal artery, sufficiently away from the branch point, mandates wide mobilization of the artery until aortic hiatus. In the case of small caliber accessory arteries, the division should be sufficiently close to the aortic origin so as to preserve a maximum possible length and allow a wide spatulated anastomosis with its counterpart. Avoidance of Endo GIA staplers (U.S. Surgicals, Norwalk, Conn) or large Hem-o-lok clips may help in gaining additional length during the division of small arteries.

Another important issue is the effect of pneumoperitoneum on the parenchymal vascular supply. We doctrine few approaches to counter this effect and these steps are diligently followed in all LLDN. Intra-abdominal pressure is maintained at 12 mm mercury throughout the operative exercise. After complete mobilization, the pneumoperitoneum is released for a sufficient interval during which papverine is applied to the artery (main and accessory arteries in cases with multiple renal arteries). During this time, the subject is well hydrated and diuretics are administered. Thereby optimum turgidity with good diuresis of the renal unit is achieved prior to vascular disconnection. The overall warm ischemia times between the 2 groups in our series differed significantly (3.5 ± 0.2 minimum in Group I versus 5.1 ± 0.4 minimum in Group II). The mean warm ischemia time in the multiple artery group was slightly better than most published series [18-20,24], but more than that were reported by Singh et al. [24]. Although a statistically significant difference in warm ischemia time between the hand-assisted approach and the total laparoscopic approach was noted, this had no correlation with the long term graft behavior among these 2 groups (hand-assisted versus total laparoscopic).

The terminal hand-assisted approach renders superior control of the renal pedicle during division and has been popular among many groups [5,7]. However, in our opinion, it limits the space available for the movement of laparoscopic instruments and a total laparoscopic approach is more comfortable to the operating surgeon. Also, with experience, even challenging vascular anatomies can be adequately mobilized by the total laparoscopic approach and no significant increase in vascular complications is encountered. Hence, in the later part of our series (since 2006), we have universally practiced the total laparoscopic approach for the left side. In view of the shorter and thin renal vein on the right side, we prefer to continue the terminal hand-assisted approach for harvesting the right renal unit. Various techniques have been proposed to accomplish the harvesting of a satisfactory length of renal vein in right LLDN [25,26].

In our practice, all right procedures were conducted without employment of any additional gadgetry (Satinsky clamp or Endo GIA stapler) and the satisfactory length of renal vein could be obtained. The division of the renal vein under hand guidance ensures superior vascular control and minimizes the potential of vascular insult. Also, the application of the Endo GIA stapler may decrease the length of the available vein and the vascular anastomosis may be jeopardized. The overall operative time was significantly different between the 2 groups (90 ± 5 minutes for Group I versus 115 ± 7 minutes for Group II) but considerably less than other published series [19,20,27]. This may be attributable to the entire series being performed by the same surgeon and the same operating team who are thoroughly trained and well versed with the entire operative protocol. The series also excluded the initial cases performed, and the possibility of a surgical learning curve confounding the results was eliminated.

Other morbidity parameters were also comparable to the other published series. No significant difference was obtained between the 2 groups in terms of serial follow-up creatinine levels and postoperative Doppler parameters. The mean serum creatinine at 1 year was not significantly different between both groups (1.6 ± 0.2 mg/dl versus1.6 ± 0.4 mg/dl) but was slightly higher than other published series [19,20,27]. One-year graft survival rates were also at par with other contemporary series [19,27,28]. A high rate of vascular complications, including graft thrombosis, renal artery stenosis, and an increased risk of renovascular hypertension, have been described for multiple renal artery grafts [17]. In our series, 2 graft thrombosis results were encountered, both in a single artery group. No additional vascular insults were encountered in multiple artery grafts. No case of graft artery stenosis was encountered in either group. This may be attributable to our routine practice of wide spatulation of both the graft artery and the recipient artery at the anastomotic site.

The overall ureteric complication rate (1%) was comparable to the series reported by Desai et al. and less than in other series [19,8,21]. The avoidance of thermal energy during ureteric handling, wide spatulation of the ureter, and watertight approximation to the bladder mucosa are important issues in minimizing the incidence of postoperative ureteric stenosis, and these steps were diligently followed. Similar to the narrations by Troppmann et al. [8], no significant difference in the occurrence of lymphoceles in a recipient was perceived between the 2 groups. The organ procurement was routinely performed by manual extraction. The graft retrieval site was in the upper midline in the hand-assisted group and Pfannenstiel in the total laparoscopic group. The mean incision length was 6.5 cm in both techniques (terminal hand-assisted versus total laparoscopic). This was in contrast to the technique of organ retrieval practiced by other groups who employed endocatch bag extraction or manual bag traction [18-20,29]. However, no additional complications attributable to this incision were remarked.

Finally, the learning curve associated with LLDN cannot be overlooked. In our practice, LLDN was established after a period of laparoscopic-assisted renal harvesting followed by laparoscopic harvesting. Additionally, LLDN for multiple arteries was regularized after gaining proficiency with single artery LLDN and other laparoscopic procedures. The operator needs to be sufficiently versed with laparoscopic anatomy and laparoscopic exercises prior to inculcating this approach in routine practice.

CONCLUSION

Although technical challenges exist, LLDN may be conveniently performed in renal donors with multiple arteries. A 3D spiral CTA is invaluable for preoperative vascular delineation and donor selection. The morbidity profile in multiple artery LLDN is comparable to that following single artery LLDN with no increased incidence of major vascular complications. The long-term outcome is also at par with that achieved following single artery LLDN.

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REFERENCES

1. Agarwal, S. K., S. C. Dash, et al. (2005). "Prevalence of chronic renal failure in adults in Delhi, India." *Nephrol Dial Transplant* 20(8): 1638-1642. PubMed ; CrossRef

2. Gill, I. S., J. M. Carbone, et al. (1994). "Laparoscopic live-donor nephrectomy." *J Endourol* 8(2): 143-148. PubMed ; CrossRef

3. Ratner, L. E., L. J. Ciseck, et al. (1995). "Laparoscopic live donor nephrectomy." *Transplantation* 60(9): 1047-1049. PubMed

4. Schulam, P. G., L. R. Kavoussi, et al. (1996). "Laparoscopic live donor nephrectomy: the initial 3 cases." *J Urol* 155(6): 1857-1859. PubMed ; CrossRef

5. Wolf, J. S., Jr., M. B. Tchetgen, et al. (1998). "Hand-assisted laparoscopic live donor nephrectomy." *Urology* 52(5): 885-887. PubMed ; CrossRef

6. Jacobs, S. C., E. Cho, et al. (2000). "Laparoscopic live donor nephrectomy: the University of Maryland 3-year experience." *J Urol* 164(5): 1494-1499. PubMed ; CrossRef

7. Slakey, D. P., J. C. Wood, et al. (1999). "Laparoscopic living donor nephrectomy: advantages of the hand-assisted method." *Transplantation* 68(4): 581-583. PubMed ; CrossRef

8. Troppmann, C., K. Wiesmann, et al. (2001). "Increased transplantation of kidneys with multiple renal arteries in the laparoscopic live donor nephrectomy era: surgical technique and surgical and nonsurgical donor and recipient outcomes." Arch Surg 136(8): 897-907. PubMed ; CrossRef

9. Tublin, M. E., R. O. Bude, et al. (2003). "Review. The resistive index in renal Doppler sonography: where do we stand?" *AJR Am J Roentgenol* 180(4): 885-892. PubMed

10. Sigirci, A., T. Hallac, et al. (2006). "Renal interlobar artery parameters with duplex Doppler sonography and correlations with age, plasma renin, and aldosterone levels in healthy children." *AJR Am J Roentgenol* 186(3): 828-832. PubMed ; CrossRef

11. Wolf, J. S., Jr., R. Marcovich, et al. (2000). "Prospective, case matched comparison of hand assisted laparoscopic and open surgical live donor nephrectomy." *J Urol* 163(6): 1650-1653. PubMed ; CrossRef

12. Jacobs, S. C., E. Cho, et al. (2004). "Laparoscopic donor nephrectomy: the University of Maryland 6-year experience." *J Urol* 171(1): 47-51. PubMed ; CrossRef

13. Flowers, J. L., S. Jacobs, et al. (1997). "Comparison of open and laparoscopic live donor nephrectomy." *Ann Surg* 226(4): 483-489; discussion 489-490. PubMed ; CrossRef

14. Ratner, L. E., J. Hiller, et al. (1997). "Laparoscopic live donor nephrectomy removes disincentives to live donation." *Transplant Proc* 29(8): 3402-3403. PubMed ; CrossRef

15. Flechner, S. M., C. M. Sandler, et al. (1985). "100 living-related kidney donor evaluations using digital subtraction angiography." *Transplantation* 40(6): 675-678. PubMed ; CrossRef

16. Pollak, R., B. F. Prusak, et al. (1986). "Anatomic abnormalities of cadaver kidneys procured for purposes of transplantation." *Am J Surg* 52(5): 233-235. PubMed

17. Roza, A. M., L. J. Perloff, et al. (1989). "Living-related donors with bilateral multiple renal arteries. A twenty-year experience." *Transplantation* 47(2): 397-399. PubMed ; CrossRef

18. Oesterwitz, H., V. Strobelt, et al. (1985). "Extracorporeal microsurgical repair of injured multiple donor kidney arteries prior to cadaveric allotransplantation." *Eur Urol* 11(2): 100-105. PubMed

19. Desai, M. R., A. P. Ganpule, et al. (2007). "Outcome of renal transplantation with multiple versus single renal arteries after laparoscopic live donor nephrectomy: a comparative study." *Urology* 69(5): 824-827. PubMed ; CrossRef

20. Hsu, T. H., L. M. Su, et al. (2003). "Impact of renal artery multiplicity on outcomes of renal donors and recipients in laparoscopic donor nephrectomy." *Urology* 61(2): 323-327. PubMed ; CrossRef

21. Kuo, P. C., E. S. Cho, et al. (1998). "Laparoscopic living donor nephrectomy and multiple renal arteries." *Am J Surg* 176(6): 559-563. PubMed ; CrossRef

22. Sasaki, T. M., F. Finelli, et al. (2000). "Is laparoscopic donor nephrectomy the new criterion standard?" *Arch Surg* 135(8): 943-947. PubMed ; CrossRef

23. El Fettouh, H. A., B. R. Herts, et al. (2003). "Prospective comparison of 3-dimensional volume rendered computerized tomography and conventional renal arteriography for surgical planning in patients undergoing laparoscopic donor nephrectomy." *J Urol* 170(1): 57-60. PubMed ; CrossRef

24. Singh, D., C. A. Sidney, et al. (2004). "Laparoscopic living donor nephrectomy in patients with multiple renal arteries or anomalous renal veins (abstract)." *J Urol* 171(4): 515.

25. Abrahams, H. M., C. E. Freise, et al. (2004). "Technique, indications and outcomes of pure laparoscopic right donor nephrectomy." *J Urol* 171(5): 1793-1796. PubMed ; CrossRef

26. Turk, I. A., S. Deger, et al. (2002). "Laparoscopic live donor right nephrectomy: a new technique with preservation of vascular length." *J Urol* 167(2 Pt 1): 630-633. PubMed ; CrossRef

27. Gurkan, A., S. Kacar, et al. (2004). "Do multiple renal arteries restrict laparoscopic donor nephrectomy?" *Transplant Proc* 36(1): 105-107. PubMed ; CrossRef

28. Basaran, O., G. Moray, et al. (2004). "Graft and patient outcomes among recipients of renal grafts with multiple arteries." *Transplant Proc* 36(1): 102-104. PubMed ; CrossRef

29. Shalhav, A. L., T. M. Siqueira, Jr., et al. (2002). "Manual specimen retrieval without a pneumoperitoneum preserving device for laparoscopic live donor nephrectomy." *J Urol* 168(3): 941-944. PubMed