



Laparoscopic Live Donor Nephrectomy: Comparison of Outcomes Right Versus Left

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ABSTRACT

Objective. To compare outcomes between right- and left-sided laparoscopic live donor nephrectomy (LDN). Left LDN (LLDN) remains the side of choice whenever possible because the left renal vein is longer; however, there are some donors in whom the right kidney is taken for donation due to anatomical or functional reasons. Right LDN (RLDN) is perceived to be difficult due to anatomical factors. Therefore, many surgeons have a bias for left kidney donation or will do right side donation as an open donor nephrectomy. At our institution, we routinely perform RLDN when indicated and herein compare the outcomes between right- and left-sided LDN.

Methods. From January 2007 to January 2017, 1850 laparoscopic donor nephrectomies were conducted at the Max Super Speciality Hospital. Of these, 168 were right-sided donor nephrectomies and 1682 were left-sided donor nephrectomies. All the donor case records were retrospectively reviewed; the operative time, warm ischemia time, intraoperative events, blood loss, and postoperative parameters were recorded. The kidney recipient data were also recorded.

Results. The donor demographic characteristics were comparable between 2 groups. Among other variables, operating time was significantly less in RLDN (120 minutes) versus the LLDN group (146 minutes). Intraoperative estimated blood loss (118 mL in RLDN; 126 mL in LLDN), warm ischemia time (4.8 minutes in RLDN; 5.2 minutes in LLDN) and hospital stay (4.2 days in RLDN; 4.3 days in LLDN) was comparable. Vascular complications occurred in four patients in the RLDN group and six cases in the LLDN group. Recipient outcomes were comparable.

Conclusions. With adequate experience, RLDN can be accomplished in a safe manner with comparable outcomes to LLDN.

LAPAROSCOPIC live donor nephrectomy (LDN) was first introduced in 1995 [1] to decrease morbidity of live kidney donation. Since its introduction, the technique for LDN has continued to be improved upon and has become the standard of care [2,3]. Left LDN remains the side of choice whenever possible because the left renal vein is longer; however, there are some donors in whom right kidney is taken for donation due to anatomical or functional reasons.

Right LDN is perceived to be difficult due to anatomical factors and is also reported to have a small increase in risk of allograft failure [4]. Therefore, many surgeons have a bias for left kidney donation or will choose to conduct right side donations as open donor nephrectomies. At the time of publication, only a few centers in India are conducting right

donor nephrectomy laparoscopically. The potential technical difficulty of harvesting the right kidney laparoscopically is shortening the relatively shorter vein and thereby increasing the complexity of the recipient surgery. We routinely perform right LDN at the Max Super Speciality Hospital when indicated, and herein compare the outcomes between right and left-sided LDN at this institution.

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MATERIALS AND METHODS

From January 2007 to January 2017, 1850 laparoscopic donor nephrectomies were conducted at the Max Super Speciality Hospital. Of these, 168 were right-sided donor nephrectomies and 1682 were left-sided donor nephrectomies. All the donor case records were retrospectively reviewed; the operative time, warm ischemia time, intraoperative events, blood loss, and postoperative parameters were recorded. The kidney recipient data regarding postoperative serum creatinine, episodes of acute tubular necrosis (ATN), vascular or ureteric complications, and delayed graft function were also recorded in addition to any readmission or complications. One hundred forty-six right LDNs were conducted using the transperitoneal approach and 22 right LDNs were conducted via the retroperitoneal approach.

Indications for Performing Right LDN

A right donor nephrectomy was performed in the following situations:

1. The left kidney was better functioning, according to a difference in GFR more than 10% as measured on diethylenetriamine pentaacetic acid renogram.
2. There were more than 2 left renal arteries and fewer renal arteries on right side.
3. The right kidney has some pathology (eg, cysts, stones, or angiomyolipomas).

Preoperative Preparation

All the donors were hydrated overnight with 1.5 L of intravenous fluids. All patients received a low molecular weight heparin injection and a rectal enema preoperatively.

Standard Operative Techniques

Laparoscopic live donor nephrectomy can be done transperitoneally or retroperitoneally on either side. The transperitoneal approach is most common, because it allows adequate working space and easy dissection.

Right Transperitoneal Approach. Modifications have been made in right laparoscopic LDN (RLDN) to compensate for shorter vessels and to prevent thrombotic complications.

Techniques to gain arterial length included:

1. Dissection of the interaortocaval space to allow division of the right renal artery at its origin, rather than at the lateral border of the vena cava (Fig 1).
2. Mobilizing the vena cava by dividing the lumbar veins to gain arterial length. This allows the vena cava to be rolled anteriorly and the kidney to be placed in a flipped position, increasing exposure of the right renal artery at its origin from the aorta (Fig 2). The kidney is then retracted laterally and a Hem-o-lok vascular clip (Weck Closure Systems, Research Triangle Park, NC, United States) placed parallel to the aorta at the origin of the right renal artery, thus allowing for the maximization of the arterial length.

Techniques to maximize venous length included:

1. Using a TA-30 stapler (Covidien, Dublin, Republic of Ireland), which fires 2 staple lines without cutting (Fig 3). The vein is subsequently cut flush with the staple line to gain extra length (Fig 4). The stapler is introduced through the lateral trocar site in a plane parallel to the inferior vena cava (IVC). The parallel

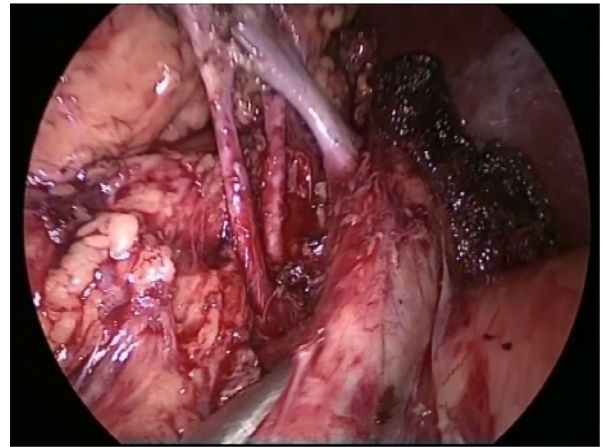


Fig 1. Inferior vena cava pushed down to gain arterial length.

orientation of the stapler in relation to the vena cava results in preservation of additional right renal vein length.

2. Using a large (15 mm) Hem-o-lok clip for the renal vein if a TA-30 stapler is not available. The applicator was introduced parallel to IVC to get maximum length of the renal vein.
3. Using a laparoscopic Satinsky clamp to obtain a cuff of the vena cava, which is then repaired intracorporeally. This was done only in 1 occasion when there were 2 renal veins joining just before opening in the IVC.
4. When the renal vein was very short, using recipients' saphenous vein to lengthen the renal vein (Figs 5, 6).
5. Completely mobilizing the iliac vein in the recipient by dividing all of its posterior branches to bring it up in the wound for a tension-free anastomosis.
6. Keeping the graft upside down for easier anastomosis.

Right Retroperitoneal Approach. The donor was placed in an overextended flank position. The first incision was given just below the tip of 12th rib, and the underlying muscles were split until the thoracolumbar fascia was seen. The fascia was incised sharply to enter the retroperitoneal space. Blunt finger dissection of the pararenal fatty tissue was done to separate the fatty tissue from the

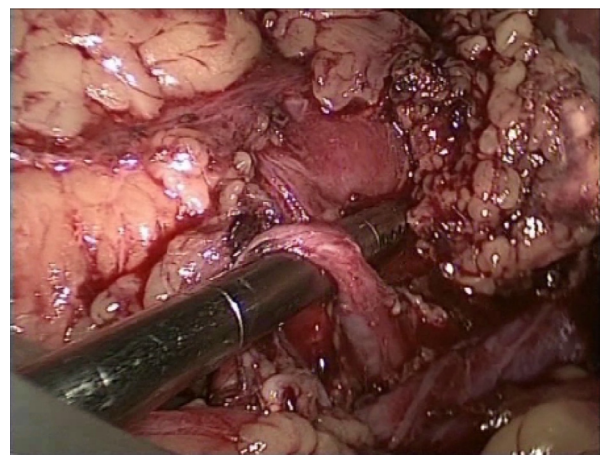


Fig 2. Kidney dissected all around and flipped medially. Right renal artery dissected behind inferior vena cava.

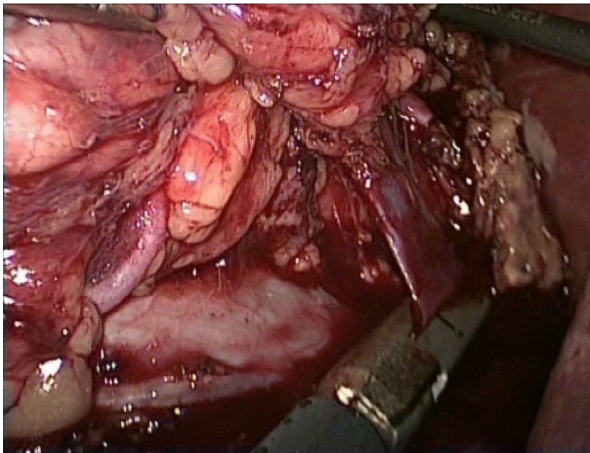


Fig 3. TA-30 stapler being applied over inferior vena cava.

abdominal wall to create an initially small retroperitoneal space for placement of the dilating balloon. The retroperitoneal space was created using a PBD-1000 balloon device (Tyco Healthcare, Norwalk, CT, United States). A 12 mm trocar replaced the balloon device and was used as a camera port. Two more trocars (12 mm and 10 mm) were placed within the field of vision. During operation, a pressure of about 10 to 12 mm Hg was sufficient to maintain a retroperitoneal working space. Monopolar hooks, scissors, or harmonic scalpels were used for dissection.

After identifying the psoas muscle, the Gerota's fascia was incised laterally in order to free the retroperitoneal space in the cranial and caudal direction. It was important to keep the psoas muscle horizontally on the video screen to remain oriented. The ureter was identified near the medial edge of the psoas muscle. Careful not to dissect the periureteric sheath and damage the nutritive vessels of the ureter, the perirenal fatty tissue was identified and the renal vessels were freed from the surrounding lymphatic tissue. Gentle and meticulous dissection was necessary to avoid injuries to the renal vessels. The kidney was retrieved by any of the following incisions: a muscle-splitting lumbotomy incision, an iliac fossa incision inferior to the anterior port, or by a Pfannenstiel incision after creating space extraperitoneally.

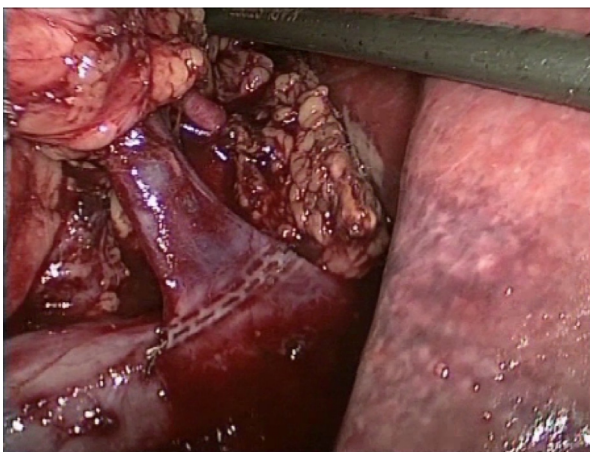


Fig 4. Right renal vein ready to be cut just above staple line.



Fig 5. Saphenous vein opened longitudinally and reconstructed.

We used 15 mm Weck Clips for ligating the renal artery and left renal vein. Two clips were applied on each artery and vein and some tissue was left over the vessels to avoid slippage. One titanium clip was placed additionally below the two Weck clips prior to renal arterial division (Fig 7). After kidney retrieval, the pneumoperitoneum was recreated to check for hemostasis at a lower intra-abdominal pressure. Patients began a clear liquid diet on the first postoperative day. Foley catheters were removed on the first postoperative day, and a metabolic panel and complete blood cell count was obtained. Patients were discharged when they were able to tolerate a regular diet and ambulate without assistance.

RESULTS

The demographic characteristics of donors were comparable between 2 groups (Table 1).

Among other variables, operating time was significantly less in the RLDN (120 minutes) versus the LLDN group (146 minutes). Intraoperative estimated blood loss (118 mL in RLDN; 126 mL in LLDN), warm ischemia time



Fig 6. Reconstructed saphenous vein sutured end to end to short renal vein.

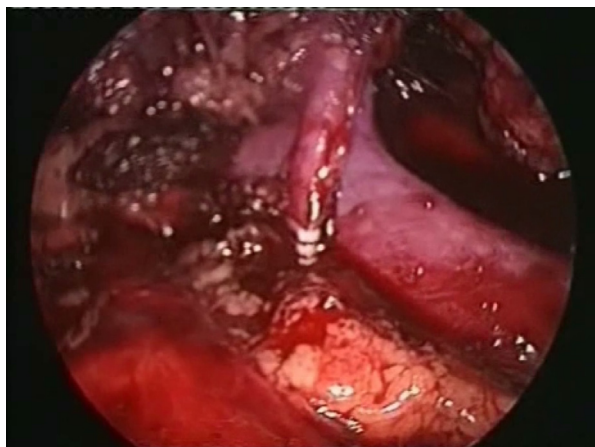


Fig 7. Right retroperitoneal live donor nephrectomy—right renal artery clipped.

(4.8 minutes in RLDN; 5.2 minutes LLDN) and hospital stay (4.2 days in RLDN; 4.3 days in LLDN) were comparable.

Twenty-eight patients had two renal arteries and three patients had two renal veins in the RLDN group. Eleven patients had early branching (within 1.0 cm from the aortic origin) of the renal artery on the right side. Division of the right renal vein was done via endo-TA-30 stapler (Covidian, Dublin, Republic of Ireland), in 104 cases and by Hem-o-lok vascular clips (Weck Closure Systems, Research Triangle Park, NC, United States) in 64 cases.

Vascular complications occurred in 4 patients in the RLDN group and 6 cases in the LLDN group.

Three patients had bleeding from the IVC that was controlled laparoscopically in 2 cases and necessitated conversion to open nephrectomy in 1 case. The patient in whom conversion to open nephrectomy was done also had a short (less than 1 cm) renal vein that was the main justification for conversion.

Three patients had aortal bleeding that was sutured laparoscopically in 2 patients. The third patient had an aortic injury during initial camera port insertion and an immediate open conversion and repair of the aortic injury were conducted.

Table 1. Patient Demographics and Other Variables

Variables	Range (mean)	
	RLDN (n = 168)	LLDN (n = 1682)
Age, years	19–65 (40.4)	18–76 (43.2)
Female/male	121/47	1156/526
BMI	20–33 (25.4)	21–35 (26.8)
Estimated blood loss, mL	60–500 (118)	50–2000 (126)
Duration of surgery, min	80–170 (120)	90–210 (146)
Warm ischemia time, min	3.5–8 (4.8)	4–7 (5.2)
Hospital stay, days	3–6 (4.2)	3–20 (4.3)

Abbreviations: BMI, body mass index; LLDN, left live donor nephrectomy; RLDN, right live donor nephrectomy.

Three patients had renal vein injuries, which were managed laparoscopically.

One patient had injury to the superior mesenteric artery (SMA) near its origin from the aorta during left LDN, which required conversion to open nephrectomy to repair the injury.

Two patients in the LLDN group had bowel injuries. One was recognized immediately and laparoscopically sutured. In the other patient, colonic injury (thermal) manifested on postoperative day 4. An open exploratory laparotomy (as the patient was 70 years old and in septic shock) and a colostomy was done. This patient did not improve and was on a ventilator and inotropic support and died on postoperative day 20 due to multiple organ failure.

One patient had self-limited liver injury due to traction. Two patients had traction-related splenic injury, which were controlled laparoscopically. Two patients received urinary bladder injuries during the Pfannenstiel incision for retrieval and were then repaired.

There were three total conversions in the RLDN group and 2 total conversions in the LLDN group. One patient in the RLDN group required a conversion to open nephrectomy due to two renal veins draining separately into the IVC more than 3 cm apart. By a planned conversion to open nephrectomy, we could harvest both renal veins on a common patch of IVC and this simplified recipient venous anastomosis. The other 2 conversions in the LLDN group were due to bleeding from renal veins near the IVC.

Chylous ascites was seen in 1 patient in the RLDN group and 9 patients in the LLDN group. All affected patients achieved resolution with conservative treatment.

Small bowel obstructions occurred in 2 patients in the LLDN group. In one patient, the ileum adhered to tissues in the raw renal bed and the second patient had internal herniation of the jejunum through an iatrogenic mesenteric defect. Both cases were successfully managed laparoscopically.

One donor in the LLDN group had a deep wound infection followed by dehiscence of the Pfannenstiel incision on postoperative day ten. Wound debridement and closure was done.

Pulmonary complications were most common (Table 2), varying from atelectasis to consolidation. One patient had a consolidation collapse of the whole lung, which resolved after bronchoscopic removal of mucus plugs.

Graft Outcome

Recipient outcomes were comparable between groups (Table 3). No graft was lost due to injury, primary non-function, or vascular or ureteric complications. Our acute rejection rate was around 8%, which is similar to other reported series. In our earlier experience when open donors were also done in the same time frame, there was no difference in rejection rate between the laparoscopic and open group. Two patients in the LLDN group had renal vein thrombosis, with predisposing factors being diseased

Table 2. Donor Complications

Complications	RLDN (n = 168)	LLDN (n = 1682)
Donor complications		
Vascular		
Aortic bleeding	0	3
IVC bleeding	1	0
Renal artery injury	0	1
Renal vein injury	3	2
SMA injury	0	1
Bowel injury	0	2
Liver injury	1	0
Splenic injury	0	2
Urinary bladder injury	0	2
Conversion	3	2
Wound dehiscence	0	1
Pulmonary		
Atelectasis	6	54
Consolidation	1	12
Bowel obstruction	1	2
Chylous ascites	1	9
Death	0	1

Abbreviations: IVC, inferior vena cava; LLDN, left live donor nephrectomy; RLDN, right live donor nephrectomy; SMA, superior mesenteric artery.

recipient external iliac or femoral veins; the cases were successfully managed by percutaneous intravascular thrombolysis. Two patients in the LLDN group had ureteric strictures that were managed by open ureteropyelostomy to the native ureter.

Follow-up

Follow-up data were obtained from office visits, inquiry of the donors' well-being from the recipient, inpatient records, and telephonic conversations. Follow-up data were available for 960 patients (51.9%) at a mean interval of 24 ± 8 months. Delayed donor complications (present beyond 30 days after surgery) were infrequent ($n = 17$) and are presented in Table 4. These complications were comparable between RLDN and LLDN. One patient in the left laparoscopic donor nephrectomy group developed glomerulonephritis 2 months after donation and required corticosteroid therapy.

DISCUSSION

LDN has now gained widespread acceptability and is credited with increasing the donor pool. There are many

Table 3. Recipient Complications

Complications	RLDN (n = 168)	LLDN (n = 1682)
Renal arterial thrombosis	0	0
Renal venous thrombosis	0	2
Ureteric leak	0	0
Ureteric stricture	0	2
Acute rejection	15	151
Mean serum creatinine at discharge, mg/dL	1.18	1.16

Abbreviations: LLDN, left live donor nephrectomy; RLDN, right live donor nephrectomy.

Table 4. Delayed Donor Complications (>30 Days)

Complications	RLDN (n = 70)	LLDN (n = 690)
Incisional hernia	1	6
Hypertension	2 (2.8%)	14 (2.02%)
Glomerulonephritis	0	1

Abbreviations: LLDN, left live donor nephrectomy; RLDN, right live donor nephrectomy.

studies comparing open donor nephrectomy with LDN and equivalent renal graft and patient survival rates have been shown for both procedures. LDN has a lower analgesic requirement, shorter hospital stay, and an earlier return to work for patients; however, most of the literature has reported on left-sided LDN only. Fewer reports of RLDN are available due to anatomical complexities of short and thin renal veins on the right side.

Hsu et al [4] compared LLDN and RLDN. They reported increased risk of early allograft failure with right-sided LDN (3.8% vs 2.5% with left-sided LDN). Kay et al [5] compared LLDN with RLDN and concluded that the functional results were the same; however, there was a greater need for back-table reconstruction of the renal vein in RLDN. Simforoosh et al [6] described an alternative technique: the right renal artery and vein were ligated by Hem-o-lok and titanium clips, which resulted in a very short renal vein (<1.5 cm). They positioned the kidney inverted in the recipient, thus placing the renal vein posteriorly, adjacent to the external iliac vein, and facilitating a simpler venous anastomosis.

The initial difficulties with right LDN described by Ratner et al [1] have not been corroborated by subsequent authors, probably as a result of modifications and improved techniques.

In the present series, we have been able to maintain adequate arterial length by using three maneuvers: first by dividing lumbar veins and rolling IVC medially, second by flipping kidney down medially (to dissect retrocaval portion of renal artery), and third by dissecting the interaortocaval space.

By using Endo TA-30 staplers, we managed to achieve sufficient venous length in almost all patients. In two of our RLDN patients, we used a saphenous vein graft to lengthen the renal vein. Use of the saphenous vein [11] and gonadal vein [12] has been reported by others also to increase renal vein length. In the RLDN group, none of the recipients developed renal vein thrombosis.

The most serious complications that occur during LDN are iatrogenic renovascular and bowel injuries. The occurrence of most serious complications is infrequent [7]. Surgical mortality from live kidney donation is reported to be 3.1 per 10,000 donors [8]. Vascular complications occurred in four patients in the RLDN group and six cases in the LLDN group. Two patients in the LLDN group had bowel injuries. There were three conversions in the RLDN group and two conversions in the LLDN group (SMA and aortic injury, as discussed already). One patient in the RLDN group required conversion to open nephrectomy

due to two renal veins draining separately into the IVC more than 3 cm apart.

A Hem-o-lok plastic locking clip may help gain extra length on the renal artery by avoiding clips or staples on the graft side; however, reports of vascular clips becoming dislodged or tearing vessels leading to hemorrhage and even death raise serious concerns about their use in LDN. Though available endovascular staplers and Hem-o-lok clips are reliable, there continues to be a risk of device failures and misapplications. Sooriakumaran et al [9] studied risk factors and predictors of failure of the Hem-o-lok vascular clip and concluded it is safe if applied at 90 degrees to the vessel surface and if a 1 mm cuff is left between the clip and the point at which the vessel is divided. It is essential that the vessels should be skeletonized completely and the tip of stapling or clipping device is seen clearly before applying it over the vessels. We additionally apply one titanium clip below the two Hem-o-lok clips prior to renal arterial division. Careful use and confirmation of correct application of these devices is vital to the safety of LLDN. This may prolong warm ischemia time slightly but prevents major intraoperative bleeding complications. We did not have and bleeding or mishap related to Hem-o-lok applications. We did lose one patient due to a missed colonic injury.

We do not use the Endocatch organ retrieval bag due to expense and reports of retrieval bag injury and difficult entrapment causing occasional increased warm ischemia times. We use hand insertion with a Pfannenstiel incision to retrieve the graft. The mean hospitalization stay was 4.2 days, but most patients were fit for discharge after 2 days. Most of the patients resided in different cities and were apprehensive about early discharge. This has prolonged the hospital stay in some cases.

Few recent studies have shown lower operating time and equivalent functional outcomes between RLDN and LLDN. Wang et al [10] conducted a meta-analysis comparing RLDN and LLDN. They found no differences between the two groups in hospital stay, delayed graft function, recipient graft loss at one year, conversion to open donor nephrectomy, and donor or recipient postoperative complications. Still, many transplant centers prefer to harvest right kidneys in an open fashion.

Though the retroperitoneal approach is easier for arterial dissection especially with early arterial branching, the transperitoneal approach is more popular. More urologists and surgeons are familiar and comfortable with transperitoneal approach due to larger space and familiar anatomy.

We believe RLDN needs to be more widely used to extend the benefits of the laparoscopic approach to all the

donors. Our results support the use of laparoscopic retrieval of right kidneys. There is a need for well-designed randomized clinical trials to further substantiate the equivalence of RLDN and LLDN.

CONCLUSION

With adequate experience, right LDN can be accomplished in a safe manner with good outcomes. It is necessary to highlight possible complications to healthy donors while obtaining consent for surgery. Right LLDN has a steep learning curve and can be learned under the mentorship of an experienced surgeon; however, there is a need for back-table reconstruction of the right renal vein in some cases.

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