Introduction of Laparoscopic Donor Nephrectomy: Challenges, Outcomes and Success Strategies

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ABSTRACT

Background: Laparoscopic live donor nephrectomy (LLDN) has become the standard of care and is popular among most of the transplant centers across the globe. Despite proven advantages of LLDN, some transplantation centers hesitate to start the program because of issues concerning donor safety and allograft function.

Objective: To discusses the main barriers for creating a successful LLDN program, strategies that allowed us to start a successful LLDN program along with the study results.

Methods: The donors undergoing LLDN from December 2016 to February 2018 were enrolled in the study and prospectively evaluated. LLDN were performed by two senior surgeons alternately with assistance by the laparoscopic urologist in all cases. Also, in the present study, two technical alterations were done in the standard surgical technique of transperitoneal LDN. The first important modification made was the use of two additional ports for use by laparoscopic urologists. The second modification involved dissection on both poles of the kidney before hilar dissection.

Results: A total of 112 transperitoneal LLDN were performed during the study period. The mean (range) of operation time was 117.5 (81–158) min; the ischemia time was 194 (171–553) sec. Only one patient needed conversion to open surgery. No other major peri-operative or posto-perative complications occurred. All kidney grafts were functioning well.

Conclusion: With proper planning, team approach, and few technical modifications, introduction of LLDN is safe and effective.

KEYWORDS: Laproscopic; Transperitoneal; Ischemia; Complications; Graft

INTRODUCTION

Innovation and development of the surgical techniques for kidney retrieval from live donors has undergone a paradigm shift. The laparoscopic live donor nephrectomy (LLDN) is associated with many benefits and has become the gold standard for kidney retrieval surgery. As compared to open donor nephrectomy (ODN), LLDN has been shown to have less post-operative pain, shorter hospital stay, and fast recovery [1-3].

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Although the overall safety of LLDN is well established, it remains a challenge for novices because of the safety concerns during the learning curve. This study shares the initial experience and an approach that allowed successful implementation of LLDN without increased donor morbidity or graft failure.

MATERIALS AND METHODS

The donors undergoing LLDN at the Department of Urology, Choithram Hospital and Research Centre, Indore, Madhya Pradesh from December 2016 to February 2018, were enrolled in the study. The study protocol was in accordance with the Declaration of Helsinki and was approved by the Institutional Review

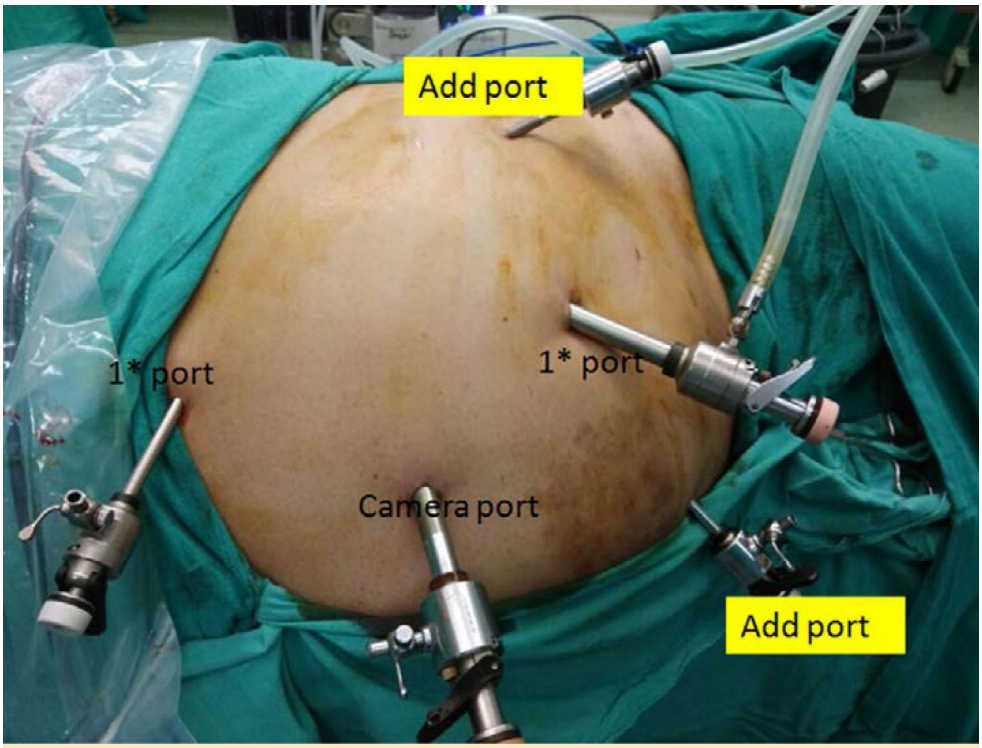

Figure 1: Port configuration: one 5-mm subumblical port and another 5-mm lateral port above the anterior superior iliac spine

Board. Informed written consent was taken from all the study participants.

Data were collected prospectively from medical records. Detailed pre-operative evaluations and testing, including 3D computed tomography (CT) and computed tomographic angiography (CTA), were done for all the donors and the recipients. The assessment of pre-, intra- and post-operative parameters included pre- and post-operative donor and recipient renal function, operative time, delayed graft function, length of hospital stay and rate of complications.

Surgical Approach

Donor nephrectomy was performed by a pure laparoscopic, non-hand-assisted procedure. The operative team had two senior surgeons, one laparoscopic urologist and general surgery residents. The senior general surgeon and the senior urologist have been part of the transplant program for 25+ years. They had large experience in open donor nephrectomy and some experience in the basic laparoscopic surgery. The laparoscopic urologist had training and experience in laparoscopic kidney surgery. LLDN was performed by two senior surgeons alternately with assistance by the laparoscopic urologist in all cases.

Surgical Procedure

Few technical modifications were made to the standard surgical technique of transperitoneal LDN. The first important modification was the use of additional ports; besides the three standard ports, the present study used two additional ports (one 5-mm subumblical port and another 5-mm lateral port above the anterior superior iliac spine) (Fig 1). With the instruments introduced through additional ports, the experienced laparoscopic urologist helped in the various steps such as retracting the bowel or giving a gentle traction on the upper or lower pole of the kidney at the time of hilar dissection, clipping, and cutting.

The second modification made involved the sequence of hilar dissection. Our modification involved dissection on both poles of the kidney before we approached actual hilum. The rationale for this approach was to reduce the level of our apprehension in the initial learning curve. The most feared part in this surgery

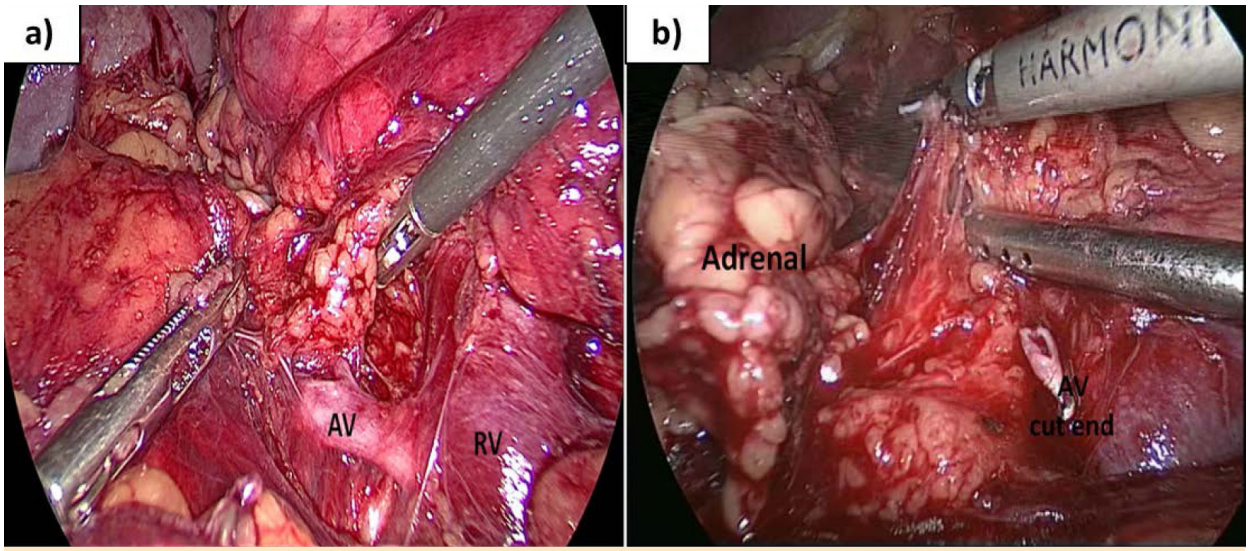

Figure 2: a) Dissection of the upper pole to expose the adrenal vein (AV) draining into the renal vein (RV); b) Dissection carried out until the point when the upper portion of the psoas muscle is seen.

was the hilar dissection. The vascular injuries leading to open conversions can sometimes be a nightmare in the live donor nephrectomy. In our opinion, if there is hilar injury in the initial learning curve requiring open conversion, the potential complications because of excessive bleeding or undue compression and vasospasm of the kidney graft would be minimized as both the poles of the kidney have already been dissected.

The detailed procedure was as follows. Start of the dissection from the caudal side by delineating the ureter, lifting up the uretrogonadal complex and mobilizing the lower pole. At this stage, we did not proceed cephalad with lumbar vein and hilar dissection. Instead, we shifted to the upper pole dissection inside Gerota's fasica, adrenal gland was released off from the upper pole of the kidney using harmonic scalpel, carrying the dissection until the point when the upper portion of the psoas muscle was seen. Adrenal vein also divided during this step (Fig 2a, 2b). Then, we tackled lumbar veins. Lumbar vein is a gateway to the renal artery. Lumbar vein usually passes near the origin of the renal artery and drain into the renal vein posteriorly. Lumbar vein dissection remains the most difficult part of vascular dissection and requires utmost care and precision to avoid injury to them, which can lead to significant bleeding. When the hilum is kept at a gentle stretch by traction on either of the poles, some length is gained for safe clipping and cutting of lumbar veins (Fig 3a, 3b). After this, we proceed to hilar dissection. Hilum becomes prominent with subtle superolateral traction on kidney. This makes intrahilar dissection easier. Renal artery is dissected up to its origin towards aorta using the combination of harmonic and low intermittent suction (Fig 3c, 3d).

RESULTS

A total of 112 LLDNs (78 females and 34 males) was performed. The age of donors ranged from 32 to 63 years. The majority (n=101) of donors had a single renal artery; 10 had two and one had three renal arteries. The mean (range) of operation time was 117.5 (81–158) min; the mean warm ischemia time was 194 (171–553) sec. The estimated mean blood loss was 40 (10–1100) mL; the mean hospital stay was 3.1 days (Table 1).

Eleven (9.8%) donors developed complications which were only of grade I and II. Only one patient needed conversion to open surgery because of bleeding (Table 2). The lumbar vein was torn, and hemostatic control could not be achieved by laparoscopy. Post-operative paralytic ileus was developed in two patients, but

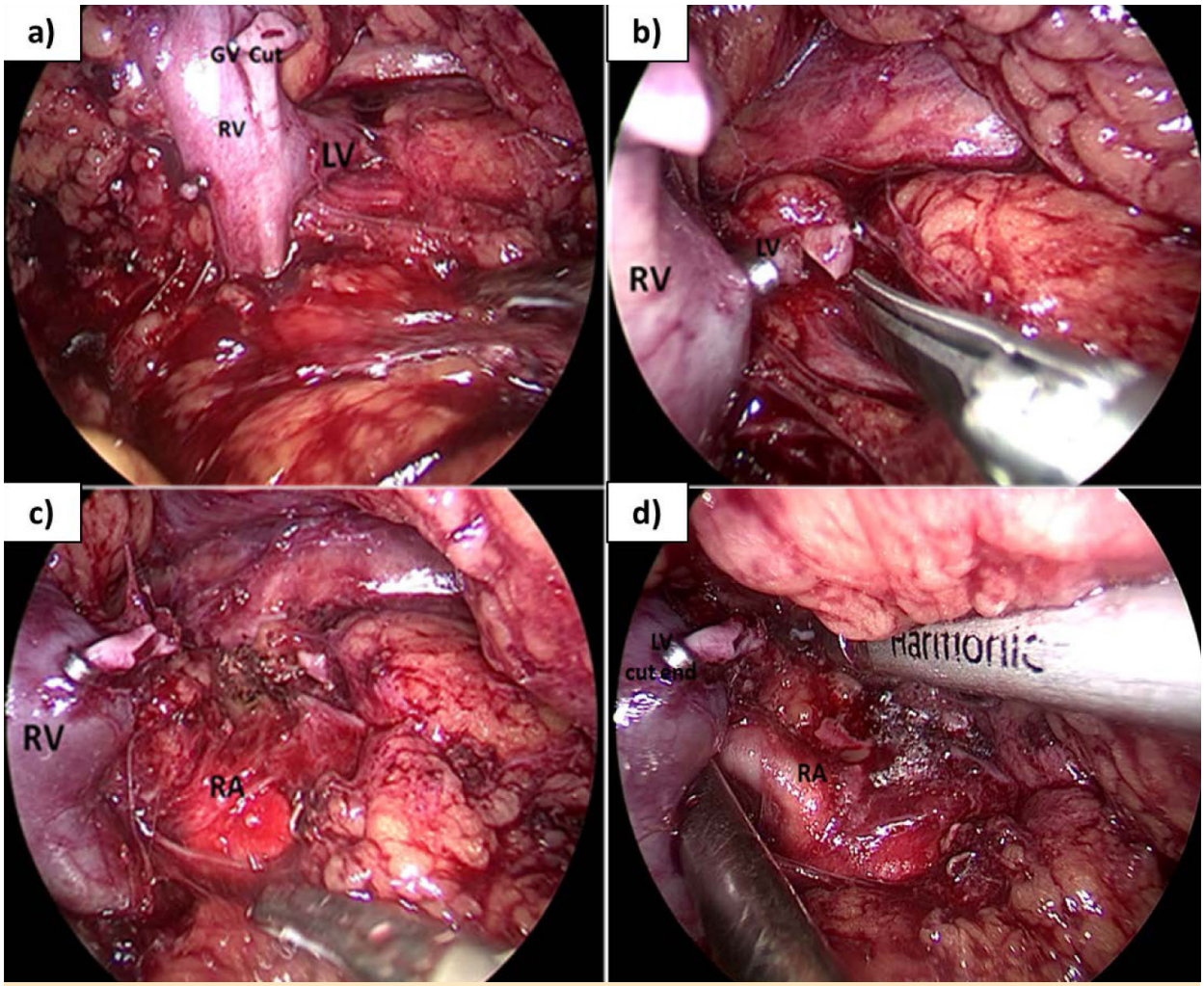

Figure 3: The hilar dissection: a) Lumbar vein (LV) seen draining into the renal vein (RV); b) The lumbar vein was clipped and cut; c) The renal artery (RA) pulsation seen after cutting the renal vein; d) The renal artery is dissected up to its origin towards aorta.

it resolved with conservative management in a few days. One donor had sustained minor splenic capsule tear. These were managed with pressure, and absorbable gelatin sponge with adequate hemostasis. One donor developed fever because of stitch line infection. No major (grade III and IV) peri- or post-operative complications occurred in the present study donors during LLDN.

Post-operative follow-up revealed that all grafts were functional up to 1-year post-operative. The mean recipient serum creatinine was 1.53 mg/dL at 1 week, 1.39 at 1 month, and 1.43 at 1 year.

DISCUSSION

The objective of the present study was to report an initial experience of LLDN, challenges faced during the procedure and success strategies applied. Having a 30-year-old kidney transplant program, the study institute was one of the oldest tertiary care institutes in Central India. However, there were many barriers that did not allow the introduction of LLDN in the past. Those included inertia of surgeons to accept new techniques, lack of expertise, fear of failure and financial barrier.

Inertia was the first barrier, which discouraged the start of laparoscopic donor program for the past 30 years. A very old and successful kidney transplant program was itself a big de-

Table 1: Patients' characteristics

Characteristics	LDN* patients (n=112)
Age range (yrs)	32–63
Sex, n (%)	
Male	34 (30.4)
Female	78 (69.6)
Number of renal arteries, n (%)	
Two	10 (8.9)
Three	1 (0.9)
Operative time in min, mean (range)	117.5 (81–158)
Warm ischemia time in sec, mean (range)	194 (171–553)
Blood loss in mL, mean (range)	40 (10–1100)
Hospital stay in days, mean (SD)	3.1 (0.9)
Mean serum creatinine level (mg/dL)	
At 1 week	1.53
At 1 month	1.39
At 12 months	1.43

*LDN: laparoscopic donor nephrectomy

terrent in starting LLDN program. Overall, there was a mindset that "the transformation is not necessary or is not doable." The second barrier was lack of expertise in laparoscopic procedures. The surgical team had both senior and young members. There was one senior general surgeon, and one senior urologist who had been part of the transplant program for 20 years. They had large experience in open donor nephrectomy and some experience in the basic laparoscopic surgery. In between, many young surgeons worked for a short period during the past 20 years. So, training and experience in LLDN was definitely lacking. The third barrier was fear. Doing the first few cases by a new technique was always challenging for a surgeon, especially in a private sector and more so on cases of transplant where no margin of error is acceptable. There was fear of vascular injury leading to lethal hemorrhage in donor or injury to the graft vessel precluding transplant surgery. Also, there was a fear of a prolonged learning curve and its consequences. The final barrier was the extra-cost involved in LLDN. Laparoscopic donor surgeries cost more for laparoscopic instruments and camera, endobags, energy sources like harmonic or LigaSure™, hem-o-locks, or stapler. This added cost inserts an extra-burden on patients coming from low socioeconomic background.

To overcome these barriers, success strategies were implemented which allowed us to introduce the program successfully. The first thing required was changing the old mindset that "the transformation is not necessary or is not doable." All members of the transplant team started sharing the vision of development of the transplant program at par. It also involved many meetings and formal consultation with nephrologist, anesthetics and administration. Laparoscopic kidney surgery cases done in the past few years at the institute for benign and malignant conditions, techniques and literature in favor of the LLDN and urgent need to start LLDN program were discussed. All these efforts helped in developing consensus

Table 2: Complications during laparoscopic donor nephrectomy

Complications	LDN* n (%) (n=112)
Conversion to open surgery	1 (0.9)
Post-operative paralytic ileus	2 (1.8)
Splenic capsular tear	1(0.9)
Fever	1 (0.9)

*LDN, laparoscopic donor nephrectomy.

for starting LLDN program. Next strategy was to overcome the lack of expertise and fear of failure. Senior members played an integral role here. Their support and presence reduced the fear of any untoward events. The team was expanded with new members who increased the team strength. A new urologist trained in minimally invasive kidney surgery joined the team; his experience proved vital in starting LLDN program. Also, careful selection of donors was crucial in the development of this program. Initially, we selected donor with average build having single artery and vein. After 15 successful LDNs, we included all obese donors and donors with multiple vessels for LDN. Finally, after 50 left LDN, we did right side LDN.

To overcome the financial barrier, we utilized few cost cutting measures. In this study, metallic reusable laparoscopic trocars by Karl Storz were used instead of disposable ones. Also, instead of staplers, only Weck® clips were used in this study. The use of hem-o-lock clips for control of the vessels in the living donor is a subject of great controversy [4, 5]. In the USA, an FDA directive forbids its use based on few reports of the clip dislodgment leading to fatal bleeding postoperatively [6]. Therefore, EndoGI vascular stapler is now used at many centers. However, the use of staplers is not without risks; malfunction of stapler may require conversion to an open surgery and even lead to death [4-6]. Also, the high cost of the stapler makes it more difficult to use in the low- and middle-income countries. Therefore, hem-o-lock clips have been used by many centers and proved to be cost-effective and secure, if applied correctly [7-9].

In our experience, dislodgement of the polymer locking clips can be avoided by using two polymer locking clips with one titanium clip under it to dampen pressure, and cutting the vessels with 1 to 2 mm of the sleeve of the vessel distal to the second clip. In this study, there were no vascular complications and no device failure during vascular control with the polymer locking clips.

No organ retrieval bags were used as these increase the cost of the procedure and also reported to be associated with technical difficulties such as a longer warm ischemia time and injuries to the bowel during organ retrieval. Manual retrieval of the graft was done by making a 7-cm oblique paramedian lower quadrant incision; the kidney was grasped and gently delivered through the wound.

All the mentioned strategies helped to start the LDN program successfully. Table 3 shows the results of previous series reported by centers from other countries. Izquierdo, *et al*, from Spain reported results of the initial 100 laparoscopic donor cases. Four patients required transfusion; one had kidney rupture; and, one had liver tear [10]. Hawasli, *et al*, from USA, reported that bleeding occurred in 6.6% of donors, out of whom two required open conversion [11]. Buresley, *et al*, reported warm ischemia of 5.7 min, conversion in 7.9% of donors with two needed re-exploration post-operatively [12]. Recent series reported by Marcelino, *et al*, from Indonesia reported major bleeding requiring transfusion in 3.2% of patients [13]. Colonic injury was another LLDN complication reported by Fettouh, *et al* [14].

Because of these complications in the initial learning curve in laparoscopic donor series, a range of alternative approaches evolved. Those included hand-assisted and recently, robotic-assisted donor nephrectomy. These techniques aid to reduce the donor morbidity as well as enhanced donor safety, especially for laparoscopic-naive surgeons.

In this study, the mean operative time for transperitoneal LLDN was 117.5 min; as the surgeons gained experience, the time decreased. Warm ischemic time is an initial issue for LLDN. This study reported the mean warm ischemic time of 194 sec. Several studies showed varied results ranging from 2 to 11 min [17]. In the current study, technical modifications, preplaced incision and careful manual kidney retrieval without use of any endobags, expedited the graft extraction and minimized the warm ischemic time.

The present study did not report any ureteral complications. In the initial LLDN series available in the literature, ureteral injuries occurred more frequently during LLDN than during open donor nephrectomy (<11% vs. <6%, respectively) [1-3]. Subsequent technical modifications (such as preservation of the periureteral tissue that allows adequate ureteral blood supply) have reduced the incidence of such complications to a minimum.

Thus, the present study demonstrated lower operative and warm ischemia time without any major (grade III and IV) peri- or postoperative complications and only one case requiring transfusion and conversion to open donor nephrectomy. Authors attribute this to various reasons. The first reason is involvement of a senior surgeon and a laparoscopic urologist in the transplant team. This collaborative approach optimized familiarity with technique and local anatomy and allowed the mastery of the new procedure in a safe manner. This approach also provided a good moral support at various stages of the surgery (e.g., where to dissect, how to continue, when to covert, etc.), hence, reducing the fatigue and subsequent impaired performance. The second reason is the use of additional ports used by the laparoscopic urologist to assist in various steps—traction, counter traction, suction, and controlling small bleeders, etc. This helped in keeping both the hands of the primary surgeons free for comfortable and safe dissection. Finally, dissection of both poles of the kidney before the hilar dissection was beneficial. This made circumferential mobilization of the renal vessels much easier and safer, as we could clear the lymphatics and fibro-fatty tissues around the vessels from both the poles. Also, due to the widely exposed field, the chance of vascular injuries was minimized.

One limitation of our series was that we have done mostly left-sided LDN and had only two right-sided LDN. The remaining all right-sided donors were managed by traditional open approach. In this study, vascular stapler was not used because of the cost constraints in the study setup. Instead, a hybrid technique was used—kidney was dissected laparoscopically,

Table 3: Previous series reported by centers from various countries. Values are mean (SD).

Study	Country	n	Operative time (min)	Warm ischemia time (min)	Estimated blood loss (mL)	Hospitalization (days)	Open conversion rate (%)
Izquierdo, *et al.*[10]	Spain	100	149.5 (56.0)	2.5 (1.3)	210.0 (45.0)	4.8 (5.1)	0
Hawasli, *et al.*[11]	United States	168	176.0 (35.0)	3.5	76.0 (66.0)	2.3 (1.0)	1.2
Buresley, *et al.*[12]	Kuwait	80	186.16	5.7	—	5.28	6 (7.9)
Marcelino, *et al.*[13]	Indonesia	250	254.1 (44.4)	4.2 (3.5)	194.3 (197.8)	3.8 (1.2)	1 (0.4)
Fettouh, *et al.*[14]	Egypt	400	117.0 (34.0)	2.6 (0.4)	56.0 (28.0)	2.1	0
van der Merwe and Hynes, *et al.*[15]	South Africa	50	149.8 (44.9)	3.0 (1.3)	139.7 (145.5)	3.2 (0.7)	0
Chin, *et al.*[16]	United States	500	208.2 (55.6)	2.7 (1.5)	197.0 (223.0)	2.3 (0.8)	1.6

Box 1: Important points to consider for the laparoscopic donor nephrectomy program

- Careful selection of the initial cases, like left kidney donor with average build having single artery and vein.
- Careful inspection of the pre-operative CT angiogram for arterial and venous anatomy is critical to minimize the risk of vascular injury.
- Team approach is vital. A collaborative approach with a transplant surgeon and laparoscopic urologist minimizes the risk to the donor and reduces the learning curve.
- Proper port placement is crucial in every case. Ports are placed in baseball diamond configuration to triangulate the working arms, keeping camera location at the level of hilum with due consideration to patient habitus. Also, two extra 5-mm ports should be placed at liberty in case one has some difficulty in maneuvering with existing ports to make the dissection easier and safer.
- Releasing the splenocolic and splenorenal ligaments is important for proper reflection of the large bowel. This leads to spleen being completely mobilized off the kidney and falls off medially without any retraction.
- Preservation of the peri-ureteral tissue allowing adequate ureteral blood supply. It is very important not to skeletonize the ureter too aggressively during the dissection in order to pReverse the blood supply.
- The upper pole dissection should be undertaken before the lumbar vein and renal hilar dissection. The upper pole should be dissected inside Gerota's fasica. Using a thermal dissector (LigaSure™ or harmonic scalpel), the tissues connecting the adrenal gland to the kidney are divided while staying as close as possible to the adrenal gland to avoid encountering the upper pole renal artery branches. Then, the lumbar veins are tackled. The lumbar veins usually pass near the origin of the renal artery and drain into the renal vein posteriorly. Dissection of the lumbar veins requires utmost care and precision to avoid injury to them, which can lead to significant bleeding. The hilum is kept at a gentle stretch by traction on either of the poles for safe dissection and cutting the lumbar veins.
- Prefer harmonic dissection around the renal artery, which has minimal thermal injury and thus lower incidence of renal artery spasm. Efforts should be made to expose the artery as close as possible to its origin at the aorta.
- Preparation of the extraction site: The kidney is now ready for extraction, and the extraction site is prepared before ligation of the ureter and hilar vessels. The previously marked mini-Pfannenstiel incision or oblique paramedian muscle splitting incision is made; the peritoneum is left intact.
- Hilar ligation: If using polymer locking clips for ligation, dislodgement of the clips can be avoided by using two polymer locking clips with one titanium clip under it to dampen pressure, and cutting the vessels with 1–2 mm of the sleeve of the vessel distal to the second clip.

and the vein was managed via an open approach using an 8–10-cm subcostal incision to obtain maximal renal vein with inferior vena cava (IVC) cuff.

Most LLDN have been performed on the left side, worldwide. Laparoscopic right donor nephrectomy is technically more difficult for lack of proper laparoscopic vascular stapler to get few mm of IVC cuff attached to the short renal vein. Without IVC cuff, a shorter right renal vein makes the implant procedure more difficult and may be associated with a higher rate of renal vein thrombosis [18-20]. Currently, Endo GI/vascular stapler is used at some centers but it is not without risks. It

fires three rows of staples line on renal vein and IVC side, so there is some shortening of renal vein after cutting the staple line. Also, the malfunction of stapler would lead to IVC and renal vein tear [5, 20]. Finally, the high cost of the stapler makes it more difficult to use in all centers, particularly in the developing countries [8, 9].

With the present study experience, we would like to propose certain important tips when starting the LDN program (Box 1).

We concluded that with proper planning, team approach and few technical modifications, introduction of LDN is safe and effective.

CONFLICTS OF INTEREST: None to be declare.

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