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Evolution of Laparoscopic Donor Nephrectomy Techniques and Outcomes: A Single-Center Experience with More than 1000 Cases

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Background: Laparoscopic donor nephrectomy (LDN) has evolved and has been established as a surgical standard of care for kidney transplantation.

Material/Methods: This study retrospectively reviews 1132 patients who underwent 4 different laparoscopic living-donor nephrectomies: hand-assisted laparoscopic nephrectomy (HALDN), pure laparoscopic donor nephrectomy (PLDN), laparoendoscopic single-site plus 1-port donor nephrectomy (LESSOP-DN), and mini laparoscopic donor nephrectomy (MLDN).

Results: The mean estimated blood loss (EBL) for the HALDN group was meaningfully higher than those of LESSOP-DN and MLDN (57.5±52.2 mL versus 21.0±30.0 mL versus 18.2±28.7 mL) (P<0.001). The EBL for PLDN (53.3±35.3 mL) was also significantly higher than those of LESSOP-DN and MLDN (P<0.001). Length of stay (LOS) for HALDN was longer than that for LESSOP-DN (4.2±1.2 day versus 4.0±1.4 days, P=0.002). There was 1 intraoperative open conversion in the HALDN group and 2 HALDN surgeries that required postoperative exploratory laparotomy. LESSOP-DN had 3 (0.8%) postoperative incisional hernias. For recipients, the results revealed no significant differences between all 4 groups in terms of estimated glomerular filtration rate (eGFR) and the 1-year graft failure rate.

Conclusions: The LESSOP-DN group was associated with a shorter incision length than those of HALDN and PLDN and shorter LOS than that of HALDN. Recipient results showed no meaningful difference regarding laparoscopic donor nephrectomy technique.

MeSH Keywords: **Kidney Transplantation • Laparoscopy • Living Donors**

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Background

In 1995, Ratner reported the first laparoscopic living-donor nephrectomy, which later became the accepted standard surgical technique for renal transplantation [1]. Since its introduction, laparoscopic donor nephrectomy (LDN) has continuously evolved and has become a surgical standard. Moreover, transplanted renal allografts acquired laparoscopically have provided short- and long-term results that are comparable to the outcomes of open donor nephrectomy [2,3]. The benefits of minimally invasive nephrectomy for kidney donations are reflected by studies that report increased compliance with donating when the laparoscopic technique is accessible [4–6]. The aims of a successful donor nephrectomy are a low rate of complications for the donors and adequate graft function for the recipients. LDN has reported acceptable donor morbidity and mortality while achieving favorable graft outcomes. Laparoscopic living-donor nephrectomy decreases the incidence of adverse outcomes of open living-donor nephrectomy and improves the prospects of living-donor nephrectomy, thus making it more appealing to prospective donors. LDN decreases postoperative pain, shortens convalescence, and improves cosmetic outcomes [7–10]. Efforts to enhance donor efficiency and to raise the number of donors has helped advance minimally invasive techniques, such as LESSOP-DN and MLDN [11]. Since 2000, over 1100 cases of living-donor nephrectomy procedures at our institution have been performed laparoscopically via HALDN. Subsequently, surgical techniques have evolved and improved from HALDN to PLDN and then been modified to LESSOP-DN and MLDN. This study is the first to review over 1000 cases of 4 different laparoscopic donor nephrectomy techniques over 18 years in a single institution. We aimed to compare the outcomes and evolution of 4 living-donor laparoscopic nephrectomy procedures, namely HALDN, PLDN, LESSOP-DN, and MLDN performed at our institution.

Material and Methods

Patients and methods

This study was approved by the Institutional Review Board of the Catholic University of Korea (KC18RESI0761). From January 2000 to December 2017, 1132 consecutive kidney donor patients underwent laparoscopic living-donor nephrectomy at our institution, performed by 6 different surgical specialists. None of the consecutive patients were excluded from the analysis. In January 2000, HALDN procedures were performed at our institution for technical convenience and were subsequently modified into other methods. Hospital records for donors were reviewed for the following data parameters: operative time, body mass index (BMI), age, sex, laterality, hospital length of stay (LOS), warm ischemia time, pre-operative estimated glomerular filtration rate (eGFR), postoperative eGFR [12], and incision length. The Clavien-Dindo classification system was used as a reference to identify and grade donor complications [13]. Recipients were matched with each donor and then data were collected on recipients including eGFR and 1-year graft failure. Indications for performing right laparoscopic living-donor nephrectomy were a better functioning left kidney, with a GFR difference >10% demonstrated on a diethylenetriamine penta-acetic acid renogram, and right kidney associated with a certain form of pathology (e.g., cysts, stones, or angiomyolipomas).

Preoperative preparation

A multidisciplinary transplant team at our institution assessed all potential donors and ensured that all donors satisfied the appropriate criteria for kidney donation. Donor preoperative evaluation comprised a thorough history, physical examination, serum eGFR assessment, intravenous urography, and 99mTc-diethylenetriamine penta-acetic acid scan. All potential donors underwent spiral computed tomography with 3-dimensional reconstruction to evaluate renal parenchyma and vasculature.

Surgical techniques

The surgical procedures were performed as described previously [14,15]. Procedures for the donors in all 4 groups were performed using the transperitoneal approach, arranging the patient in a lateral decubitus position prior to the procedure.

In the HALDN technique, a 7-cm upper midline incision was made above the umbilicus, entering into the subcutaneous tissue, muscle, and peritoneum. A GelPort (Applied Medical, Rancho Santa Margarita, CA, USA) was installed over the upper midline incision and tightened over the operator's left hand. Two or 3 additional ports were subsequently inserted (Figure 1A).

In the PLDN technique, 3 or 4 ports were placed for the surgical procedure. The umbilicus was used for the first 10-mm camera port. The second port was inserted 10 cm above the umbilicus in the left midclavicular line, and the third port, which was a 12-mm port, was inserted in the left anterior axillary line above the iliac crest. During the procedure, the telescope and conventional laparoscopic devices were the same instruments used in the HALDN procedure. Following port insertion, the operational procedures were almost identical to those in HALDN. In the PLDN group, prior to renal vessel ligation and division, a Lap bag (Sejong Medical, Seoul, Korea) was used to prebag the graft kidney, which was then removed through a Pfannenstiel incision in the lower abdomen (Figure 1B).

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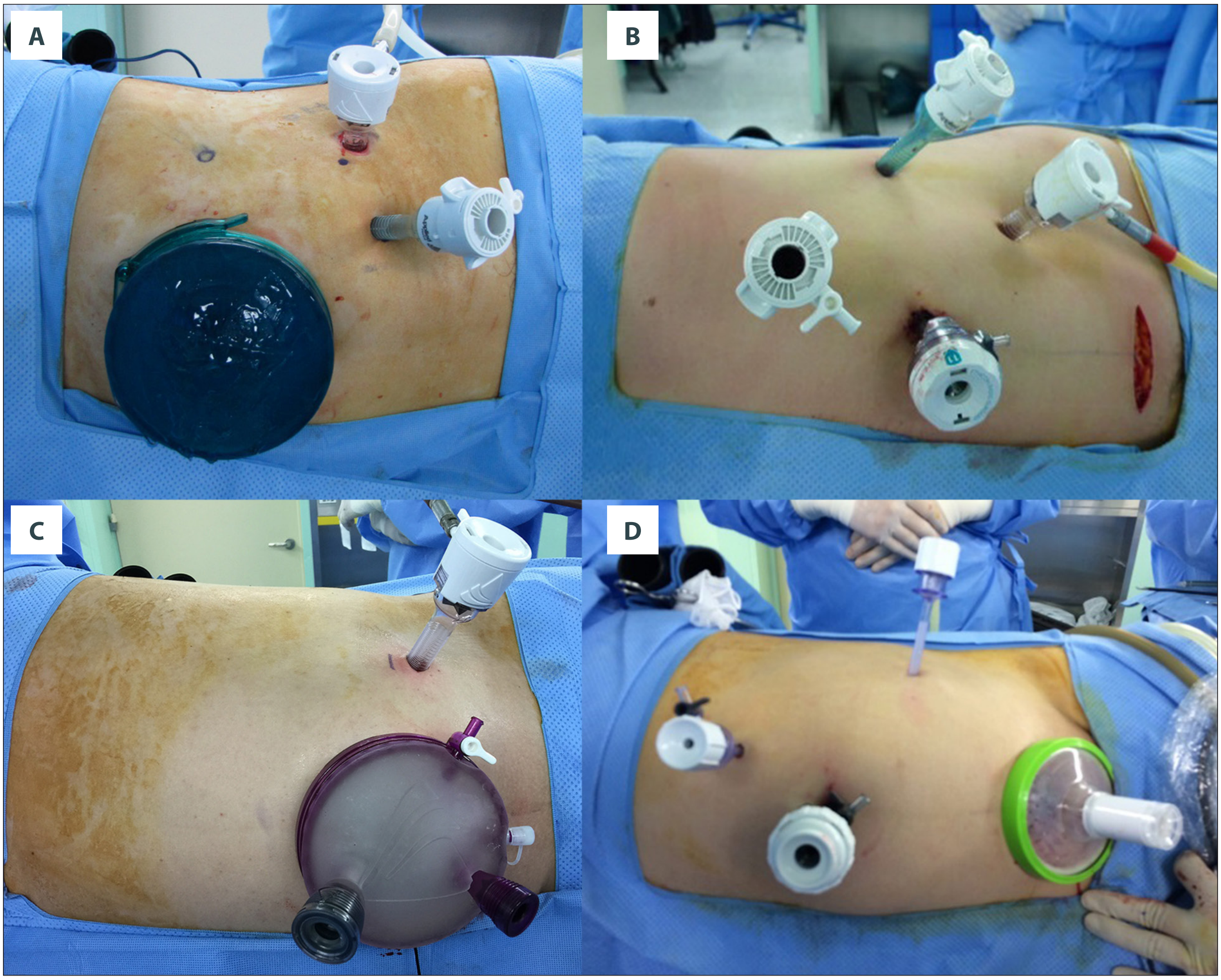

Figure 1. Port placement for HALDN (**A**), PLDN (**B**), LESSOP-DN (**C**), MLDN (**D**) HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus 1-port donor nephrectomy; MLDN – mini-laparoscopic donor nephrectomy.

The LESSOP-DN technique performed a single periumbilical incision, 3–3.5 cm long, with the installation of a Gel-POINT™ (Applied Medical Rancho Santa Margarita, CA, USA) during surgery. An additional 12-mm port working channel was placed at the lateral abdominal wall. Within the Gel-POINT™, a 12-mm trocar for the operating instrument and an 11-mm trocar for the camera were installed (Figure 1C).

The MLDN procedure performed a Pfannenstiel incision which can be covered by the donors' undergarments or hair. 4–5 cm long, and placed a SurgiTractor (SurgiCore Co., Ltd., Ansan, Korea) into the incision. This provided access for large instruments, including the right-angle forceps, Endo Retract™ II 10 mm (Covidien, Norwalk, CT, USA), Multifire Endo GIA™ stapling device (Covidien), and Lap bag. Subsequently, an 11-mm umbilical trocar was inserted for the camera and 2 5-mm trocars were placed for the operating instruments; there are studies of 3-mm trocars in use for cosmetic purposes [16,17], but in our institution 5-mm trocars were placed in order to use the conventional laparoscopic equipment, and thus provide a more convenient environment for the surgeons. The donor kidney was procured through a periumbilical incision in LESSOP-DN or by a Pfannenstiel incision in MLDN (Figure 1D). Figure 1 demonstrates port placement techniques for all 4 surgical procedures.

Statistical analysis

The HALDN, PLDN, LESSOP-DN, and MLDN groups were compared for complication rates in donors and recipients, and relative data were reported as either the mean and standard deviations or as frequencies and percentages for continuous and categorical variables, respectively. The data were analyzed using the Kruskal-Wallis test with Bonferroni's correction. All statistical analyses and calculations were done using IBM SPSS version 22.0 (IBM Corp., Armonk, NJ, USA).

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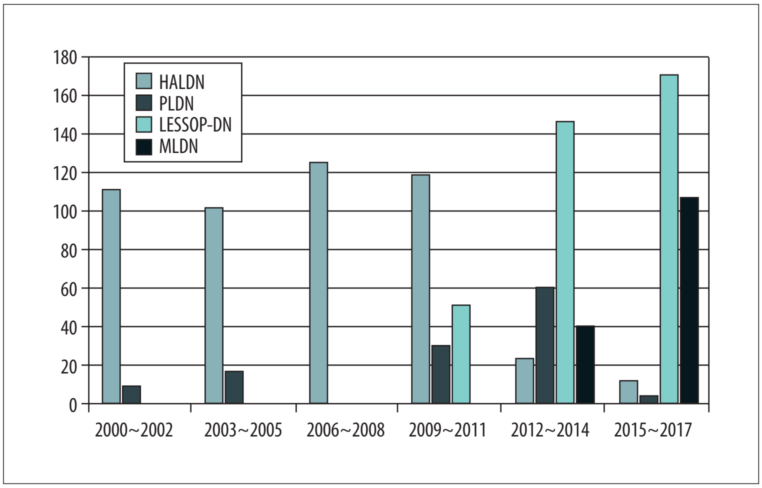

Figure 2. Distribution of donor nephrectomy methods during the study period (2000–2017). HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus 1-port donor nephrectomy; MLDN – mini-laparoscopic donor nephrectomy.

Table 1. Donor characteristics.

Variable	HALDN (n=496)	PLDN (n=124)	LESSOP-DN (n=370)	MLDN (n=143)	*p*-Value
Age (years)	39.7±11.4[a]	41.7±10.4	42.6±12.7	41.3±11.8	<0.001
BMI (kg/m²)	23.5±3.1	23.1±2.8	24.0±3.4[b]	23.6±3.2	0.013
Male (%)	270 (54.5)[c]	41 (33.1)	176 (47.6)	50 (35.0)	<0.001
Left side (%)	455 (91.9)[c]	94 (75.8)	338 (91.5)[c]	99 (69.1)	<0.001
Multiple renal arteries (%)	106 (21.4)	20 (16.1)	69 (18.6)	35 (24.5)	0.121
Multiple renal veins (%)	16 (3.2)	6 (4.8)	7 (1.9)	13 (9.1)[d]	0.002

BMI – body mass index; HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus one-port donor nephrectomy; MLDN – mini laparoscopic donor nephrectomy; SD – standard deviation; Values were presented as mean±standard deviation, median, or absolute number (%). The data was compared using Kruskal-Wallis test, and presented as median. [a] *P*<0.05 compared with LESSOP-DN and MLDN group; [b] *p*<0.05 compared with PLDN group; [c] *p*<0.05 compared with PLDN and MLDN group; [d] *p*<0.05 compared to HALDN and LESSOP-DN.

Results

Patients and clinical characteristics

We performed 1132 LDN procedures from 2000–2017. Figure 2 depicts the temporal distribution of our case volume. The LESSOP-DN procedure began in 2009, with 52 cases in the first 3 years in which it was performed. The number of LESSOP-DN cases increased every year, and from 2015 to 2017 the number of LESSOP-DN cases grew to 171. During this period, HALDN cases decreased yearly, and from 2015 to 2017, only 12 cases of HALDN had been performed. Included in this analysis are 496 (43.8%) HALDN, 124 (11.1%) PLDN, 370 (32.7%) LESSOP-DN, and 143 (12.6%) MLDN cases. Table 1 describes the demographic and preoperative data for donors. Of the 1132 patients who underwent these surgical procedures, 537 (47.4%) were males and 230 (20.3%) had multiple renal arteries. The majority (87.1%) of kidneys extracted from donors were left-side operations.

Donor perioperative parameters

Table 2 depicts the perioperative parameters of donors. EBL was significantly greater in the HALDN (57.5±52.2 mL; *P*<0.001) than in the LESSOP-DN (21.0±30.0 mL) and MLDN (18.2±28.7 mL) groups. The PLDN group also had a significantly greater EBL compared to the LESSOP-DN and MLDN groups. Conversion to other surgical methods was statistically more frequent in the PLDN group (n=4, 3.2%) than in the HALDN (*P*=0.002) and MLDN groups (*P*=0.027) (Table 2). There were 4 cases of PLDN to HALDN conversions. In 1 case, PLDN was converted to HALDN due to vein injury. The other 3 conversions were due to difficulties in the surgical procedure. Conversion to open surgery was done once in HALDN due to renal capsular injury bleeding (Table 2). Incision length was meaningfully shorter in LESSOP-DN (7.0±1.4 cm) than HALDN (11.4±1.4 cm), PLDN (9.6±2.1 cm), and MLDN (9.1±1.8 cm). The LOS was significantly longer in the HALDN than in LESSOP-DN (4.2±1.2 days versus 4.0±1.4 days, *P*=0.002) (Table 3).

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Table 2. Donor perioperative parameters.

	HALDN (n=496)	PLDN (n=124)	LESSOP-DN (n=370)	MLDN (n=143)	*p*-Value
Intraoperative					
Operative time (min)	115.5±22.1	111.7±30.2	118.8±27.0	125.1±28.6	0.171
EBL (ml)	57.5±52.2[a]	53.3±35.3[a]	21.0±30.0	18.2±28.7	<0.001
WIT (sec)	142.2±44.0	135.9±50.0	157.9±51.1	170.4±60.5	0.069
Conversion	1 (0.2)	4 (3.2)[b]	2 (0.5)	–	0.003
To open	1 (0.2)	–	–	–	0.732
To HALDN	–	4 (3.2)	2 (0.5)	–	0.006
Incision length (cm)	11.4±1.4	9.6±2.1[c]	7.0±1.4	9.±1.8	<0.001
Postoperative					
LOS (days)	4.2±1.2[d]	4.3±2.2	4.0±1.4	4.0±1.2	0.011
Change in eGFR (ml/min/1.73 ml)	18.8±12.8[e]	22.2±14.5[f]	24.2±11.7[g]	18.6±8.6	<0.001

EBL – estimated blood loss; WIT – warm ischemic time; LOS – length of stay; eGFR – Estimated glomerular filtration rate; HALDN – hand-assisted laparoscopic donor nephrectomy. PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus one-port donor nephrectomy; MLDN – mini laparoscopic donor nephrectomy. [a] $p<0.001$ compared to LESSOP-DN and MLDN group; [b] $p<0.05$ PLDN compared to HALDN, LESSOP-DN, and MLDN; [c] $p<0.05$ for all groups compared except for PLDN *vs.* MLDN; [d] $p=0.002$ compared to LESSOP-DN; [e] $p<0.05$ compared with MLDN; [f] $p<0.05$ compared to all four groups; [g] $p<0.05$ compared to MLDN.

Table 3. Comparison between the four groups for EBL, LOS, and incision length.

	HALDN *vs.* PLDN	HALDN *vs.* LESSOP-DN	HALDN *vs.* MLDN	LESSOP-DN *vs.* PLDN	LESSOP-DN *vs.* MLDN	MLDN *vs.* PLDN
EBL	57.5±52.2 *vs.* 53.3±35.3 (*P*=0.987)	57.5±52.2 *vs.* 21.0±30.0 (*P*<0.001)	57.5±52.2 *vs.* 8.2±28.7 (*P*<0.001)	21.0±30.0 *vs.* 53.3±35.3 (*P*<0.001)	21.0±30.0 *vs.* 18.2±28.7 (*P*=0.749)	18.2±28.7 *vs.* 3.3±35.3 (*P*<0.001)
LOS	4.2±1.2 *vs.* 4.3±2.2 (*P*=0.674)	4.2±1.2 *vs.* 4.0±1.4 (*P*=0.002)	4.2±1.2 *vs.* 4.0±1.2 (*P*=0.253)	4.0±1.4 *vs.* 4.3±2.2 (*P*=0.113)	4.0±1.4 *vs.* 4.0±1.2 (*P*=0.942)	4.0±1.2 *vs.* 4.3±2.2 (*P*=0.093)
Incision length	11.4±1.4 *vs.* 9.6±2.1 (*P*=0.206)	11.4±1.4 *vs.* 7.0±1.4 (*P*<0.001)	11.4±1.4 *vs.* 9.1±1.8 (*P*=0.004)	7.0±1.4 *vs.* 9.6±2.1 (*P*=0.023)	7.0±1.4 *vs.* 9.1±1.8 (*P*<0.001)	9.1±1.8 *vs.* 9.6±2.1 (*P*=0.919)
eGFR change	18.8±12.8 *vs.* 22.2±14.5 (*P*=0.027)	18.8±12.8 *vs.* 24.2±11.7 (*P*<0.001)	18.8±12.8 *vs.* 18.6±8.6 (*P*=0.547)	24.2±11.7 *vs.* 22.2±14.5 (*P*=0.037)	24.2±11.7 *vs.* 18.6±8.6 (*P*<0.001)	18.6±8.6 *vs.* 22.2±14.5 (*P*=0.477)

EBL – estimated blood loss; LOS – length of stay; eGFR – estimated glomerular filtration rate; HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus one-port donor nephrectomy; MLDN – mini laparoscopic donor nephrectomy. The level of statistical significance was set at $p<0.05$.

Donor complications by Clavien classification

Differences in intraoperative and postoperative complications were not statistically significant across all 4 groups (Table 4). Transfusions were required 9 times overall (0.8%): 6 times intraoperatively (0.5%) and 3 times postoperatively (0.3%). In 1 case, transfusion was performed following an intraoperative inferior vena cava (IVC) injury in the LESSOP-DN group. Transfusions were required intraoperatively in the HALDN group in 3 cases due to polar artery injury, lumbar vein injury, and renal vein branch

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Table 4. Donor complications by Clavien classification.

	Clavien	HALDN (n=496)	PLDN (n=124)	LESSOP-DN (n=370)	MLDN (n=143)	*p*-Value
Intraoperative		9 (1.8)	2 (1.6)	5 (1.3)	3 (2.1)	0.872
Transfusion	II	3 (0.6)	–	2 (0.5)	1 (0.7)	0.851
Bowel injury	IIIb	1 (0.2)	1 (0.8)	–	–	0.294
Vessel injury	IIIb	4 (0.8)	1 (0.8)	3 (0.8)	2 (1.4)	0.920
Open conversion	IIIb	1 (0.2)	–	–		0.734
Postoperative		10 (2.0)	3 (2.4)	10 (2.7)	1 (0.7)	0.863
Wound dehiscence	I	1 (0.2)	–	1 (0.3)	–	0.879
Wound infection	I	1 (0.2)	–	1 (0.3)	–	0.879
Chylous ascites	I	4 (0.8)	2 (1.6)	4 (1.0)	–	0.460
Ileus*	II	2 (0.4)	–	–	–	0.460
Transfusion	II	–	1 (0.8)	1 (0.3)	1 (0.7)	0.295
Exploratory laparotomy	IIIb	2 (0.4)	–	–	–	0.460
Incisional hernia	IIIb	–	–	3 (0.8)	–	0.103
Total complication (%)		19 (3.0)	4 (3.2)	12 (3.2)	2 (1.4)	0.713

HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy;
LESSOP-DN – laparoendoscopic single-site plus one-port donor nephrectomy; MLDN – mini laparoscopic donor nephrectomy.
The level of statistical significance was set at $p<0.05$.

Table 5. Recipient parameters.

	HALDN (n=496)	PLDN (n=124)	LESSOP-DN (n=370)	MLDN (n=143)	*p*-Value
Recipient serum eGFR at one month (ml/min/1.73 m^2)	69.0±24.3	60.3±18.7	65.5±20.2	64.7±21.0	0.601
Recipient serum eGFR at six months (ml/min/1.73 m^2)	66.5±22.9	55.6±14.3	57.0±14.6	59.8±18.3	0.155
1 year graft failure (%)	15 (3.0)	6 (4.8)	7 (1.9)	1 (0.6)	0.699

eGFR – estimated glomerular filtration rate; HALDN – hand-assisted laparoscopic donor nephrectomy; PLDN – pure laparoscopic donor nephrectomy; LESSOP-DN – laparoendoscopic single-site plus one-port donor nephrectomy; MLDN – mini laparoscopic donor nephrectomy. The level of statistical significance was set at $p<0.05$.

injury, respectively. In the PLDN and MLDN groups, there was 1 case each requiring transfusion postoperatively because of a renal vein branch injury.

A small intraoperative bowel serosal injury occurred in the HALDN group and another in the PLDN group; both were repaired using primary sutures. Ten vessel injuries were reported (Table 4). Four occurred in the HALDN group: 1 left iliac vein injury, 1 renal vein branch injury, 1 polar artery injury, and 1 lumbar vein injury. The LESSOP-DN group exhibited 1 renal artery injury, 1 IVC injury, and 1 renal vein branch injury. Two occurred in the MLDN group: 1 IVC injury and 1 renal vein branch injury, both of which were treated with sutures. The iliac vein injury in the HALDN group was repaired using Prolene sutures. The polar artery injury in HALDN resulted in an EBL of 500 mL, which was resolved by clamping the vessel with a 5-mm clip. The 1 renal vein branch injury in the LESSOP-DN group was resolved using a 10-mm clip clamp and conversion to HALDN. The IVC injury in LESSOP-DN had an EBL of 100 mL and received 1 pint of transfusion. The renal vein branch injury sustained in MLDN caused an EBL of 300 mL and was treated with 1 pint of transfusion and sutures. Two patients (0.2%) in

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the HALDN group were treated postoperatively for ileus with a nasogastric tube, which was resolved without further complications. 3 patients (0.8%) in the LESSOP-DN group had a postoperative incisional hernia and were surgically repaired. Two HALDN group patients required re-exploration, 1 for bleeding, which was resolved by applying glue and cauterization, and the other to remove a gauze that had been left in the abdomen during surgery.

Recipient parameter

Differences in recipient graft function outcomes were not statistically significant across all 4 groups (Table 5). The mean recipient serum eGFR levels at 1 month and 6 months after surgery were similar between the 4 groups. The 1-year graft failure results were comparable, without significant differences between the 4 groups.

Discussion

Laparoscopy has transformed living kidney donor transplantation, making donation more appealing because of the reduction in LOS, pain, and convalescence; a faster return to normal activity; and improved cosmesis [18,19]. Donor nephrectomy is a distinctive major surgical procedure because the operation involves an otherwise healthy individual subjected to the hazards of a major operation entirely for altruistic purposes. Compared to open donor nephrectomy, LDN showed superior donor postoperative recovery and convalescence [20]. Our institution has been performing LDN procedures since 2000. Currently, LESSOP-DN and MLDN are the standard laparoscopic techniques preformed at our institution. MLDN is selected in cases when either the donor presents prior C-section scars, right nephrectomy is indicated, or when the donor wants the surgical scar hidden in their undergarments. In this technique, a 5-mm trocar was placed rather than a 3-mm trocar to use conventional laparoscopic instruments [16,17].

Even though conversion is not fully acknowledged as a complication, it is a necessary point made when discussing possible outcomes before any surgery with patients. There was only 1 case (0.2%) of open conversion resulting from HALDN among all 4 groups. This was attributed to hemorrhaging from a renal capsular injury. There are reports demonstrating the percentage of HALDN conversion to open surgery as 1–2% and that the most common cause for conversion to open donor nephrectomy was intraoperative hemorrhage or vascular injury [21,22].

In this study, for the 4 groups, the conversion rate from PLDN to HALDN was 3.2% (n=4) and from LESSOP-DN to HALDN was 0.5% (n=2). Previous reports described a 3.3% or a 2.8% conversion to HALDN rates, which are comparable with our results [23,24].

Comparison of all 4 groups with respect to donor complications revealed no significant intraoperative or postoperative complication rates. Among the complications, transfusion was required mostly for the occurrence of intraoperative vessel injury (n=6). The renovascular complication rate (0.6%) was comparable to that of other studies [25–27], including the study by Hsu et al. that reported a 2.3% renovascular complication rate [28]. All vascular complications required an individualized approach. Two were repaired with metal clips, 3 required sutures, 2 were given additional transfusions after repair, 1 required conversion to HALDN, and 1 was converted to open surgery.

When looking at the overall population of our analysis, the donor's BMI were relatively low compared to western cases, and a series of reports among obese donors showed insignificant results regarding morbidity, mortality, and surgical outcome. In addition, there were no meaningful differences in other major complications. There was a slight increase in minor complications and operative time for obese patients, but these were relatively insignificant, making LDN safe for obese donors [29–31]. Surgeons with less laparoscopic experience may find tissue dissection, retraction, and intraoperative exposure challenging. In particular, the LESSOP-DN technique is more demanding because it is less ergonomic than the other 3. In such cases, a transperitoneal approach using PLDN or HALDN may be more appropriate. In our study, LESSOP-DN donors postoperatively had a 0.8% (n=3) rate of incisional hernia. We assume that this was due to the close proximity with which the periumbilical incision was made during the operation. In early cases of LESSOP-DN, the incision was made in middle of the umbilicus, but in later cases the incisions were modified to periumbilical incisions, which prevented hernias afterwards. When comparing our results to those of other studies, La Mattina et al. reported that the most common complication in LESS-DN was an umbilical hernia, which resulted in 1.9% postoperative hernia operations [32]. Serrano et al. reported a 4% rate of incisional hernia in HALDN [33]. However, no incisional hernias occurred after HALDN in this study.

The overall transfusion rate for all 4 groups was 0.7% (n=9) and the reoperation rate was 0.4% (n=2) at our institution. There is a report that reviewed 381 cases of PLDN at a single institution which demonstrated a 3.4% transfusion rate and a 1.8% reoperation rate; these results are comparable to the outcomes at our center [10,22].

Finally, regardless of donor technique, all 4 procurement techniques produced essentially equivalent recipient results. During the 18 years of our study, surgical techniques have been modified to lower rates of morbidity and improve cosmetic satisfaction and quality of life [14,26,34]. Most complications were minor in the data we reviewed. There were no

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significant differences in outcomes or complication rates for donors and recipients. This is probably because our surgeons, who are skilled at performing laparoscopic surgeries, including laparoscopic radical prostatectomy and laparoscopic partial nephrectomy, performed the LDN procedures. This minimized the effects that result from the learning curve of novice surgeons at other hospitals.

However, this study has limitations including its retrospective nature and the fact that it was from a single center. In addition, the outcomes for each LDN procedure were strongly influenced by the learning curve and improvements of LDN skills. Furthermore, this study was a multi-surgeon comparative study and may have been affected by individual surgical skills. However, during the latter 10 years of this study, a single, more experienced surgeon performed donor nephrectomies. However, this may be affected by improvements in LDN skills as well. For instance, the relatively low blood loss in the LESSOP-DN group may be due to the surgeons' experience rather than the advantages of the technique. The donors were discharged when mobilization and normal food intake were possible. The statistical numbers regarding LOS overlap between HALDN and LESSOP-DN groups may appear less clinically meaningful, but this study was done with a large number of patients, giving significant statistical difference between HALDN and LESSOP-DN. The LESSOP-DN technique had a significantly shorter incision length, but in both MLDN and PLDN the incision is placed in an area that can be covered by underwear and hair growth. This could make MLDN and PLDN more cosmetically satisfactory for some donors. Finally, long-term follow-up of patients was absent, and the retrospective nature of this study meant that there may have been shortcomings in the collection of minor complication data.

Conclusions

This is a retrospective study of more than 1000 cases done for more than 10 years at a single institution. The findings showed that the LESSOP-DN technique had a significant advantage over HALDN regarding LOS and incision length, and also over PLDN concerning incision length. Intraoperative and postoperative complications for all 4 groups showed no significant differences for donors. Recipient graft outcomes were comparable, with no significant differences between surgical techniques.

Conflict of interest

None.

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