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The Evolution of Laparoscopic Right Donor Nephrectomy: Progression to Single Site Surgery

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Abstract

Background: Laparoscopic donor nephrectomy represents a significant source of allografts to patients with end-stage renal disease. Given the increasing wait-list and limited number of deceased donors, utilization of the right kidney is necessary to maximize the donor pool.

Materials: We retrospectively reviewed 122 right-sided kidney donors; 73 hand-assisted laparoscopic donor nephrectomies (R-HAL-DN), 36 standard laparoscopic donor nephrectomies (R-LAP-DN), and 13 laparoendoscopic single site donor nephrectomies (R-LESS-DN). We compared these groups to matched left donors and each other, analyzing various parameters including operative times, warm ischemia time (WIT), estimated blood loss (EBL), incision length, length of stay (LOS), convalescence data and complications.

Results: Right and left donors demonstrated no difference in analysis parameters in all 3 procurement techniques. When comparing all right donors total operative time and allograft extraction time were lowest in the R-LAP-DN group ($p=0.003$ & $p=0.04$, respectively). The R-LESS-DN group had the lowest EBL ($p=0.06$) and shortest incision length ($p<0.0001$). The LOS was shortest in the R-LAP-DN group ($p=0.03$). WIT, donor convalescence, and recipient allograft function were similar in all 3 groups.

Conclusion: Our data demonstrates the safety and reproducibility of procuring the right kidney. Donor safety and allograft function have continued through evolution of the technique.

Keywords: Donor nephrectomy; Laparoscopy; Living donor; Minimally invasive surgery; Right kidney; Single port

Introduction

The transition from open to laparoscopic donor nephrectomy (LAP-DN) at most high volume kidney transplant centers began in 1995 after Ratner et al. reported the first successful laparoscopic living renal allograft recovery [1]. Since that time, long term data on low complication rates, improved donor recovery, and equivalent allograft function has solidified LAP-DN as the gold standard for living kidney donation [2]. However, even with well documented parameters of improved cosmesis, decreased peri-operative pain, decreased recovery time, and an overall improvement in patient satisfaction intended to further increase the limited organ pool, an important number of live donor kidneys are still procured via an open approach. One of the most common reasons to perform open donor nephrectomy remains right-sided nephrectomy [3].

Despite improvements in surgical techniques and innovation of novel devices and instrumentation, right-sided LAP-DN (R-LAP-DN) remains a source of trepidation for even the most experienced laparoscopic surgeon. Early attempts at using the right kidney were associated with a high incidence of renal vein thrombosis and graft loss [4]. Technical modifications in the surgical technique, such as extending the renal vein length and reducing stretch on the renal artery, improved operative and post-operative outcomes by decreasing vascular complications [4-7]. In addition, several studies have shown that right kidneys procured via traditional hand-assisted or standard laparoscopic methods have shown equivalent function compared to a matched group of left sided allografts [5,8-11]. Nevertheless, many centers remain reluctant to procure the right kidney, even if multiple vessels are present on the left kidney [3].

Herein, we report over a decade of experience procuring the right kidney, as our technique has evolved from hand-assisted laparoscopic donor nephrectomy (HAL-DN), to standard LAP-DN, to our current use of laparoendoscopic single site donor nephrectomy (LESS-DN).

Materials and Methods

Patients

We analyzed 122 right donor nephrectomies performed at our institution from 2000-2010. There were 73 R-HAL-DN from 2000-2007, 36 R-LAP-DN from 2007-2009, and 13 R-LESS-DN from 2009-2010. A multidisciplinary team screened all potential donors preoperatively. Obese donors, older donors, and donors with multiple arteries on both sides were not restricted from laparoscopic renal donation. Computerized tomography scans with three-dimensional vascular reconstruction was performed on all donors to map out the renal hilum. Renal scintigraphy was obtained when there was an observed >1cm size difference between kidneys.

Selection of the appropriate kidney for donation was based on long standing criteria that has governed open donor nephrectomy. If there was a >10% difference in function as measured by scintigraphy, the smaller kidney was used. If possible, the kidney with the simplest vascular anatomy was recovered. If imaging revealed a unilateral anatomic abnormality, such as renal artery stenosis, that side was chosen.

At our institution we transitioned from the various surgical

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procurement techniques in parallel with technological surgical innovations. We no longer perform R-HAL-DN and have not performed them, at least to start a case, since 2007. Moreover, we do not routinely perform R-LAP-DN as we have transitioned to R-LESS-DN. If a patient is having a surgical procedure performed at the same time as the nephrectomy, we may begin such a case laparoscopically. Obesity, age, and previous surgery do not preclude the LESS-DN technique.

To demonstrate the feasibility of right donor nephrectomies across all three procedures, we proceeded to match these donors to left donors of the same era. Donors were matched by age, gender, body mass index (BMI), creatinine clearance, and procurement technique/era. Because we transitioned quickly to conventional LAP for left donors, the number of L-HAL-DN (n=9) was significantly less than the number of R-HAL-DN and thus we did not include the L-HAL-DN group in this study. Additional analyses were performed comparing the right donor procurement techniques to each other.

Parameters

Donor perioperative parameters analyzed included allograft extraction time (time from skin incision to allograft recovery), total operative time, estimated blood loss (EBL), visual analog pain scores (VAPS), time to tolerance of clears and length of stay. Convalescence data included the following: (i) time to return to work, (ii) time to "normal" activity defined as the amount of time needed to resume usual day to day activities besides work, and (iii) time to "100% recovery" defined as the amount of time needed to feel complete resolution of physical symptoms with energy levels equal to preoperative levels. These outcomes were collected in a patient questionnaire at a two month postoperative visit. This included questions regarding how they would rate their happiness on a scale of 1 (displeased) to 10 (extremely pleased) with the appearance and discomfort of their surgical scar.

Complications data was collected and analyzed. Intraoperative complication data compared included the rate of conversion to open or HAL surgery as well as types of injuries. Postoperative complications were classified using the Clavien-Dindo classification system [12]. Minor complications (Clavien grades I & II) included those complications that did not require an invasive intervention, while major complications (Clavien grades III-V) required invasive interventions or resulted in organ dysfunction.

Recipient outcomes analyzed included serum creatinine at 1 week, 1, 3, 6, 12 and 24 months, when applicable, incidence of delayed graft function (DGF), incidence of allograft thrombosis, incidence of allograft loss within the 1st week post-transplantation, one year acute rejection (AR) rates, and overall AR rates. DGF was defined as the need for hemodialysis within the 1st week post-transplantation.

Data was collected retrospectively, utilizing hospital and office visit charts, and entered in an Institutional Review Board-approved database. Total operative time is defined as the time from skin incision to skin closure. The term warm ischemia time is the time from renal artery occlusion to back-table perfusion with ice-cold Custodial HTK solution.

Surgery

All procedures in this study were performed by a single surgeon (JJD). The HAL and LAP donor techniques have been described in previous studies [4,13].

We have previously described the components and working mechanism of the GelPoint™ (Applied Medical, Rancho Santa Margarita, CA) as well as our LESS-DN technique [14]. Patients are placed in a modified flank position with the operating table flexed so as to extend the right flank. A 4-5 centimeter vertical periumbilical incision is made with the abdominal skin on stretch. After creation of a vertical midline anterior rectus fasciotomy, the abdomen is entered. The GelPort™ device with three trocars in place is inserted into the abdomen and pneumoperitoneum is established. Initially, two 5-mm trocars and one 15-mm trocar are used to maximize intracorporeal spacing. A bariatric 10-mm rigid laparoscope is used through the 15mm port with a right angle attachment for the light cord to optimize triangulation. Standard, non articulating laparoscopic instruments are used in the majority of the procedure. Other instrumentation, including curved (Novare Surgical Systems, Cupertino, CA, USA) or articulating (Cambridge Endo, Framingham, MA, USA) instruments were used as necessary.

The LESS-DN surgical technique essentially duplicates standard LAP. Three ports are used initially in order to optimize our working space. A Diamond-Flex retractor (Genzyme Surgical Products, Tucker, GA) is used for retraction of the right lobe of the liver to facilitate division of the triangular and coronary ligaments. Using mostly one handed dissection, the duodenum is kocherized bluntly to expose the inferior vena cava (IVC). The hepatic flexure was gently lifted and the plane between Gerota's fascia and the mesocolon was identified. The colon was bluntly dissected and mobilized in a medial and caudal direction, down to the iliac vasculature. The ureter and gonadal vein are identified and lifted off of the psoas muscle together, maintaining periureteral attachments and dissected towards the hilum. At this point, a fourth trocar (5mm) is placed through the Gelport™ device for retraction of the right lobe of the liver (Figure 1).

As with LAP-DN, the renal vein is skeletonized down to the level of the IVC. The renal artery is dissected medial to the lateral edge of the IVC to maximize length, and the interaortocaval region is skeletonized. The adrenal gland is dissected free from the medial upper aspect of the kidney using a harmonic scalpel. Lastly, the posterior and lateral attachments were divided. A 12-mm trocar replaces one of the 5-mm trocars in anticipation of using the EndoGIA vascular stapler (United States Surgical, Norwalk CT).

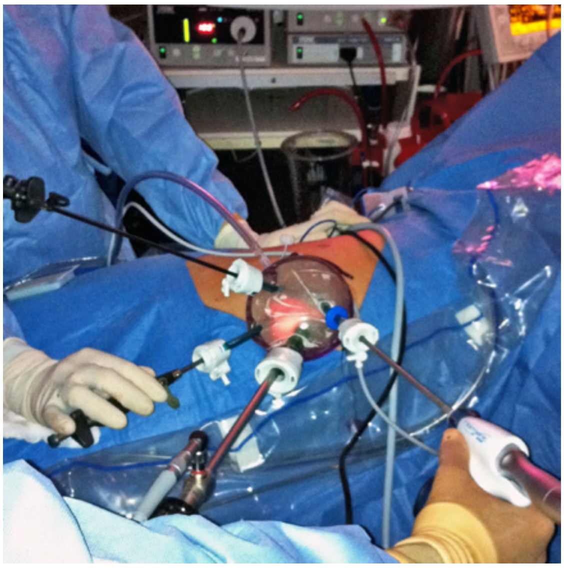

Figure 1: The figure depicts the placement of the 4 trocars through the GelPort device during a right laparoendoscopic single site donor nephrectomy.

Once the recipient team is ready, the ureter is divided at the pelvic brim. The kidney is then retracted laterally. Using an EndoGIA stapler, the renal artery is divided first, followed by the vein, with the vein being divided flush with the IVC. An endocatch bag is introduced, and the allograft is gently entrapped and extracted. The final incision is shown in Figure 2.

Statistical analyses

Statistical calculations were performed using GraphPad Prism v.5 software. Data are reported as mean±standard deviation (SD), unless otherwise stated. EBL is given as a median and range because of the large SD in most groups (SD>mean). Categorical variables were compared using Fisher's exact or chi-square test; continuous variables were compared using Kruskal-Wallis tests (3 groups) or Mann-Whitney U-test (2 groups). Survival analysis was performed using the Kaplan–Meier curve method and groups were compared with the log rank test. A p value of less than 0.05 (two-tailed) was considered significant.

Results

Donor characteristics

Donor baseline characteristics are listed for all left and right donors in Table 1. There was no significant difference in baseline characteristics, including age, gender, creatinine clearance, BMI, and number of patients with multiple vessels (>1 renal artery and/or >1 renal vein) between L-LAP & R-LAP donors, and L-LESS & R-LESS donors. The demographic data is also listed for R HAL donors.

Further analyses comparing the R-HAL, R-LAP, and R-LESS groups demonstrated no difference between them with respect to age, gender, creatinine clearance, or BMI (p=0.47, p=0.50, p=0.06 & p=0.15 respectively). Additionally, the number of patients with multiple vessels was not significantly different between the 3 right donor groups (p=0.69). Based on pre-operatively imaging, renal vein length was not significantly different between R-LAP-DN and R-LESS-DN (p=0.46). Because renal vasculature length was not officially measured on pre-operatively imaging until 2007, the R-HAL-DN renal vein length data was not available.

Operative outcomes

Intraoperative data is listed in Table 2 for all left and right donors. There was no difference in allograft extraction time, total operative time, warm ischemia time, and blood loss between R-LAP & L-LAP donor nephrectomies and R-LESS & L-LESS donor nephrectomies. There was no difference in incision length between R-LAP-DN & L-LAP-DN and R-LESS-DN & L-LESS-DN.

Additional analyses comparing the 3 right donor cohorts demonstrated that the total operative times and allograft extraction times were significantly different (p=0.003 & p=0.04) between the three groups. Moreover, there was a trend towards more blood loss in the R-LAP-DN (p=0.06), whereas warm ischemia time did not differ between the three groups (p=0.33). The incision length was shortest in the R-LESS-DN group compared to the other two groups (p<0.0001).

Post-operative outcomes and convalescence data

Postoperative parameters comparing right and left donors in the 3 procurement techniques are listed in Table 3. In each procurement technique, right and left donors had similar outcomes, including time to tolerating clears, length of hospitalization, and convalescence data.

There were several differences in the post-operative outcomes between the 3 right donor groups. R-LESS-DN patients tolerated clears sooner (17.9 hrs) than R-HAL-DN (19.4 hrs) and R-LAP-DN patients (21.8 hrs) (p<0.0001). Mean length of hospitalization was shortest in the R-LAP-DN group (2.1 days) compared to the R-HAL-DN (2.4 days) and R-LESS-DN (2.4 days) groups (p=0.03). The VAPS were similar between the three groups at 1 month post-transplant (p=0.80). No difference was noted for patients to return to work (p=0.42), time to return to normal activity (p=0.35), or the time required for patients to report 100% recovery (p=0.96).

Complications data

Perioperative complications are listed in Table 4. Three patients in the R-HAL-DN group experienced an intraoperative complication which included one liver laceration; one iatrogenic IVC injury requiring conversion to open surgery; and one iatrogenic transection of an accessory renal artery, reimplanted in the main renal artery on the recipient backtable. Two R-LAP-DN cases experienced an intraoperative complication including an IVC injury requiring conversion to open surgery and a partial renal artery transaction. Two L-LAP-DN intraoperative complications occurred including a splenic laceration and adrenal vein injury.No intraoperative complications occurred in the LESS-DN groups, although one right and one left case were converted to HAL to optimize hilar dissection.

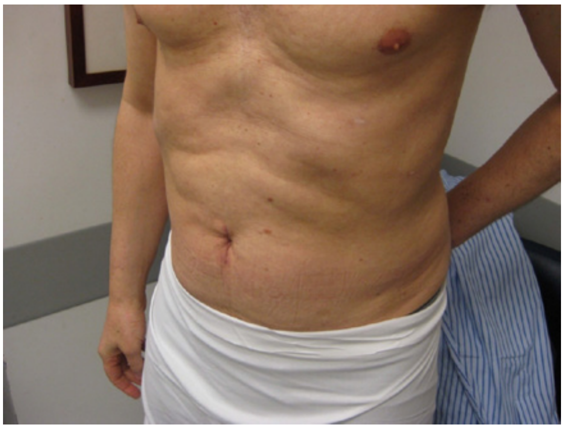

Figure 2: The figure depicts the postoperative umbilical incision of a patient 8 weeks after undergoing a laparoendoscopic single site donor nephrectomy.

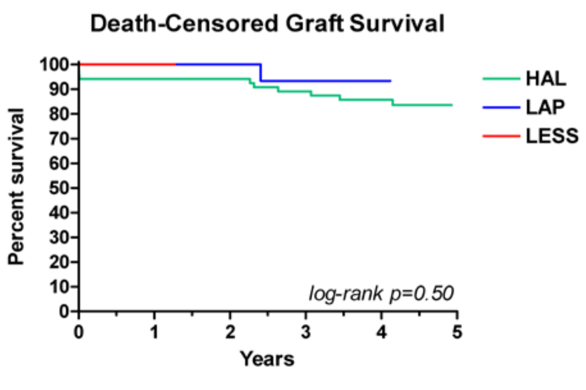

Figure 3: The figure illustrates the Kaplan–Meier curve depicting death-censored graft survival based on donor procedure. The y-axis is the number of years posttransplant. No significant difference was noted between the 3 groups (log rank p=0.50).

Four post-operative complications occurred in the R-HAL-DN group. All of these complications were classified as minor complications including one case of orchitis; one case of pyelonephritis; one superficial surgical site infection (SSSI); and one case of orchialgia. In the R-LAP-DN group, three postoperative complications occurred, including one incisional hernia (major complication); one hydroceole; and one blood transfusion. In the L-LAP-DN group four postoperative complications occurred including one case of testicular torsion (major complication); one SSSI; one case of epididymitis; and one blood transfusion. In the R-LESS-DN group one patient had FUO, while in the L-LESS-DN group one patient had an ileus and one patient had a SSSI.

There was no difference between the three right donor groups in the number of patients experiencing an intraoperative and postoperative complication, severity of complications, or types of complications ($p>0.05$).

Recipient outcomes

The recipients of right donor data are listed in Table 5. Four patients developed DGF. In the R-HAL-DN group, there were 2 patients (2.9%); one patient did not receive induction therapy, and one patient received Basiliximab for induction. In the R-LAP-DN group, there were also 2 patients (5.7%); one patient developed acute tubular necrosis in the setting of hypotension from Thymoglobulin induction therapy, and one patient with a history of posterior uretheral valves developed urinary retention postoperatively. All 4 of these patients recovered allograft function within 2 weeks. All patients in the R-LESS-DN group had immediate graft function. Five recipients in the R-HAL-DN group had vascular thromboses post-operatively; 3 involving the renal vein and 2 involving the renal artery. Of these 5 patients, 4 lost their graft immediately. One of the renal vein thromboses was diagnosed early enough to salvage the graft. One year and overall AR rates were similar for all 3 groups. Post-operative serum creatinine values were similar between the 3 groups at 1 week, 1-, 3-, and 6 months.

Graft suvival

The mean follow-up times for the R-LESS-DN, R-LAP-DN, and R-HAL-DN groups are 226 days, 845 days, and 1952 days, respectively. The death-censored graft survival based on procurement technique is depicted in Figure 3. The overall 1-year death-censored graft survivals for the 3 groups were 100%, 100% and 94.1%, respectively. The 3-year death-censored graft survivals for R-HAL-DN and R-LAP-DN groups were 89.1% and 93.3%, respectively. The 5- and 10-year death-censored graft survivals of the R-HAL-DN group were 83.5% and 74.6%, respectively. There was no significant difference in death-censored graft survival between the three groups (log rank p=0.50).

	HAL		p	LAP		p	LESS		p
	RIGHT (N=73)			RIGHT (N=36)	LEFT (N=36)		RIGHT (N=13)	LEFT (N=13)	
Age (years)	42±11.7	--	--	45±13.7	43±12.3	0.57	45±10.5	45±9.8	0.92
Sex (M:F)	24:49	--	--	16:20	16:20	1.0	5:8	5:8	1.0
CrCl (mL/min)	120±21.1	--	--	113±25.4	118±19.8	0.10	111±17.9	108±22.3	0.49
BMI (kg/m^2)	26.7±4.8	--	--	25.8±3.3	25.6±3.4	0.58	24.3±4.4	25.0±3.4	0.44
Multiple Vessels, n (%)	24 (33%)	--	--	13 (36.1%)	12 (33%)	0.80	3 (23%)	3 (23%)	1.0
Vein Length (cm)[a]	--	--	--	2.48±2.39	5.05±1.30	<0.0001	2.34±0.73	4.95±1.23	<0.0001

HAL: hand-assisted laparoscopy, LAP: standard laparsopcy, LESS: laparoendoscopic single site surgery, CrCl: creatinine clearance, BMI: body mass index
[a]Based on preoperative radiographic imaging

Table 1: Donor Characteristics.

	HAL		p	LAP		p	LESS		p
	RIGHT (N=73)			RIGHT (N=36)	LEFT (N=36)		RIGHT (N=13)	LEFT (N=13)	
Allograft Extraction Time (min)	90±18.2	--	--	84±20.3	82±14.7	0.80	97±19.8	94±25.5	0.68
Total Operative Time (min)	146±35.1	--	--	126±33.4	126±27.9	0.53	149±28.1	148±31.4	0.86
Warm Ischemia Time (min)	4.09±0.89	--	--	4.18±0.83	4.18±0.80	0.86	3.72±0.40	3.72±0.49	0.94
Blood Loss (mL)[a]	100 (10-1000)	--	--	100 (50-2100)	68 (50-600)	0.78	75 (25-300)	50 (25-300)	0.96
Incision Length (cm)[a]	7.09±0.95	--	--	6.13±0.37	5.97±0.49	0.26	5.04±0.32	5.00±0.65	0.37

HAL: hand-assisted laparoscopy, LAP: standard laparsopcy, LESS: laparoendoscopic single site surgery
[a]median (range)

Table 2: Intraoperative Data.

	HAL		p	LAP		p	LESS		p
	RIGHT (N=73)	--		RIGHT (N=36)	LEFT (N=36)		RIGHT (N=13)	LEFT (N=13)	
Time to Clears (hour)	22±3.4	--	--	19±4.8	21±5.4	0.13	18±4.3	18±1.9	0.84
Length of Stay (days)	2.4±0.6	--	--	2.1±0.4	2.1±0.4	0.58	2.4±0.7	2.2±0.8	0.38
VAPS at discharge	1.2±1.3	--	--	1.4±1.5	1.6±1.2	0.51	1.4±1.0	1.5±1.5	0.92
Return to Work (days)	12±3.3	--	--	11±3.1.83	12±2.9	0.26	11±1.6	12±2.6	0.66
Return to Normal Activity (days)	19±4.1	--	--	19±3.8	20±3.0	0.20	18±2.9	19±3.9	0.30
Return to 100% (days)	26±4.6	--	--	26±4.1	27±5.0	0.17	26±2.8	27±3.9	0.68

HAL: hand-assisted laparoscopy, LAP: standard laparoscopy, LESS: laparoendoscopic single site surgery, VAPS: visual analog pain score

Table 3: Postoperative Parameters.

	HAL			LAP			LESS		
	RIGHT (N=73)	--	p	RIGHT (N=36)	LEFT (N=36)	p	RIGHT (N=13)	LEFT (N=13)	p
Intraoperative Complications, n (%)	3 (4.1%)	--	--	2 (5.6%)	2 (5.6%)	1.0	0 (0%)	0 (0%)	1.0
Conversion to Open/HAL, n (%)	1 (1.4%)	--	--	1 (2.8%)	0 (0%)	1.0	1 (7.7%)	1 (7.7%)	1.0
Type of Injury n (%): **Liver laceration** **Splenic laceration** **Adrenal vein injury** **Renal artery injury** **Accessory artery injury** **Renal vein injury** **Inferior vena cava injury**	 1 (1.4%) 0 (0%) 0 (0%) 0 (0%) 1 (1.4%) 0 (0%) 1 (1.4%)	--	--	 0 (0%) 0 (0%) 0 (0%) 1 (2.8%) 0 (0%) 0 (0%) 1 (2.8%)	 0 (0%) 1 (2.8%) 1 (2.8%) 0 (0%) 0 (0%) 0 (0%) 0 (0%)	--	 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%)	 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%) 0 (0%)	--
Postoperative Complications, n (%)	4 (5.5%)	--	--	3 (8.3%)	4 (11.1%)	1.0	1 (7.7%)	2 (15.3%)	0.38
Postoperative Complication, n (%): **I-II (minor)** **III-V (major)**	 4 (5.5%) 0 (0%)	--	--	 2 (5.6%) 1 (2.8%)	 3 (8.3%) 1 (2.8%)	1.0	 1 (7.7%) 0 (0%)	 2 (15.3%) 0 (0%)	1.0
Type of Postoperative Complications, n (%): **Wound** **Genitourinary** **ID** **Hematological** **Gastrointestinal** **Ophthalmic**	 1 (1.4%) 1 (1.4%) 2 (2.7%) 0 (0%) 0 (0%) 0 (0%)	--	--	 1 (2.8%) 1 (2.8%) 0 (0%) 1 (2.8%) 0 (0%) 0 (0%)	 1 (2.8%) 1 (2.8%) 1 (2.8%) 1 (2.8%) 0 (0%) 0 (0%)	--	 0 (0%) 0 (0%) 1 (7.7%) 0 (0%) 0 (0%) 0 (0%)	 1 (7.7%) 0 (0%) 0 (0%) 0 (0%) 1 (7.7%) 0 (0%)	--

HAL: hand-assisted laparoscopy, LAP: standard laparsopcy, LESS: laparoendoscopic single site surgery

Table 4: Complications Data.

	HAL (N=68)[a]	LAP (N=35)[a]	LESS (N=12)[a]	p
Age (years)	46±13.7	47±15.5	49±15.1	0.64
Related:Unrelated Donor	41:27	28:7	6:6	0.07
Thymoglobulin Induction, n (%)	46 (68%)	23 (66%)	9 (75%)	0.84
Delayed Graft Function, n (%)	2 (3%)	2 (6%)	0 (0%)	0.60
Post-op Vascular Thrombosis, n (%)	5 (7%)	0 (0%)	0 (0%)	0.16
Graft Loss in 1st week, n (%)	4 (6%)	0 (0%)	0 (0%)	0.24
Mean Follow-up Time (days)	1952	845	226	<0.0001
One Year Acute Rejection Rate	3%	8%	0%	0.31
Overall Acute Rejection Rate	12%	14%	0%	0.40
Serum creatinine at 1 week (mg/dl)	1.89±1.19	1.56±0.96	1.71±0.76	0.26
Serum creatinine at 1 month (mg/dl)	1.66±0.85	1.45±0.61	1.88±1.03	0.25
Serum creatinine at 3 months (mg/dl)	1.51±0.53	1.43±0.56	1.48±0.39	0.81
Serum creatinine at 6 months (mg/dl)	1.50±0.51	1.41±0.48	1.42±0.29	0.77
Serum creatinine at 1 year (mg/dl)	1.48±0.52	1.35±0.58	---	0.27
Serum creatinine at 2 years (mg/dl)	1.67±1.26	1.39±0.71	---	0.40

HAL: hand-assisted laparoscopy, LAP: standard laparsopcy, LESS: laparoendoscopic single site surgery
[a]Data is unavailable on 5 recipients in the HAL, 1 recipient in the LAP group, and 1 recipient in the LESS group

Table 5: Recipient Characteristics & Outcomes of Right Donors.

Discussion

Right-sided donor nephrectomy in living kidney donation is essential in order to maximize the pool of renal donors. Furthermore, R-LAP-DN has been well-established and offers the donor all of the advantages associated with laparoscopic donor nephrectomy. Prior studies have shown that R-LAP-DN is faster than L-LAP-DN, with equivalent complication rates; however in our experience, laterality does not affect operative time [5,8-10]. Left kidneys have been the preferred kidney at the majority of transplant centers because of the early documented increased incidence of venous thrombosis and early graft loss in right kidneys [4,15]. The shorter vein length has been implicated as culprit in these early experiences of vascular complications with the right renal vein. As a result, the rate of right kidney procurement is less than 5% at high volume transplant centers [2,15]. At our institution, the right kidney is procured in approximately 15% of all living donors.

As our practice evolved from HAL-DN to LAP-DN, we saw an initial decrease in total operative times and, expectedly, allograft extraction times. A possible explanation could be increased surgeon experience as well as the similarity in the technical aspects of the two procedures. As we continued to evolve from LAP-DN to LESS-DN, our total operative times and allograft extraction times slightly increased. This is not surprising as LESS-DN is a technically more challenging procedure. Not only is the workspace limited, but also instrument triangulation is significantly hindered. In addition, assessing adequate tissue tension is more difficult. Given these technical challenges in LESS-DN, careful allograft dissection and extraction may take slightly longer than LAP-DN. Nevertheless, our R-LESS-DN total operative times are lower than other studies currently in the literature. Gil et al. reported a median operative time of 3.3 hours [16]. Desai and colleagues reported a mean operative time of 230 minutes (vs. 142

minutes in our study) [17]. Furthermore, both of these studies report using an additional 2mm needlescopic grasper [16] or 5mm port for liver retraction [17], whereas we do not utilize any additional ports. In a more recent study comparing LESS-DN to conventional LAP-DN, operative times for each procedure far exceeded ours (269 minutes and 239 minutes, respectively) [18].

In our study, only 3 R-DNs were converted to open or HAL. Two conversions were due to bleeding from an IVC injury and one elective conversion occurred (in the R-LESS-DN group). Our conversion rates were not significantly different between left and right donors or right donor techniques, and our overall conversion rate was similar to that reported in the literature. Dols et al. reported 2 conversions in 159 R-LAP-DN [5]. In another series of 97 R-LAP-DN, 3 conversions occurred [19].

In right sided donors, liver lacerations and injuries to the retro-aortic renal arteries are more common. On the other hand, intraoperative complications related to splenic lacerations during mobilization of the splenic flexure of the colon or injuries to the supra-adrenal branches of the left renal vein are more common in left sided donors [10]. In our study the overall intraoperative complication rate was 4.1%. Moreover, the intraoperative complication rates were similar between left and right donors, and the 3 right procurementtechniques. Our intraoperative complication rates are similar [5] if not better than others have reported [10,19]. We have not seen an increase in intraoperative complications despite the evolution of more technically challenging methods of procurement.

Postoperative complications occurred in 8 right donors. All but one of these complications was considered a minor complication [12]. Comparable rates have been reported in the literature in R-HAL-DN and R-LAP-DN [5,20]. However, none of the R-LESS-DN cases experienced a postoperative complication. Other studies have reported significantly higher postoperative complication rates in LESS-DN. Desai et al. reported 2 postoperative complications in a series of 17 predominantly left-sided LESS-DN [17]. Canes and colleagues reported 2 postoperative complications in their series of 18 consecutive LESS-DN [18]. In this study, only one case was a right-sided donor and was converted to standard laparoscopy and excluded from their analysis.

With the evolution of surgical practice, improvements in patient care and outcome should become evident. The R-LESS-DN had the added benefits of significantly less EBL and a shorter incision length. Meanwhile, the length of stay was shortest in the R-LAP-DN group and longest in the R-HAL-DN. Perhaps the difference between staying 2.1 days in the R-LAP-DN compared to 2.4 days in the R-LESS-DN may not carry any clinical benefit given the small sample size of the R-LESS-DN group. Moreover, a patient's physical departure from the hospital is delayed at times for logistical reasons, such as the availability of transportation, nursing availability for discharging the patient, or physician's availability to input orders. Thus, the benefits of the LESS-DN procedure may not be obvious at this time, but as the volume and technology matures this may become apparent.

In our study, our overall renal vasculature thrombosis rate was 4% (5 out of 122). Three of these were cases of renal vein thrombosis. Graft loss occurred in only 4 of the 5 recipients experiencing renal vessel thrombosis. Furthermore, these complications occurred during our initial experience and represent the infancy of right kidney procurement at our institution. In all of these cases of vascular thrombosis, we did not use extension grafts for venous or arterial extension of the right renal vasculature. Mandall et al. reported 3 venous thromboses in his first eight right sided donors [4]. Buell et al. described a renal vein thrombosis rate of 4% (3 out of 85) in right-sided donors [9]. We modified our technique by firing the stapling device flush against the IVC, while laterally retracting the kidney to maximize vein length. No allograft vascular complications occurred in recipients of LAP-DN or LESS-DN. Thus, we have not experienced an increased incidence of vascular thromboses when procuring the right kidney.

Because of the perennial shortage of allografts, prolonging allograft survival is of the utmost importance to curtail the expanding waitlist. Recipient serum creatinine values were similar between the 3 right recipient groups at the various time points. Our overall combined 1-year graft survival irrespective of procedure was 96.5%, slightly higher than the national 1-year graft survival rate for all living donors of 95.1% [21]. Furthermore, our overall combined 3-year graft survival, irrespective of procedure, was 91.2%, compared to a national 3-year graft survival rate for all living donors of 87.8%. Finally, our overall combined 5- and 10-year graft survival rate irrespective of procedure was 85.7%, which is higher than the national 5-year graft survival rate for all living donors of 79.7%.

Several limitations are evident in this study. This is a single institution, retrospective analysis, which may not capture all the data points on every patient. The sample size is small for all three groups, especially the R-LESS-DN. The follow-up time of the R-LESS-DN group is short. Additionally, the learning curve for the various procedures could influence differences between outcomes of the 3 groups. Nevertheless, to our knowledge this is the first time 3 different surgical techniques to procure the right kidney have been compared at a single institution. Moreover, to our knowledge, this is the largest reported series of R-LESS-DN in the literature.

Our data demonstrates the safety and reproducibility of procuring the right kidney for live donor nephrectomies. Utilization of the right kidney expands the donor pool without compromising patient outcomes. When comparing various right donor procurement techniques, LAP demonstrated the shortest operative time and hospitalization period; however, surgical morbidity, convalescence data, and most importantly, recipient outcomes were similar irrespective of surgical technique. The LESS technique may not be superior to the LAP technique; however, it does not appear inferior in this early stage. With time, one hopes that the LESS-DN technique could demonstrate superiority over the standard LAP approach. Additional prospective, randomized controlled trials are needed to assess the potential benefit of LESS-DN over conventional LDN; we are currently performing such a study at our center (NCT01236326).

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