Evolution of Living Donor Nephrectomy at a Single Center: Long-term Outcomes With 4 Different Techniques in Greater Than 4000 Donors Over 50 Years

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Background. The development of minimally invasive surgical approaches to donor nephrectomy (DN) has been driven by the potential advantages for the donor, with questions remaining about long-term outcomes. **Methods.** All living DN performed from June 1963 through December 2014 at the University of Minnesota were reviewed. Outcomes were compared among 4 DN techniques. **Results.** We performed 4286 DNs: 2759 open DN (ODNs), 1190 hand-assisted (HA) laparoscopic DNs (LDNs), 203 pure LDN (P-LDNs), and 97 robot-assisted-LDN. Laparoscopic DN was associated with an older ($P < 0.001$) and heavier ($P < 0.001$) donor population. Laparoscopic DN was associated with a higher probability of left kidney procurement ($P < 0.001$). All 3 LDN modalities required a longer operative time ($P < 0.001$); robot-assisted-LDN took significantly longer than HA-LDN or P-LDN. Laparoscopic DN decreased the need for intraoperative blood transfusion ($P < 0.001$) and reduced the incidence of intraoperative complications ($P < 0.001$) and hospital length of stay ($P < 0.001$). However, LDN led to a significantly higher rate of readmissions, both short-term (<30 day, $P < 0.001$) and long-term (>30 day, $P < 0.001$). Undergoing HA-LDN was associated with a higher rate of an incisional hernia compared with all other modalities ($P < 0.001$). For recipients, LDN seemed to be associated with lower rates of graft failure at 1 year compared with ODN ($P = 0.002$). The odds of delayed graft function increased for kidneys with multiple arteries procured via P-LDN compared with HA-LDN (OR 3 [1,10]) and ODN (OR 5 [2, 15]). **Conclusions.** In our experience, LDN was associated with decreased donor intraoperative complications and hospital length of stay but higher rates of readmission and long-term complications.

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In an effort to meet the increasing demand for kidney grafts, the transplant community has increasingly turned to living donor kidney transplantation (LDKT), an option that continues to expand and evolve. A recent international report on the global LDKT trends across 69 countries noted a greater than 50% growth in LDKT over the last decade in 62% of countries.[1] In Western nations, living donors account for the majority of the kidney donor pool, although deceased donors still account for the majority (67.6%) of actually transplanted kidneys.[1-4] In contrast, in Asia and the Middle East, living donors account for greater than 95% of transplanted kidneys, illustrating the impetus to continue refining LDKT to be as safe as possible.[2]

Donor nephrectomy (DN) for transplantation is a rare surgical procedure in that a healthy patient undergoes major abdominal surgery that requires manipulation of central blood vessels, with the potential of life-threatening hemorrhage.[5] Therefore, the safety of DN continues to be intensely scrutinized. As surgical technology has evolved, great strides have been made to delineate and mitigate intraoperative complications, as well as short-term and long-term adverse events.[6-11] Laparoscopic DN (LDN) addresses some of these deterrents, namely, pain and recovery time.[6] The first successful LDN was described in 1995.[12] Shortly thereafter, groups began to experiment with variations to the LDN, including the hand-assisted LDN (HA-LDN) and robot-assisted LDN (RA-LDN) techniques.[13,14] For donors, the now well-established advantages of LDN over open DN (ODN) include a reduction in hospital length of stay (LOS) and in pain, a faster return to normal activity, and improved cosmesis.[7]

In 2014, in the United States alone, living donors accounted for a total of 5538 transplanted kidneys (32.4%

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of the total number of kidney transplants).[4] The overwhelming majority of those LDKTs were performed with minimally invasive surgical (MIS) approaches. The rate of procedure-related complications and hospital LOS have declined over the past decade, but the complication rate still remains significant—on par with the complication rates from laparoscopic cholecystectomy and appendectomy.[15] Studies evaluating long-term outcomes for living donors using matched controls as a comparison group have suggested minimal long-term risks, including no increased overall mortality; however, relative increases in surgical mortality have been observed for several subgroups of living donors, including blacks, Hispanics, men, and donors with hypertension.[16]

A number of large series have reported on the outcomes of greater than 1000 LDNs, specifically looking at perioperative and short-term morbidity.[8-11] Taken together, those series demonstrate an overall complication rate of 5.6% to 7.9% with LDN, with a conversion rate to ODN of 0.3% to 0.9%. Cumulatively, these data confirm minimal short-term risks for living donors, but the long-term impact is still ill-defined.

At the University of Minnesota, the LDKT program began in 1963. We have previously published our outcomes with ODN and have demonstrated an evolution and improvement in surgical technique over time.[17] In the early 2000s, we incorporated MIS approaches into our LDKT program. In this study, we compared donor and recipient outcomes for 3 LDN variations to ODN.

MATERIALS AND METHODS

Study Cohort

From June 1963 through December 2014, we performed 4286 DNs at the University of Minnesota. For this analysis, we excluded DNs for the incision type was not recorded, ODNs after 2000, HA-LDN and P-LDN before 2001, and RA-LDN before 2004 (n = 166). All living donor and recipient information Are prospectively maintained in a database approved by the University of Minnesota Institutional Review Board. Living donors and recipients are routinely followed up postoperatively at 2 weeks, 6 months, 12 months, and yearly thereafter, and multidisciplinary clinical information was abstracted from the electronic medical records.

Data collected on living donors included birthdate, sex, body mass index (BMI), race, ethnicity, relationship to the recipient, date of donation, last known alive date and death status, cause of death, kidney function (as creatinine level and end-stage renal disease [ESRD] status) at 1, 5, 10, and 15 years postdonation, incision type, organ used, renal vasculature, operative time, estimated blood loss (EBL), any intraoperative blood transfusion, cold ischemia time, any intraoperative complications according to the Clavien-Dindo classification (CDC) of Surgical Complications,[18] LOS, any postoperative short-term (≤30 days) and long-term (>30 days) complications (defined as untoward events within the perioperative period that affected their recovery, prolonged their hospital stay, or required technical deviations during the surgical procedure), readmission, reoperation, and preoperative and postoperative blood pressure, and blood work and urinalysis results.

Data collected on recipients included their birthdate, sex, primary renal disease, transplant status, allograft failure, cause of failure, delayed graft function (defined as the need for hemodialysis within 7 days posttransplant), acute rejection episode status, and pretransplant and posttransplant blood pressure, and blood work and urinalysis results.

Our living donor evaluation criteria have previously been described.[19,20] To verify the presence of 2 functional kidneys and assess vascular anatomy, we used angiography, high-resolution computed tomographic angiography, or magnetic resonance angiography. If we found a large-size discrepancy between the 2 kidneys, we obtained a split-function renogram to individually assess the functional status of each kidney. For all DNs (whether open or laparoscopic), if there was a single artery, our practice has been to remove the left kidney. If there were 2 renal arteries or greater on the left kidney and a single artery on the right kidney, we removed the right kidney. If there were multiple arteries bilaterally, we removed the left kidney. If there was an incidental minor abnormality (eg, a simple cyst), we removed the kidney with the abnormality, leaving the living donor with the normal kidney. For the purposes of this study, if historical angiographic information was not available for an individual living donor, we determined vessel anatomy from the donated kidney report.

Surgical Techniques

For standard ODN, we used a 6-in. muscle-splitting flank incision. This surgery is associated with significant pain and recovery time, ranging from 3 to 6 weeks.

For left HA-LDN, we used a vertical midline 2.5-in. incision and 2 laparoscopic ports: 1 at the midclavicular line in the left upper quadrant (2 finger breadths below the costal margin) and the other at the level of the umbilicus to the left of the midline. For right HA-LDN, we also placed 2 laparoscopic ports: 1 at the midclavicular line in the right upper quadrant (2 finger breadths below the costal margin) and the other in the subxiphoid midline. In addition, we placed a liver retractor in the right subcostal anterior axillary line. In the subxiphoid midline, we used a pneumatic sleeve (GelPort; Applied Medical, Rancho Santa Margarita, CA) to permit tactile sensation for mobilization of the kidney, for better tissue control, and for removal of the kidney.

For left P-LDNs, we used 3 laparoscopic ports (2 in the left upper quadrant and 1 in the subxiphoid midline). To remove the kidney at the end of the procedure, we used a Pfannenstiel (suprapubic transverse) incision. For right P-LDNs, we used an additional liver retractor port.

For RA-LDNs, we used 4 laparoscopic ports (2 in the left upper quadrant, 1 in the subxiphoid midline, and 1 in the umbilicus). To remove the kidney at the end of the procedure, we used a Pfannenstiel incision.

Statistical Analysis

Demographic and clinical data were summarized by a percentage for categorical data and mean (standard deviation) for continuous variables by incision type. For demographic data, overall composite tests comparing incision types were performed using χ^2 tests for categorical variables, analysis of variance for continuous variables, and log-rank tests for incidence rates. Composite test *P* values have been adjusted using the Benjamini-Hochberg method to control the false discovery rate. For pairwise comparisons of incision types, we used the χ^2 test and Fisher exact test for categorical variables; and the Wilcoxon rank-sum test, for continuous variables. Estimates of graft survival and acute rejection were performed using Kaplan-Meier method, and differences between groups were compared using log-rank tests. Variables were assumed to be significant for a corresponding adjusted *P* less than 0.05.

In addition to the univariable analyses, we also considered the effect of incision type after adjusting for donor risk factors in multivariable linear and logistic regression models of perioperative outcomes including OR time, LOS, indicator for EBL above 150 mL and interoperative complication. Variable selection was conducted using backward selection with a *P* value to stay of 0.05. Donor variables considered for inclusion in these models were incision type, age, obese donor (BMI > 30), sex, race (white versus not-white), blood relative of the recipient, left kidney used (yes/no), prior kidney stones, prior abdominal surgery, and single artery used.

Multivariable analyses of recipient outcomes included a logistic model for delayed graft function adjusted for surgical technique, cold ischemia time, multiple arteries, and interactions between surgical technique and the other covariates.

RESULTS

During our 51.5-year study time period, we performed 4120 DNs included in this analysis: 2642 ODNs occurred from June 1963 to 2000, 1184 HA-LDN and 200 P-LDN occurred from 2001 onward, and 94 RA-LDN occurred from 2004 on. The temporal distribution of our case volume is depicted in Figure 1. Donors were followed for a median of 26 years (25th and 75th percentile 18-33 years) in the ODN cohort, and 6 years (3-9 years) in the LDN cohorts, with no significant difference in time to death (*P* = 0.81). Recipients were followed up for a median of 26 years (19-33 years) in the ODN cohort and 9 years (5-11 years) in the LDN cohorts. Of these, 75% of recipients in the LDN cohorts compared with 67% of recipients in the ODN cohort were surviving 11 years past transplant (*P* = 0.0004).

Donor Characteristics

Characteristics of the living donor are listed in Table 1 grouped by surgical technique. A majority of donors were women across surgical technique, and the differences among

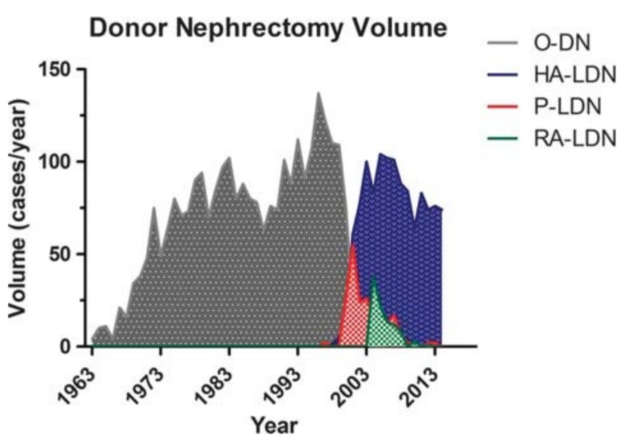

FIGURE 1. Donor nephrectomy volume per year since inception of live-donor kidney transplant program at the University of Minnesota. Open DN, HA-LDN, P-LDN, and RA-LDN donor nephrectomy were performed during this period.

procedures were not significant (56% ODN, 58% HA-LDN, 61% P-LDN, 62% RA-LDN, *P* = 0.51). Laparoscopic DN made donation more accessible to a population that is on average older (mean age: ODN, 37 years; HA-LDN, 42 years; P-LDN, 41 years; RA-LDN, 40 years; *P* < 0.001) and more overweight (mean BMI: ODN, 25 kg/m^2; HA-LDN, 27 kg/m^2; P-LDN, 26 kg/m^2; RA-LDN, 25 kg/m^2 ; *P* < 0.001). The percentage of living donors related by blood to the recipient declined by more than 28 points between the ODN and LDN cohorts (ODN, 94%; HA-LDN, 55%; P-LDN, 62%; RA-LDN, 66%; *P* < 0.001). Additionally, LDN was associated with reduced of estimated glomerular filtration rate at donation (ODN, 106 mL/min per 1.73 m^2; HA-LDN, 90 mL/min per 1.73 m^2; P-LDN, 88 mL/min per 1.73 m^2; RA-LDN, 88 mL/min per 1.73 m^2; *P* < 0.001) and with a small but statistically significant decline in average creatinine at donation (ODN, 0.92 mg/dL; HA-LDN, 0.87 mg/dL; P-LDN, 0.88 mg/dL; RA-LDN, 0.88 mg/dL; *P* < 0.001).

Intraoperative Parameters

Intraoperative parameters by surgical technique is reported in Table 2. Laparoscopic DN was associated with an increase of left kidney procurement (ODN, 68%; HA-LDN, 78%; P-LDN, 87%; RA-LDN, 94%; *P* < 0.001). All 3 LDN modalities required an operative time that was on average 0.32 hours longer (4.75 vs 4.43 hours; *P* < 0.001); RA-LDNs (5.1 hours) took longer than HA-LDN (4.7 hours) or P-LDN (4.9 hours). In multivariable modeling of OR time, the difference between incision type remained significant when adjusted for obese donor, sex, and single artery used.

Laparoscopic DN decreased the need for intraoperative blood transfusion (0.3% vs 3%; *P* < 0.001). The odds of having EBL greater than 150 mL were significantly higher for each of the LDN compared with ODN (*P* < 0.0001): HA-LDN 15 (95% confidence interval [95% CI], 12-18), P-LDN 5 (95% CI, 3-6), RA-LDN 19 (95% CI, 8-41), adjusted for obese donor, sex, relationship to recipient, and single artery used.

Laparoscopic DN was also associated with nearly half the incidence of intraoperative complications (3.3% vs 6.3%, *P* < 0.001) and severity of complications (CDC II: ODN, 3%; HA-LDN, 0.5%; P-LDN, 1%; RA-LDN, 0%; or CDC III: ODN, 3%; HA-LDN, 2%; P-LDN, 2.5%; RA-LDN, 2%; *P* = 0.02). For the ODN cohort, the most common complication was bleeding requiring a blood transfusion. For the LDN cohorts, the most common complication was an unplanned adrenalectomy. In all, 13 (1.1%), 0 (0.0%), and 3 (3.2%) of the HA-LDN, P-LDN, and RA-LDN, respectively, were converted to ODN, and 11 (0.4%) of ODN, 7 (0.6%) of HA-LDN, 3 (1.5%) of P-LDN, and 1 (1.1%) of RA-LDN required reoperation. After adjusting for sex, we found that, compared with ODN, the odds of having a complication were half with HA-LDN (adjusted OR, 0.46; 95% CI, 0.3-0.7) and RA-LDN (adjusted OR, 0.50; 95% CI, 0.2-1.6), and were reduced by 20% with P-LDN (OR, 0.80; 95% CI, 0.4-1.5). Of note, there were no intraoperative or immediately postoperative living donor deaths in our study.

Postoperative Outcomes

Postoperative outcomes for our cohort are listed in Table 3. Laparoscopic DN was associated with a reduction

TABLE 1.

Donor demographics

Procedure	Age, y	BMI, kg/m^2	Sex, female	White	Related to recipient	History of nephrolithiasis	Prior abdominal surgery	eGFR at donation
O-DN (2642)	37 (12)	25 (5)	56%	95%	94%	1%	27%	106 (28)
HA-LDN (1184)	42 (11)	27 (4)	58%	93%	55%	1%	26%	90 (17)
P-LDN (200)	41 (10)	26 (4)	61%	94%	62%	2%	22%	88 (17)
RA-LDN (94)	40 (11)	25 (4)	62%	96%	66%	2%	31%	88 (13)
Adjusted P-value	<0.001	<0.001	0.51	0.054	<0.001	0.72	0.37	<0.001

eGFR, estimated glomerular filtration rate.

in the average hospital LOS (ODN, 5.1 days; HA-LDN, 3.1 days; P-LDN, 3.4 days; RA-LDN, 3.0 days; $P < 0.001$). This effect remained significant ($P < 0.0001$) when adjusted for relationship to recipient, left kidney used, and prior abdominal surgery.

The most common complication in the perioperative period (<30 days) was urinary tract infection (5%) for ODN but the incidence of UTI was much smaller for LDN (1%, $P < 0.001$). In contrast, the most common perioperative complication for LDN was ileus (3%), and this was not significantly different from ODN ($P = 0.88$). Laparoscopic DN led to a significantly higher rate of readmissions both short-term (<30 day: ODN, 1%; HA-LDN, 4%; P-LDN, 2%; RA-LDN, 4%; $P < 0.001$) and long-term (>30 day: ODN, 1%; HA-LDN, 5%; P-LDN, 2.5%; RA-LDN, 4%; $P < 0.001$). The percentage of living donors who developed an incisional hernia was highest for HA-LDN (4%) and relatively rare among the other techniques (ODN, 1%; P-LDN, 2.5%; RA-LDN, 1%; $P < 0.001$). Of interest, the percentage of women who became pregnant after donation declined with LDN although this may be related to the older age of subjects undergoing LDN (ODN, 22%; HA-LDN, 8%; P-LDN, 7%; RA-LDN, 15%; $P < 0.001$).

Long-Term Renal Function in Living Donors

For the living donors in our study, long-term renal function represented by creatinine level is summarized in Figure 2. We noted minor but statistically significant differences in the creatinine level between the LDN and ODN cohorts at baseline ($P < 0.001$), but those differences generally disappeared over time as long-term creatinine level postdonation seemed to be unaffected by the surgical technique used. Ten-year postdonation creatinine levels were 1.13 for ODN, 1.09 for HA-LDN, 1.11 for P-LDN, and 1.01 for R-LDN. Incidence of ESRD was close to zero for all donors throughout follow-up, and this did not differ significantly by procedure ($P = 0.95$).

Of interest, our lost-to-follow-up rate at 5 years was 2% for ODN, 17.5% for HA-LDN, 8.2% for P-LDN, and 6.5% for RA-LDN. At 10 years, our lost-to-follow-up rate was 3% for ODN, 23.9% for HA-LDN, 23.1% for P-LDN, and 20.7% for RA-LDN.

Recipient Outcomes

Recipient outcomes are listed in Table 4. Regardless of the donation technique, 4% to 6% of recipients developed delayed graft function ($P = 0.72$ for comparison among the surgical groups). The odds of delayed graft function increased for kidneys with multiple arteries procured via P-LDN compared with HA-LDN (OR, 3; 95% CI, 1-10) and ODN (OR, 5; 95% CI, 2-15). Cold ischemia time was not found to be associated with delayed graft function. The 1-year creatinine level was higher for recipients whose living donor was in the ODN and P-LDN cohorts (both 1.5) compared with the HA-LDN and RA-LDN cohorts (both 1.4), but not significantly different ($P = 0.20$). Graft loss was significantly higher for recipients whose living donor was in the ODN cohort compared with the LDN cohorts ($P = 0.002$). The early (1 year) graft loss rate for recipients whose living donor was in the ODN cohort was 9% versus the 2% in HA-LDN, 2% in P-LDN, and 1% in RA-LDN cohorts. The 10-year graft loss rate for recipients whose living donor was in the ODN cohort was 27% versus the 23% in HA-LDN, 20% in P-LDN, and 22% in RA-LDN cohorts (Figure 3). Across the surgical techniques, the LDNs had higher rates of acute rejection ($P < 0.001$). The 1-year acute rejection rate was similar for recipients whose living donor was in the ODN (17%) and P-LDN (17%) cohorts, but the rate seemed to be slightly higher in the HA-LDN (20%) and RA-LDN (22%) cohorts.

DISCUSSION

Laparoscopy has transformed LDKT, making donation more appealing because of a reduction in LOS, pain, and convalescence; a faster return to normal activity; and

TABLE 2.

Donor intraoperative parameters

Procedure	Left kidney	Single artery	OR time, h	Estimated blood loss, mL	Transfusion	Intraoperative complications	Cold ischemia time, min	Reoperation	Conversion
ODN (N = 2642)	68%	88%	4.4 (0.8)	296 (306)	3%	6.3%	629 (446)	0.4%	
HA-LDN (N = 1184)	78%	87%	4.7 (0.9)	91 (100)	0.3%	3%	440 (317)	0.6%	1.1%
P-LDN (N = 200)	87%	85%	4.9 (1.2)	130 (117)	0.5%	5%	668 (209)	1.5%	
RA-LDN (N = 94)	94%	91%	5.1 (0.8)	80 (66)	0	3.2%	665 (139)	1.1%	3.2%
Adjusted *P*	<0.001	0.37	<0.001	<0.001	<0.001	<0.001	<0.001		

TABLE 3.

Donor postoperative outcomes

		Short-term (< 30 d)							> 30 d		
Procedure	**LOS**	**Infection**	**Ileus**	**Arrhythmia**	**Pneumonia**	**DVT**	**UTI**	**Readmit**	**Readmit**	**Incisional hernia**	**Pregnancy postdonation (n = 2114)**
ODN (N = 2642)	5 (2)	1%	3%	0.2%	0.3%	0.1%	5%	1%	1%	1%	22% (290/1316)
HA-LDN (N = 1184)	3 (1)	1%	3%	0.5%	0.5%	0.1%	1%	4%	5%	4%	8% (50/634)
P-LDN (N = 200)	3 (2)	0	4%	0	0	0	1%	2%	3%	3%	7% (8/110)
RA-LDN (N = 94)	3 (1)	1%	3%	0	0	0	4%	4%	4%	1%	15% (8/54)
Adjusted *P*	<0.001	0.66	0.88	0.38	0.72	0.97	<0.001	<0.001	<0.001	<0.001	<0.001

DVT, deep venous thrombosis; UTI, urinary tract infection.

improved cosmesis.[7,21-23] Initial fears about allograft quality with LDNs have largely been allayed by randomized trials, reviews, and meta-analyses demonstrating equivalent results between open and MIS approaches.[6,22-27] As a result, LDN has quickly become the new standard for living donors.[6,21,24]

Variations of LDN—especially HA-LDN and P-LDN—have evolved in an effort to improve surgical technique, donor safety, and postoperative recovery. Hand-assisted LDN have been demonstrated by other groups to reduce operative time and intraoperative bleeding, when compared head to head with P-LDN, likely because of the better vascular control with HA-LDN.[28-31] Furthermore, P-LDN have been suggested to lead to more intraoperative complications.[31] Considering that the use of LDN is still growing worldwide and that bleeding remains a significant cause of morbidity and mortality for living donors,[5,15,16] the procedure and its variations need to be critically analyzed.

Worldwide experience with RA-LDN is limited, although early reports suggest that it can be performed safely and with favorable outcomes.[32-34] Overall, RA-LDN has demonstrated a 12.6% perioperative complication rate, but it is worth noting that none of these complications escalated beyond a CDC II complication. In a small randomized prospective study, RA-LDN was shown to improve postoperative pain scores when compared with P-LDN.[35] Similar to our own experience, increased intraoperative time was observed but this seems to be offset by a decreased postoperative LOS and pain.[32-35] Furthermore, another important consideration for small and relatively new programs, RA-LDN have yet to be proven cost-effective.[36] Taking all of these issues into consideration, it is clear that the role of RA-LDN in kidney donation needs to be further investigated. As experience accumulates with this technique, some of these answers will become apparent.

Intraoperative considerations have also evolved with the adoption of LDN, which have made left kidney procurement preferable (given anatomic and ergonomic characteristics). Similar to other published series, our study demonstrated a longer operative time with LDN versus ODN, but also a reduction in blood loss and complications.[9,21,28] Our results were in line with the published literature standards of 0.92% to −2.97% for the conversion rate[8,25,31] and 0.4% to 0.67% for the reoperation rate.[6,11,37] More significantly, with LDN, we observed a reduction not

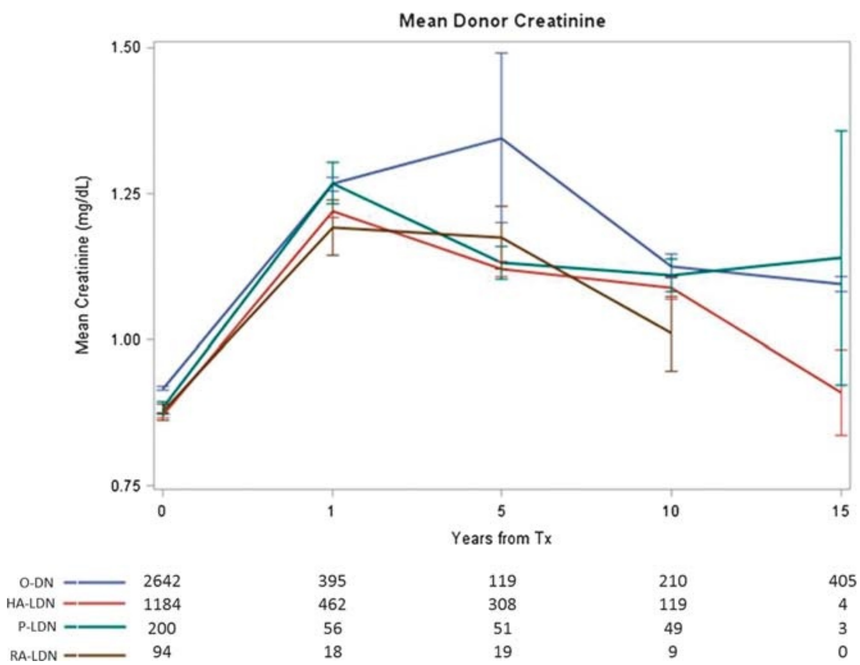

FIGURE 2. Renal function after ODN, HA-LDN, P-LDN, and RA-LDN donor nephrectomy at 1, 5, 10, and 15 years.

TABLE 4.

Recipient outcomes

	DGF	Creatinine	Recipients graft failure			Recipients acute rejection		
Procedure	1 wk	1 y (n = 2436)	1 y	5 y	10 y	1 y	5 y	10 y
ODN (N = 2642)	4%	1.5 (0.6)	9%	17%	27%	17%	21%	24%
HA-LDN (N = 1184)	4%	1.4 (0.9)	2%	10%	23%	20%	29%	34%
P-LDN (N = 200)	6%	1.5 (0.9)	2%	10%	20%	17%	27%	32%
RA-LDN (N = 94)	4%	1.4 (0.6)	1%	11%	22%	22%	28%	30%
Adjusted *P*	0.72	0.20		0.002			<0.001	

only in the incidence of intraoperative complications but also in their severity.

Consistent with published reviews and other large series, LDN in our experience decreased hospital LOS.[7-11,21-23] Interestingly, we found that the most common postoperative complication in the ODN era was urinary tract infection, and its incidence was significantly reduced in the LDN era. This reduction could be a phenomenon of the general evolution of surgical care, because urinary drainage after any major operation is discontinued earlier in the more recent era.

In our study, similar to the experience of others, the most common postoperative complication in the LDN was ileus, as would be expected after an intraperitoneal operation.[8,11,38] Even though the incidence of intraoperative complications and their severity was reduced in the LDN era, short-term and long-term readmission rates were higher. This finding could be a consequence of shorter LOS, which has also been observed at the national level with LDN.[39]

Of interest, we found that HA-LDN led to a higher rate of incisional hernia than any of the other modalities, confirming observations of hand-port use in prior large series studies.[11,40] We suspect that a midline hand-port incision—which can stretch the fascia when the assisting hand is introduced—may thus weaken the fascia, making it susceptible to a future incisional hernia. We did not observe any such weakening with P-LDN or RA-LDN, where the Pfannenstiel incision is somewhat protected from significant intra-abdominal forces postoperatively.[11]

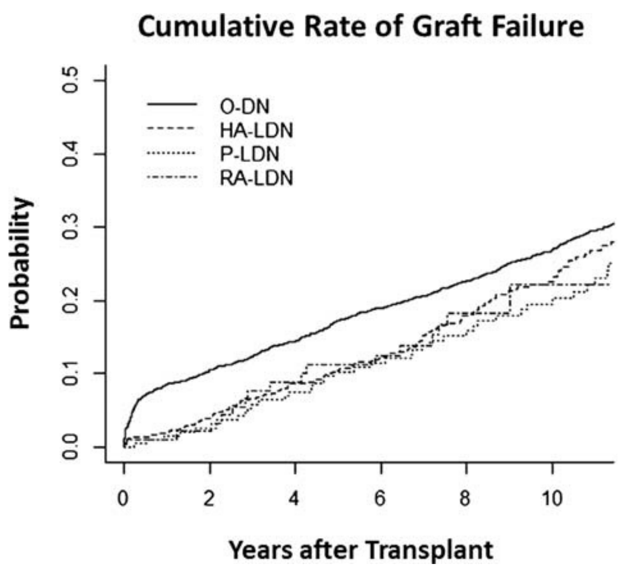

FIGURE 3. Cumulative rate of graft failure after ODN, HA-LDN), P-LDN, and RA-LDN donor nephrectomy.

Another significant concern with regard to LDN has been long-term renal function postdonation. Our group has previously published on this issue,[19] confirming national[41] and international trends.[42-45] In our current study, even with minor differences in estimated glomerular filtration rate and baseline creatinine, these differences could be partly explained by our long time span and our large number of living donors. The actual clinical relevance of these minor differences is subject to debate, because the incidence of ESRD in our patient population was similar among the study groups and to the general population.[19,46]

Finally, initial reports raised concerns about the quality of allografts procured by LDN versus ODN, however, other large series demonstrated similar recipient outcomes, comparable to our study, irrespective of the procurement technique.[8-11,47-50] Moreover, our graft failure rates may be confounded by the long time span of our study, encompassing the entire history of immunosuppressive therapy, which could in part explain the inferior outcomes with ODNs. Additionally, it is important to consider that our ODN group had a significantly larger proportion of related donors, and likely better HLA matches, which probably contributed to similar 1-year rejection rates.

In conclusion, in this single-center study, we demonstrated that LDN was associated with decreased intraoperative complications and hospital LOS; previous studies have shown LDN is associated with less pain and quicker recovery. Even though, in our series, LDN was associated with a higher readmission rate and some long-term complications, this evolution in surgical technique has brought about a new era in LDKT, with tangible benefits to both donors and recipients.

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