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Hand-assisted Laparoscopic Nephrectomy: Evaluation of the Learning Curve

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ABSTRACT

Background. Hand-assisted laparoscopic donor nephrectomy (HALDN) has rapidly become the best alternative to open nephrectomy for living kidney donation. As more centers continue to adopt the laparoscopic technique, the safety of the initial transplants must be ensured while ascending the learning curve (LC). This study looks to determine the safety of HALDN and to describe the results of the LC in our center.

Methods. We conducted a retrospective review of 500 HALDNs performed in our center from July 2003 to July 2017. We analyzed demographic and perioperative characteristics and complications during the first postoperative month. We divided HALDNs into 2 groups: before and after completing the LC (50 nephrectomies). For each group, we assessed operating room time, estimated blood loss, length of stay, and complication and conversion rates.

Results. A total of 500 HALDNs were performed in the study period. Of those, 454 were analyzed in the 2 groups. The median operating room time was 2 hours, length of stay was 2 days, and blood loss was 50 cc. The overall rate of complication was 6.8%. There were significant differences between the 2 groups in operating time, blood loss, and length of stay ($P < .05$). No differences were found in terms of complication ($P = .42$) and conversion ($P = .28$) rates.

Conclusion. There was a significant decrease in operating time, blood loss, and length of stay in patients who underwent laparoscopic donor nephrectomy by an experienced laparoscopist. However, no differences were found in complication and conversion rates, which suggests that improvement in surgical training can be accomplished without altering the donor safety.

SINCE 1995 when Ratner et al described the first laparoscopic donor nephrectomy (LDN) for renal living donation, it has become progressively "standard of care" [1,2]. This procedure has allowed transplantation groups to combat organ shortage for patients with end-stage renal disease; as reported by the United Network for Organ Sharing in 2017, 29.2% of total donations were from living donors [2–5]. Although the development of LDN has improved the donation shortage around the world, it has some issues to be considered [6]. First, it seems that operating room time increases in comparison with open donor nephrectomy. Second, the learning curve (LC) seems to be harder to reach with LDN [6–8]. On the other hand, LDN has reported shorter hospital stay, better aesthetics results, and less postoperative pain; hence, the number of living kidney donors has increased [9].

As accounted, LDN raised some questions and variations of the technique since then with the hand-assisted

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Table 1. Baseline Characteristics of Donors (n = 500)

Sex, No. female (%)	256 (51)
Age, median (IQR), y	37 (18)
Related to recipient, No. (%)	428 (85.6)
Kidney removed, No. (%)	
Left	447 (89.4)
Right	53 (10.6)
Surgical incision, No. (%)	
Pfannenstiel	436 (87.4)
Midline	63 (12.6)
Operating room time, median (IQR), h	2 (0.5)
Hospital stay, median (IQR), d	2 (0)
Warm ischemia time, median (IQR), min	3 (1)
Estimated blood loss, median (IQR), cc	50 (50)

Abbreviation: IQR, interquartile range.

laparoscopic nephrectomy (HALN), the minimally invasive laparoscopic nephrectomy, the robotic-assisted laparoscopic nephrectomy, and transvaginal natural orifice transluminal endoscopic surgery–assisted living donor nephrectomy [10,11]. From cited techniques, HALN is one of the most commonly used because it preserves advantages from LDN, it improves results in terms of operating room time, and the LC is easier to gain [12,13]. Considering that LDN is a procedure performed on a healthy patient, meaning complications ranged between 5% to 10%, the tipping point in which LC is completed becomes very important and has been depicted as a paramount variable bearing in mind donor outcomes [14,15].

Considering all the arguments exposed, we aimed to register perioperative variables in a living donor program among 2 surgeons in 14 years, looking for differences before and after completing the LC. At the same time, we described the experience of a single living donor transplantation center that is, to our knowledge, the most extensive series reported in South America.

MATERIALS AND METHODS

Study Population

HALN was performed in 500 patients from January 2003 to July 2017 at Colombiana de Transplantes, Bogota, Colombia. During this period, 6 surgeons collaborated on operations, but 2 of them performed most of the procedures (n = 454). Accordingly, 46 patients were excluded from the comparative analysis. All donors underwent a medical evaluation before imaging study. Computerized tomography angiography was performed to identify vascular anatomy before surgery. Additionally, a renogram with diethylenetriamine-penta acetic acid was ordered in patients with asymmetric kidneys.

Definition of the Learning Curve

During the period, the first 100 consecutive donors operated on using hand-assisted laparoscopic donor nephrectomy (HALDN) (involving 2 surgeons, 50 cases each) were defined as the LC not complete group (LCNC), and all HALDN performed over 50 cases (by each surgeon) were defined as the LC complete group (LCC). A total of 46 cases were excluded from the comparative analysis because they were performed by other 4 surgeons, and there was not enough information to analyze the learning curve.

Table 2. Summary of Complications in 500 Patients Undergoing Laparoscopic Donor Nephrectomy Graded by Severity

Grade	Percentage of All Complications (n = 34)	Percentage of Total Series (n = 500)	Complication	Patient, No.
1	20.5 (n = 7)	1.4	Epigastric vessel injury	1
			Splenic capsule injury	2
			Colonic laceration	1
			Inferior renal artery section	2
			Gonadal vessel injury	1
2	76.4 (n = 26)			
2a	23.5 (n = 8)	1.6	Readmission/upper gastrointestinal bleeding	1
			Anatomical variant injury (bleeding > 500 cc)	2
			Splenic capsule injury (bleeding > 500 cc)	1
			Renal vein injury (bleeding > 500 cc)	2
			Other	2
2b	38.2 (n = 13)	2.6	Renal vessel injury	1
			Ventral hernia	1
			Chylous ascites	1
			Evisceration	2
			Colonic injury + colonic suture	4
			Duodenal injury	1
			Colonic injury + colostomy	2
			Infected hematoma + drainage	1
2c	14.7 (n = 5)	1	Aortic injury + conversion	1
			Splenic injury + conversion	2
			Renal injury + conversion	2
3	0	0		0
4				
4b	2.9 (n = 1)	0.2	Massive pulmonary thromboembolism	1

Table 3. Demographic Characteristics in Each Group

	Learning Curve Complete		
Variable	Yes (n = 354)	No (n = 100)	*P* Value
Sex, No. female (%)	191 (54)	49 (49)	.38
Age, median (IQR), y	38 (30-47)	32 (25-42)	< .001
Related to recipient, No. (%)	309 (87.2)	82 (82)	.31
Kidney removed, No. left (%)	316 (89.2)	89 (89)	.94
Surgeon, No. (%)			< .001
1	262 (74)	50 (50)	
2	92 (26)	50 (50)	

Abbreviation: IQR, interquartile range.

Surgical Technique

The technique of choice was HALN in all cases. The patients were placed in the semilateral decubitus position using slight table flexion. Once positioned, 10-cm cloth tape was used to secure the patient at the level of the chest, hips, and ipsilateral arm. The initial access consisted of placing a hand port through a low incision. The hand may be introduced through variously placed incisions in the anterior abdominal wall, depending on patient and surgeon' preference. A 30° video endoscope and 2 additional 12-mm trocars were introduced. The intrabdominal pressure was set to 15 mm Hg. The hepatic or splenic flexure of the colon was mobilized and displaced medially using ultracision. Ureter, renal vein, and renal artery were identified and dissected. Renal vessels were secured using locking polymer clips. In the case of the right kidney being retrieved, the right renal vein was exposed into the inferior vena cava, and we used an endovascular linear stapler of 60 mm for the renal vein so that adequate length could be obtained. The kidney was extracted manually through the hand port. Urine output was maintained using aggressive intravenous hydration; we do not use unfractionated heparin. The postoperative protocol included analgesia with dipyrone on demand, removal of the Foley catheter, and regular diet on postoperative day 1.

Study Sample and Design

During the study, 500 consecutive donors were included in this research. We retrospectively reviewed the medical records of the total of donors. The primary outcome was total operating room time, length of hospital stay, and estimated blood loss. A modification of Clavien classification [16] system describing procedure-related complications was developed. A total of 46 cases were excluded from the comparative analysis because they were performed by other 4 surgeons, and there was not enough information to analyze the LC.

Table 4. Bivariate Analysis Between Completion of Learning Curve and Relevant Variables

	Learning Curve Complete		
Variable	Yes (n = 354)	No (n = 100)	*P* Value
Operating room time, No. (%)			< .001
> 2 h	52 (14.7)	32 (36.7)	
≤ 2 h	301 (85.2)	55 (63.2)	
Length of stay			< .001
> 2 d	28 (8)	18 (30.5)	
≤ 2 d	324 (69.5)	41 (70)	
Estimated blood loss, median (IQR), mL	50 (50-100)	100 (100-200)	< .001
Complication rate, No. (%)	21 (5.9)	3 (3)	.42
Conversion rate, No. (%)	5 (1.4)	3 (3)	.28

Abbreviation: IQR, interquartile range.

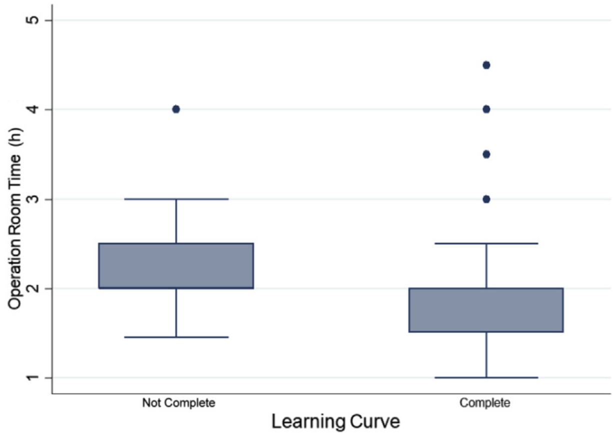

Fig 1. Surgery time in patients with laparoscopic nephrectomy according to the surgeon's learning curve.

Statistical Analysis

A univariate and bivariate descriptive analysis was carried out according to the LC; frequencies and percentages were used to describe categorical variables. The quantitative variables were described through measures of central tendency and dispersion, and bivariate analysis was carried out according to the LC through parametric or nonparametric tests according to the nature of the variables. We compared the 2 groups for operating room time, length of hospital stay, estimated blood loss, and complication and conversion rate. The differences in parameters between the 2 groups were analyzed using the χ^2 test and Mann-Whitney test.

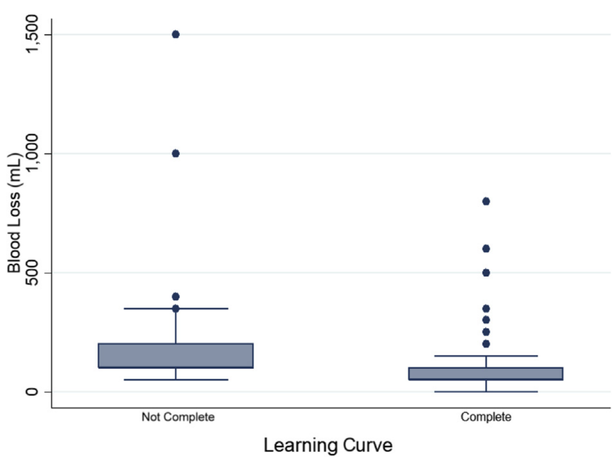

Fig 2. Estimated blood losses in patients with laparoscopic nephrectomy according to the surgeon's learning curve.

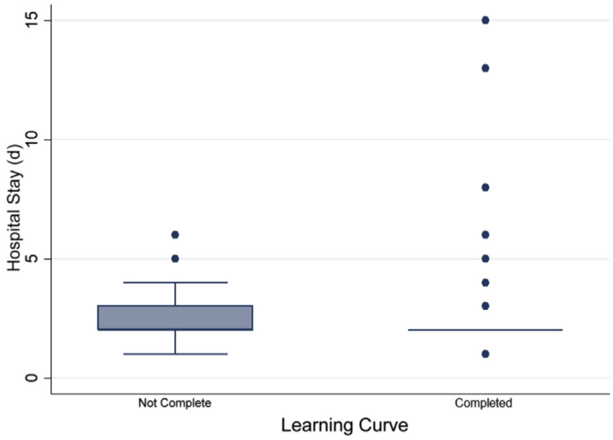

Fig 3. Hospital stay in patients with laparoscopic nephrectomy according to the surgeon's learning curve.

RESULTS

Donor Characteristics

A total of 500 HALNs were performed from January 2003 to July 2017. Baseline characteristics of donors are shown in Table 1. Half the donors were women (n = 256; 51.2%) and were related to recipients (85%). The median age of patients was 37 years. Left kidneys (n = 447) were removed in the greater number of cases (89.4%).

Operative Characteristics

Intraoperative and postoperative data are shown in Table 1. Pfannenstiel surgical incision was performed in 436 cases (87.4%). Operating room time was less or equal to 2 hours in 372 patients (77.5%), and the length of hospital stay was less or equal to 2 days in 87.4% (n = 397) of the group. Median warm ischemia time and estimated blood loss were 3 minutes (interquartile range, 3-5 minutes) and 50 mL (interquartile range, 50-100 minutes), respectively.

Perioperative Complications

HALN was successfully performed in 492 patients. Eight patients were converted to open surgery; of those, 3 were elective because of technical difficulties because patients were overweight or they had intraperitoneal adherences. The remaining 5 were secondary to renovascular injuries. Intra- and postoperative complications included splenic injury, wound infected hematoma, readmission because of upper gastrointestinal bleeding, renovascular injury, epigastric vessel injury during the port introduction, chylous ascites, and evisceration (Table 2). The overall complication rate was 6.8% (n = 34), graded by modified Clavien classification for laparoscopic nephrectomy [16]. There was 1 complication that needed intervention under general anesthesia in a patient who presented intestinal obstruction secondary to evisceration. In the early postoperative period, 1 of the donors evolved unsuspectingly to massive pulmonary thromboembolism and died.

Table 5. Comparison Data Between Different Institutions

Institution/Year	No.	Age, y	ORT, min	Warm I schemia, s	Conversion, No. (%)
Mt Sinai/2009[8]	512	39.2	213.9	166	1.4
BUMC/2015[4]	526	41	149.6	117	0.1
Northwestern/2004[23]	500	38	-	156	1.8
CT/2017	500	37.4	120	180	1.6

Abbreviations: BUMC, Baylor University Medical Center; CT, Colombiana de Trasplantes; ORT, operating room time.

LC Analysis

A completed LC was defined as a surgeon who had completed more than 50 cases of a HALN. Consequently, the HALDNs were divided into 2 groups. The first 100 consecutive donors (50 cases by each 1 as main surgeon) corresponds to the first group of HALDNs in which the learning curve was not completed (LCNC) and other group in which the learning curve was completed (LCC). A total of 46 cases were excluded from the comparative analysis because they were performed by other 4 surgeons, and there was not enough information to analyze the learning curve. After these patients were excluded, 454 operations were analyzed, and 2 surgeons performed them in all cases. Surgeon number 1 performed 31.3% (n = 142) of the cases, and surgeon number 2 performed 68.7% (n = 312) of the cases. A total of 100 HALNs (22%) were performed before both surgeons completed the LC participating as primary surgeons. Demographic characteristics of the 2 groups are summarized in Table 3.

Complications occurred in 3% of the LCNC group and occurred in 5.9% of the LCC group. In the LCNC group, grade 2b complications appeared in 33% (n = 1) of the cases. In the LCC group, the most frequent complication was 2b in 52% (n = 11) of the cases. There were no significant differences between both groups in terms of complication rates ($P = .42$).

Variables found statistically significant were operating room time, estimated blood loss, and length of stay ($P <$ .005), as shown in Table 4. Conversion to open surgery occurred in 1.4% (n = 5) of the HALNs in the LCC group compared with 3% (n = 3) in the LCNC group, showing no significant difference between the 2 groups ($P = .28$).

Operation room time was 2 hours or less after 50 HALNs were completed, as seen in Fig 1. Likewise, Fig 2 shows that after the LC was completed, there were more procedures with estimated blood losses greater than 50 mL in the LCNC group. Finally, Fig 3 illustrates that hospital stay is longer than 2 days in more cases from the LCNC group that in the LCC group.

DISCUSSION

Living donor kidney transplant has become the best option available for patients with end-stage chronic kidney disease [17]. This technique has also contributed to the organ shortage around the world since 1995 when Ratner et al [1] introduced the procedure, bringing multiple advantages like

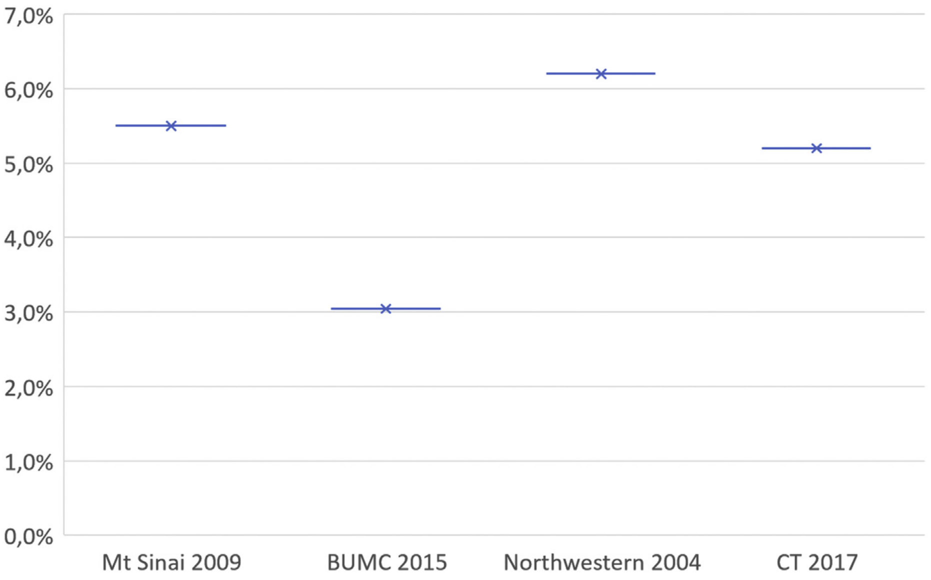

Fig 4. Complications comparation between transplantation series and Colombiana de Transplantes.

better aesthetic results, lower hospital stay, and shorter time of recovery after LDN [4,10,18]. Introducing this technique in a transplantation center has presented new challenges for surgical teams, such as obtaining the LC, a process in which warm ischemia time and intraoperative bleeding can be affected, and even selecting the adequate variant of the technique [14,19]. This report presents our experience with 500 HALDNs demonstrating the safety of the procedure in a single transplantation center in a developing country. Additionally, we performed an analysis of the process to obtain the LC, finding an improvement in the results after each surgeon completed the 50 HALDNs.

Although LDN is the choice currently, developing countries have special considerations because health systems vary from the developed ones. One of the considerations to be made is the fact that health systems in low-income countries suffer from a lack of resources, and that becomes an obstacle for implementing strategies such as living donation [20,21]. Consequently, modifications of the technique and even new techniques have been proposed to achieve same results with lower cost [20,22]. We consider that overcoming those obstacles is the cornerstone to adopt this strategy in South America, and this study will contribute to that cause. To our knowledge, there is not an article with a large series that shows the experience of a transplantation center in South America.

Comparing variables obtained by this study with demographic results reported by Leventhal et al [3,23], there is no significant difference in age. Relationship predominance was similar to findings from other series in which donors and recipients were related in around 85% of cases [2,10,24]. Even though the first option for LDN in this center is the left kidney, our series showed 10.6% in which the kidney obtained was the right one, and this proportion is higher than other series ranging from 1% to 7% [3,7,25]. Intraoperative variables such as warm ischemia time and conversion rate were not significantly different to what is reported by other authors as it is shown in Table 5 [3,4]. Various reports from different transplant groups have been published, and their similarity supports the replicability and safety of this surgery [2,21,24].

The total complication rate in our series was 6.8%, a result comparable with experiences from other centers that range between 3% and 13.5% [4,10,17,18,24]. Additionally, when comparing the results obtained by this research with series with a comparable number of cases described as seen in Fig 4, total complication rates are rather similar [4,8,23]. From total complications, 3 major ones required colostomy, affecting the quality of life of living donors temporally. Another important complication was a case with chylous ascites after HALDN; this complication motivated the surgical team to improve the strategy to control lymphatic vessels, and consequently no new cases have appeared since. Other intraoperative variables measured are compared in Table 5, showing that findings of LDN in this study are equivalent to what was found by other groups at different points in time.

Achieving the LC in LDN has been researched previously by other authors, and they have differed widely from each other [13–15,26]. Saad et al [26] suggested that 10 cases were enough to complete the LC. However, Barth et al [27] and Troppmann et al [15] reported a cutoff point of 60 and 50 LDNs, respectively. A systematic review conducted by Raque et al [13] in 2015 found that the tipping point to reach the LC was 24 to 28 cases and a volume of 50 cases per year in the transplantation center. The Organ Procurement and Transplantation Network policy dictates that to be the primary surgeon in an LDN in the United States, at least 15 cases must be performed in the last 5 years, and out of those, at least 7 must be performed as a main surgeon [28]. In the current analysis, the cutoff point used was 50 cases evaluating intraoperative bleeding, operating room time, and length of stay, proving that after LC was completed, the outcomes analyzed changed positively. In the experience gained over the years in our living donor program, we consider that laparoscopic skills acquired and updated knowledge in transplant are paramount to safely optimize the LC acquisition.

CONCLUSION

Living donor nephrectomy, specifically HALDN, is a safe surgical procedure, and the results obtained by this research supports that intraoperative and early complications are rare. There was a significant decrease in operating time, estimated blood loss, and length of hospital stay in patients who underwent HALDN by an experienced laparoscopist. However, surgical training can be accomplished without compromising patient safety, and it allows a gradual increase in experience that reflects better results over time.

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