Reproducibility and Step-By-Step Learning Curve of Retroperitoneal Video-Assisted Mini-Laparotomy Surgery for Living Donor Nephrectomy: A Single-Center Experience

Jae Won Park,[1,2] Hyung Ho Lee,[3] Hyung Soon Lee,[4] Young Sig Kim[1]

Abstract

Objectives: **Living donor transplant techniques must ensure donor safety and minimize complications. To achieve this goal, in 2003, we developed a new surgical procedure named video-assisted mini-laparotomy surgery for living donor nephrectomy. Video-assisted mini-laparotomy surgery standardizes the retroperitoneal mini-laparotomy technique as an alternative to open surgery. We have previously reported on video-assisted mini-laparotomy surgery techniques for use in kidney surgery. However, there are no reports of video-assisted mini-laparotomy surgery performed at other institutions. Therefore, we introduced video-assisted mini-laparotomy surgery at another institution, and here, we report on our experience.**

Materials and Methods: **We evaluated a consecutive series of 38 donors who underwent video-assisted mini-laparotomy living donor nephrectomy at National Health Insurance Service Ilsan Hospital from August 2016 to November 2019. All 38 patients were enrolled. Perioperative data and outcomes were retrospectively analyzed. We recorded perioperative and postoperative data, including operative time, estimated blood loss, and duration of hospital stay.**

Results: **The mean operative time was 144.35 ± 22.79 minutes, and the mean warm ischemia time was 184.35 ± 4.97 seconds. Mean estimated blood loss was 72.85 ± 60.81 mL. At 12 months after video-assisted mini-laparotomy surgery, the mean posttransplant serum creatinine level was 1.05 ± 0.18 mg/dL, and estimated glomerular filtration rate (according to the Modification of Diet in Renal Disease study equation) was 71.9 ± 10.34 mL/min/1.73 m^2. There was no intraoperative or postoperative complication.**

Conclusions: **Previous studies reported that video-assisted mini-laparotomy surgery has a steep learning curve and is difficult to reproduce. However, video-assisted mini-laparotomy surgery is a feasible and safe technique at our institution. Video-assisted mini-laparotomy surgery is a solo surgery that can be safely performed by any surgeon with prior kidney surgery experience.**

Key words: *Living kidney donor, Modification of Diet in Renal Diseas, Video-assisted surgery*

Introduction

Conventional flank incision donor nephrectomy causes cosmetic blemishes and induces paresthesia that results from a large skin incision and wide muscle division and subsequent nerve damage.[1] Thus, the contemporary demand for minimally invasive surgery has induced the development of new surgical techniques and instruments. The development of novel surgical instruments has a high financial cost but may potentially reduce the necessity for human assistance compared with conventional open surgery. In an attempt to resolve the shortcomings of conventional open surgery in urology, in 1991, Yang and colleagues developed a new video-assisted surgical procedure that is a hybrid of laparoscopic surgery and open surgery and has the combined advantages of both methods.[1] This experience has allowed for modification and improvement of the technical aspects of each step and for standardization

From the [1]Department of Urology, National Health Insurance Service Ilsan Hospital, Goyang, Korea; the [2]Department of Urology, Urological Science Institute, Yonsei University College of Medicine, Seoul, Korea; the [3]Department of Urology, National Cancer Center, Goyang, Korea; and the [4]Department of Transplantation Surgery, National Health Insurance Service Ilsan Hospital, Goyang, Korea

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Corresponding author: *Young Sig Kim, Department of Urology, National Health Insurance Service Ilsan Hospital, 100 Ilsan-ro, Ilsandong-gu, Goyang-si, Gyeonggi-do, 10444, Korea*
Phone: *+82 31 900 0249* ***E-mail:*** *urokim@nhimc.or.kr*

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and reproducibility of the technique. However, until now, the technique known as video-assisted mini-laparotomy surgery (VAMS) for living donor nephrectomy has been reported at only a single institution, and there has been controversy about reproducibility. Our study, here, aimed to demonstrate the reproducibility and feasibility of VAMS for donor nephrectomy.

Materials and Methods

The study and technique were approved by the Institutional Review Board of National Health Insurance Service Ilsan Hospital (No. 2017-04-028-008). Informed consent from the participants was waived by the institutional review board because our study satisfied the following requirement for the waiver of informed consent: our study was a retrospective data analysis of previously collected medical records, so the research has no more than a minimal risk to the participants.

From August 2016 to November 2019, there were 38 consecutive living donor nephrectomies performed at National Health Insurance Service Ilsan Hospital in Gyeonggi-do, Korea, all performed by the same surgeon. The surgeon had experience with open nephrectomy and laparoscopic nephrectomy. However, he had no experience with VAMS donor nephrectomy.

All procedures were performed with the VAMS technique, for which the donor patient is placed at rest in the semilateral position. The VAMS technique had been developed as a standardized procedure for retroperitoneal mini-laparotomy renal surgery at Severance Hospital (Seoul, Korea).[1]

For this procedure, it remains important for the donors to be checked according to the standard preoperative protocols, including medical history, physical examination, and blood and urine analyses. Before surgery, the following tests should be performed to select healthy living kidney donors: (1) the estimation of glomerular filtration rate (eGFR) according to the Modification of Diet in Renal Disease study equation and (2) renal scintigraphy with technetium-99m-diethylenetriaminepentaacetic acid. These tests facilitate the accurate assessment of to exclude donors with eGFR less than 80 mL/min/1.73 m^2. We used multiple-detector computed tomography to determine the anatomic structure of the kidney. In all cases reported here, the left kidneys were donated because the left kidney allows the sufficient length of the renal vein that is required for this procedure.

We collected intraoperative data according to donor protocol, including operative time (OPT), estimated blood loss (EBL), warm ischemia time (WIT), and intraoperative complications. All postoperative data, including complications, duration of hospital stay, and follow-up data, were prospectively collected. The donors were followed up according to the protocol at 1 week, 1 month, 3 months, 6 months, 9 months, and 1 year after operation.

We divided the VAMS procedure into 2 stages. Phase I is the process of finding the ureter and setting up the instrument. Phase II is defined as the period from the end of phase I to the time of kidney removal. The results are reported as mean values (with SD) for continuous variables. To compare phase I versus phase II, we used the Mann-Whitney U test for continuous variables. We used SPSS software (version 23.0, IBM) for the statistical analyses. $P < .05$ was considered statistically significant.

Surgical technique

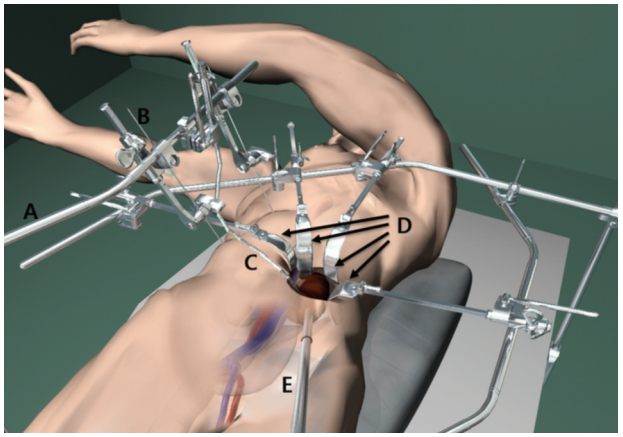
The VAMS donor nephrectomy was performed with a laparoscopic kit and a specially designed self-retaining retractor set, including a piercing abdominal wall elevator (Thompson Surgical), as previously described (Figure 1).[2] The surgical techniques have been previously published,[3] and we provide a step-by-step description here.

Patients were given general anesthesia and placed at rest in the flank position. A transverse incision (approximately 6 cm) was made into the lateral abdomen. The subcutaneous fat and fascia were separated, and the abdominal muscles were split without cutting. After detaching the peritoneum and fascia, we inserted the piercing laparoscopic trocar into the space and connected this to the upper deck of retractors. A 10-mm trocar was inserted at a point 5 cm to the lower left of the main incision site, and a 30-degree laparoscopic image system was used to obtain the surgical view. A blade was connected to the table-mounted system (Figure 1) to secure the surgical space. For the ureter identification, the first step was to insert the piercing peritoneal retractor to deflect the peritoneum that covers the ureter. After the ureter was identified, the kidney was resected in order of the lower pole, lateral side, upper pole, and

adrenal gland. The gonadal vein and lumbar vein were ligated with extracorporeal knots. After the ureter was resected, the renal artery was sutured with endoclips. The renal vein was ligated with Satinsky forceps, and the kidney was resected and removed. Then, the renal vein was mended with 5-0 polymer polypropylene sutures (Prolene). A drainage tube was inserted through the trocar site.

All data generated or analyzed during our investigation are included in this study.

Figure 1. Setting for Video-Assisted Mini-Laparotomy Surgery for Living Donor Nephrectomy



(A) Horizontal bar. **(B)** Piercing abdominal wall elevator. **(C)** Flexible light wand. **(D)** Horizontal self-retaining retractors. **(E)** Telescope. Image from Choi and colleagues,2 republished with permission.

Results

Patient characteristics are summarized in Table 1. The 38 donors consisted of 22 females and 16 males. Among all the donors, 6 had a history of smoking and 5 had a positive medical history of hypertension. The participants were related donors in 22 cases, and 14 of these were first-degree relatives and 8 were second-degree relatives. There were 16 unrelated patients who donated their kidney for their husbands or wives. No donors had a history of diabetes mellitus (Table 1). Mean OPT was 144.35 ± 22.79 minutes, and mean WIT was 184.35 ± 4.97 seconds. There were no conversions to open surgery, no perioperative or postoperative complications, and no blood transfusion (Table 2). Postoperatively, lymphorrhea was observed in 1 patient and was successfully managed by delayed drain removal. Postoperative transfusion was not needed for any living donors. The pain was significant on day 1 but resolved quickly. All patients resumed consistent oral intake on day 1 and were able to resume full ambulatory activity by day 2 and day 3. The final length of the mended incisions did not exceed 8 cm (7.23 ± 0.62 cm), and all patients expressed satisfaction with the cosmetic results (Figure 2). Changes in eGFR during the 12-month follow-up are shown in Figure 3. Compared with the results from other studies, a similar pattern of eGFR changes was observed. There was no complication in any donor during the 12-month observation period.

Table 1. Living Kidney Donor Preoperative Characteristics

Variable	Value
Age, mean ± SD, y	45.28 ± 13.46
Sex, No. of patients	
Female	22
Male	16
Laterality, No. of patients	
Left	38
Right	0
BMI, mean ± SD	27.12 ± 5.21
Hypertension, No. of patients	
Yes	5
No	33
Diabetes mellitus, No. of patients	
Yes	0
No	38
Smoking, No. of patients	
Yes	6
No	32
Alcohol, No. of patients	
Yes	7
No	31
Creatinine, mean ± SD, mg/dL	0.69 ± 0.12
MDRD-eGFR, mean ± SD, mL/min/1.73 m^2	114.61 ± 17.51
99mTc-DTPA (split renal function), mean ± SD, %	
Left	48.45 ± 2.47
Right	51.55 ± 2.47

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); MDRD-eGFR, estimated glomerular filtration rate according to the Modification of Diet in Renal Disease study equation; 99mTc-DTPA, renal scintigraphy with technetium-99m-diethylenetriaminepentaacetic acid

Table 2. Results of 38 Living Kidney Donor Nephrectomies

Variable	Mean ± SD
Mean operative time, min	144.35 ± 22.79
Phase I, min	28.14 ± 5.85
Case 1 (patient 6)	33.83 ± 2.78
Case 2 (patient 32)	23.87 ± 3.09*
Phase II, min	116.21 ± 21.88
Warm ischemia time, s	184.35 ± 4.97
Mean blood loss, mL	72.85 ± 60.81
Complications, No. of patients	
Yes	1
No	37
Transfusions, No. of patients	
Yes	0
No	38
Postoperative hospital stay, d	9.14 ± 1.56
Length of incision, cm	7.23 ± 0.62

*$P < .001$, significant difference compared with the earlier surgery in the series.

Figure 2. Abdomen Incision Site After Video-Assisted Mini-Laparotomy Surgery for Living Donor Nephrectomy

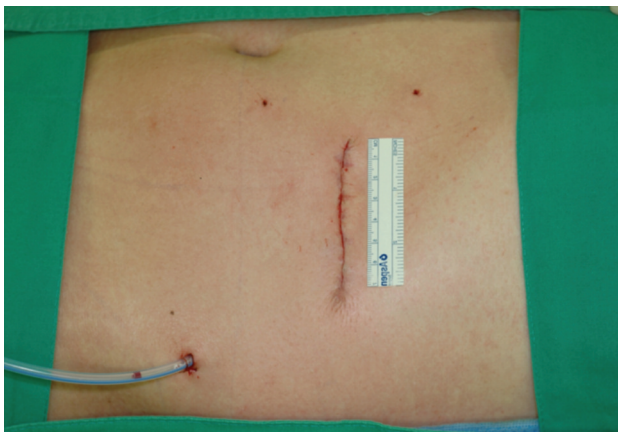
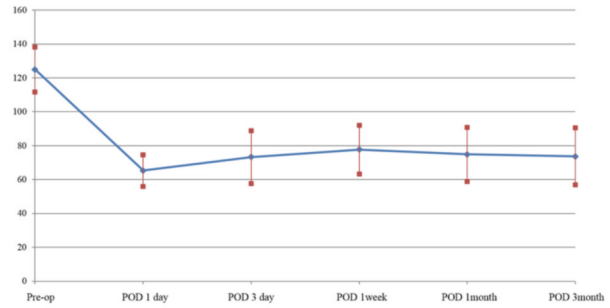


Figure 3. Postoperative Renal Function: Estimated Glomerular Filtration Rate According to the Modification of Diet in Renal Disease Study Equation



Abbreviations: POD, postoperative period; Pre-op, preoperative
Estimated glomerular filtration rates are shown as mL/min/1.73 m^2.

Discussion

The risk of progression to end-stage renal disease is high in living kidney donors, and living donor nephrectomy is an operation without any medical benefit for the donor.[4] Therefore, the evaluation of complications is a primary focus for outcome assessment. Single kidney and various other complications are associated with living donor nephrectomy. Therefore, safety and efficacy are the most important considerations for living donor nephrectomy. Previous studies have reported that open surgery living donor nephrectomy has the advantages of improved OPT and improved WIT, whereas laparoscopic living donor nephrectomy has advantages related to EBL, pain, and duration of hospital stay.[5,6] However, laparoscopic living donor nephrectomy requires extensive vascular dissection, careful handling of the kidney and vessels, and rapid specimen removal to minimize WIT.[7]

To enhance the safety of living donor nephrectomy, Yang and colleagues standardized VAMS living donor nephrectomy.[1] With this technique, the hooking angle, tension, and direction of retracting force are well controlled and sustained by adequate use of malleable retractors (Figure 1).[2] The standardization trial of VAMS living donor nephrectomy allowed us to avoid intraoperative complications and to immediately and safely control any potential adverse event. Additionally, VAMS living donor nephrectomy is a surgical technique that combines the advantages of open surgery and conventional laparoscopic nephrectomy. Also, VAMS allows easy maintenance of anatomic orientation, because the operation is performed under observation on the video monitor or direct vision and a smaller incision (5-7 cm) than that used in open surgery. A small incision site facilitates less surgical trauma, alleviates postoperative pain, and promotes a quicker recovery.[1-3] The VAMS technique provides the advantages of both laparoscopic surgery and open surgery. However, VAMS living donor nephrectomy was performed at only a single institution, and there was a limit to the reproducibility and learning curve.

In a case report regarding the learning curve challenge associated with laparoscopic donor nephrectomy, the researchers reported no significant reduction in the mean OPT, EBL, or WIT, even after 381 cases. However, there was a significant reduction in donor complications after the first 285 cases.[8] Some reports have determined that complication rates may be significantly reduced for surgeons who have performed about 100 cases of laparoscopic living donor nephrectomies.[9-11] Another study reported that a series of 74 cases was sufficient to achieve success with robotic hand-assisted donor nephrectomy without complications.[12]

In a report published by Park and colleagues,[13] the analysis of the learning curve for VAMS donor nephrectomy showed that the surgeon effectively completed VAMS donor nephrectomy with optimized WIT, total OPT, and low EBL within 49 to 50 cases. Compared with other techniques, VAMS donor nephrectomy requires a shorter learning period to achieve a notable decrease in clinical complications.

Moreover, we have demonstrated the reproducibility and safety of VAMS living donor nephrectomy performed by other institutions. In our study, mean OPT (144.35 minutes) was shorter than previously reported data for VAMS (154 ± 41 minutes) because the surgeon had substantial experience with renal surgery. However, an average of 20 to 30 minutes

was required to set the piercing retractors.[3] Mean OPT was comparable to that of previous large-scale laparoscopic living donor nephrectomy studies (180-221 minutes).[14-16] Mean WIT (184.35 seconds) for VAMS living donor nephrectomy was similar to that reported for open surgery living donor nephrectomy (mean, 1.4 to 3 minutes) and shorter than that reported for laparoscopic living donor nephrectomy (mean, 2.8 to 6 minutes).[14,15] Mean hospital stay (7.2 days) tended to be longer than for other surgical procedures[5] because the living donor patients were not discharged until after the sutures were removed.

We divided the VAMS procedure into 2 phases. Phase I is for access to the ureter and device installation. Phase II is the step of kidney removal. Although phase I requires more time for first-time operators, our experience shows that a series of 6 surgeries is sufficient to produce a reduction in the duration of phase I (Table 2). However, phase II tends to be influenced more by patient factors (eg, body mass index and anatomic structure) rather than the surgeon's level of experience.

As for renal function, the 12-month follow-up serum creatinine level (1.05 ± 0.18 mg/dL) was similar to that of previously reported studies (1.16 mg/dL at postoperative year 1).[17-19] Choi and colleagues[2] reported eGFR of 65 mL/min/1.7 m^2 for postoperative year 1, and their findings showed an inferior tendency compared with our results (71.22 ± 10.19 mL/min/1.7 m^2 for postoperative year 1).

One limitation of our present study is the comparatively small sample size. However, to our knowledge, this is the first report to demonstrate reproducibility of VAMS living donor nephrectomy. Another limitation of our study is the absence of long-term renal function data for the patients included in our analyses. The 12-month observation period is too short to allow interpretation of long-term renal function. However, renal function stabilized in living kidney donors at 1 month after nephrectomy, and this effect persisted through the entire first postsurgical year.[20]

A prospective, multicenter study is required to facilitate robust comparisons of this technique versus other methods for living donor nephrectomy.

In summary, the primary advantage of VAMS is the combination of open surgery with laparoscopic surgery, and several details are worthy of mention. Traditional laparoscopic surgery incorporates needle drivers that some surgeons find difficult to use; however, VAMS does not require this equipment. Compared with open surgery, the telescope provides a magnified view, and an internal light source promotes clear direct surgical observation. The VAMS technique allows for an extraperitoneal approach, with a very low risk for bowel injury and subsequent low morbidity. With the VAMS technique, the surgeon can freely operate without bowel injury and without the need for adhesiolysis; thus the learning curve for VAMS is shorter than for laparoscopic donor nephrectomy. Also, a VAMS procedure can be easily converted to open surgery in case of a major complication, such as a vascular accident.

Although laparoscopic donor nephrectomy is presently the most popular technique for renal transplant, it is clear that VAMS has distinct advantages. Therefore, VAMS is an important alternative to standard laparoscopic nephrectomy, especially for physicians who may lack substantial laparoscopic experience or for patients judged unsuitable for the standard laparoscopic technique.

Conclusions

The VAMS living donor nephrectomy procedure is a feasible and safe technique. Here, we have demonstrated reproducibility of this technique, which had been an elusive goal, as noted in previous studies. The VAMS technique for living donor nephrectomy is a solo surgery that can be safely performed by any surgeon with prior kidney surgery experience.

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