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Robotic-Assisted Laparoscopic Donor Nephrectomy: Decreasing Length of Stay

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ABSTRACT

Background: The number of robotic operations performed with the da Vinci Surgical System has increased during the past decade. This system allows for greater maneuverability and control than hand-assisted laparoscopic procedures, resulting in less tissue manipulation and irritation.

Methods: We retrospectively analyzed the results of 100 consecutive robotic-assisted laparoscopic donor nephrectomies and compared them to our most recent 20 hand-assisted laparoscopic donor nephrectomies.

Results: Between May 2008 and June 2012, 120 laparoscopic donor nephrectomies were performed at Ochsner Clinic Foundation. Of those, 100 live kidney donors underwent robotic-assisted laparoscopic donor nephrectomies. Surgical time and hospital length of stay improved after the first 20 patients receiving robotic-assisted laparoscopic nephrectomies, which was considered the learning curve. Sixty percent of patients who underwent robotic-assisted laparoscopic donor nephrectomies were released on postoperative day 1 compared to 45% of patients who underwent hand-assisted laparoscopic techniques.

Conclusion: In our experience, robotic-assisted laparoscopic donor nephrectomy resulted in decreased postoperative length of stay that decreased the global cost of the procedure and allowed our institution to admit more patients.

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INTRODUCTION

Living kidney transplantation provides a high rate of immediate allograft function, superior long-term patient and graft survival, shorter waiting time, and the possibility of preemptive transplantation compared to deceased kidney transplantation.[1]

Open donor nephrectomies were used for nearly 50 years until the implementation of the laparoscope in 1995 by Ratner et al.[2] The laparoscopic approach for donor nephrectomy reduced blood loss, pain, and patient convalescence and improved aesthetic results. Nowadays, the laparoscopic approach is the most common method for performing donor nephrectomies, resulting in an increased acceptance of donor operations and consequent expansion of the donor pool.[3,4]

In 2000, the US Food and Drug Administration approved the da Vinci Surgical System (Intuitive Surgical Inc.), a system that combines robotic techniques and computer imaging to enable microsurgery in a laparoscopic environment, for use in the United States. The da Vinci Surgical System's advantages include the precision and instinctive movements of open surgery, an optimal ergonomic environment for the surgeon, and a 3-dimensional (3-D) vision system that restores the hand-eye coordination lost in laparoscopic procedures.[5,6]

In 2001, the University of Illinois at Chicago reported the first series of robotic-assisted laparoscopic donor nephrectomies.[7,8] Since then, the use of the da Vinci Surgical System has increased, and many centers have reported that the procedure is feasible and safe and provides excellent results with low morbidity compared to the laparoscopic approach.[6,9]

The laparoscopic donor program at Ochsner Clinic Foundation was established in 2000, and approximately 20 hand-assisted laparoscopic donor nephrectomies were performed per year. In June 2009, we began using the robotic-assisted laparoscopic approach as the standard procedure for all donor nephrectomies. In this study, we examine the results of our first 100 robotic-assisted laparoscopic donor nephrectomies and compare them to our last 20 hand-assisted laparoscopic donor nephrectomies.

METHODS

Between May 2008 and June 2012, 120 laparoscopic donor nephrectomies were performed at our institution. With institutional review board approval, we retrospectively analyzed our first 100 consecutive patients who underwent robotic-assisted laparoscopic donor nephrectomies, as well as the last 20 consecutive patients who had hand-assisted laparoscopic donor nephrectomies. For comparison and to address the learning curve, patients were divided into 3 groups: Group A, the last 20 hand-assisted laparoscopic donor nephrectomies (representing our established practice beyond a learning curve after 10 years of practice and >200 cases); Group B, the first 20 consecutive robotic-assisted laparoscopic donor nephrectomies; and Group C, the last 80 consecutive robotic-assisted laparoscopic donor nephrectomies.

Preoperative patient characteristics, including age at time of surgery and body mass index (BMI), were recorded. All donors underwent similar standard preoperative evaluation. Split renal function and anatomy were determined by renal nuclear scan and computed tomography angiography. The selection of right or left kidney was based on split renal function and vascular anatomy. Neither patient nor kidney side influenced the selection of surgical procedure. The principle of leaving the better kidney with the donor was adopted when applicable, and the left kidney was used preferentially for technical reasons. In cases involving 2 or more renal arteries, vascular reconstruction was carried out before implantation to the recipient vessels.

Robotic-assisted laparoscopic procedures were performed by a group of 4 surgeons with experience in laparoscopic and hand-assisted laparoscopic donor nephrectomy. All cases involved 2 staff surgeons, one acting as a surgeon in the console and another assisting at the operating table.

The surgical technique for robotic-assisted laparoscopic donor nephrectomy has been described elsewhere.[6] Briefly, an orogastric tube and a Foley catheter are placed, and one dose of prophylactic antibiotic is given before the skin incision. The patient is positioned in a 45° dorsal position with the operating table flexed to maximize kidney exposure. A 12 mm trocar is placed at the umbilicus, and the pneumoperitoneum is created. Under laparoscopic supervision, 3 extra ports are placed. Once the instruments are docked, the surgeon sits at the distant console. The patient-side assistant (second surgeon) operates the suction-irrigation and exchanges robotic instruments. The procedure consists of colon retraction and dissection of the ureter and the renal pedicle. The gonadal vein is clipped and divided close to the renal vein and excluded from the ureter dissection. Adrenal and lumbar veins are clipped and divided as needed. Finally, the kidney is separated from the surrounding tissue in the extracapsular plane. Once the dissection is complete, the robot is undocked, the umbilicus incision is extended, a hand port device is placed, and vascular staplers are used to divide and secure the ureter and renal vessels. We prefer a hand-assisted approach for this portion of the operation to add tactile dissection, minimize graft warm ischemia time, and increase safety by having the ability to easily control major bleeding if indicated.

Once the kidney is removed from the donor, it is flushed with cold heparinized University of Wisconsin solution and prepared for transplantation. No prophylactic antibiotics or preoperative heparin are administered.

Donor surgical time was defined as the period between the initial incision and renal vessel clamping. Skin closure was not used as a time reference because the surgeon paused to flush the kidney allograft and perform the back table work.

Implantation of the kidney transplant was similar in all three groups. The hospital revenue department collected gross charges for each patient and forwarded the information to us for analysis.

RESULTS

Donor information is reported in Table 1. No differences were found in age or BMI. Left kidneys were procured in 85.0% of the donors who underwent hand-assisted laparoscopic procedures (Group A), 100.0% of the first 20 donors who had robotic-assisted nephrectomies (Group B), and 73.7% of the last 80 donors who underwent robotic-assisted procedures (Group C). Double renal arteries were seen in 15% of the patients in Group A and in 30% and 15% in groups B and C, respectively. Mean surgical time was 131 (range, 83-275) minutes, 149 (range, 109-205) minutes, and 139 (range, 113-261) minutes for groups A, B, and C, respectively.

Mean hospital length of stay was 2 days for Group A, while Group B had the longest length of stay (2.30 days), and Group C had the shortest length of stay (1.55 days) (Table 2). Seventy-five percent of the donors who had hand-assisted laparoscopic procedures (Group A) were discharged from the hospital by

Table 1. Demographic Comparison of Donor Groups

	Group A – Hand-Assisted Laparoscopic Nephrectomy n=20	Group B – Initial Robotic-Assisted Laparoscopic Nephrectomy n=20	Group C – Robotic-Assisted Laparoscopic Nephrectomy n=80
Mean age, years	41.0	36.1	37.7
Body mass index, kg/m^2	27.6	27.2	27.1
Left kidney, %	85.0	100.0	73.7
Double renal arteries, %	15.0	30.0	15.0
Surgical time, min	131	149	139

postoperative day (POD) 2, compared to 88.8% of the donors in Group C who underwent robotic-assisted nephrectomies (Figures 1 and 2).

No donor mortality was observed. No significant complications were observed in Group A. Group B had three complications: one patient had arm deep vein thrombosis, one patient was returned to the operating room (OR) on POD 1, and one patient's procedure was converted to an open procedure. The surgical site of the patient who was returned to the OR on POD 1 was explored using a hand-assisted laparoscopic approach, and a small bleed from the renal artery staple line was identified and corrected. The other patient was converted to an open procedure because of the inability to control bleeding from a lumbar vein. Three complications were observed in Group C: one patient presented intractable nausea for about 2 weeks after the nephrectomy, one patient was returned to the OR on POD 1 because of bleeding from an adrenal vessel, and one patient needed a transfusion on POD 1 after bleeding because of a tear in the mesocolon during the Hassan trocar placement. Complications in Group C occurred in the initial 30 patients, and no complications were seen in the remaining 50 patients.

Recipient creatinine was recorded to assess allograft function. The mean creatinine levels at discharge and 30 days postnephrectomy were 1.8 mg/dL, 1.7 mg/dL, and 1.7 mg/dL, and 2.0 mg/dL, 1.4 mg/dL, and 1.6 mg/dL for groups A, B, and C, respectively.

Global costs for all three groups are summarized in Table 3. The high cost in Group B suggests a learning curve effect because costs were lower in the established programs, in both hand- and robotic-assisted procedures. Importantly, the cost for a robotic-assisted laparoscopic nephrectomy decreased ~8% after the first 20 procedures (Group C vs Group B).

DISCUSSION

With the increasing number of patients requiring kidney transplantation, multiple strategies to increase the number of donors, including living donation, have been developed. Among them, the implementation of laparoscopic donor nephrectomy was a major cornerstone because donors benefit from reduction of pain, bleeding, and length of stay and improved aesthetic outcomes. However, the gap is still growing between the number of patients waiting for a kidney transplant and the number of organs available. Therefore, we must continue looking for the optimal nephrectomy procedure that can be performed safely, be considered attractive, and provide minimal disruption in a donor's life.

The advantages of the da Vinci Surgical System, such as magnification, 3-D vision, and increased

Table 2. Comparison of Donor Length of Stay

	Group A – Hand-Assisted Laparoscopic Nephrectomy n=20	Group B – Initial Robotic-Assisted Laparoscopic Nephrectomy n=20	Group C – Robotic-Assisted Laparoscopic Nephrectomy n=80
Mean length of stay, days	2.00	2.30	1.55
Median length of stay, days	2.00	2.00	1.00
Discharged POD 1, %	45.0	40.0	60.0
Discharged POD 2, %	30.0	20.0	28.8
Discharged POD 3, %	5.0	15.0	7.5
Discharged POD 4, %	20.0	25.0	3.7

POD, postoperative day.

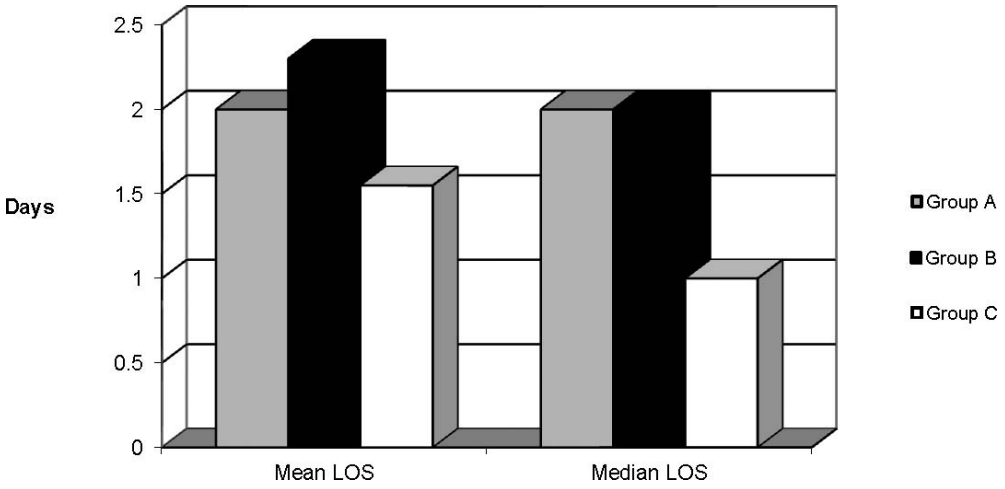

Figure 1. Average length of stay (LOS) for donors who underwent the last 20 hand-assisted (Group A), the first 20 robotic-assisted (Group B), and the last 80 robotic-assisted (Group C) nephrectomies.

flexibility and accuracy, seem to be a natural complement to the already proven laparoscopic procedure. Although the da Vinci Surgical System has been used for donor nephrectomies since 2000, our institution did not adopt it until 2009 when we were looking for ways to improve our living kidney donor program. Since then, we have observed an increase in the number of kidney transplants from living donors (from ~20 per year to ~40 per year). Because different strategies were implemented at the same time, it is impossible to identify which one has been more effective. We believe the robotic-assisted approach has made donor nephrectomies safe and attractive.

In this report, we show that the robotic-assisted laparoscopic donor nephrectomy can be performed safely without detrimental effects on surgical times,

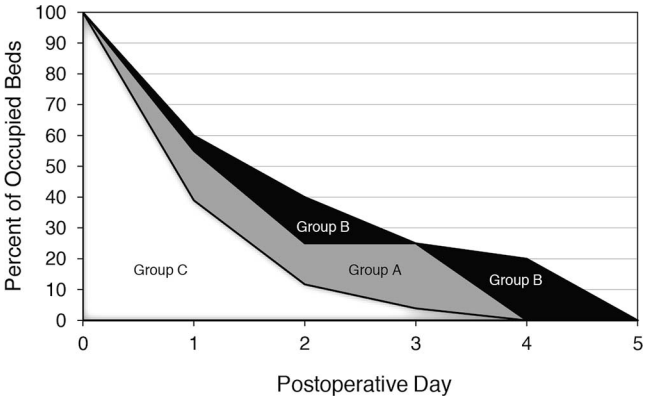

Figure 2. Percent of beds occupied on average by donors who underwent the last 20 hand-assisted (Group A), the first 20 robotic-assisted (Group B), and the last 80 robotic-assisted (Group C) nephrectomies.

complications, or kidney allograft function compared to the hand-assisted laparoscopic approach. Moreover, no changes in our donor selection criteria (age, BMI, or presence of multiple renal arteries) or side selection (right or left kidney) were necessary or influenced our decision because of the use of the robotic-assisted approach. In this regard, the implementation of the new technique did not jeopardize or restrict our living donor program policies. Previous reports have found similar results in smaller populations.[10,11]

Our report also addresses the learning curve. During our learning period (Group B), we performed only left nephrectomies and, as expected, operative times as well as lengths of stay were longer than in the established groups (A and C). Consequently, costs were higher for Group B. We saw complications beyond our first 20 robotic-assisted procedures (in fact, in the first 30), suggesting a longer learning curve; however, our learning curve reflects 4 surgeons. The learning curve period would likely have been shorter if only 1 or 2 surgeons had performed all the initial procedures and then instructed the others instead of sharing the early experience among a group of 4 surgeons. Some of the complications in both the hand-assisted and robotic-assisted laparoscopic procedures could have been prevented by better judgment, careful technique, and surgical experience. We did not find the complications were directly related to the use of the robotic device.

Length of stay showed important differences among the groups, mainly between the established programs, hand-assisted (Group A) and robotic-assisted (Group C). Median length of stay was twice

Table 3. Comparison of Donor Nephrectomy Cost

	Group A – Hand-Assisted Laparoscopic Nephrectomy n=20	Group B – Initial Robotic-Assisted Laparoscopic Nephrectomy n=20	Group C – Robotic-Assisted Laparoscopic Nephrectomy n=80
Year(s)	2008	2009-2010	2010-2012
Average cost, $	7,823	8,913	8,220

as long for donors who had hand-assisted procedures. On average, donors who underwent robotic-assisted procedures were released 0.45 days earlier, and 15% more patients were discharged on POD 1 when robotic assistance was used for the procedure. Twenty percent of donors who underwent hand-assisted laparoscopic nephrectomies (Group A) were still in the hospital on POD 3 compared to only 3.7% of donors who had robotic-assisted laparoscopic nephrectomies (Group C). We hypothesize that the short length of stay in the established robotic-assisted program is attributable to reduced manipulation of the peritoneum, better identification of dissection planes (avascular planes), and limited energy use from cauterization leading to minimal inflammation and pain. Reduction of length of stay makes the robotic-assisted nephrectomy procedure convenient for a donor, who as a healthy person, wants to return as soon as possible to routine activities and, in some cases, to his/her native town. Our report did not focus on other aspects of postoperative recovery such as a resumption of diet, pain control, or patient satisfaction—criteria related to the laparoscopic approach, not specifically to the robotic-assisted approach, that have been previously reported.[12]

Financial advantages of using the da Vinci Surgical System have been controversial.[13,14] We did not find a clear financial advantage of using the robotic-assisted approach compared to the hand-assisted approach. However, our financial data indicate that by discharging patients sooner, we can decrease the global cost of the procedure. Also, by discharging patients earlier, an indirect benefit is created by allowing a greater number of patients to be admitted to the institution, which is a large benefit for a transplant center operating at 100% capacity year-round.

The limitations of our study include the retrospective analysis, the single-center protocol, and the relatively small sample size, although ours is one of the largest reported series of laparoscopic donor nephrectomies using robotic-assisted technology. Additionally, a time bias is possible because procedures were performed in different eras when factors other than those related only to the surgical interventions could have affected the outcomes.

CONCLUSION

Our experience shows that the robotic-assisted laparoscopic donor nephrectomy procedure does not compare negatively against the hand-assisted laparoscopic approach. Robotic-assisted laparoscopic donor nephrectomy can be performed safely, is an attractive option for both patients and surgeons, and causes minimal donor life disruption because of short hospital stays.

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