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Routine left robotic-assisted laparoscopic donor nephrectomy is safe and effective regardless of the presence of vascular anomalies

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Summary

The classic approach to donor nephrectomy consists of preferential procurement of the kidney without vascular anomalies. We studied the effect of routine procurement of the left kidney regardless the presence of multiple arteries on the outcomes of robotic-assisted laparoscopic living donor nephrectomy (LLDN) with particular reference to the incidence of urological complications. From August 2000 to July 2005, 209 left LLDNs were performed. We analyzed the outcomes of donors and recipients in relation to the presence of multiple vessels versus normal anatomy. We divided the patients into two groups: group A ($n = 148$) with normal vascular anatomy and group B ($n = 61$) with vascular anomalies. In the donors, no significant difference in conversion to open surgery rate, blood loss, length of stay, was noted between the two groups; operative time and warm ischemia time were slightly higher in group B. One-year patient survival was 98% in both groups while the 1-year graft survival was 96.6% in group A and 96% in group B. Only one urological complication was noted in the group with normal anatomy (0.7%) versus none in the group with multiple arteries. Left kidney procurement using robotic-assisted laparoscopic technique is safe and effective, even in the presence of vascular anomalies.

Introduction

In the last decade, laparoscopic living donor nephrectomy (LLDN) has gained widespread acceptance. The popularity of the procedure is mainly because of its association with decreased postoperative pain, shorter hospitalization, and faster recovery when compared with open nephrectomy [1–9]. The availability of a minimally invasive approach has also significantly increased the number of live kidney donations in the United States. In 2001, the number of kidney transplants from living kidney donors exceeded the number from cadaver donors, partly as a consequence of the availability of LLDN [10,11].

Proper definition of kidney vascular anatomy has traditionally been essential for planning the side of the donor nephrectomy. In the presence of normal anatomy (single artery and single vein) bilaterally, the left kidney is always preferred because of the superior length and better quality of the wall of the left renal vein [12–14]. However, the literature reports presence of multiple renal arteries in 18–30% of the potential donors [15]. In general, in the presence of normal vascular anatomy of the right kidney and multiple arteries to the left, the right kidney has been preferentially procured [16].

Historically, the presence of multiple renal arteries was considered a contraindication to kidney transplant because of the increased risk of technical complications [17]. Currently, the presence of multiple arteries is not considered a contraindication to kidney procurement for transplantation and a variety of techniques for management of multiple vessels have been described [18,19].

The initial experience with laparoscopic procurement of the right kidney has been unfavorable because of a higher incidence of venous complications resulting in increased graft loss [20,21]. However further experience has demonstrated the feasibility and safety of laparoscopic right nephrectomy, which represents a viable alternative whenever the anatomy of the left kidney is challenging [22]. A recent publication from Carter *et al.* has suggested an increased rate of urological complications in recipients of laparoscopically procured kidney graft with multiple arteries, raising concern about the opportunity to perform left laparoscopic nephrectomy in this setting [23].

In August of 2000, we began to perform LLDNs using the da Vinci™ Robotic Surgical System (Intuitive Surgical®, Sunny Valley, CA, USA). As the beginning of our experience, we have implemented the policy of routinely harvesting the left kidney regardless of the presence of vascular anomalies to take advantage of the longer length of the left renal vein. In this study, we reviewed our experience to assess the effect of such a policy on the outcomes of robotic-assisted LLDN for kidney transplantation, with particular reference to the rate of urological complications.

Patients and methods

Between August 2000 and July 2005, 213 robotic-assisted LLDNs were performed at the University of Illinois at Chicago. Four patients underwent robotic-assisted right donor nephrectomies; therefore they were excluded from the analysis. The study population ($n = 209$) was divided into two groups based on the preoperative spiral CT scan and surgical findings. Group A consisted of 148 patients (70.8%) without vascular variations (single renal artery and vein), while group B included 61 patients (29.2%) with an abnormal vascular anatomy, namely multiple renal arteries and veins. All donors were screened according to a thorough medical evaluation specified by a standardized protocol. Renal vascular anatomy was studied using spiral CT scan with 3D reconstruction. The left kidney was chosen for procurement regardless of the presence of anatomical variations. Right donor nephrectomies were only performed in the presence of a smaller size kidney, stones and cystic disease of the right kidney. All candidates were informed about the possibility of conversion to the open approach in the event of complications. Our surgical technique has been previously described in detail [24]. We performed a robotic laparoscopic left nephrectomy with hand-assisted technique. In the presence of multiple arteries or veins, a careful back-table reconstruction was carried out to minimize the number of arterial or venous anastomoses to be performed in the recipient. The kidney transplant operation was carried out with the standard extra-peritoneal approach to the external or common iliac artery and vein in adults and most of the pediatric patients. However, in pediatric patients weighing <15 kg, a *trans*-abdominal approach to the infra-renal aorta and cava was used for exposure. In 2/3 of the cases a double J-stent was used for the ureteral anastomosis. Vascular patency was routinely evaluated on postoperative day 1 with duplex ultrasound, which was repeated in case of any evidence of graft dysfunction.

The charts of all donors and recipients were reviewed retrospectively. For the purpose of the study, we carefully evaluated the intra- and postoperative complications, operative time, warm ischemia time, conversion to open surgery rate, length of hospitalization and clinical outcomes in both recipients and donors, with particular emphasis on the occurrence of urological complications in the transplanted patients. Primary warm ischemia time was defined as the time between clamping of the renal artery and flushing with cold preservation solution. Total warm ischemia time was calculated by adding to the primary warm ischemia the time intercurring from removal from cold storage to graft reperfusion. Delayed graft function was defined as the need for dialysis after transplantation. Graft loss was defined by either patient's death or return to dialysis. We used serum creatinine at 6 months as an indicator of graft function. The various end-points were then compared in the two study groups.

All data are expressed as mean and range. Statistical significance was calculated using Student *t*-test and significance was defined as $P < 0.05$. Statistical analysis was performed utilizing StatView (SAS Institute, Cary, NC, USA). Patient and graft survival was calculated using Kaplan–Meyer analysis.

Results

Of the 209 patients who underwent left robotic-assisted LLDNs, 108 were male and 101 female, with a mean age 35 years (range: 18–60). Eighty-three patients were African-American, 45 Caucasian, 73 Hispanic and eight of other races. The patient population was divided in two groups based on the presence of normal renal vascular anatomy (group A, $n = 148$, 71%) or multiple renal arteries or veins (group B, $n = 61$, 29%). Only patients with multiple renal arteries or multiple veins requiring vascular reconstruction were considered in Group B. The 25 patients with small upper polar accessory branch, which was ligated in the back table were included in the single artery group for the purpose of this study. The two study groups were comparable in terms of demographic data in relation to both donor and recipient (Table 1).

We found a perfect correlation between the CT and the intra-operative findings in terms of renal vascular anat-

Table 1. Donor and recipient demographics.

Groups (*n*)	Gender (M/F)	Average age, years (range)	Race (AA, C, H, O)
Donors			
A = 148	74/74	35 (18–60)	AA = 59
			C = 31
			H = 54
			O = 4
B = 61	27/34	35 (19–58)	AA = 24
			C = 14
			H = 19
			O = 4
Recipients			
A = 148	70/78	42 (1–68)	AA = 59
			C = 31
			H = 54
			O = 4
B = 61	30/31	43 (8–68)	AA = 24
			C = 31
			H = 19
			O = 4

AA, African-American; C, Caucasian; H, Hispanic; O, Other.

Table 2. Comparison of donor outcomes between the two study groups.

	Group A	Group B	*P*-value
Mortality (%)	0	0	
Associated morbidity (%)	5	7	NS
Conversion to open procedures	1.5	0.5	NS
Estimated blood loss (cc)	76 (20–1500)	107 (10–1500)	NS
Primary warm ischemia time (s)	94 (50–200)	102 (60–170)	<0.001
Operative time (min)	146 (60–320)	158 (70–280)	<0.05
Length of stay (days)	2	2	NS

Group A, no vascular anomalies; Group B, vascular anomalies.

omy. Of the 61 patients with abnormal vascular anatomy, 54 had two renal arteries; two patients had three renal arteries; one patient had five renal arteries, three patients had a duplicated renal vein and one patient had double artery and double vein. The kidneys with multiple renal arteries were transplanted after back table reconstruction of the multiple arteries into a single conduit in 55 cases. In three of these patients, the single conduit was constructed using recipient saphenous vein grafts. In three additional cases, two individual anastomoses of widely separated double renal arteries to the recipient iliac artery were performed. In all the kidney grafts with double renal vein, a side-to-side anastomosis was performed to obtain a single venous conduit.

The robotic dissection of the left kidney with its vascular pedicle was successfully completed in all cases. However, in four cases conversion to open procedure was necessary because of failure of the stapling device on the renal artery stump (three cases) and bleeding from renal vein laceration (one case); all the conversions occurred during our initial 100 cases. Overall, mortality was 0%, while postoperative morbidity included pneumonia (n = 2, 0.95%), mild pancreatitis (n = 1, 0.47%), and superficial wound infections (n = 8, 3.8%). All complications were successfully treated with conservative management. No donors received blood transfusions.

In the donors, no significant difference in mortality, morbidity, conversion rate, blood loss, and length of hospital stay was noted between the two groups. The operative time and primary warm ischemia time were higher in group B (P-values 0.05 and 0.001). The donors' outcomes in the two study groups are summarized in Table 2.

The outcomes of kidney transplantation in the recipients were also similar in both groups. There were no differences in the total warm ischemia time since almost all grafts were revascularized using a single arterial conduit (30 ± 7 min in group A vs. 29.8 ± 6 min in group B). The average hospital stay was 5 days (range: 4–40). One-year patient survival was 98% in both groups while the 1-year graft survival was 96.6% in group A and 96% in group B (P = NS). The incidence of delayed graft function was 0% in both groups. Two vascular thrombosis occurred in the group transplanted with a single artery graft versus none in the other group (P = NS). One patient who received a graft with single renal artery developed a stricture of the pyelo-ureteral junction 2 months after transplant (1/148, 0.67%); no urological complications were noted in recipients of graft with vascular anomalies. Average serum creatinine at 6 months post-transplant was 1.4 mg/dl in both groups (range: 0.8–2.2).

Discussion

Over the last few years, laparoscopic donor nephrectomy has became increasingly popular, and currently above 85% of transplant centers in the US offer laparoscopic donor nephrectomy, suggesting that LLDN is becoming the procedure of choice in living donor kidney transplantation [25]. In the presence of normal vascular anatomy bilaterally, the left kidney is always chosen to take advantage of the longer renal vein.

Whenever the vascular anatomy of the left kidney is abnormal and the right pedicle is normal, the right kidney has been preferentially used. Right donor nephrectomy has been performed in 20–30% of living donor cases reported in published literature [12]. The reported indication for right nephrectomy has been mainly complex left vascular anatomy. However, donor right nephrectomy has been also performed in the case of smaller size, stones, and cystic disease of the right kidney with concomitant normal anatomy of the left kidney [12,17]. In the latter cases, the right kidney was chosen to 'protect' the donor by preserving the healthier left kidney.

Historically, the presence of multiple renal vessels has been considered a relative contraindication to kidney transplantation [18]. Transplantation of an allograft with multiple renal arteries has several potential disadvantages. It requires complex surgical reconstruction, which may prolong warm ischemia time and increase the rate of delayed graft function [19,26,27]. Associated increased risks of vascular complications such as renal artery thrombosis and stenosis have been reported in the past [28]. Furthermore, the use of grafts with multiple arteries has been associated with a higher incidence of ureteral necrosis and urinary fistulas [29]. However, a study in a large population of kidney transplant recipients has shown no difference in outcomes, or short- and long-term vascular complications in grafts with single versus multiple renal arteries [30].

Although the presence of multiple renal arteries could potentially increase the technical challenge of laparoscopic kidney procurement, Kuo *et al.* have shown no differences in complications and graft survival rates in LLDN compared with the open procedure [31].

The early published experience with laparoscopic procurement of the right kidney for renal transplantation reports a high incidence of venous complications, resulting in increased graft losses [20,21]. Although a decreased number of complications have been reported with increasing experience [22,32] concerns with the use of right kidney grafts for kidney transplant still remain.

The debate has been recently stimulated by data presented by Carter *et al.* from University of California San Francisco. In a large single center experience of 361 consecutive robotic nephrectomies the authors documented a 16.6% rate of urological complications in recipients of kidney graft with multiple revascularized arteries versus 3.2% in recipients of grafts with single renal artery. Given the good outcomes of right donor nephrectomy in their experience, the authors advocate routine procurement of the kidney grafts with single artery irrespective of the side [23].

In our center, we have routinely performed left kidney removal even when the right kidney procurement would have been more favorable because of the presence of normal vascular anatomy. In fact, 20 donors (9.5%) in our series with abnormal vascular anatomy on the left presented a single vein and artery on the right side. Only four patients underwent right donor nephrectomy, either because smaller size kidney, stones or cystic disease on the right side. Therefore, our rate of kidney graft with multiple vessels requiring reconstruction is quite high (29%).

Our study showed no difference in mortality, morbidity, conversion rate, blood loss, and length of hospital stay among the two groups, although operative time and warm ischemia time were slightly higher in donors with multiple arteries. In the recipients, we did not document any increase in warm ischemia time, ATN and thrombosis rates, and urological complications in patients receiving grafts with multiple arteries; patient and graft survivals were also similar.

Our experience suggests that routine procurement of the left kidney despite the presence of abnormal vascular anatomy can be performed without additional risk for donors or recipients. The left kidney can be routinely procured by robotic LLDN in order to take advantage of the better quality and superior length of the left renal vein except when right-sided renal pathology mandates right nephrectomy for donor's protection.

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