Evolution of Minimally Invasive Surgery for Donor Nephrectomy and Outcomes

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ABSTRACT

Background: Laparoscopic donor nephrectomy was introduced into Australia in 1997 by this unit. However, some donors may be considered unsuitable, and few modifications to the existing technique can tailor this procedure for an individual donor. Recently, further changes including clustering of ports and single-port methods have been investigated.

Methods: The laparoscopic method was offered to all but 3 donors from May 1997 to October 2009. Data were collected on all 289 donors who underwent laparoscopic procedures.

Results: All but 5 donor procedures were completed laparoscopically, and in 4 of them conversion to open was necessary due to hemorrhage. The fifth was a planned conversion in our first right LDN. Delayed graft function was seen in 7 recipients and 5 required dialysis postoperatively. Two kidneys were lost due to arterial thrombosis, and 5 patients underwent segmental infarction with decreased renal function. Mean hospital stay was 2.35±1.67 days. There were no donor deaths or serious morbidity.

Conclusions: Although the benefits to the donor of the laparoscopic method are well recognized, our modifications will benefit those who may be precluded from this method.

Key Words: Laparoscopic donor nephrectomy, Laparoscopy, Renal transplantation, Single port.

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INTRODUCTION

Renal transplantation has become the preferred renal replacement therapy for those on maintenance dialysis who are medically fit, and immunologically acceptable for surgery. At the end of 2007, 1264 patients were on the waiting list in Australia for renal transplantation. There were 271 live donor kidney transplants performed in the same period, representing 44% of all transplants.[1] Live donor activity increased during the last decade as the waiting lists grew longer.

Laparoscopic donor nephrectomy (LDN) is safe for the donor and the transplant kidney. It offers the advantage of decreased morbidity for the donor, with a shorter hospital stay, earlier return to normal activity and for some, early return to work.[2] In 12 years, 289 kidneys were procured using this method at our institution. We have modified the technique to include some donors who may be considered unsuitable. We offer it to all donors in our unit.

The aim of this article is to assess this procedure and also the effect of the modifications we have made to make it suitable for all donors.

METHODS

Since the introduction of the laparoscopic method in 1997, LDN has been offered to all donors except 3 who were not offered this procedure in the early phase of our experience with this method.[2] This study included 289 donors who underwent laparoscopic nephrectomy, and the 3 open procedures were excluded. There were 128 male and 161 female donors aged between 20 and 70 years (mean, 45.62±11.18). Their BMI varied between 18.55 and 47.85 (mean, 26.56±4.34). The majority were related donors (67%) and the remaining 33% were unrelated including 3 nondirected altruistic donors.

Donors underwent stringent medical assessment followed by a psychological interview. Computed tomography angiography (CTA) was done to image the renal vessels, followed by a plain abdominal X-ray to evaluate the urine collecting systems of the kidneys. Differential renal function and GFR were assessed by nuclear perfusion scan,

and the kidney with better function was left with the donor.

Kidneys with anatomical variations (multiple vessels and ureters) that are acceptable for transplantation are not excluded from the laparoscopic method. The laparoscopic method was used in all, and the use of a hand port was restricted to hasten the mobilization, delivery of the kidney, and in case of right kidneys, to gain the maximum length of vessels safely. The operative technique for LDN was as previously described.[3] Donors were well hydrated with intravenous fluids during surgery, and they received 20g of mannitol and 80mg of frusemide. Wound drain was not placed routinely.

Patient's recovery was fast tracked by early mobilization. They were encouraged to take fluids by mouth soon after they recovered from general anesthesia. Patient controlled analgesia (PCA) with parenteral narcotics was used on the first postoperative day. On the second day, patients received oral medication (tramadol, oxycodone, or paracetamol) with parenteral analgesia supplements, if required. Prophylaxis for deep venous thrombosis and deep breathing exercises were routinely used. Indwelling bladder catheter and drains (if used) were removed on the first postoperative day. The majority of patients were discharged on the second postoperative day.

Modifications to the Standard Technique

Surgery Without Undue Strain on the Spine
Donors with chronic backache or previous spinal surgery were operated on while in a modified right/left lateral decubitus position without breaking the table to increase the space between the iliac crest and the subcostal margin. This did not pose any difficulties during the procedure.

Extraperitoneal Approach
This approach was used in donors who had extensive intraabdominal surgery with possible adhesions, because the standard intraperitoneal approach involved extensive dissection to gain access to the kidney. The donor was positioned as in the standard laparoscopic nephrectomy position. An incision about 5-cm to 6-cm long was made in the corresponding iliac fossa, and the peritoneum was mobilized medially to create an extraperitoneal space. A GelPort (Applied Medical, USA) was positioned in the incision, and the kidney was approached extraperitoneally. The rest of the dissection was similar to the intraperitoneal method. Not breaking the table will lessen the chances of peritoneal tears; however, torn peritoneum will not hamper the dissection.

Clustering the Ports Method
Traditionally, we have used 3 ports (2 for dissection in addition to the one for the video scope). In 7 cases, we placed both the instrument ports adjacent to each other during dissection (usually in the iliac fossa) and joined the port sites by a short 4-cm incision to deliver the kidney. Alternately, a GelPort (Applied Medical, USA) was placed in the iliac fossa early, and 2 instrument ports were inserted through the dome for the dissection. The kidney was delivered through the GelPort.

Single-Port Method
After we had gained experience using clustered ports, 6 single-port donor nephrectomies were performed initially with a Triport (R-port from Advanced Surgical Concepts, Dublin, Ireland) and later with a single incision port (SILS Port from Covidien, USA) using the technique described earlier.[4] Both the R-port and SILS have 3 ports each, a 12-mm and two 5-mm ports apart from the gas inlet. We used conventional as well as roticulator instruments (Roticulator Endo Grasp 5mm Covidien) but have not tried the recently released flexible instruments that offer 7 degrees of freedom (CambridgeEndo, USA).

Data were collected from the departmental database, case notes, the hospital database, and the ANZDATA registry. Descriptive analyses were carried out in this study. Results on continuous measurements are presented as mean±SD (Min-Max), and results of categorical measurements are presented as number (%). Significance was assessed at 5% level of significance. The Student t test (2-tailed, independent) was used to find the significance of study parameters on a continuous scale between 2 groups (intergroup analysis), and the Student t test (2-tailed, dependent) was used to find the significance of study parameters on a continuous scale within each group.

Outcomes analyzed were operative time, technical difficulties faced with right or left donor nephrectomies and multiple donor vessels, complications, hospital stay, and nadir creatinine achieved by the donors and recipients. The statistical software namely SPSS 15.0, Stata 8.0, MedCalc 9.0.1, and Systat 11.0 were used for analysis of the data.

RESULTS

All the donor nephrectomies were done in a teaching hospital, and this was not a single operator experience. During the period of this study, 289 kidneys were procured: 235 left (81.3%) and 45 right (18.7%). Kidneys with a single artery were 243 (84%), and multiple arteries were

present in 46 (16%). Venous anatomy (renal, adrenal, gonadal, and lumbar) came in various combinations, and 268 (93%) of the donor kidneys had a single renal vein. The donor demographics and anatomical variations are shown in **Table 1.** A specimen retrieval bag (Endocatch II, Tyco, Australia) was used in retrieving 142 (49%) kidneys. The rest were delivered by hand through a GelPort or hand port. The operating time ranged from 1.25 hours to 6 hours (mean, 3.66±0.86). Previous abdominal surgeries had no significant impact on the operating time (3.4 hours±0.6 vs 3.66±0.86). Operating time for the cluster method and single port were longer, 4.54 hours and 4.68 hours, respectively, reflecting a new learning curve. Warm ischemia time ranged from 1.25 minutes to 12 minutes (mean, 4.69±1.77). The cold ischemia period varied from 1.45 hours to 6.37 hours (mean, 3.44±0.75), and it reflects our setup, performing the transplant in the same operating room after the donor surgery.

Postoperative stay varied from 1 day to 3 days (mean, 2.35±1.67). After the surgery, the hemoglobin fell from 16.95g/dL (preoperative) to 12.39g/dL (postoperative). The preoperative donor serum creatinine ranged from 49μmol/L to138 μmol/L, and the mean was 80.29±16.42μmol/L. The donor creatinine at 1 week, 1 month, and late follow-up of over 1 year were a mean of 120.49±25.28, 117.97±23.23, and 106.8±23.69μmol/L, respectively. One donor returned to the surgical theater on the second postoperative day for resuture of the kidney delivery wound, which had given way following a vigorous coughing episode. Donor morbidity is shown in **Table 2.**

Seven recipients suffered delayed graft function, and 5 required dialysis. Two kidneys were lost due to arterial thrombosis, and 5 underwent segmental infarction with decreased renal function. The mean recipient serum creatinine after 1 month was 110.52±28.86μmol/L. Ureteric necrosis/stenosis was repaired in 14 recipients. The recipient morbidity is shown in **Table 3.** One kidney had an injury to the renal pelvis at the time of bagging the kidney in the donor. This has been reported.[5]

Modified Laparoscopic Donor Nephrectomies

The operating table was not broken on 17 occasions. The warm ischemia period and the operating time in this group was 3.94±1.71 minutes and 3.89±0.86 hours, respectively. The extraperitoneal approach was used in 8 donors, the warm ischemia time was 4.4±1.14 minutes, and the operating time was a mean of 3.4±0.7 hours.

The port clustering method was used on 7 occasions with warm ischemia a mean of 3.85±1.95 minutes and operating time a mean of 4.54±1.04 hours. Single-port laparoscopic donor nephrectomy (SPLDN) was performed in 6 donors. Two of these kidneys had 2 arteries, one had 2 renal veins, and one had 2 lumbar veins. Five left and one right kidney were procured. A comparison between the

Table 1.
Donor Demographics and Anatomical Variations

Sex	
Male	128
Female	161
Age (years)	
20–60	263
61–70	26
Side of Kidney	
Left	235
Right	54
Number of Arteries	
1	243
2 or more	46
Number of Veins	
1	268
2 or more	21

Table 2.
Donor Morbidity

Conversion to Open	5
Bleeding	4
Planned	1
Return to Operating Room	1
Pneumothorax	1
Pneumonia	2
Wound Infection	8
Incisional Hernia	1

Table 3.
Recipient Morbidity

Arterial Thrombosis	2
Segmental Thrombosis	5
Ureteral Complications	14
Delayed Graft Function	7

single-port and the conventional multiport method is shown in **Table 4.**

DISCUSSION

The benefits of live donor transplantation are well recognized, with a lower incidence of delayed graft function, better graft survival, and shorter recipient hospital stay. The major disincentives to live donation are the postoperative morbidity and the prolonged recuperation period with possible loss of income.[6] Open live donor nephrectomy requires a long flank incision with significant postoperative pain and longer hospital stay. Wound complications include infection and hernia formation in 9% of donors. In up to 25% of donors, chronic incisional pain, wound "diastasis" or bulging has been reported, and return to normal activity may not occur for as long as 6 weeks to 8 weeks after nephrectomy.[7,8]

Ratner et al[9] performed the first LDN in 1995. This procedure has now become the gold standard and has replaced the open technique of donor nephrectomy in most centers. Traditionally, multiple ports are used for optimal instrument triangulation. The intraperitoneal approach is the more popular, because the space is restricted in the extraperitoneal method. It is a challenging technique with a steep learning curve. In 1998 Wolf et al[10] and Slakey et al[11] described the hand-assisted approach to make it more appealing and easier to master. The advantages of this technique include the ability to use tactile sense to facilitate dissection, retraction, exposure, and reduction in the learning curve. However, using the hand further reduces the available space in the peritoneal cavity.

Any kidney fit for transplantation can be procured by the laparoscopic method, but some are hesitant to use this method for kidneys with anatomical variations. Donors with previous spinal surgery or chronic back pain can be operated on in the lateral position without flexing the spine. Early in our experience, we were hesitant to accept donors with extensive abdominal surgery with possible adhesions. We accept them now for the extraperitoneal approach and do not find this method difficult except for some reduction in available operating space. Unlike the extraperitoneal approach from the back, this is no different from the standard procedure once the extraperitoneal space has been created. Laparoscopic nephrectomy is the current preferred method. With the 2 modifications we made to our technique, we have been able to offer laparoscopic nephrectomy to every donor and it has eliminated the use of the open method at our center.

In an effort to further reduce postoperative morbidity and improve cosmesis, 2 new procedures are being tested, natural orifice transluminal endoscopic surgery (NOTES) and single incision laparoscopic surgery (SILS) using a single port. In NOTES, an endoscope is passed through a natural orifice, such as the mouth, anus, vagina, or urethra, and the viscus of entry is perforated to reach the target organ to be removed. The hole in the viscus is closed after the removal of the dissected organ, for example, the appendix or gallbladder. Obviously, a larger organ like the kidney cannot be removed through a small caliber viscus by this method. In February 2009, surgeons at Johns Hopkins Hospital removed a donor kidney through the vagina after conventional laparoscopic separation of the kidney from the body, thus eliminating a delivery incision.[12] A month later, a completely transvaginal nephrectomy was performed through a multi-channel port placed in the vagina.[13] These procedures are still experimental, and it is difficult to see them gaining early acceptance.

Table 4.
Comparison Of Warm Ischemia Time, Cold Ischemia Time, Operative Time, and Postoperative Hospital Stay in Single-Port and Traditional Multiport Nephrectomy

Variables	Single Port (Mean±SD)	Multiport (Mean±SD)	P Value
Warm ischemia time	7.33±2.66	4.64±1.71	<0.001[a]
Cold ischemia time	3.50±0.55	3.44±0.76	0.866
Operative time	4.68±0.49	3.60±0.85	0.003[a]
Inpatient days	3.17±0.75	3.96±0.99	0.053[b]

[a]Strongly significant (P value ≤0.01).
[b]Suggestive significance (P value: 0.05<P<0.10).

Several surgeons doing single-port/single-incision laparoscopic surgery have proposed laparoendoscopic single-site surgery (LESS)[14] to include all these procedures, and possibly it has more prospects of coming into increased clinical use. All the ports enter through the same channel, and the kidney is also removed through the same site. The newer flexible laparoscopic instruments will make it easier. Worldwide experience with this method for donor nephrectomy is limited (around 20 cases), and it is too early to assess the efficacy and safety of this procedure. Our limited, initial experience is encouraging. It is feasible but needs to be assessed in select units with greater experience with LDN. Using smaller and fewer trocars will reduce the postoperative morbidity.[15–17] These donors are fit individuals who do not require this surgery but have volunteered for emotional reasons. We should make the procedure safe and give them a good cosmetic result, and most of them will appreciate it.

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