Is Laparoscopic Donor Nephrectomy the New Criterion Standard?

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Hypothesis: The posttransplantation renal function outcomes between consecutive open donor and laparoscopic donor nephrectomies (LDNs) are similar and affect living donation.

Design: Using the medical records of renal living donor–recipient pairs, 36 consecutive open donor nephrectomies were compared with the subsequent 100 LDNs. Data collected on donor characteristics included demographics (age, race, sex, weight, and height), renal vascular and ureteral anatomical features, surgical information (blood loss, number of blood transfusions, operating time, warm ischemia time, and renal injury), complications, and length of hospital stay. Recipients’ data also included renal function information (serum creatinine level on postoperative days 7 and 30) and ureteral complications during the initial hospital stay.

Setting: A not-for-profit tertiary care teaching hospital in a metropolitan area.

Patients: Adults who had end-stage renal disease and received a living donation kidney.

Main Outcome Measures: Operative time, warm ischemia time, blood loss, and posttransplantation serum creatinine level.

Results: Patient characteristics were not significantly different between the open donor nephrectomy and LDN groups. No right kidney LDNs were done because of the shortness of the right renal vein; and, after the initial experience, left kidneys with more than 2 arteries were excluded. Warm ischemia time was recorded only for LDN, and it was found that a warm ischemia time of 10 minutes or longer was associated with difficulty in extraction and was uniformly associated with elevated mean serum creatinine levels on postoperative day 7.

Conclusions: The length of hospital stay was decreased and cosmetic result enhanced. The number of living donors has increased from 28 in 1997 to 53 in 1998 and to 63 in 1999 at our institution. The length of hospital stay, incidence of complications, and comparable kidney quality indicate that LDN should be the initiating procedure for most patients.

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Laparoscopic donor nephrectomy (LDN) was designed to reduce postoperative pain, shorten convalescence, improve cosmetic results, and reduce the financial disincentives to organ donation. Since the initial report on LDN by Ratner et al in 1995, the popularity of the procedure has increased and other institutions have reported their initial experiences with LDN. However, the reported incidence of primary nonfunction, acute tubular necrosis, and ureteral complications with LDN has raised concerns.

Open donor nephrectomy (ODN) has more than a 30-year record of proved safety and effectiveness. Some consider ODN to be the “criterion standard” to which other methods are compared. We compared the results from 36 consecutive ODNs completed before the introduction of LDN with the data from the subsequent 100 consecutive LDNs.

RESULTS

The patient characteristics were not significantly different between the ODN and LDN groups, as shown in Table 1. Obesity did not exclude a potential donor from a laparoscopic donation. Helical computed tomographic scans were used to evaluate the vascular and ureteral anatomical features. Patients with a horseshoe or pelvic kidney were excluded from undergoing LDN. Multiple vessels was a relative criterion for exclusion. All LDNs were on the left side.

In the LDN group (n=100), 19 patients had multiple arteries and 3 had mul-
PATIENTS AND METHODS

Between June 1, 1996, and August 31, 1997, 36 consecutive ODNs were performed. Laparoscopic donor nephrectomy was introduced in September 1997; by mid-November 1999, 100 LDNs had been performed. During the same period, 12 ODNs were performed, but these were excluded from this review. The reasons for those 12 ODNs were either the transplantation surgeon’s preference or the donor had multiple left renal arteries or other vascular or renal anomalies. All data were collected using recipients’ and donors’ medical records.

Donor characteristics included age, race, sex, weight, and renal vascular and ureteral anatomical features. Surgical data were amount of blood loss, number of blood transfusions, operating time (time from the skin incision to closure), warm ischemia time (WIT) - time from renal arterial stapling to back table kidney perfusion, and renal injury. The length of hospital stay and complications also were recorded.

Recipient characteristics were those related to kidney function: serum creatinine levels on postoperative days (PODs) 7 and 30. Ureteral complications during the initial hospital stay and the outpatient follow-up period also were recorded. Data are given as mean ± SD unless otherwise indicated.

Multiple veins on the left side; these 22 patients did undergo LDNs and are included in the analyses. No patients had a duplicate ureteral system; however, 1 patient had an extra renal calix. For the LDN group, the length of the renal artery averaged 3.05±0.67 cm; renal vein, 3.30±0.62 cm; and ureter, 13.50±1.21 cm.

The operative times and amount of blood loss are given in Table 2. Two patients received blood transfusions in the LDN group, one during surgery and the other on POD 1. Also in the LDN group, 2 procedures were converted to an open procedure due to: (1) difficulty in exposure of the kidney due to donor obesity and (2) excessive bleeding following a renal artery injury. These 2 cases are included as complications. One patient underwent laparoscopy again for possible bleeding; however, no blood was found. Another patient developed a laparoscopy site neuroma, and one patient was readmitted for nausea and vomiting. One kidney had a stripped ureter, and a ureteroureterostomy was done. Another patient developed distal ureteral stenosis and required a subsequent operation. Both of these complications to the drainage system occurred early in our experience; consequently, the ureter and testicular (ovarian) vein are kept intact during dissection and no further complications have occurred. In the ODN group, 2 patients had an intraoperative pneumothorax, one developed pneumonia and one developed acute pancreatitis. There were no mortalities in either group. The average lengths of hospital stay for the LDN and ODN groups were 4.07±1.39 and 5.33±1.45 days, respectively.

For the 100 consecutive LDNs, urethral complications were within the first 20 patients; conversions from laparoscopy to an open procedure were distributed throughout the 100 patients; and the operative time decreased over time. Consequently, all 100 LDNs were used in the analysis.

The WIT for LDN was as follows:

<table>
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<th>WIT, min</th>
<th>Serum Creatinine Level on POD 7, µmol/L*</th>
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<tr>
<td>≤5</td>
<td>154 ± 86 (86-201)</td>
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<tr>
<td>6-9</td>
<td>135 ± 44 (63-212)</td>
</tr>
<tr>
<td>≥10</td>
<td>493 ± 256 (203-743)</td>
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* Data are given as mean ± SD (range). To convert creatinine level from micromoles per liter to milligrams per deciliter, divide micromoles per liter by 88.4.

A WIT of 10 minutes or longer was associated with difficulty in extraction (eg, a kidney fell out of the endoextraction bag or use of an inadequate incision). The longest WIT, approximately 30 minutes, occurred with injury to the renal artery and subsequent conversion to an ODN. The patient required postoperative dialysis, but the baseline serum creatinine level became 124 µmol/L (1.4 mg/dL). Warm ischemia times longer than 10 minutes were uniformly associated with a mean serum creatinine level elevation on POD 7.

Recipient’s serum creatinine levels on PODs 7 and 30 for the ODN and LDN groups are given in Table 3. In the ODN group, there were 10 recipients (28%) with POD 7 serum creatinine levels greater than 177 µmol/L (>2.0 mg/dL). The primary reasons for the serum creatinine levels included excessive cyclosporine (>500 µg/mL) or tacrolimus (>20 ng/mL) levels (n=4), early acute rejection (n=2), cardiac failure (n=1), and procurement injury (n=3). None of these patients required dialysis. In the LDN group, there were 25 recipients with serum creatinine levels greater than 177 µmol/L (>2.0 mg/dL). The major causes were determined to be excessive cyclosporine or tacrolimus levels (n=9), acute pyelonephritis (n=1), procurement injury (n=8), donor-recipient size disparity (n=4), and recipient myocardial infarction or acute respiratory distress syndrome (n=3). One of these LDN recipients required dialysis.

COMMENT

With proper patient selection, LDN may achieve results equivalent to ODN. No right kidney LDNs were done because of the shortness of the right renal vein and the proximity of the right lobe of the liver, which makes the procedure more difficult. After the initial experience with multiple arteries and veins, left kidneys with more than 2 arteries were excluded. When there are more than 2 arteries, the vessels tend to be small and access to them is difficult. Traction and dissection near those vessels may cause arterial spasm and renal ischemia. In addition, anastomoses of more than 2 vessels magnify the difficulties with arterial reconstruction. If such reconstruction is necessary, ex vivo reconstruction with the saphenous vein or internal iliac artery is preferred. Ex vivo reconstruction limits the WIT, allows direct visualization of all anatomic angles, and facilitates the confirmation of the patency with the use of probes and irrigants.

Warm ischemia time, the time from renal arterial transection to back table renal perfusion, longer than 10
minutes is associated with acute tubular necrosis (creatinine level >177 µmol/L [>2.0 mg/dL] on POD 7). As illustrated by the kidney with a WIT of 30 minutes, which required postoperative recipient dialysis, a prolonged WIT may not preclude a favorable baseline creatinine level (124 µmol/L [1.4 mg/dL]). This is consistent with the reported transplantation experience with prolonged WIT in uncontrolled non–heart-beating donor kidneys.4 However, to optimize the quality of the donor kidney, the WIT should be limited to less than 5 minutes. This goal can be achieved with proper planning. If an endoextraction bag is used, it should be at least 15 mm long and the suture for bag separation should be reinforced with sutures to prevent premature bag separation during kidney capture. Whether a bag or hand extraction is used, the tendency is to use the smallest abdominal incision possible. Incisions that are too small cause compression of the kidney and may lead to small cortical tears and unnecessary fumbling and delay. “Bragging rights” afforded by ever-smaller incisions are to be condemned.

Renal perfusion is encouraged during LDN by: (1) adequate hydration, (2) mannitol administration, and (3) dopamine hydrochloride administration. Urine output is maintained (300 cc/h). Arterial spasm may be minimized by dissecting the renal artery near the aorta, where the diameter of the artery is the largest. Traction on the vessel also may cause spasm. A bluish discoloration of the renal cortex is usually an indication of arterial spasm. Return of the kidney to its natural position and use of local antispasmodic agents (Papavine or lidocaine hydrochloride) may be helpful. Discoloration (arterial spasm) of a significant portion of the kidney may result in acute tubular necrosis. Persistent discoloration should lead to an expedited recovery, if necessary by ODN.

Conversion from LDN to ODN occurred with 2 of the 100 patients; however, other patients may have benefited from conversion as well. More liberal use of the open technique may have avoided injury (acute tubular necrosis) to some kidneys. Most common, conversion should be considered for excessive bleeding (>300 cc) and difficult exposure of the kidney (usually due to a thick colon and mesentery or excessive retroperitoneal fat). An intermediate step may be the use of a hand-assisted pneumosleeve. Use of hand retraction may improve visualization, and finger pressure may control bleeding. Each of the 3 procedures has its limitations and benefits, and the proper use of each procedure ensures consistent safety and donor kidney quality. Use of LDN should not exclude the use of other methods.

### Table 1. Demographic Characteristics of Open Nephrectomy and Laparoscopic Nephrectomy Donors

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Open Nephrectomy (n = 36)</th>
<th>Laparoscopic Nephrectomy (n = 100)</th>
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<tr>
<td>Age, y</td>
<td>37.31 ± 8.97 (23-55)</td>
<td>36.44 ± 10.63 (18-61)</td>
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<tr>
<td>Male-female ratio</td>
<td>14:22</td>
<td>53:47</td>
</tr>
<tr>
<td>African American–non–African American ratio</td>
<td>15:21</td>
<td>58:42</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>26.81 ± 6.00 (17.1-44.2)</td>
<td>26.65 ± 4.75 (18.3-37.8)</td>
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*Data are given as mean ± SD (range) unless otherwise indicated.

### Table 2. Operative Times and Amount of Blood Loss for Open Nephrectomy and Laparoscopic Nephrectomy Donors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Open Nephrectomy (n = 36)</th>
<th>Laparoscopic Nephrectomy (n = 100)</th>
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<tbody>
<tr>
<td>Operative time, min</td>
<td>185.36 ± 43.05 (120-280)</td>
<td>306.80 ± 54.65 (150-400)</td>
</tr>
<tr>
<td>Blood loss, cc</td>
<td>150.00 ± 88.39 (100-500)</td>
<td>130.00 ± 114.53 (99-750)</td>
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</table>

*Data are given as mean ± SD (range).

### Table 3. Open Nephrectomy and Laparoscopic Nephrectomy Recipients’ Serum Creatinine Levels on Postoperative Days 7 and 30

<table>
<thead>
<tr>
<th>Postoperative Day</th>
<th>Open Nephrectomy (n = 36)</th>
<th>Laparoscopic Nephrectomy (n = 100)</th>
</tr>
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<tr>
<td>7</td>
<td>178 ± 124 (80-601)</td>
<td>173 ± 130 (53-743)</td>
</tr>
<tr>
<td>30</td>
<td>132 ± 35 (71-221)</td>
<td>136 ± 47 (71-301)</td>
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*Data are given as mean ± SD (range). To convert creatinine level from micromoles per liter to milligrams per deciliter, divide micromoles per liter by 88.4.

Donor satisfaction with LDN has been extremely high. Pain has been lessened, and convalescence has been shortened.

### CONCLUSIONS

With LDN, donor length of stay has decreased. Cosmetic result has been enhanced. The number of living donors has increased at our institution from 28 in 1997 to 53 in 1998 and to 63 in 1999. The increase has been a direct consequence of acceptance of LDN. The low incidence of complications and comparable kidney quality indicate that LDN should be the initiating procedure for most patients.


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REFERENCES


DISCUSSION

Oscar Salvatierra, Jr, MD, Palo Alto, Calif: There is a tremendous learning curve with this procedure, but the rationale for performing the procedure is sound, when one considers the goals of decreased postoperative pain, shorter hospital duration, less incisional morbidity, and earlier return to normal activity. Another benefit of laparoscopic nephrectomy is that it appears to attract an increased number of living organ donors at a time when the numbers of patients on dialysis are progressively increasing at a pace disproportionate to the number of transplants that we are able to perform, because of a continued shortage of cadaver donor organs. The incremental increase in Dr Sasaki's program from 28 living donors in 1997 to 53 and 63 in the subsequent 2 years is very impressive. I personally envision that every kidney transplant program in the country will eventually be performing laparoscopic donor nephrectomy (LDN), thanks to the pioneering efforts of the Johns Hopkins and Maryland groups, and now, as we hear today, of the Washington, DC, group.

However, it is fair to indicate that laparoscopic nephrectomy may not be universally applicable to all situations. Dr Sasaki has been very honest in indicating possible pitfalls and limitations, such as limiting nephrectomy to the left kidney. Perhaps one should also examine other options. For example, I have been personally using a small flank incision for donor nephrectomy that also reduces incisional morbidity, but appears at very low risk for subsequent problems with transplantation of adult-sized kidneys into infants. This is a small 2-in [3.80 cm] incision in one of our donors. The incision is usually more often approximately 3 in [7.62 cm] in length. In this picture, the kidney has already been dissected out. Here is the ureter with good length, and the surgery has gone very well because we see a good jet of urine from the end of the ureter. This is the right kidney coming out from one of these small incisions, and one can appreciate the size of the incision from the size of my hand here. There is one clamp on the vena cava and another clamp on the renal artery. There have been no real untoward hemodynamic effects during the procurement as we have a good flush of the kidney following its procurement. We have now performed over 110 of these donor nephrectomies with a small flank incision. An advantage of our procedure is that one can avoid or easily control for adverse renal hemodynamic changes.

Posttransplantation, there have been no ureteral complications, vascular complications, or delayed graft function. A guarantee of early superb renal function is extremely important in infant recipients of adult-sized kidneys, where the best that infants can do under conditions of optimum intravascular volume is to provide only two thirds of the blood flow to the adult-sized kidney that was present in the donor prior to its removal. Anything less will predispose to a lower blood flow state, which can be lethal in these infants with high risk for vascular thrombosis, delayed graft function, or even permanent nonfunction.

Nationally, vascular thrombosis primary nonfunction and technical problems account for an astounding 15% loss of living donor kidneys in the immediate postoperative period. Unfortunately, some of these infants will never ever be able to receive another kidney transplant because of sensitization and possible death from long-term dialysis.

There is also the issue of the potential female donors in the childbearing age group. Since pregnancy results in an increased risk of right hydronephrosis and pyelonephritis of pregnancy, should not the right kidney be the one removed? Here is an example of right hydroureteronephrosis to the pelvic brim during the third trimester. If this was the remaining kidney after left donor nephrectomy, this patient could be at risk for renal insufficiency in the future.

In closing, I have 2 questions and a request for a comment for Dr Sasaki. (1) Do you remove the left kidney from women in the childbearing age group who are likely to have children in the future? If so, how do you counsel these patients? (2) What do you consider the ideal makeup by subspecialty of a laparoscopic donor nephrectomy team?

Last, I would appreciate any comment you might have on this advertisement that appeared in the international edition of the New York Times, which to me appears to commercialize living donor transplantation.

Donating a kidney is a tough decision. Deciding where to go is easy. For a patient suffering from kidney failure, a transplant means new life. That is why we operate the world's largest, most successful live donor laparoscopic kidney transplant program. In 1999 alone we performed more kidney transplants than any other transplant center in the United States and more laparoscopic living related donor transplants are performed here than anywhere else. So if you or a loved one needs a transplant, call us at . . .

Again, I congratulate the authors on their commitment and meticulous attention to both surgical detail and fluid management in the successful evolvement of laparoscopic donor nephrectomy at their center. Their outstanding, very honest, and candid report will be of considerable help to us at Stanford and to other centers as we pursue laparoscopic donor nephrectomy in the near future.

Bruce M. Wolfe, MD, Sacramento, Calif: Our experience with this technique now approaches 60 patients. An important consideration is the expansion of the donor pool. How many of your patients came from outside of the region where you have received patients in the past? It was difficult for us to be certain that the donor pool was indeed expanding all that much because a number of patients came to Sacramento for a donor nephrectomy that probably would not have traveled as far if we were doing the standard open operation.

When we instituted this program, our literature review showed that the incidence of chronic pain or troublesome hernia at the site of the donor nephrectomy incision exceeds 10%. I gather in the small number of donors with open incisions you compared in this trial, you didn't see that. Do you have any comment from your previous experience? We have found it very useful to use imaging studies to define the anatomy of the arterial and venous circulation to the proposed donor kidney. It's been very helpful to us technically to know how many arteries, and in particular, that we need to identify as the dissection proceeds since it's technically challenging to not injure these vessels as you approach them.

Finally, the animal data with pneumoperitoneum suggest diminished renal blood flow, urine output, and renal function due to pneumoperitoneum. We have used aggressive volume expansion in our donors as volume expansion in our porcine model showed that you could eliminate most, but not all, of this renal impairment. How aggressive are you in volume expansion of your donors?
Pat Healey, MD, Seattle, Wash: Clearly, the prospective donors are interested in this procedure. Many potential donors wish to donate, but the open nephrectomy operation is a bigger hurdle to donation. As a result, we can offer less morbid surgery, and donation rates in centers performing LDN are increasing. However, it's not clear to me whether the outcomes in terms of renal function or technical complications are actually any better or even equal to the open nephrectomy, which is the gold standard right now. I do have a couple of technical questions. Were these entirely laparoscopic procedures or did you use the pneumosleeve, and were they hand assisted?

Second, in addition to the ureteral complications are delayed graft function and vascular thrombosis. What was your incidence of delayed graft function in these laparoscopic donor kidneys, and did you have any vascular thrombosis? Along that line, do you routinely heparinize your donors prior to nephrectomy?

Quan-Yang Duh, MD, San Francisco, Calif: I have a few technical questions. Do you use the pneumosleeve? And, if you do, in how many patients did you use the pneumosleeve, and where did you make the incision for the pneumosleeve? How did you take the renal vessels? Did you use a stapler, and did you have any trouble with the stapler?

Albert D. Hall, MD, San Francisco: Do you have a program for prophylaxis of potential thromboembolism in these patients? Your operating time in some of these patients was quite long.

Dr Sasaki: Dr Salvatierra, we have only taken the left kidney. Regarding donors in the childbearing age, did we exclude these patients? The answer is no. The reason is that when we started, we talked to our neighbors at Johns Hopkins and the University of Maryland, and they found no evidence that taking the left kidney impacted on childbearing. We also looked at the literature, and we could find no solid evidence that that was the case. I know that is what we are taught, but we could find no solid evidence that that was the case.

The makeup of the laparoscopic donor team: what is the ideal situation? I feel that the ideal situation should include an experienced transplant surgeon and someone who has facility with the laparoscopic equipment. Those 2 should do the first 20 to 30 to 40 procedures until each one becomes comfortable with what they are doing. These are healthy patients. You can make zero mistakes.

Advertising in the New York Times. I believe in the first amendment. They can advertise if they want. It is something that I will not do. Our hospital used the media when a 70-year-old donor had a laparoscopic procedure to donate a kidney to her husband on Valentine's Day; that is a human interest story. That made television. Will we use the New York Times? Absolutely not.

Has the use of LDN increased the donation rate? I can say it has in our patient referral area. We are right next to Hopkins and the University of Maryland. These are 2 Goliaths on the playing field. We are just a little David, 30 miles [48 km] away. We don't advertise in the New York Times. We have had a couple of patients, however, that read about us on the Internet. The Internet is a great tool, and we are on the net. One patient, the 70-year-old lady who donated, came from Richmond because they don't have a laparoscopic program. We had another patient who came from the Cleveland Clinic because they did not have an established program.

Regarding the question about donor site pain for the open nephrectomies, I don't do ODN. So I can't comment on the incidence of pain at the operation site. We try to avoid anything that is painful to the donor. We use the helical CT [computed tomographic] scan to identify the renal anatomy. When we initially used the helical CT, the slices were too thick and we missed some arteries. We limit the LDN to 2 arteries. When you have more than 2 arteries, it is very difficult to reconstruct and you may cause vasospasm during the procedure. If that kidney turns blue during that procedure, you may have delayed graft function.

Does pneumoperitoneum cause renal impairment? I believe it does. What do we do about it? We put these patients on renal dose dopamine, mannitol, and fluids. We like to maintain their urine output somewhere in the neighborhood of 300 mL/h.

Have we used the pneumosleeve? Yes, we have in 2 cases. Why did we do it? In one case we had difficulty retracting the colon and so through a periumbilical incision we used the pneumosleeve. In the other case we had a little bit of bleeding and it is really very comforting to go to that bleeding site and put your finger on it. The pneumosleeve is very comforting to use because it makes you feel like a surgeon. Would I use the pneumosleeve in every case? No, because it is unnecessary.

What is our incidence of vascular thrombosis? Zero. What is the incidence of delayed graft function with laparoscopic donor nephrectomy? Eight out of 100, and I think I presented these data. The incidence in the open was 3 out of 36. There is no statistical difference.

Do we use heparin before we take the kidney? Yes, we give 5000 U of heparin, take the kidney, and immediately reverse it with protamine sulfate.

A technical question: We use the endovascular stapler, Ethicon. Have we ever had that misfire? Yes, we did once, but fortunately it didn't transect the vessel that we were stapling. It was a renal vein, I believe, and we used another staple. But it is frightening to have a stapler malfunction.

Our incidence of deep vein thrombophlebitis was zero. What do we do to prevent it? We use the pneumatic stocking, and that is essentially it.

The procedures are very long in the beginning, but a simple straightforward patient now will take 3 hours to 3½ hours. We are at present training our urologist colleagues, and there is a very long learning curve.