More Than 500 Consecutive Laparoscopic Donor Nephrectomies Without Conversion or Repeated Surgery

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Hypothesis: Concern exists as to the safety of laparoscopic donor nephrectomy (LDN) compared with open donor nephrectomy. Reported complications of LDN include emergent conversion to an open procedure, repeated surgery for postoperative bleeding, and even death. We hypothesize that LDNs can be performed safely, with a complication rate comparable with that of open donor nephrectomies.

Design: Case series and review of the literature.

Setting: Tertiary care university hospital.

Patients: Five hundred thirty kidney donors.

Intervention: An LDN performed without hand assistance, with the kidney extracted through a low transverse incision.

Main Outcome Measures: Mean operative time, requirement for transfusion, intraoperative complications, and postoperative complications.

Results: This series includes 84 right-sided donor nephrectomies, 86 donors with a body mass index greater than 30 (calculated as weight in kilograms divided by the square of height in meters), and 91 donors with complex vascular anatomy. Mean donor age was 40 years (range, 18-73 years), and mean±SD operative time was 196±43 minutes. The only conversion occurred early in the series, and there have been 525 subsequent cases without the need for conversion or repeated surgery. There were no donor deaths. Five donors (0.9%) required perioperative blood transfusions. Overall complication rate was 6.4%, including 14 minor wound infections, 2 bowel injuries, 1 case of prolonged ileus, 3 splenic injuries, 2 bladder infections, 1 bladder injury, 1 case of rhabdomyolysis, 1 case of pneumonia, and 2 thromboembolic events.

Conclusion: This series demonstrates that LDN can be performed at least as safely as open donor nephrectomy, with minimal bleeding and few postoperative complications.

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The advent of laparoscopic donor nephrectomy (LDN) has contributed to a dramatic increase in living kidney donation during the past 10 years. Benefits of the laparoscopic approach include reduced postoperative pain, faster return to usual activities and work, and improved cosmetic results.2,3 Despite these benefits, some studies4 have reported higher complication and mortality rates compared with open donor nephrectomy. However, few studies5 have described the complications of LDN and the details of how they were managed.

We previously reported our initial technique and experience with LDN and subsequent modifications.6,7 Most recently, we reported that LDN of the right kidney performed without using hand-assisted devices is safe and yields kidneys with excellent function.8 At the University of California–San Francisco, laparoscopy has become the preferred approach for the procurement of right and left kidneys, and selection of the appropriate kidney for donation is now based on the same criteria used in the past when open nephrectomy for donors was the standard of care. In this article, we compare our series, now consisting of 530 patients, with similar series published in the literature, focusing specifically on the safety of LDN.

METHODS

Between November 3, 1999, and December 28, 2004, 530 LDNs were performed at the University of California–San Francisco, a tertiary care medical center. A transplant surgeon in collaboration with a laparoscopic general surgeon and a laparoscopic urologist performed the first 27 procedures. One of 3 transplant sur-
In our series, a gastrointestinal anastomosis (GIA) stapler (Endo-GIA; US Surgical, Norwalk, Conn) was used to ligate and transect the renal artery. This stapler places 4 staple lines and transects the vessel between the middle 2 staple lines, leaving 2 staple lines on either side. Before implantation, the staple line, placed on the graft artery, had to be trimmed off, foreshortening the artery. Insufficient hemostasis at a GIA staple line on the renal artery stump led us to convert to an open procedure in our fifth patient. As previously described, this prompted us to modify our technique. The renal artery is now occluded using a locking plastic clip (Hem-o-lok clip; Weck Closure Systems, Research Triangle Park, NC) and 2 metal clips placed proximal to the locking clip. The artery is divided distal to the clips using laparoscopic scissors (Endo-Shears; US Surgical). If there are multiple arteries, each vessel arising from the aorta is occluded with a locking plastic and 2 metal clips. The use of clips rather than the stapler also allows for more precise control of the vessel and leaves the kidney side of the vessel open and ready for anastomosis once the vessel is divided using scissors. The heparin solution is reversed with protamine sulfate, and the renal vein is stapled using a 2.5-mm vascular staple (Endo-TA; US Surgical). The vein is divided distal to the staple line using laparoscopic scissors, and the kidney is removed through the suprapubic incision. A second surgical team imitates the recipient operation so that they finish their dissection and are able to receive the graft immediately once it has been removed from the donor. Donor patients were seen 2 and 8 weeks after surgery for follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
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<tbody>
<tr>
<td>Age, mean ± SD (range), y</td>
<td>40.4 ± 11.0 (18-73)</td>
</tr>
<tr>
<td>Sex, No., (%)</td>
<td>M 223 (42)</td>
</tr>
<tr>
<td></td>
<td>F 307 (58)</td>
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<tr>
<td>Height, mean ± SD (range), cm</td>
<td>169 ± 10 (135-203)</td>
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<tr>
<td>Weight, mean ± SD (range), kg</td>
<td>74 ± 15 (41-124)</td>
</tr>
<tr>
<td>Body mass index, mean ± SD (range)*</td>
<td>26.1 ± 4.0 (16.9-30.0)</td>
</tr>
<tr>
<td>Side of donated kidney, No., (%)</td>
<td>Left 446 (84)</td>
</tr>
<tr>
<td></td>
<td>Right 84 (16)</td>
</tr>
<tr>
<td>Renovascular anatomy, No., (%)</td>
<td>Single artery and vein 439 (83)</td>
</tr>
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<td></td>
<td>Multiple arteries or veins 91 (17)</td>
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*Calculated as weight in kilograms divided by the square of height in meters.

Donor characteristics are given in Table 1. The donors ranged in age from 18 to 73 years, with a mean of 40 years; 7.5% were older than 55 years. Of the 530 LDNs performed during the study, 84 (16%) were right sided. More donors (58%) were women. Although our initial donor selection criteria excluded patients with a BMI greater than 30, after the first 50 cases, we favored laparoscopic procurement in all suitable kidney donors, regardless of BMI. We performed 86 laparoscopic nephrectomies in donors with a BMI greater than 30. The mean ± SD BMI in our series was 26.1 ± 4.0.

Ninety-one donor kidneys (17%) had accessory renal arteries, veins, or both. Superior pole arteries with a diameter less than 2 mm that supplied less than 10% of the renal cortex were revascularized. Operative time averaged 196 minutes (range, 116-402 minutes), and it decreased from 237 minutes in the first 100 patients to 174 minutes in the last 100 patients (Table 2 and Figure). Table 2 lists the 34 complications observed in our cohort of 530 patients, for a complication rate of 6.4%. There were no patient deaths or repeated surgical procedures. As noted previously herein, our fifth patient required an intraoperative blood transfusion and conversion to an open procedure when the GIA staple provider inadequate hemostasis of the renal artery stump. In another patient, we considered per-
forming a laparoscopic procedure; however, we created an unintended enterotomy when attempting to obtain access to the peritoneum through a donor’s previous cholecystectomy incision. The bowel was repaired primarily, and an open nephrectomy was subsequently performed with no additional donor complications. This was not considered a true conversion because no laparoscopic instruments were used, and pneumoperitoneum was never established.

Four patients required a blood transfusion in the postoperative period. No patient required more than 3 U of blood. One patient developed a rectus sheath hematoma from a port site bleed. A second patient bled from inadvertent heparin overanticoagulation and was managed with protamine and a blood transfusion. One patient was anemic (hematocrit level, 29%) at the start of the donor procedure and required a 1-U blood transfusion after surgery. In our most recent 350 cases, no donor has required transfusion.

Three patients (0.6%) sustained minor splenic injury during laparoscopic procurement. One injury occurred during Veress needle placement, and the other 2 occurred during splenic flexure mobilization. All these injuries were managed with pressure, oxidized regenerated cellulose (SurgiCel; Ethicon, Somerville, NJ), and absorbable gelatin sponge (Gelfoam; Pfizer, New York, NY) with adequate hemostasis. No patient who sustained a splenic injury required a transfusion.

Several intraoperative complications were related to the low transverse Pfannenstiel incision used to extract the kidney. Two patients (0.4%) sustained small-bowel injury and 1 (0.2%) sustained bladder injury during incision. The injuries were recognized and repaired in the primary procedure without complications. Thirteen patients (2.5%) developed wound infections at the Pfannenstiel incision and were managed with antibiotics and bedside drainage when required. One additional patient (0.2%) required a bedside incision and drainage of a port site abscess.

In 2001, the number of living kidney donors surpassed for the first time the number of deceased donors. This rise in popularity of living kidney donation is due in part to the favorable adverse effect profile of laparoscopic kidney procurement. As this procedure becomes the de facto standard of care for donor nephrectomies in this healthy patient population, it is important to document its safety and to address the cause of any complications. In this article, we describe a large series of 530 patients, the complications, and our modifications to the procedure to reduce repeated complications.

In this series, the conversion rate to open nephrectomy was 0.2%, lower than the rates reported in other large series. In 2001, the number of living kidney donors surpassed the number of deceased donors. This rise in popularity of living kidney donation is due in part to the favorable adverse effect profile of laparoscopic kidney procurement. As this procedure becomes the de facto standard of care for donor nephrectomies in this healthy patient population, it is important to document its safety and to address the cause of any complications. In this article, we describe a large series of 530 patients, the complications, and our modifications to the procedure to reduce repeated complications.

There were 3 significant pulmonary complications. One patient sustained a pulmonary embolism confirmed by a ventilation/perfusion study; another patient had hypoxemia with accompanying deep venous thrombosis. Both patients were treated with intravenous heparin and warfarin sodium for 6 months. A third donor developed pneumonia after surgery manifested by fever and productive cough, which resolved with oral antibiotic therapy.

One patient experienced rhabdomyolysis characterized by flank pain and a mildly elevated creatine kinase level. He was treated with intravenous hydration and a bicarbonate drip, and he did not develop renal insufficiency. One patient presented 1 week after surgery with abdominal pain and an inability to move his bowels. He was admitted to the hospital for 23 hours and was treated for a prolonged ileus. Another patient developed hernia at a port site, and 2 patients developed bladder infections that were managed with oral antibiotic agents.

COMMENT

In 2001, the number of living kidney donors surpassed the number of deceased donors. This rise in popularity of living kidney donation is due in part to the favorable adverse effect profile of laparoscopic kidney procurement. As this procedure becomes the de facto standard of care for donor nephrectomies in this healthy patient population, it is important to document its safety and to address the cause of any complications. In this article, we describe a large series of 530 patients, the complications, and our modifications to the procedure to reduce repeated complications.
of the GIA stapler across the renal vessels led to bleeding and required conversion to open nephrectomy in 2 patients.12

We modified our laparoscopic procedure to eliminate GIA stapler misfires.6 We currently place a single self-locking plastic clip and 2 metallic clips on the proximal renal artery before transection using laparoscopic scissors. Although this nontransfixation technique has been called into question owing to several reports of postoperative clip failures, we believe that this is a safe technique as long as adequate renal artery stump length is maintained, with an adequate cuff distal to the most distal clip. The renal vein is ligated using a vascular stapler before transection using laparoscopic scissors. These techniques essentially separate vessel occlusion and vessel transection, allowing careful visualization of the arterial and venous ligations before transection. An added benefit of this technique is additional vessel length because there is no loss of length due to the unnecessary staple line placed on the kidney side of the transection line by the GIA stapler. Since these modifications were made, we have experienced no significant bleeding with ligation of the renal vessels. Other important techniques that we believe have enabled us to avoid conversion to the open procedure include the use of a “cigarette sponge” that is easily inserted and removed through the laparoscopic ports. We use the sponge to facilitate tissue retraction, to control hemorrhage, and to improve visualization. We believe that use of the sponge has prevented the need for conversion in several patients. Finally, vessel loops placed around each vessel facilitate gentle traction and help localize the vessels during the posterior dissection of the kidney.

Other significant intraoperative complications include 2 bowel injuries, a bladder injury, and 3 minor splenic injuries. Each was immediately recognized and managed in the primary procedure. None of these complications required conversion to open, and none has caused long-term sequelae for the patients. Each of the bowel injuries and the bladder injury occurred when the midline peritoneal incision was made through the transverse Pfannenstiel incision to extract the kidney. In 1 patient, this incision was made more difficult by the presence of adhesions at a previous cesarean section incision. We now take extra precautions to identify any bowel that may be entrapped in scar tissue beneath old incisions or pulled up with peritoneal tissue as we make the incision. We now visualize with the laparoscope, when possible, the area of entry into the peritoneal cavity to ensure that there is no bowel present.

In our series, 1 patient (patient 113) developed rhabdomyolysis after surgery. He experienced flank pain and elevated creatine kinase levels, peaking at 6070 U/L (reference range, 55-380 U/L) on postoperative day 3. Hydration and urine alkalinization resolved his condition. The operative time for this patient was 311 minutes, and his weight was 90 kg, which are well above the averages of 196 minutes and 74 kg, respectively, from this series. Prolonged operative times and overweight patients are well-known risk factors for rhabdomyolysis.

In this study, 2 patients (0.4%) developed symptomatic pulmonary emboli that required outpatient anticoagulation despite prophylaxis (consisting of sequential compression devices placed at the time of anesthesia induction) and early ambulation in the immediate postoperative period. Donor patients are generally healthy otherwise and fall into lower risk categories for thromboembolic events. Because our operative time decreased, it is likely that the risk further decreased (Figure). Fourteen patients (2.6%) developed superficial surgical site infections that were managed by antibiotic drug therapy and drainage of the wound abscesses, when present. No patient developed a deep space infection or fascial dehiscence related to a superficial infection. All of these postoperative complications have previously been reported for open donor nephrectomies and LDNs except for rhabdomyolysis, which has been previously reported only in LDNs.7 The mean operative time for laparoscopic nephrectomies may be greater than that for open nephrectomy; however, with experience, our mean operative time decreased (Figure).

The procedure of LDN has faced a great deal of scrutiny and criticism, especially early in its development. Any new procedure is associated with a learning curve, and complications of the LDN procedure have been well documented. Our series also noted some technical complications and procedure-specific complications. These complications have diminished as we have identified potential complications and modified our surgical approach. The technique of open nephrectomy has been the standard of care since the advent of living donor transplantation more than 50 years ago. Publication of single-center series, such as the one from the University of Wisconsin that included 1000 patients during a 28-year period with a 17% donor complication rate and 1 donor death, established open donor nephrectomy as a well-accepted, safe procedure. However, there are really no good large series reports comparing LDN with open donor nephrectomy. A randomized trial of the 2 procedures also is not feasible. Therefore, trying to quantify the risk of the laparoscopic procedure relative to the open procedure is difficult because there are no modern studies measuring various complication rates in the open procedure in a manner similar to what has been done for the laparoscopic procedure. Studies such as the one from the University of California–San Francisco set benchmarks for what the expected complication rates should be, and the use of these benchmarks will allow for comparison as new techniques are introduced.

Several groups have advocated use of the hand-assist device during LDN,13 citing improved vascular control, speed, facilitation of resident/fellow training, and a general sense of improved overall safety. Our series demonstrates that the hand-assist device is not required for maximal safety or training. In addition, our operative times are comparable with those of most hand-assist studies. We believe that there is a cosmetic benefit to the Pfannenstiel incision compared with the incisions conventionally used for the hand-assist device.

The indications for performing an open donor nephrectomy are diminishing. In our series, 17% of the donors had complex renal vascular anatomy; 16% had right-sided nephrectomies compared with 1% to 5% reported in other large series.3,11,12 Although we initially avoided...
performing right-sided nephrectomies, we now routinely perform them if indicated. One of the few contraindications to LDN is the presence of extensive abdominal adhesions from previous surgical procedures, which prevent safe access to the peritoneal space. With the availability of a retroperitoneal approach, even this relative contraindication could vanish.

In conclusion, this study illustrates that LDNs can be performed safely with complication rates comparable with those for traditional open donor nephrectomy. The low rate of complications, coupled with the known benefits to the donor, mean that LDN can now be considered the standard of care. The laparoscopic procedure should be offered to all potential donors except for patients who may have had extensive previous intra-abdominal procedures. The complication rate seems to diminish as the technique is mastered with greater experience. Moreover, surgical residents and fellows can be trained to perform this procedure while still providing a safe environment for the donor.

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REFERENCES

sion, significantly lower than all other major series reported and nonetheless highly commendable.

In reviewing your complications, a few questions come to mind. There are 5 patients who required blood transfusion. Given this high rate, would you consider or reconsider not using heparin during the donor procedure but instead flushing the kidney with heparinized solution on the back table? I am aware that some surgeons do not use heparin for the donor in the procedure and have not had bleeding or thrombotic complications. A corollary to this question is, you had a patient who had a hematocrit of 29%—a donor—and obviously anemia. Why would you not perhaps put that patient on iron or at least work up the cause of anemia before proceeding with the donor procedure? Thirteen patients developed wound infections in their Pfannenstiel incision, and 1 patient had a port site abscess. Do you use prophylactic antibiotics and, if so, how long? One patient developed a port site hernia. Do you close your port sites? I am aware that some surgeons do and some don’t.

From reading one of your other publications on LDN, I gleaned that you actually extract the kidney by putting a hand in the peritoneum and pulling out the kidney. This, in fact, is a modification of the “hand-assisted procedure.” So if you are using a hand at the end of the procedure, why not perhaps use it for improving exposure through other portions of the case yet through the cosmetically preferable Pfannenstiel incision? This may perhaps prevent some of the complications that you have sustained, such as bowel and bladder injury, and allow you to include patients with previous extensive intra-abdominal procedures.

Finally, I would like to make some comments about your conclusions. You state this report illustrates that LDNs can be performed safely with complication rates comparable to traditional open donor nephrectomy. However, you never mention the results and complication rates of open donor nephrectomy, making this conclusion not entirely substantiated, although in your presentation, Dr Melcher, you did mention the University of Wisconsin’s complication rate and I appreciate that. You also mentioned that you are comparing your series and an additional 237 patients to those in the literature, but I am not sure where those 237 patients came from. Are they open donor patients from your institution? You also state that surgical trainees can be trained to do this procedure while providing a safe environment for the donor. How do you train your fellows and residents to perform this technically challenging operation? Do you use laparoscopic simulators, or do they practice on animals? I am just amazed that they do such a great job with such a technically challenging operation.

In conclusion, this paper represents a very important contribution to the evolution of a surgical technique that has made an enormous impact on the number of kidney allografts available for transplantation and consequently has improved lives and prevented death in a number of patients today.

Dr Freise: First, I absolutely do agree that the recipient outcome is very important to know about. We are saving that paper for the future PCSA [Pacific Coast Surgical Association] meeting in Kona, but we have looked at a smaller subset of these patients, about 150 of the recipients of laparoscopically recovered kidneys. At 1-year follow-up, there was certainly no difference in ATN [acute tubular necrosis] rate, no difference in patient outcome, no difference in graft outcome, no difference in serum creatinine at 1 year, and no difference in rejection rates. Certainly other centers have looked at longer-term follow-ups, specifically the University of Maryland has looked out as long as 5 years, and there also does not appear to be a difference in recipient outcome.

In terms of the criteria for our donors, I think we are fairly conservative as you probably remember when you came through with your training. We typically set as a target for potential donors a BMI of less than 35. We do have exception cases where patients have been heavier and tried to lose some weight and are approaching that goal. They definitely have to have no evidence of diabetes or propensity toward diabetes. They have to have a normal glucose tolerance test. In general they have to be normotensive as defined by the National Kidney Foundation and American Heart Association, although recently we have embarked on at least the evaluation of potential donors who may have good blood pressure control on just 1 antihypertensive agent, much the way the Mayo Clinic has proposed expanding the donor pool.

In terms of anatomy, we have done as many as 3 renal arteries in a donor kidney with success. We have certainly done several kidneys that have duplicated ureters and duplicated veins. The bottom line is that in the current practice at UCSF [University of California–San Francisco], our indications for choosing a kidney are exactly the same as they were back in the days when open donor nephrectomy was the standard.

In terms of adhesions in the abdominal cavity, I agree with Dr Orloff that it’s technically possible in many patients who have had previous abdominal surgeries to successfully complete a laparoscopic recovery of the kidney. However, in a patient who may have had extensive trauma and has a big widened scar from a packed open wound, I don’t know that I would attempt to try a transperitoneal laparoscopic approach. Certainly the use of retroperitoneal laparoscopic nephrectomy is something to consider.

Dr Orloff commented about our conversion rate and the inclusion of the 1 patient who she believes should really be considered a conversion. I guess we argue back and forth among ourselves about this case. This was a patient who had a previous right upper quadrant incision for an open cholecystectomy that was a difficult operation by his preoperative history. What we intended to do was to do a small mini laparotomy through this incision just to see if we could proceed. We actually didn’t use a Veress needle and very quickly encountered some adhesions and decided we wouldn’t proceed with a laparoscopic approach. So in an intent-to-treat analysis, certainly you are correct that this would be considered a conversion, although technically we did not use any laparoscopic instruments.

In terms of a few technical issues, we have had patients who have required transfusions in the perioperative period. We do give a bolus of heparin just before the arteries are clipped. We do, however, reverse the heparin with protamine. I think in general the bleeding issues have improved, especially in the last 350 cases where we have not required any perioperative transfusion. We do give antibiotics. I think most of what we are calling wound infections is a little erythema around the incision that may or may not have resolved without any treatment, but, nonetheless, we do use 1 dose of perioperative antibiotic. We do not close our port sites for the majority of cases, and as far as I know we have only had the 1 port site hernia.

Dr Orloff’s last point, which I think is probably the most critical, is regarding the training. When I started this I don’t think I had any gray hair. I accumulated a little bit as I learned to do the procedure myself, but I really grayed when I had to start training residents and fellows. It’s a taxing duty. It’s also a rewarding duty as evidenced by the fact that 2 of the fellows that I was able to train have now joined our group and are successfully doing laparoscopic donors on their own. However, it is a type of operation where I think one must take the fellows through the procedure in stages, and that’s the real answer to how at least I try to train fellows. We start them out with the simple mobilization of the colon and the spleen. Eventually they do the venous dissection; later they do the arterial dissection. Finally, we put all of those pieces together until they are competent in doing the procedure.