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LAPAROSCOPIC VERSUS OPEN DONOR NEPHRECTOMY: Comparing Ureteral Complications in the Recipients and Improving the Laparoscopic Technique

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Abstract TOP

Background. Laparoscopic live donor nephrectomy (LDN) is a recently developed procedure, the performance of which needs to be studied. Given the reported advantages in the donors, this study looks at graft outcome and ureteral complications in recipients of kidneys procured by open donor nephrectomy (ODN) versus LDN.

Methods. The LDN recipients consisted of 193 patients since 3/27/96. A total of 168 ODN recipients from 1991 to 1998 served as controls. Immunosuppression protocols were similar for both groups.

Results. Two-year graft survival for LDN and ODN was 98% and 96%, respectively. Two-year patient survival for LDN and ODN was 98% and 97%, respectively. The incidence of delayed graft function and mean serum creatinine at 3 and 12 months was similar in both groups. However, the number of ureteral complications that required operative repair was significantly higher for LDN recipients compared to ODN recipients, 7.7% (n=15) vs. 0.6% (n=1) respectively (*P*=0.03). Ureteral stenting was required in an additional 3.1% (n=6) of LDN and 2.4% (n=4) of ODN (*P*=NS). There was, however, a learning

curve with time. For the first 130 LDN patients, a total of 20 ureteral complications were recorded, whereas only one occurred in the more recent 63 patients (*P*=0.03).

Conclusions. The higher ureteral complication rate in LDN recipients has improved over time as technical causes have been identified. We have noted significant improvement in ureteral viability by using the endogastrointestinal anastomosis instrument on the ureter and peri-ureteral tissue. LDN is therefore an excellent alternative to ODN. Identification of hazards unique to this technique is critical before its broader application.

According to the United Network for Organ Sharing (UNOS*) Scientific Registry reports, live donor renal transplantation provides significant advantages of graft and patient survival when compared with cadaveric donor renal transplantation (1). The 1- and 5-year graft survival for cadaveric allografts is 81% and 59%, respectively, compared to 92% and 76% for live donor allografts. Patient survival at 1 and 5 years for cadaveric allografts is 93% and 81%, respectively, whereas patient survival for live donor allografts is 97% and 90%, respectively.

Furthermore, live donor renal transplantation provides a way of addressing the growing shortage of organs for kidney transplantation. By the end of 1994, 27,498 patients were on the waiting list for a kidney transplant with a median waiting time of 842 days, and 11,392 (41%) received transplants (1). 3009 Live donor renal transplants were performed that year, accounting for only 26.4%. Live donor renal transplantation therefore continues to be an underutilized resource that can substantially reduce waiting times and provide the survival benefits described above. Resistance to this procedure in many centers can be attributed to concerns by the donors regarding the operation, the necessary hospital stay, prolonged recuperative period, and the financial feasibility.

Laparoscopic minimally invasive surgery has become an established alternative approach to various "open" procedures, including the use on retroperitoneal organs such as the adrenals and kidneys (2, 3). Laparoscopic nephrectomy for neoplasms has proven to reduce postoperative pain, hospital length of stay, and convalescent time compared to the open approach (3). This has provided the rationale for the development of minimally invasive donor nephrectomy. Laparoscopic live donor nephrectomy has been performed at the University of Maryland since March 1996. The morbidity and mortality compares to open donor nephrectomy, but with substantial improvements in donor recovery (4). The sum of these improvements should result in an increased acceptance of the donor operation, resulting in an expanded pool of potential kidney donors.

Ureteric complications with variable incidence have been well reported in renal transplantation, with the majority of cases comprising of urinary obstruction (5, 6). Extravesical ureteric implantation has demonstrated a lower complication rate (2-3%) compared to the Politano-Leadbetter technique (7-9%) and has therefore gained wide usage in the majority of transplant centers (5-8). Although infrequently reported, the incidence of ureteric complications in recipients from living donors compared to cadaveric donors does not appear to be increased (7). As laparoscopic live donor nephrectomy is becoming a viable option and graft function in the recipients appears unchanged (4, 9), ureteric complications after the procedure have yet to be reported. In this study, we compare the ureteric complication rate in laparoscopic live donor nephrectomy to the open procedure that was performed in our institution before March 1996.

PATIENTS AND METHODS TOP

Between May 1991 and February 1998, 361 live donor nephrectomies were performed at the University of Maryland. From March 1, 1996 to February 28, 1998, 193 laparoscopic and 10 open live donor nephrectomies were performed (168 total open nephrectomies). Six patients who underwent open nephrectomy were excluded from consideration for laparoscopy because of morbid obesity (two patients), patient preference, renal artery aneurysm, unavailability of a laparoscopic surgeon, and the presence of a pelvic mass requiring operative evaluation. Five patients were converted from laparoscopic to open donor nephrectomy.

We retrospectively reviewed our computerized kidney transplant database and patient medical records. Both recipients and donors were matched for age, sex, and race. Recipient data collected included type of immunosuppression, postoperative serum creatinine, need for dialysis, and graft failure. Delayed graft function was defined as a need for dialysis within the first 7 postoperative days. Graft survival was calculated using Kaplan-Meier analysis with Mantel-Cox

comparisons. Group proportions were compared using the chi-square test. Pearson's correlation coefficient with a two-tailed test was used to correlate delayed graft function and ureter complications.

From May 1991 to September 1995, immunosuppression consisted primarily of cyclosporine, azathioprine, and prednisone. Induction with ATGAM was routinely administered. Between September 1995 and October 1997, the microemulsion form of cyclosporine (Neoral) was used with mycophenolate mofetil and prednisone, and induction was no longer given. From October 1997 on, cyclosporine was replaced by FK-506 as primary immunosuppression.

Potential candidates for donor nephrectomy underwent a standard preoperative evaluation by the transplant division. High resolution computed tomographic angiography was performed to assess the vascular anatomy and presence of two functional kidneys. Standard arteriography was performed for equivocal results. The laparoscopic operative technique used has been described previously **(4)**. Briefly, under general anesthesia, the patient is draped to allow access for a standard left flank incision as well as the midline. A total of four operating ports (three 12 mm and one 5 mm) are used for the dissection. After dissection of the renal vein, artery, and ureter, and after mobilization of the kidney, a linear stapler with a vascular cartridge is used for division of the renal vessels, and more recently for the ureter. The kidney is then placed in an extraction sac and removed via a short midline incision. The allograft is immersed immediately in iced saline solution and transferred to the recipient operating suite, where it is quickly perfused with Euro-Collins solution before implantation. The recipient operation is started soon after the donor operation to minimize the cold ischemia time of the allograft.

With some exceptions, the recipient kidneys were placed in the right retroperitoneal ileac fossa. The ureteroneocystostomy was performed using the extravesical technique. The bladder wall musculature was incised to expose the mucosa. A small incision was then made in the mucosa, and the ureter was trimmed to an appropriate length and spatulated. The anastomosis of full-thickness ureter to the bladder mucosa was performed with running absorbable suture. The muscle layer was then reapproximated for a short distance to create a submucosal tunnel.

When a rise in creatinine was noted after initial graft function, an ultrasound was the diagnostic test of choice to rule out a mechanical cause for this change in function. Fluid collections were usually aspirated and analyzed. For equivocal results, a nuclear scan was obtained to rule in a leak or obstruction. For small leaks or obstruction, stent placement with the cystoscope was first attempted, and if unsuccessful, operative repair was performed. For large urine leaks, operative repair was the procedure of choice.

RESULTS TOP

Donor and recipient characteristics. Mean duration of follow up was 10.7±0.6 months for the live donor nephrectomy (LDN) recipients and 41.5±1.6 months for the open donor nephrectomy (ODN) recipients. Donor characteristics for the LDN and ODN groups were similar and are shown in **Table 1**. There were no significant differences of age, sex, or race between ODN and LDN donors. Recipient characteristics were also well matched with the results depicted in **Table 2**. No significant differences in age, sex, and race between the two groups were noted.

Table 1. Donor characteristics

Table 2. Recipient characteristics

Graft and patient survival. Graft survival at 2 years is depicted in **Figure 1a**. The 2-year graft survival for LDN and ODN was 98% and 96%, respectively (*P*=NS). Patient survival at 2 years is depicted in **Figure 1b**. The 2-year patient survival for LDN and ODN was 98% and 97%, respectively (*P*=NS).

Figure 1. (Top) Two-year actuarial graft survival for LDN (dashed line) and ODN (solid line) recipients is 98% and 96%, respectively (*P*=NS). (Bottom) Two-year actuarial patient survival for LDN (dashed line) and ODN (solid line) recipients is 98% and 97% respectively (*P*=NS).

Graft function. To assess the effect laparoscopic donor nephrectomy may have on graft function, recipient mean serum creatinine at 3 and 12 months after the transplants was collected. The results listed in **Table 3** demonstrate no significant difference between kidneys harvested from LDN and ODN donors.

Table 3. Mean serum creatinine of recipients

Incidence of delayed graft function (DGF) was 5.1% in ODN recipients and 6.2% in LDN recipients (*P*=0.68). When patients were divided by era (see **Fig. 3**), the incidence of DGF was 7.8% in era 1, 3.1% in era 2, and 7.8% in era 3 (*P*=0.52). Furthermore, in the LDN recipients, there was no correlation between DGF and ureteral complications that required operative repair (*r*=0.078, *P*=0.280), non-operative intervention (*r*=0.078, *P*=0.284), or overall (*r*=0.110, *P*=0.127).

Figure 3. Number of ureteral complications for LDN recipients by era. The 193 patients are divided into three groups by order of their transplant. The one complication in era 3 (patients 131-193) is significantly lower than the number of complications observed in the other two eras (*P*=0.03).

Ureteral complications. The number of ureteral complications that required operative repair was significantly higher in the LDN recipients compared to the ODN recipients. There were 15 operations for ureteral complications in the LDN recipients compared to 1 in the ODN recipients (*P*=0.001). **Table 4** displays all the LDN ureter complications, including their presenting symptoms, their work-up, and their management. All but two of the complications requiring an operation were leaks or strictures resulting from necrotic ureters. In one patient, the necrosis was a result of a 360° twist during implantation, and in the second, a hematoma at the ureterocystostomy was thought to be responsible for the breakdown of the anastomosis. The remaining operative complications appear to be a direct result of the harvesting procedure. Ureteral stenting was required in an additional 3.1% of LDN and 2.4% of ODN recipients (*P*=NS). In two of these LDN recipients, the viability of the ureter was in question at the time of transplantation, and an intraoperative decision to perform a ureteroureterostomy over a stent was made. The results are depicted in **Figure 2**. The overall ureteral complication rate including operative and non-operative intervention was 10.8% for LDN and 3.0% for ODN (*P*=0.03).

Table 4. Ureteral complications: diagnostic and therapeutic interventions[a]

Figure 2. Ureteral complications in LDN and ODN recipients. Percentage of cases of non-operative (*P*=NS), operative (*P*=0.001), and total (*P*=0.002) ureteral complications are compared.

In order to delineate a pattern or cause for this, correlation with the operative donor and recipient surgeons was performed. For the donor operation, the majority of cases involved at least two surgeons. There was no correlation between the donor surgeons and ureteral complications. Similarly, there was no correlation between the recipient surgeons and ureteral complications.

Given the high ureteral complication rate being observed, there were several modifications to the laparoscopic procedure in an effort not to devascularize the ureter. Since October 1997, a laparoscopic gastrointestinal anastomosis instrument stapler has been used to divide the ureter distally in order to include the peri-ureteral tissue. Before that, the ureter was being dissected, mobilized, and clipped before division, rendering it vulnerable to devascularization. Since this modification, there has been no ureteral complication that required reoperation, and only one required non-operative stenting in contrast to the previous period. **Figure 3** displays the learning curve associated with this modification. The recipients were divided into three equal eras, with the last 64 patients undergoing nephrectomy since October 1997. The first and second eras had 11 and 10 total ureteral complications, respectively, in contrast to 1 complication in the third era (P=0.03).

DISCUSSION TOP

Laparoscopic live donor nephrectomy is an advanced procedure, evolving from the first laparoscopic nephrectomy performed for a neoplasm in St. Louis **(10)**. Although the first case involved preoperative embolization of the renal vessels, laparoscopic nephrectomy is now routinely performed for both benign and malignant disease with intraoperative renal vasculature dissection. Laparoscopic live donor nephrectomy, however, requires that the integrity of the renal parenchyma, renal vessels and ureter remain unharmed. In addition, the warm ischemia time must be kept short to maximize graft function postoperatively. Previous reports from our institution have documented no deleterious effects on immediate graft function with the laparoscopic nephrectomy compared to the traditional open procedure **(4)**. The data reported here from a larger cohort confirms these previous findings. Overall graft and patient survival is nearly identical at 2 years. As a better assessment of renal function, serum creatinine was reported at 3 and 12 months. Again, there was no difference in these values between the two groups.

Laparoscopic live donor nephrectomy, in the early stages, has also been associated with longer warm ischemia times. However, our data demonstrated a similar delayed graft function incidence in both LDN and ODN recipients. Furthermore, there was no correlation between delayed graft function and era or between delayed graft function and ureteral complications. Therefore, despite the introduction of the laparoscopic donor nephrectomy and a learning curve associated with warm ischemia, our delayed graft function rate has remained low.

Ureteral complications after laparoscopic live donor nephrectomy have yet to be described. We have reported a significantly higher incidence of ureteral complications requiring operative repair. The vast majority of these complications were leaks or strictures resulting from ischemic necrosis of the ureter. The native ureter receives its blood supply from multiple feeding branches along its course. After reaching the ureter, the arterial branches course longitudinally within the peri-ureteral adventitia in an extensive anastomosing plexus. The transplanted ureter on the other hand is entirely dependent on the renal artery for its blood supply. Necrosis of the ureter can therefore result when either the adventitia is stripped or the ureteral branch off the renal artery is injured. The incidence of urological complications after renal transplantation has ranged from approximately 2% to over 30%, depending on the criteria used in the assessment of problems. The most frequent ureteral implantation technique utilized was the one popularized by Leadbetter and Politano in 1958. Ureteric complications with the Leadbetter-Politano technique, including leaks and strictures, ranged between 7% and 13% **(5, 12, 13)**. The procedure is currently being replaced in most centers by an extravesical anastomosis, which has proven benefits including fewer ureteral complications. The ureter leak and stricture rate reported currently with the extravesical anastomosis is generally around 2% **(13-15)**. Most of these series of transplants did not differentiate the kidneys harvested from live donors or cadavers. Earlier reports demonstrated higher urological complications in recipients of kidneys harvested from living related donors **(11)**. This was attributable to suboptimal mobilization and visualization of the donor kidney. Our series of open donor nephrectomy, however, has failed to demonstrate the above findings. A total ureteral complication rate of 3% is compatible with the complication rates noted for kidneys harvested from cadavers.

In the laparoscopic live donor nephrectomy, dissection of the ureter was being performed bluntly and the gonadal vein was separated from the ureter. This allowed us to properly visualize the ureter in order to place surgical clips before division. Although care was taken not to disturb the "golden triangle," the risks of disturbing the adventitia and arterial plexus with this maneuver was increased. This technique is probably responsible for the high incidence of necrotic ureters observed. Several modifications to the laparoscopic procedure have therefore been made. Since October 1997, in order to include the peri-ureteral tissue and minimize the chance of stripping the adventitia, we adopted the use of a laparoscopic

gastrointestinal anastomosis instrument stapler to divide the ureter distally. This modification has drastically reduced the number of ureteral complications as witnessed in **Figure 3**. Since this modification, only one ureteral stricture has been observed, and this was treated successfully with sequential stenting and dilation.

Despite the initial success and patient satisfaction associated with laparoscopic live donor nephrectomy, this study has emphasized the necessary learning curve associated with technically difficult procedures. The benefits of laparoscopic live donor transplants to the donors are readily emerging. Donors are experiencing improved convalescence, including shorter length of hospital stay and lower overall costs (data currently submitted for publication). Laparoscopic live donor nephrectomy can now be performed with low morbidity and mortality to both donors and recipients, and is proving to be the preferred operation for living donation. As with other minimally invasive procedures, patient demand has dictated a widespread interest in the operation. This may increase the willingness to donate or to identify potential donors, ultimately resulting in expansion of the organ pool.

ADDENDUM TOP

Subsequent to this report of 193 cases, we have performed 85 more laparoscopic donor nephrectomies with the modified procedure and have had no ureteral complications in the recipients.

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* Abbreviations: DGF, delayed graft function; LDN, laparoscopic donor nephrectomy; ODN, open donor nephrectomy; UNOS, United Network for Organ Sharing. [Context Link]

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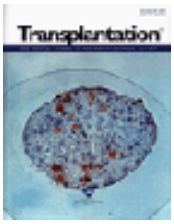

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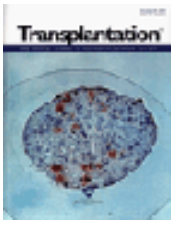

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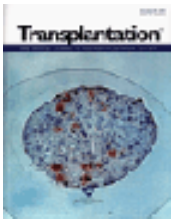

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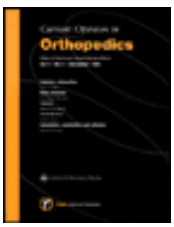

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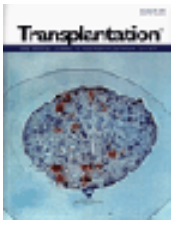

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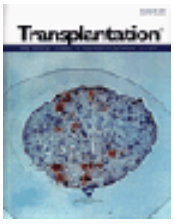

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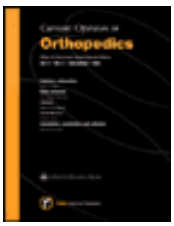

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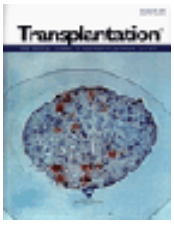

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