Hand-assisted laparoscopic versus open nephrectomies in living donors

Amer Rajab, MD, PhD;* John E. Mahoney, MD;† Mitchell L. Henry, MD;* Elmahdi A. Elkhammas, MD;* Ginny L. Bumgardner, MD;* Ronald M. Ferguson, MD, PhD;* Ronald P. Pelletier, MD*

Shortages of cadaveric kidneys for transplant into rising numbers of patients with end-stage renal failure have increased the demand for kidneys from live donors. The morbidity associated with traditional open donor nephrectomies (ODN) may discourage many candidates. The newer laparoscopic technique has been promoted as having less morbidity. **Objectives:** To evaluate outcomes of hand-assisted laparoscopic nephrectomies (HALN) and prospectively compare HALN and ODN. **Methods:** After retrospectively reviewing donor and recipient outcomes in 33 HALN (December through August, 2000), we prospectively compared another 47 with 30 ODN performed from September 2000 through April 2001. **Results:** All 80 HALN were successful, with no requirement to convert to an open procedure. Four donors experienced surgery-related complications: wound infection, retroperitoneal hematoma, prolonged ileus and early small-bowel obstruction, respectively. Two recipients had ureteral complications (1 stricture, 1 leak); 5 experienced delayed graft function, 2 requiring dialysis; and 2 kidneys were lost from infarction. The prospective comparison showed the operative time for HALN (mean 184 min, standard deviation [SD] 39 min) was significantly longer (143 [SD 27] min, $p < 0.01$), but resulted in less blood loss ($p < 0.05$). Lengths of time to warm ischemia/early graft function, resumption of oral intake/first bowel movement, and hospital discharge were similar. The abdominal-wall laxity and loss of cutaneous sensation from the flank incision experienced by many ODN patients after was uncommon in the HALN group. Three months after nephrectomy, donor complaints of incisional pain were less common after HALN ($p < 0.01$). **Conclusions:** HALN had good outcomes for donors and recipients, with quicker, more complete recoveries 3 months afterward.

Les pénuries de reins de cadavre à greffer à des patients de plus en plus nombreux atteints d'insuffisance rénale au stade ultime ont augmenté la demande de reins de donneurs vivants. La morbidité associée aux néphrectomies traditionnelles «ouvertes» peut décourager beaucoup de candidats. On préconise une nouvelle technique laparoscopique qui réduirait la morbidité. **Objectifs :** Évaluer les résultats de la néphrectomie laparoscopique avec assistance manuelle et comparer de façon prospective les techniques laparoscopique et ouverte. **Méthodes :** Après avoir effectué une étude rétrospective de l'évolution de l'état de santé du donneur et du receveur dans 33 cas d'interventions pratiquées par la technique laparoscopique (décembre à aout 2000), nous avons comparé de façon prospective 47 autres sujets chez lesquels on a pratiqué 30 néphrectomies ouvertes du septembre 2000 jusqu'en avril 2001. **Résultats :** Les 80 interventions pratiquées par la technique laparoscopique ont été fructueuses et il n'a pas été nécessaire de les convertir en intervention ouvertes. Quatre donneurs ont eu des complications reliées à l'intervention chirurgicale : infection de la plaie, hématome rétropéritonéal, occlusion intestinale prolongée et occlusion précoce de l'intestin grêle, respectivement. Deux receveurs ont eu des complications de l'urètre (1 rétrécissement, 1 fuite); dans cinq cas, le greffon a pris du temps à fonctionner; deux patients ont eu besoin de dialyse et on a perdu deux reins à cause d'un infarctus. La comparaison prospective a montré que l'intervention laparoscopique (moyenne de 184 min, écart type [ET] de 39 min) pre-

*From the *Division of Transplantation, Department of Surgery, Ohio State University College of Medicine, Columbus, Ohio, and the †Division of Urology, Department of Surgery, Ottawa Hospital, Ottawa, Ont.*

These data were presented at the XIX International Congress of The Transplantation Society, Miami, Fla., August 25–20, 2002.

Accepted for publication Dec. 22, 2003

Correspondence to: *Dr. Amer Rajab, Means Hall, Room 359, 1654 Upham Dr., Columbus, OH 43210; fax 614 293-4541; rajab-1@medctr.osu.edu*

nait beaucoup plus de temps (143 [ET 27] min, $p < 0,01$), mais réduisait la perte de sang ($p < 0,05$). Les durées des périodes écoulées jusqu'à l'ischémie chaude et au fonctionnement précoce du greffon, à la reprise des ingérés oraux et de la première selle et au congé de l'hôpital étaient semblables. La laxité de la paroi abdominale et la perte de sensation cutanée à la suite de l'incision pratiquée au côté qu'ont connues beaucoup de patients après l'intervention ouverte sont peu courantes chez les sujets qui ont subi l'intervention laparoscopique. Trois mois après la néphrectomie, les plaintes de douleur à l'incision étaient moins courantes chez les donneurs opérés par laparoscopie ($p < 0,01$). **Conclusions :** La technique laparoscopique avec assistance manuelle produit de bons résultats pour les donneurs et les receveurs, et le rétablissement est plus rapide et plus complet trois mois après l'intervention.

The modest increase in cadaveric kidney transplants performed annually over the last decade has not kept pace with the tremendous increase in patients with end-stage renal failure placed on the waiting list for transplant.[1] As a result, the waiting time for a patient to receive a cadaveric kidney in the United States continues to increase.[2] The US transplant community has placed a greater emphasis on kidney transplantation from living donors as one of several means to reduce the number of patients who await transplantation.

Increasingly, transplant centres are offering techniques of laparoscopic (LN) or hand-assisted laparoscopic nephrectomy (HALN) as an alternative to standard open donor nephrectomy (ODN). It is hoped that these newer techniques will increase the number of candidate donors willing to undergo nephrectomy, thereby reducing the number of potential recipients waiting for a cadaveric organ. Recent reports[3] indicate that laparoscopic procedures result in less postoperative pain, a shorter hospitalization, a more rapid return to normal activities, a more cosmetically acceptable incision, and greater patient satisfaction.

Here we describe our early experience in establishing a safe, relatively rapid technique for HALN. Once the technique was firmly established, we proceeded to compare outcomes for donors and donated organs after HALN with those after ODN.

Methods

This report describes 2 studies. In the first, we reviewed the first 80 HALNs performed between December 1999 and April 2001 retrospectively, with special attention to outcomes as related to refinement of the surgical technique. For this study, operating room (OR) time was calculated as the interval between entering and leaving the OR.

In the second study, we prospectively compared 47 HALNs with 30 ODNs performed on living donors over the same period. For this study, data collected included operating time, defined in this study as the interval from skin incision to skin closure; estimated blood loss; warm ischemia time, measured from the clamping of the first renal artery in situ to flushing of the kidney with chilled solution on the back table; and intraoperative urine output by the recipient, an early indicator of donated organ quality.

From hospital records we collected data for age, gender and race of all patients studied; length of hospital stay, time to oral intake, time to first bowel movement and in-hospital narcotic requirement of all donors; and urine output in the first 24 hours by the kidney recipients. All donors were evaluated for postoperative recovery at routine follow-up as well, in the transplant clinic 1 month after surgery.

Three months after surgery, a transplant nurse obtained additional donor data through telephone survey on the presence or absence of incisional pain experienced with and without movement, the use of analgesics, and time until full activity and (where appropriate) return to work. Data collectors were not blinded to the surgical technique used. Outcome data from patients who made further appointments because of complaints during their recovery period were also noted.

Description of HALN technique

The patient is put into the lateral decubitus position, with the kidney rest fully raised and the table flexed 20°. A 7–8-cm midline infraumbilical incision is made for insertion of the hand through the Pneumo sleeve device (Dexterity Surgical, Rosewell, Ga.).

Two subcostal 5–12-mm ports are made: 1 just off the midline for insertion of an endoscope, and 1 at the midclavicular line for insertion of a working instrument (Fig. 1). If the organ is a right kidney, an additional 5-mm port is made in the flank at

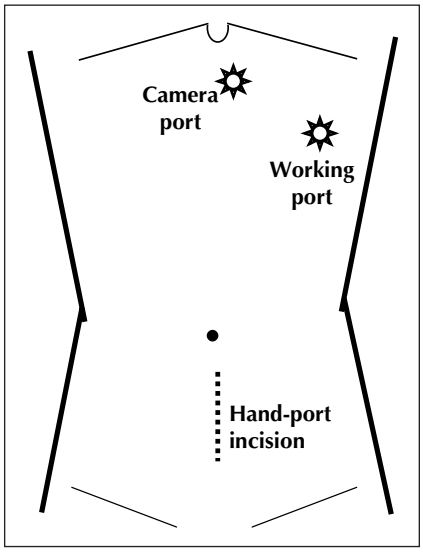

FIG. 1. Schema showing port placement for a left nephrectomy, hand-assisted laparoscopic donor technique.

the midaxillary line for liver retraction.

Pneumoperitoneum pressure is 15 mm Hg. All donors receive plentiful intraoperative fluid to offset the deleterious effect of pneumoperitoneum on renal blood flow. Intraoperative urine output and evaluation of the kidney guides fluid resuscitation.

The technique calls, in order, for the surgeon to mobilize the colon; identify and mobilize the ureter; expose the kidney anteriorly; isolate the renal vein and (left kidney only) divide its branches; completely mobilize the kidney; and isolate the renal artery. Sharp dissection (colon mobilization, dissection of Gerota's fascia from the kidney capsule) is done with electrocautery and a harmonic scalpel (United States Surgical Inc., Norwalk, Conn.). Blunt dissection is performed with the inserted hand.

Before the renal artery is exposed, all donors receive 10 mg furosemide and 12.5 g mannitol intravenously, and are fully heparinized prior to division of the renal artery.

The gonadal vein is purposefully excluded from the ureteral dissection. To remove the kidney the ureter is divided, followed by the artery and then the vein; the kidney is then extracted through the hand port. The ureter is doubly clipped with 10-mm endoclips, and the artery and vein stapled. (For the first 13 donors in our series, we used a GIA 30 endostapler, and thereafter a TA 30 endostapler: Auto Suture endoclips and endostaplers, United States Surgical Inc.)

The effects of heparin are reversed after removal of the kidney. The fascial defect at the 12-mm port sites is closed with a single interrupted absorbable suture. The hand-port incision is closed with a single layer of running absorbable suture for the fascia. All skin incisions are closed with a running, subcuticular layer of absorbable suture. At the end of the procedure all incisions are infiltrated with 0.5% bupivacaine.

Description of standard technique of open donor nephrectomy

The patient is placed in a lateral decubitus position, with the kidney rest fully raised. The operating table is flexed 45° to maximize kidney exposure. A flank incision is made at the level of the lowest rib, which is not resected; dissection is confined to the retroperitoneal space.

The technique calls, in order, for the surgeon to identify and mobilize the ureter; completely mobilize the kidney; isolate the renal vein and (if it is a left kidney) divide its branches; and isolate the renal artery. As in the HALN technique, all donors receive 10 mg furosemide and 12.5 g mannitol intravenously before the renal artery is exposed, and are fully heparinized by the time the renal artery is divided.

First the ureter is divided and the donor side suture-ligated. The artery and vein are clamped proximally, then sharply divided. The kidney is removed directly through the flank incision.

The clamped stumps of the renal artery and vein are suture-ligated before clamp removal. The fascial layers are reapproximated with interrupted absorbable suture, and the skin incision with a running subcuticular absorbable suture. The incision is infiltrated with 0.5% bupivacaine.

Statistical analysis

All data are presented as means and standard deviations (SDs). Statistical analysis for nominal variables was done with the χ^2 test where appropriate. Continuous variables were compared with Student's t test. SPSS software (Chicago, Ill.) was used for all statistical analyses. A p value under 0.05 was considered significant.

Results

Retrospective review of the first 80 HALN donors

The first 80 HALN procedures were performed between December 1999 and April 2001. Donor and recipient demographics are shown in Table 1. After the tenth HALN procedure, this procedure was made available to donors with multiple renal arteries (Table 2).

Donor morbidity

All HALNs were successful, with no need to convert to an open approach. Five complications, 2 major and 3 minor, occurred in 5 donors.

One donor (case 32) was noted to have a poor urine output and falling hemoglobin between 24 and 48 hours after surgery. This donor was

Table 1

Demographics of the early group of hand-assisted laparoscopic donor nephrectomies: 80 cases

Characteristic	Donors	Recipients
Mean age (and standard deviation (SD)), yr	38 (11)	46.4 (14.6)
Sex, male:female	38:42	46:34
Race, black:non-black	8:72	6:74
Mean BMI (and SD)	26.5 (5.1)	

BMI = body mass index

Table 2

Anatomy in hand-assisted laparoscopic donor nephrectomies (HALN) and open-donor transplants

Kidney characteristic	Retrospective HALN ($n = 80$)	Prospectively studied cases	
		HALN ($n = 47$)	Open ($n = 30$)
Left:right	74:6	41:6*	15:15*
Arteries, 1:2:3+	63:14:3	36:9:2	25:4:1
Vein(s), 1:2	78:2	45:2	29:1
Ureter(s), 1:2	78:2	46:1	28:2

*Significantly different, $p = 0.001$

the only patient who received a perioperative blood transfusion. A CT scan revealed a large retroperitoneal hematoma at the nephrectomy site. The bleeding stopped spontaneously; no other intervention was necessary.

The second major complication, a complete small-bowel obstruction, developed on posttransplant day (PTD) 6 in a donor (case 80) who had never undergone any other abdominal surgery. During re-exploration through the infra-umbilical midline incision, a single band adhesion at the umbilicus was encountered. Adhesolysis was performed, and the donor's further recovery was uneventful.

As for the minor complications, 1 donor (case 1) developed cellulitis of the midline wound on PTD 17, which failed to respond within 48 hours to oral antibiotics. The patient was therefore hospitalized for 2 days and treated with intravenous antibiotics, which fully resolved the cellulitis. A second donor (case 6) with lower-extremity varicosities who had a history of superficial thrombophlebitis developed a painful episide of it on PTD 16, which resolved spontaneously. The third donor (case 46) developed a pronounced ileus on PTD 9 requiring hospitalization and intravenous fluid for bowel rest and nasogastric decompression. A normal diet was resumed after 6 days.

Recipient outcomes

Nine recipients developed 9 complications: 2 kidney infarctions, 2 ureteral complications and 5 instances of delayed graft function (DGF, defined as a lack of decline in serum creatinine during the first 24 hours posttransplant).

The first kidney thrombosis (case 34), of unknown cause, occurred within 24 hours after implantation. A hypercoagulable state was suspected but not confirmed. The second kidney thrombosis (case 66) occurred between 2 and 5 days postoperatively; again, no cause could be identified. For the remaining 78 patients, mean serum creatinine over the first 24 hours posttransplant was 6.6 mg/dL, which dropped to 2.0 mg/dL by PTD 7 (Fig. 2).

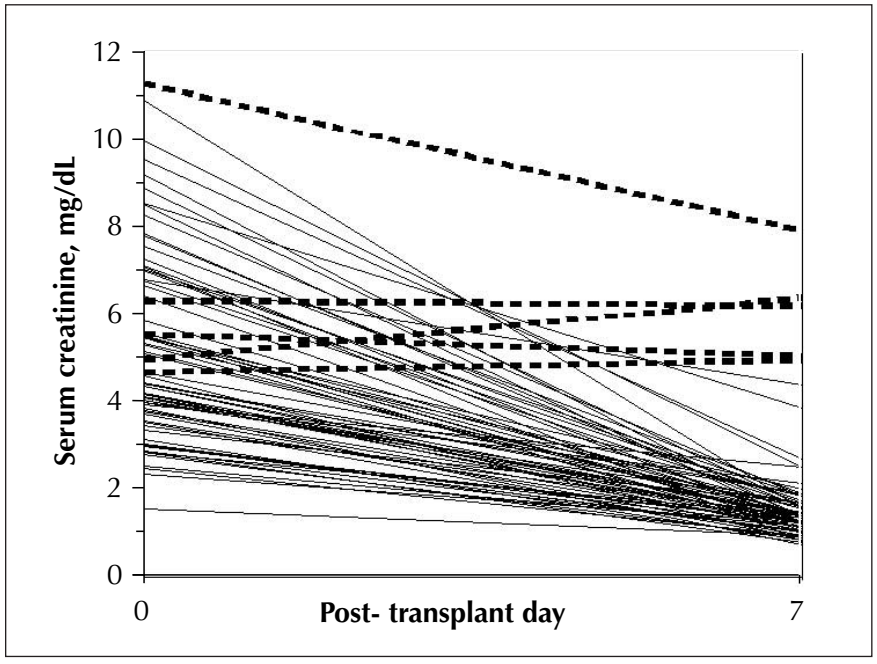

FIG. 2. Serum concentrations of creatinine for the individual recipients of the first 78 hand-assisted laparoscopic donor nephrectomy kidneys, on the day of transplant (day 0) and 1 week afterward (day 7). (Two recipients who developed renal infarction were excluded.) The heavy dashed lines show serum levels for the 5 patients with delayed graft function.

Of the 2 recipients who developed ureteral complications, 1 ureter (case 35) developed a stricture 2 months after transplantation, and the other (case 56) was found to have a small leak upon re-exploration of the recipient for evacuation of a wound hematoma on PTD 18.

Of the 5 recipients who experienced DGF (dashed lines, Fig. 2), 2 required dialysis; renal function returned on PTDs 7 (case 28) and 27 (case 51). In the other 3, renal function returned on PTDs 6 (case 12), 3 (case 65) and 5 (case 72) without dialysis. All kidneys have recovered normal function, with a mean serum creatinine level at 1 year posttransplant in these 5 recipients of 1.6 (SD 0.4, range 1.1–2.1) mg/dL.

Two other patients had early posttransplant renal dysfunction due to recipient factors. The first recipient (case 43) had good renal function until PTD 6, when acute severe rejection developed that ultimately led to cortical necrosis and graft loss. The other (case 31) developed early recurrence of focal segmental glomerulosclerosis with proteinuria in the nephrotic range. This kidney continues to function; the patient's serum creatinine concentration 1 year after transplant was 3.4 mg/dL.

Evolution of the HALN technique

Only left-sided HALNs were performed initially, until a routine technique was established. Our first right-sided procedure was the 37th donor nephrectomy performed. Refinements in our surgical technique were developed and incorporated over our first 25–30 procedures.

Several refinements considerably reduced the time required for transplantation (Fig. 3). We learned to verify the location of the ureter immediately after the colon was mobilized, so that the lower renal pole could be dissected rapidly without risk of ureteral injury. This included

dissection down to the ureter adjacent to the psoas muscle to avoid creating a defect in the colonic mesentery, which occurred in 3 of our first 8 donors. We also learned to avoid unnecessary dissection of the splenocolic ligament, excessive mobilization of the spleen, and excessive dissection between the splenocolic ligament and the left adrenal gland. Dissection of the posterior and superior pole attachments to Gerota's fascia, followed by caudal retraction of the kidney, hastened the exposure and dissection of the renal artery cephalad to the renal vein. This is done immediately after division of the renal vein branches (left kidneys only). This manœuvre also helps remove the kidney from behind the spleen (left side) or liver (right side).

These refinements decreased OR time from the first to the 60th donor procedure (Fig. 4), and may have contributed to the modest decline in donor hospital stay. The slight increase in OR time between the 61st and 80th donors reflects the training of fellows in the procedure, which commenced during this period.

Our technique for dividing the renal vessels has also been modified to increase their length. We initially used an Endo-GIA stapler to divide the vessels (6 rows of staples), which leaves 3 rows of staples on the donor vessels that must be excised before implantation. We switched to an Endo-TA stapler (3 rows of staples) followed by sharp division of the vessels distal to the staples. This technique, used in both left and right donor nephrectomies, eliminates the need to excise the stapled ends of the donor vessels, which shortens them.

Due to the episodic incidence of an initial delay in graft function, after the 80th HALN we added a minimum 10-minute period of deflation of the abdomen with cessation of kidney manipulation to the procedure. The intent was to maximize renal blood flow before kidney removal by decreasing intra-abdominal pressure and minimizing manipulation-induced spasm of the renal vasculature.[4] From then until January 2002, 64 HALN procedures have resulted in no episodes of DGF.

Laparoscopic versus open donor nephrectomies

HALN outcomes were not compared with those of the traditional open procedure until we had established a routine HALN technique. Thus, we began to study outcomes prospectively at the 30th HALN procedure, in September 2000.

Group allocation was not randomized: all potential donors were offered their choice of the 2 techniques. The HALN group comprised the last 51 of the 80 patients already described, who underwent HALN from September 2000 through April 2001. They were compared with the 30 patients who underwent the open procedure during the same period (the open group).

Four HALN donors could not be reached for follow-up and were therefore excluded from the study, leaving 47 patients in the HALN group for analysis. Demographic (Table 1) and anatomic differences between the groups (Table 2) were not significant, except that more patients in the open group donated their right kidney ($p = 0.001$).

Intraoperative outcome variables: Mean operating time from incision to skin closure was longer for the HALN group ($p < 0.01$), whereas their estimated blood loss was less ($p < 0.05$; Table 3). Warm ischemia time, from renal artery occlusion until flushing of the organ, did not differ significantly between the groups; nor did recipient urine output in the OR after kidney implantation (Table 3).

Inpatient outcome variables: Overall, the inpatient experience in the HALN and open donor groups was very similar. Mean lengths of hospital stay, time until resumption of oral intake, and time until first bowel movement were similar for both groups (Table 3). Recipient urine output within the first 24 hours, an indicator of organ quality, did not differ significantly between the 2 groups.

Convalescent outcome variables: Patients in this study were seen in follow-up at 1 month, and contacted by telephone 3 months after their nephrectomy. When queried as to the presence of incisional pain, those in the HALN group reported less pain than the open group, both at rest and with movement, but the difference was statistically significant only at 3 months posttransplant (Table 3).

Patient-controlled narcotic analgesia was routine during the first 24 hours after surgery, along with oral narcotic during donors' hospital stay. Narcotic and analgesic use by donors was similarly assessed during recovery

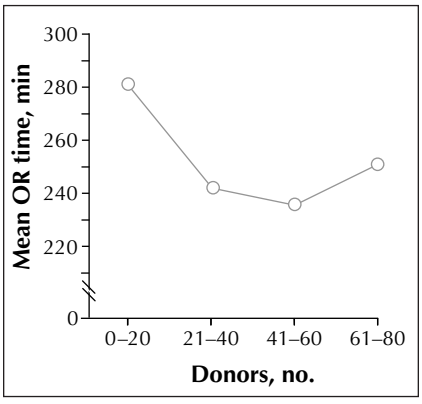

FIG. 3. Mean operating-room (OR) time for the first 80 kidney donors, grouped into cohorts of 20. OR times reached a plateau by the second cohort (donors 21–40).

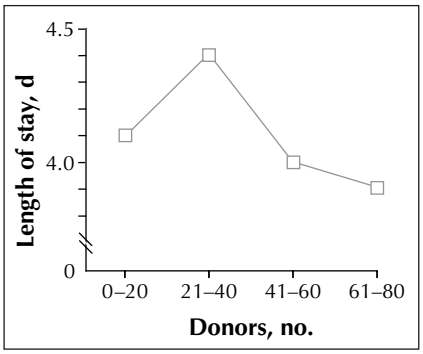

FIG. 4. Mean lengths of hospital stay, in days, for the first 80 kidney donors studied (grouped into cohorts of 20). Overall, mean stay in hospital decreased slightly from the first cohort of donors to the last.

at 1 and 3 months. The percentage of patients using narcotics or analgesics was similar in both donor groups, throughout (Table 3).

Finally, all patients were asked at their 1- and 3-month follow-up appointments whether they had any laxity of their abdominal-wall musculature or loss of sensation over their abdomen. The frequency of both abdominal laxity and sensory loss was greater in the open group at 1 month and 3 months, but also reached statistical significance only at 3 months (Table 3). Time taken off from work was similar for both groups.

The 47 HALN donors were asked whether availability of the HALN technique for donor nephrectomy influenced either their decision to donate a kidney or their selection of our centre for the transplant. Eight people (17%) stated that the offer of the HALN technique influenced their decision to proceed with donation; of these, 7 donors (15%) said they chose our centre for the availability of that technique.

Table 3

Comparison of donor and donated kidney outcome variables between the HALN and open-donor nephrectomy patients studied prospectively

Outcome variable	No.	Patient group; mean (and SD)* HALN	Open-donor	*p* value†
Intraoperative	77	(*n* = 47)	(*n* = 30)	
Time in operating room		184 (39) min	143 (27) min	< 0.01
Estimated blood loss		150 (157) mL	234 (190) mL	< 0.05
Warm ischemia time		189 (73) s	177 (121) s	ns
RUO in operating room		411 (369) mL	499 (417) mL	ns
Inpatient	77	(*n* = 47)	(*n* = 30)	
RUO in first 24 hours		10 313 (5868) mL	10 339 (5164) mL	ns
Nil per os/nothing by mouth		25 (6) h	26 (5) h	ns
Time to 1st bowel movement		47 (26) h	53 (32) h	ns
Length of hospital stay		4 (0.7) d	4 (0.6) d	ns
Convalescence, 1 mo postsurgery		(*n* = 42)	(*n* = 26)	
Any pain at rest	68	24%	35%	ns
Any pain with movement	68	59%	69%	ns
Any pain medication needed	66	15%	24%	ns
Abdominal wall laxity	77	4%	23%	< 0.05
Loss of sensation, abdominal wall	77	28%	60%	< 0.01
Convalescence, 3 mo postsurgery		(*n* = 36)	(*n* = 27)	
Any pain at rest	63	11%	22%	< 0.01
Any pain with movement	63	22%	56%	< 0.01
Any pain medication needed	59	0	0	ns
Abdominal wall laxity	77	8%	30%	< 0.05
Loss of sensation, abdominal wall	77	13%	60%	< 0.01
Days of work missed	60	25.5 (12.4) d	26.1 (12.1) d	ns
Return to normal activity level	69	90%	70%	0.05
Mean time to normal activity	57	5.3 (2.2) d	5.7 (2.0) d	ns
Kidney outcome, no. (and %)	77	(*n* = 47)	(*n* = 30)	
Infarction	2	2 (4%)	—	ns
Delayed graft function	7	3 (6%)	4 (13%)	ns
Ureteral leak	2	1 (2%)	1 (3%)	ns
Ureteral stenosis	0	0	0	ns
Mean serum creatinine levels, mg/dL				
Baseline, just before transplant: PTD 0		6.8 (2.0)	6.3 (2.6)	ns
Posttransplant day 1		4.3 (2.0)	4.2 (2.1)	ns
Posttransplant day 2		2.8 (2.3)	3.1 (2.4)	ns
Posttransplant day 3		2.5 (2.3)	2.9 (2.3)	ns
At follow-up, 6 months		1.5 (0.5)	1.6 (0.4)	ns
At follow-up, 12 months		1.6 (0.5)	1.6 (0.4)	ns

*Unless otherwise indicated.
ns = not significant ($p > 0.05$); RUO = recipient's urinary output after kidney implantation

Transplanted kidney outcomes

As already described, 2 posttransplant kidney infarctions occurred in the HALN donor kidney group and none in the open group. Incidences of DGF and ureteral leak or stenosis were not statistically different between the 2 groups.

To gauge donor kidney function between the groups, recipients' serum creatinine concentrations were measured 4 times during the first month posttransplant, and averaged for intervals of 3–6, 7–14 and 15–28 days (Fig. 5). The 2 infarcted kidneys were excluded from this analysis of renal function. Baseline and declines in mean serum creatinine values were similar in both groups ($p > 0.05$, Student's t test).

Discussion

Retrospective analysis of the first 80 HALN donors

The retrospective review of our early HALN experience demonstrates several important points. Three of our reasons for choosing HALN over a completely laparoscopic technique were vindicated. First, the HALN is generally considered to be quicker to perform than the completely laparoscopic approach. Slakey and associates[5] previously noted a 1-hour reduction in operating time when they switched from a completely laparoscopic to a HALN technique. The rapid decline in OR time in our study (Fig. 3) shows that a surgeon with few skills in advanced laparoscopy mastered the HALN procedure relatively quickly.

Second, HALNs were safe for all

our donors, with none requiring conversion to the open approach. Even though HALN has additional costs related to the sleeve, we think the presence of the surgeon's hand in the abdomen contributed to our 0% conversion rate.

Third, warm ischemia times as reported for HALN are significantly shorter than for the completely laparoscopic technique; for example, Slakey's group[5] noted a mean warm ischemia time of 1.3 minutes for the former, compared with 3.9 minutes for the latter. Between our 2 groups, the warming periods were comparable. Wolf and coauthors[6] did note an increase (of mean 87 s) in warm ischemia time in their HALN donors compared to their open donors, which did not translate into a noticeable difference in graft function after transplantation.[6] Shalhav and colleagues[7] significantly reduced warm ischemia time in total laparoscopic donor nephrectomies by retrieving the kidney by hand through a Pfannensteil's incision without use of a sleeve.

Operative mortality for open donor nephrectomy has been estimated at 0.03%–0.07%,[8] with an incidence of major complications of 1%–8%.[8–10] Our results with the HALN technique compare favourably, with no mortality and a 2.5% incidence of major complications. Among those in our patients (2/80), 1 donor bled postoperatively and required blood transfusion. Perioperative hemorrhage requiring blood transfusion has been previously reported with laparoscopic donor nephrectomy.[11] Small-bowel obstruction has to our knowledge been reported by 2 centres.[12,13] Obstruction occurred very early in our patient, and was relieved by opening the hand-port site and bluntly releasing an adhesive band. Small-bowel obstruction after transperitoneal open nephrectomy has been estimated as a 2% lifetime risk.[14] The long-term risk after laparoscopic donor nephrectomy is yet to be determined.

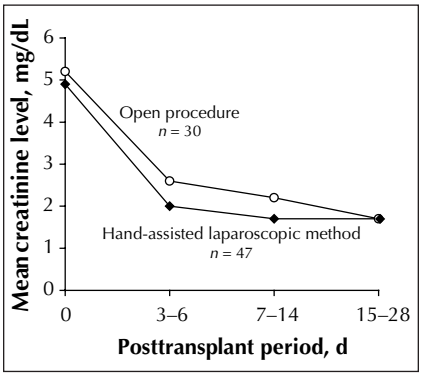

FIG. 5. Mean concentrations of serum creatinine in recipients of kidneys from living donors who chose hand-assisted laparoscopic nephrectomy (diamonds) or an open procedure (dots; $p > 0.05$).

Our 2.5% incidence of DGF necessitating dialysis in our first 80 HALN donors compares favourably with those reported previously (3%–7%),[6,11,15–18] and our incidence of ureteral complications (also 2.5%) in kidneys from HALN donors is similar to that from open procedures.[19–20] We did not experience the initial high incidence of ureteral complications noted by 1 group of investigators.[16]

Concurrently performed HALN versus open donor nephrectomies

A commonly cited disincentive to offering donors the option of laparoscopic kidney procurement is a concern about graft quality.[21] In this report we compared early renal function (as determined by recipient serum creatinine and urine output) between our HALN and open donor groups, and found them to be similar. This differs from results reported by Nogueira and associates[15] for kidneys that were removed completely laparoscopically, whose early renal function (as determined by recipient serum creatinine) was significantly worse during the first week posttransplant than that of kidneys from open nephrectomies. Other studies have noted no difference in the incidence of DGF when comparing the open technique with either HALN[6] or completely laparoscopic[11,22] techniques, but in those studies, recipient serum creatinine was not critically evaluated.

Our incidence of DGF was not significantly different between the HALN and open donor groups. In 1 recipient of an open donor kidney, the time required to implant the organ was longer than usual due to the presence of multiple renal arteries and a diseased recipient artery. Development of DGF in this recipient was not entirely unexpected. In all other cases (both groups), no unusual intraoperative events occurred to explain the development of DGF.

In regard to the 2 infarcted kidneys, the donor nephrectomies and transplantations proceeded without incident. Reperfusion of the organs was uneventful, and the kidneys made urine in the OR.

Patient allocation to either technique was not randomized. However, selection for HALN was not based on difficulty. BMI, number of arteries, veins and ureters, and demographic factors did not differ significantly between the groups. In fact, we find HALN to be easier than open-donor nephrectomy in obese patients. More right kidneys were donated by patients in the open-nephrectomy group their in the HALN group. The larger number of right nephrectomies in the open donor group resulted from our initial reticence to use the HALN technique to remove the right kidney, based on bias among recipients' surgeons that the HALN approach would result in an unacceptably short renal vein. Ultimately, this was not found to be a material issue. Thus, although there were more right nephrectomies in the open donor group, we considered it reasonable and informative to compare these 2 groups.

The in-hospital recovery experience was very similar between the HALN and open donor groups, notably length of in-hospital stay. Previous studies[6,11,22] have reported shorter hospital stays by donors after laparoscopic than open nephrectomy. However, the donors who had open

nephrectomy were a historical control group, and as such received their operation in the past, in earlier days when hospital stays in general tended to be longer. Indeed, the number of hospital days reported for these patients was 6–9 days, much longer than the 4 days expected in our program. These studies also reported a quicker return to work by donors after laparoscopic nephrectomy (whether HALN or completely laparoscopic) than after open removal. We found no significant differences, although it should be noted that in the majority of our cases, donors elected to take the maximum period allowed away from their work.

In our study, important differences were noted in outpatient convalescence, related to the increased morbidity of a flank incision for kidney extraction over that of a lower midline incision. The midline incision results in reductions in pain and abdominal wall laxity, and not as much loss of cutaneous sensation as frequently accompanies a flank incision. The laparoscopic technique has previously been reported to improve postoperative pain, resulting in a reduction in parenteral analgesic use.[6,11,22] Our study also revealed reductions in pain and analgesic usage that did not reach statistical significance until 3 months after surgery.

Finally, a significant percentage of our HALN donors stated that their decision to proceed with donation was made based on the availability of a laparoscopic technique. Additionally, a significant percentage chose our centre for their nephrectomy because of the availability of the laparoscopic technique. Given the small number of patients, this finding should not be overstressed. Nevertheless, availability of this newer approach is likely to increase the pool of organs obtainable by patients with renal failure who are awaiting transplantation. Centres providing this approach should expect an increase in transplants from living donors.

Conclusions

Development of our laparoscopic donor nephrectomy program utilizing the HALN technique resulted in good outcomes for both donor and recipient. Outcome comparison of donors undergoing this technique to those who had the open technique revealed a quicker and a more complete recovery at 3 months postnephrectomy.

Competing interests: None declared.

References

1. Cecka JM. The UNOS scientific renal transplant registry. In: Cecka JM, Terasaki PI, editors. *Clinical transplantation*. Los Angeles (CA): UCLA Tissue Typing Laboratory; 1996. p. 1-14.
2. Harper AM, Taranto SE, Edwards EB. The OPTN waiting list, 1988–2001. In: Cecka JM, Terasaki PI, editors. *Clinical transplantation*. Los Angeles: UCLA Tissue Typing Laboratory; 2002. p. 79-92.
3. Merlin TL, Scott DF, Rao MM, Wall DR, Francis DM, Bridgewater FH, et al. The safety and efficacy of laparoscopic live donor nephrectomy: a systematic review. *Transplantation* 2000;70:1659-66.
4. Harman PK, Kron IL, McLachlan HD, Freedlender AE, Nolan SP. Elevated intra-abdominal pressure and renal function. *Ann Surg* 1982;196:594-9.
5. Slakey DP, Wood JC, Hender D, Thomas R, Cheng S. Laparoscopic living donor nephrectomy: advantages of the hand-assisted method. *Transplantation* 1999; 68:581-3.
6. Wolf JS Jr, Merion RM, Leichtman AB, Campbell DA Jr, Magee JC, Punch JD, et al. Randomized controlled trail of hand-assisted laparoscopic versus open surgical live donor nephrectomy. *Transplantation* 2001;72:284-90.
7. Shalhav AL, Siqueira TM Jr, Gardner TA, Paterson RF, Stevens LH. Manual specimen retrieval without a pneumoperitoneum preserving device for laparoscopic live donor nephrectomy. *J Urol* 2002;168(3): 941-4.
8. Bay WH, Hebert LA. The living donor in kidney transplantation. *Ann Intern Med* 1987;106:719-20.
9. DeMarco T, Amin M, Harty JI. Living donor nephrectomy: factors influencing morbidity. *J Urol* 1982;127:1082-3.
10. Weinstein SH, Navarre RJ, Loening SA, Corry RJ. Experience with live donor nephrectomy. *J Urol* 1980;124:321-2.
11. Flowers JL, Jacobs S, Cho E, Morton A, Rosenberger WF, Evans D, et al. Comparison of open and laparoscopic live donor nephrectomy. *Ann Surg* 1997;226:483-9.
12. Knoepp L, Smith M, Huey J, Mancino A, Barber H. Complication after laparoscopic donor nephrectomy: a case report and review. *Transplantation* 1999;68:449-51.
13. Ruiz-Deya G, Cheng S, Palmer E, Thomas R, Slakey D. Open donor, laparoscopic donor and hand-assisted laparoscopic donor nephrectomy: a comparison of outcomes. *J Urol* 2001;166(4):1270-3.
14. Dunn JF, Nylander WA Jr, Richie RE, Johnson HK, MacDonell RC Jr, Sawyers JL. Living related kidney donors: a 14-year experience. *Ann Surg* 1986;203:637-43.
15. Nogueira, JM, Cangro JC, Fink JC, Schweitzer E, Wiland A, Klassen DK, et al. A comparison of recipient renal outcomes with laparoscopic versus open live donor nephrectomy. *Transplantation* 1999;67: 722-8.
16. Philosophe B, Kuo PC, Schweitzer EJ, Farney AC, Lim JW, Johnson LB, et al. Laparoscopic versus open donor nephrectomy: comparing ureteral complications in the recipients and improving the laparoscopic technique. *Transplantation* 1999; 68:497-502.
17. Ratner LE, Montgomery RA, Cohen C, Maley WR, Burdick J, Chavin KD, et al. Laparoscopic live donor nephrectomy: the recipient [abstract]. *Transplantation* 1998; 85:S109.
18. Lee BR, Chow GK, Ratner LE, Kavoussi LR. Laparoscopic live donor nephrectomy: outcomes equivalent to open surgery. *J Endourol* 2000;14:811-9.
19. Shoskes DA, Hanbury D, Cranston D, Morris PJ. Urologic complications in 1000 consecutive renal transplant recipients. *J Urol* 1995;153:18-21.
20. Rigg KM, Proud G, Taylor RM. Urological complications following renal transplantation: a study of 1016 consecutive transplants from a single centre. *Transplant Int* 1994;7(2):120-6.
21. Finelli FC, Gongora E, Sasaki TM, Light JA. A survey: the prevalence of laparoscopic donor nephrectomy at large US transplant centers. *Transplantation* 2001; 71:1862-4.
22. Ratner LE, Kavoussi LR, Sroka M, Hiller J, Weber R, Schulam PG, et al. Laparoscopic assisted live donor nephrectomy: a comparison with the open approach. *Transplantation* 1997;63:229-33.