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Retroperitoneoscopic Donor Nephrectomy: A Retrospective, Non-Randomized Comparison of Early Complications, Donor and Recipient Outcome with the Standard Open Approach

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Abstract

Objectives: We retrospectively performed a comparative analysis of retroperitoneoscopic and open donor nephrectomy in terms of donor complications, as well as recipient complications and functional graft outcome.
Methods: A total of 134 donor nephrectomies including 69 open (ODN) and 65 retroperitoneoscopic (RDN) nephrectomies was analyzed retrospectively. Both groups were comparable in terms of age, body mass index (BMI), operating time (OPT), warm ischemia time (WIT) and blood loss.
Results: There were no statistically significant differences with respect to recipient outcome, mean values for age, BMI, OPT and cold ischemia time (CIT). The overall donor complication rate did not differ. Early functional graft follow-up showed significant differences in 24 h-urine output between the two groups ($p < 0.001$), but serum creatinine was comparable after 7, 30, 180 and 365 days. The early rejection rate in the recipients was similar in the two groups.
Conclusion: Retroperitoneoscopic donor nephrectomy (RDN) provides comparable perioperative features, such as operating time, warm ischemia time (WIT) and overall complication rate to the open donor nephrectomy (ODN). Additionally, it has no negative impact on recipients' operating time, graft ischemia and early graft function.

Keywords: Retroperitoneoscopy; Donor nephrectomy; Comparison of techniques; Recipient outcome; Laparoscopy

1. Introduction

Living donor nephrectomy is unique in that it affects a healthy individual rather than a sick person. This makes it a very demanding and sophisticated surgical procedure. The safety and efficiency of the surgical technique are of utmost concern for the donor and the recipient. Therefore, the surgical technique recommended must entail the lowest possible morbidity

Abbreviations: ODN, open living donor nephrectomy; HLDN, hand-assisted laparoscopic living donor nephrectomy; RDN, retroperitoneoscopic living donor nephrectomy; OPT, operating time; WIT, warm ischemia time; BMI, body mass index; CIT, cold ischemia time; CsA, Cyclosporine microemulsion; MMF, Mycophenolate Mofetil; SRL, Sirolimus; AZA, Azathioprine; FK, Tacrolimus; Pred, Prednisolone.

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without compromising the functional outcome of the graft.

Since the early 1990s, transperitoneal laparoscopic techniques have been successfully adapted for various open urologic procedures, including laparoscopic living donor nephrectomy which was first described in 1995 [1].

Only few centers have reported a large number of kidney donations performed with the retroperitoneoscopic approach [2–5]. The most frequent arguments against the retroperitoneoscopic approach are the difficulty in establishing the topography, the smaller working space and a probably steeper learning curve compared to the transperitoneal approach.

In this retrospective study, we analyzed the perioperative outcome and early complication rate of donors and recipients after retroperitoneoscopic donor nephrectomy (RDN) as compared to standard open donor nephrectomy (ODN).

2. Materials and methods

From November 1997 to March 2004, 69 ODN and 65 RDN were performed at the Basel University Hospital. Since November 2001, retroperitoneoscopy has become our favored approach for living donor nephrectomy after we had used a standard open approach for donor nephrectomy for more than ten years. Right-sided donor nephrectomy was performed in 45 donors (34%). Indications for right-sided nephrectomy are listed in Table 1. All potential donors were routinely evaluated according to a donation protocol. Their suitability was discussed in detail by the transplantation team comprising nephrologists, urologists, visceral and vascular surgeons, transplantation coordinators, immunological laboratories and psychosomatics experts. Preoperatively, a conventional or a contrast enhanced magnet resonance angiography was performed to evaluate the vascular anatomy in all donors.

All perioperative data including operating time (OPT), warm ischemia time (WIT) and complication rate of donors and recipients were prospectively collected in the RDN group and compared retrospectively with the ODN group.

Table 1
Indications for right-sided living donor nephrectomy

	OLDN ($n = 69$)	RLDN ($n = 65$)
Left side		
Multiple arteries	13	9
Upper/lower pole artery	5	
Early division of artery branch	2	6
Doubled pyelon		1
Venous anomalies	1	
Right side		
Arterial stenosis	3	3
Vascular dysplasia	2	
Total	$n = 26$ (37.7%)	$n = 19$ (29.2%)

All intraoperative and postoperative complications within a period of 30 days were analyzed for this study. Intraoperative complications were immediately documented in the patient's chart by the surgeon. Postoperative complications were documented by the ward nurse or the ward resident. Complications after discharge were documented by an outpatient resident. Major complications were defined as complications that significantly detract from donor well-being, graft function or recipient well-being, including conversion, transfusion, re-operation or surgical graft damage.

A standard open extraperitoneal approach through a subcostal flank incision without rib resection was used in ODN. Our technique for RDN has recently been published in detail [6]. With the donor in a slightly overextended flank position, a 1–2 cm skin incision just below the tip of the twelfth rib is made and a small initial retroperitoneal space is created by index finger dissection. After insertion of a balloon dissector, the retroperitoneal space is bluntly dissected with infusion of approximately 800–1200 ml sterile 0.9% saline solution into the dissection balloon. We prefer to use water instaed of air, because the volume of infused water correlates exactly with extraperitoneal volume created by the following blunt balloon dissection. After removal of the balloon-dissector, a pneumoperitoneum is established with an intraabdominal pressure of 12–15 mmHg and the peritoneal reflection is bluntly mobilized antero-medially from the undersurface of the anterior abdominal wall with the tip of the camera in order to get a larger working working space and to be able to insert the additional trocars safely under vision. Intraabdominal pressures during nephrectomy above 15 mmHg are avoided. Finally, three more trocars (2×12 mm, 1×5 mm) are inserted in a typically diamond position. Gerota's fascia is incised laterally and the hilum is exposed. Dissection of the renal vessels is performed first after the kidney has been freed from the covering fatty tissue. The ureter is carefully dissected and clipped with two absorbable 12 mm clips. Only harvesting of the kidney is performed with hand-assistance. For this purpose, the lower trocar access is enlarged up to 7–9 cm by a muscle split incision and the surgeon's hand is inserted directly into the retroperitoneum. The incision diameter is large enough to ensure a safe, quick and careful removal of the kidney. Pre- (and postoperative) administration of diuretics was abandoned after February 2003. However for intra vessel volume expansion saline infusion is increased immediately prior to transsection in order to improve early onset of renal graft function. The kidney is raised and the renal vessels are optimally exposed for transection that is performed using a TA*-30-2.5 (AutoSuture®) disposable stapler on both artery and vein. Subsequently, the kidney is stored on cold storage solution (Viaspan®) until a clear venous effluvium is visible. The kidney is put in a sterile plastic bag and taken forthwith to the next operation room, where the implantation is performed immediately.

Operating time (OPT) was defined as the period between skin incision and skin closure. We defined warm ischemia time (WIT) as the time from closure of the renal artery to the time when clear outflow of the cold irrigation solution (Viaspan®) in the renal vein was detected.

As part of a study protocol, recipients transplanted from February 1998 to December 2000 were randomized 1:1 to either triple therapy with CsA/MMF/Pred or FK/AZA/Pred. As part of a second study protocol, patients transplanted from January 2001 to October 2003 were randomized 1:1 to either SRL/MMF/Pred or CsA/MMF/Pred. From October 2002 all patients additionally received two doses of anti-interleukin-2 receptor antibody basiliximab (day 0 and day 4). All patients with clinical suspected acute rejection (creatinine increase more than 25% from baseline, weight gain, and

elevated blood pressure) were biopsied within 72 hours. Between January 2001 and February 2004, as a part of a study, we performed a renal protocol biopsy at the end of month 3 and 6 post transplantation.

All data expressed as mean ± standard deviation or available numbers of cases, if appropriate. Statistical analysis was performed with the SPSS 11.5 (SPSS Inc., Chicago, IL) statistical software package. The Mann–Whitney *U* test was used to compare the two categories of independent non-parametric numerical data. The chi-square test was employed to compare categorical data. A p value of less than 0.05 was considered to be statistically significant.

3. Results

From November 1997 to March 2004, we retrospectively analyzed 134 medical records after 69 ODN operations and 65 RDN operations. Detailed donor characteristics are presented in Table 2. With RDN, two (3%) conversions were necessary because of a renal artery disruption ($n = 1$) and because of two very short renal veins (<1 cm) on the right side, which opened directly into the vena cava. In both cases, the kidney was harvested and subsequently transplanted successfully without persistent impairments for the donors or recipients.

Both groups were comparable in terms of age, body mass index (BMI), OPT, WIT and blood loss. Donors after RDN were discharged from the hospital significantly earlier ($p < 0.001$) than after ODN. In RDN donors, serum creatinine was significantly higher during the first five postoperative days when compared to the ODN group (Fig. 1).

Overall, major, minor, intraoperative and postoperative donor complication rates did not differ significantly between the two groups. Donor complications are listed subsequently in Table 3.

General demographic recipient data and functional follow-up is presented in Table 4. Differences of mean values for age, OPT and cold ischemia time (CIT) were not statistically significant. Early functional follow-up showed significant differences in 24 h-urine output between the two groups ($p < 0.001$), but this parameter was comparable after 7, 30, 180 and finally 365 days (Table 4). Corresponding to the higher serum creatinine values in the RDN group, grafts after RDN showed a greater delay in onset of function than after ODN. However, from the 7th postoperative day there was no statistically significant difference between the two groups.

Table 2
Perioperative data and donor characteristics after 134 living kidney donations*

	OLDN	RLDN	$p^{\dagger}$
No. of donors	69	65	
Age (years)	53 (29–77)	53 (27–79)	0.924
BMI (kg/m^2)	26 (17–32)	26 (17–40)	0.521
Gender female/male	45/24	44/21	–
Side left/right	43/26	44/19	–
Operating time (min)	160 (60–240)	152 (60–270)	0.072
WIT (s)	114 (60–190)	127 (50–480)	0.379
Blood loss (ml)	210 (50–600)	187 (50–1200)	0.117
Hospital stay (days)	13 (9–22)	11 (4–29)	<0.001

* Data rounded.
† Mann–Whitney *U* test.

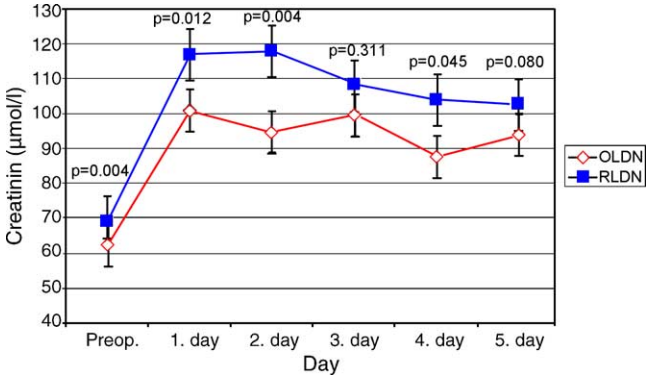

Fig. 1. Early postoperative follow-up of serum creatinine (donor) after standard open (ODN) and retroperitoneoscopic (RDN) donor nephrectomy.

Overall recipient complication rate and total early rejection rate within 30 days were similar within the two groups. There was no elevation of the rate of surgical complications due to technical problems during endoscopic kidney delivery in the RDN group. However, a renal artery kinking led to a primary nonfunctioning of the graft in one recipient after RDN. This recipient was re-operated. Moreover, a venous saphena patch was necessary in two right-sided donations because of very short right renal veins (<2 cm). Longer functional follow-up of both grafts was uneventful, although early glomerular function was delayed in these grafts. The recipients' major complication rate was comparable in the two groups (Table 4). After RDN, we observed a significantly delayed onset of early function ($p = 0.025$), but this did not entail repercussions for longer-term follow-up (Table 4).

4. Discussion

During the last fifty years, the standard open extraperitoneal or transperitoneal access has proved to be a safe approach for donor nephrectomy and is associated with a low complication rate [6]. However, flank incision entails significant postoperative problems including prolonged postoperative pain, scarring, permanent flank bulging, pleural irritation or subcostal

Table 3
Perioperative donor complications within 30 days after open (OLDN) and retroperitoneoscopic living donor nephrectomy (RLDN; $n = 134$)

	OLDN	RLDN	$p^{\ddagger}$
Number of cases	69	65	
Intraoperative	–	2	
Conversion to the open approach[‡]	1	0	
Pleural laceration with necessity of drainage[‡]	0	1[†]	
Bleeding with blood transfusion[‡]	0	1	
Ureter injury[‡]			
Total	1/69 (1.5%)	4/65 (6.2%)	0.198
Postoperative	4	1	
Severe wound pain	0	1	
Hematoma requiring transfusion[‡]	0	1	
Chyloretroperitoneum with chylothorax requiring re-operation[‡]	1	0	
Paralysis, nausea, vomiting	4	1	
Wound infection/dehiscence/large hematoma (no transfusion)	0	1	
Transient fever within 24 h postoperative	0	1	
Pyelonephritis	2	2	
Pneumonia	1	3	
Pleural emphysema/effusion	0	1	
Cardiac ischemia[‡]	1	0	
Asthmatic distress[‡]	3	1	
Urinary problems (retention, prostatitis)			
Total	16/69 (23.2%)	13/65 (20%)	0.839
Major complication[‡]	2/69 (2.9%)	7/65 (10.7%)	0.090
Minor complication	15/69 (22.1%)	10/65 (15.4%)	0.382
Overall complications	17/69 (24.6%)	17/65 (26.1%)	0.846

Data presented as frequencies.
[†] This case is one of the cases that had to be converted.
[‡] Fisher's exact test (2-sided).

nerve injury [7]. Therefore, some surgeons were happy to carry out minimal flank incision for living donor nephrectomy in order to minimize skin incision [8]. Usually, the main argument for choosing this technique is to avoid the well-known learning curve associated with laparoscopic donor nephrectomy. Drawbacks of the minimal flank incision technique are the limited overview of the anatomical structures and the confined working space which can make it very difficult to handle intraoperative problems.

Since Ratner et al. first performed a laparoscopic living donor nephrectomy in 1995 this procedure has become a widely accepted alternative for living donation [1]. Data is also available suggesting that it can increase the rate of kidney donations [9]. The laparoscopic access is technically challenging and is usually associated with longer OPT and WIT. However, the conventional laparoscopic technique leads to less perioperative pain, earlier mobilization and return to normal activities when compared to the open approach [10–12]. Besides these advantages of minimally-invasive techniques, graft integrity must be maintained and adequate lengths of ureter and renal vasculature must be available.

Our preliminary experience with RDN in comparison to the ODN has recently been published [13]. The retroperitoneoscopic approach combines the blunt and quick endoscopic creation of the anatomical retroperitoneal space and obviates lateral-colic peritoneal dissection or the adhesiolysis entailed in the conventional laparoscopic approach. OPT comparable to those for the ODN have not been published for the conventional laparoscopic approach up to now. Hand-assistance would appear to be an appropriate tool for improving safety and shortening OPT [4,14,15]. However, hand-assistance does not necessarily speed up OPT with the retroperitoneoscopic approach. In contrast to the conventional laparoscopic approach, hilum preparation is performed first during retroperitoneoscopy. That guarantees fixation of the kidney by anterior connective tissue with the peritoneum with enough room for vessel dissection. Therefore, hand-assistance itself only entails limited advantages during this step. However, hand-assistance makes the harvesting process safe and quick during retroperitoneoscopic donor nephrectomy. Additionally, the artery that has to be transected first is easily reached for the transection process because of the dorsal

Table 4
Recipient outcome after standard open (ODN) and retroperitoneoscopic (RDN) donor nephrectomy

	ODN	RDN	$p^{\dagger}$
Perioperative data			
No. recipients	69	65	
Age (years)	48 (19–69)	47 (17–72)	0.897
BMI (kg/m^2)	24 (15–33)	23 (19–32)	0.116
Gender female/male	45/24	44/21	
Operating time (min)	138 (75–270)	150 (90–240)	0.051
CIT (min)	58 (29–120)	67 (40–127)	0.055
Hospital stay (days)	17 (6–46)	12 (6–39)	0.001
Functional follow-up			
S-Creatinine (μmol/l) preoperative	710 (451–1138)	791 (391–1561)	0.095
Urine output, −24 h (l)	11 (2–22)	7 (2–22)	<0.001
Creatinine fall (%, −24 h)	43 (40–86)	41 (8–82)	0.275
S-Creatinine-day 7 postoperative	153 (66–752)	173 (67–549)	0.255
S-Creatinine-day 30 postoperative	134 (78–313)	146 (62–542)	0.363
S-Creatinine-day 180 postoperative	155 (85–298)	166 (79–461)	0.586
S-Creatinine-day 365 postoperative	159 (77–430)	148 (62–570)	0.312
Complications			
Rejection rate overall within 30 days (based on renal biopsy)	30 (43.5%)	20 (30.8%)	0.110
Interstitial	23	11	
Vasculare	7	9	
Major complication[‡]	15 (21.7%)	10 (15.4%)	0.382
Delayed non function	0	5 (7.6%)	
Primary non function	0	1 (artery kinking, reoperation)	

S-creatinin, serum creatinin.
[†] Mann–Whitney *U* test.
[‡] Related to surgery, re-operation required or vascular revision (angiography with PTA) or bleeding needing transfusions (>3 units) or consequences on graft function.

access to the vessels. This contrasts with the conventional laparoscopic approach. Therefore, we observed statistically comparable WIT for both approaches in our series (Table 2). It should be noted that a WIT of 2–4 minutes has never been demonstrated to affect delayed graft function or acute tubular necrosis. To our knowledge, no study confirming that hand-assisted retroperitoneoscopic donor nephrectomy is superior to fully retroperitoneoscopic donor nephrectomy in terms of OPT, WIT and complication rate has been published. However, the advantage of the hand-assisted retroperitoneal approach compared to the standard open or conventional laparoscopic approach has been demonstrated [3,14,15].

Besides optimized graft function, donor safety is of utmost concern. It is therefore mandatory to offer the donor a surgical technique that is safe and subject to minimal complications. Laparoscopic donor nephrectomy is a complex procedure and should be performed only by surgeons skilled in laparoscopy to maximize safety and assure efficient complication management. As a result of our series, the overall complication rates in donors and recipients were statistically similar in the two groups (Tables 3 and 4). The present study thus confirms that RDN has a low rate of major and minor complications that is comparable with that of the standard open and laparoscopic technique [6,10,11,14,16,17]. We found that the greater complexity of the retroperitoneoscopic procedure led to a slight tendency to more intraoperative problems during RDN (Table 3). However, differences in the rate of intraoperative and postoperative complications did not reach significant levels. The absence of intraoperative and postoperative visceral complications is an advantage of endoscopic extraperitoneal surgery. Most of the donors typically recommenced oral food intake and were fully mobilized without any delay. RDN donors experienced less postoperative pain, irrespective of the type of perioperative regional anesthesia [18]. Depending on how these were defined, the rate of major complications in our series was in the range of published data for open (1–6%) or laparoscopic techniques (1–6.3%) [10,13,14,18,19]. The pleural and pulmonary complications observed after RDN (6.3%) have to be seen in conjunction with the close proximity of the first trocar to the 12th rib. Pleural complications are not confined to retroperitoneoscopy, as 5.6% pneumomediastineum and atelectasis have been reported with open donor nephrectomy, too [19]. Because of our experience, we try to place the first 12 mm trocar more distally to the tip of the 12th rib in order to avoid these complications in RDN. Our reported complication rate represents the whole learning curve of

two laparoscopic experienced surgeons. The retroperitoneoscopic approach has become the favoured approach for renal surgery since years at our institution. Even after having experiences with all kind of renal surgery including tumor enucleation and partial nephrectomy, pyeloplasty, adrenalectomy and laparoscopic radical prostatectomy for years, we have adopted donor nephrectomy to the retroperitoneoscopic approach. This is important to mention, because donor nephrectomy remain a high-risk operation with potential to harm donor and the graft and learning curve for donor nephrectomy should and has to be zero [20].

Carbon dioxide absorption is an issue familiar from conventional laparoscopic surgery. In order to prevent this, RDN was performed in a gasless technique [4]. The authors emphasized that this technique seems to suffer from the disadvantages that more wound pain is caused by the retractor and that the working space achieved is smaller than with a retropneumoperitoneum. Similar to the problem of carbon dioxide absorption, donors after RDN experienced significantly higher serum creatinine retention than donors after ODN within the first postoperative days in our series. Correspondingly, graft function in recipients after RDN shows a tendency to delayed onset of renal function as measured by 24 hours urine output. However, this effect was not significant in the subsequent postoperative days (Table 4). We observed no statistically significant difference between the groups for decrease of creatinine within 24 hours postoperatively or in the serum creatinine at 7, 30, 180 and 365 days (Table 4). However, we observed a tendency of delayed creatinine decrease (graft function) within the first weeks in the RDN group. Graft function within a follow-up of one year shows comparable results in the two groups. It still remains speculative whether the delayed onset of renal function after RDN (Fig. 1) in donors and grafts is associated with the CO_2-based respiratory acidosis as a result of pneumoretroperitoneum during RDN. In addition, the higher abdominal pressure that diminishes renal blood flow can also cause renal failure. Additionally, it has been shown by experimental studies, that the increased intra-abdominal pressure during laparoscopic nephrectomy significantly reduces renal blood flow, especially diastolic perfusion [21]. Thus, intra-abdominal pressures of 20 mmHg lead to a decrease of glomerular filtration rate by approximately 25% of normal [22,23]. Although we used a strictly retroperitoneal access, the problems associated with carbon dioxide gas resorption encountered in the conventional laparoscopic approach also seem to be present during retroperitoneoscopy. Others have shown that retroperitoneal carbon dioxide insufflation causes more carbon dioxide absorption than intraperitoneal insufflation [24] However, the issue of retroperitoneal carbon dioxide absorption during retroperitoneoscopy remain unsolved, as prospective clinical studies have shown no greater carbon dioxide absorption compared to transperitoneal laparoscopy [25].

The number of acute rejection episodes within the first 30 days was comparable in the two techniques. We are aware that the early rejection rate we observed was considerably higher than others have reported. However, this has to be seen in the context of our biopsy policy, that might leading to a higher rejection detection rate. One-year results of serum creatinine, which are a strong predictor for long-term graft outcome, were not negatively influenced by the choice of the harvesting technique [26,27].

5. Conclusion

The retroperitoneoscopic approach is a safe, quick and practicable access route for living donor nephrectomy. The perioperative features of retroperioneoscopic living donor nephrectomy such as operating time, warm ischemia time and overall complication rate are comparable to those of open donor nephrectomy. It has no negative impact on recipients' operating time, graft ischemia and graft function.

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Editorial Comment

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Living donor nephrectomy (LDN) is a surgical challenge where surgery is performed in a healthy individual. Classically open approach has been considered the gold standard for LDN. At present, laparoscopic approach allows to obtain kidneys for renal transplant with minimal morbidity for the donor. However, it has a long learning curve and is associated with longer operative and first warm ischemia times than open nephrectomy.

A purely retroperitoneoscopic access in LDN is used only by few centres worldwide. Theoretically, this approach has some advantages: it obviates laterocolic peritoneal dissection, the renal artery is easily reached due to the dorsal approach to the kidney and the procedure is entirely extraperitoneal, reducing the risks of intraoperative visceral lesions.

Bachmann et al. reported one of the longer series in the literature on retroperitoneoscopic nephrectomy for renal transplant with two important details: It is the first reference in which an endoscopic approach reflects a comparable operative time to the classical open approach with a similar first warm ischemia time. Secondly, the long-term functional outcome of the grafts harvested by retroperitoneoscopy is similar to those obtained by open techniques.

Anyway, from a practical point of view, considering the shortage of cadaveric kidneys for transplantation, living organ donation should be potentiate. The less invasive character of laparoscopic or retroperitoneoscopic LDN is an important factor in order to increase the number of kidneys for transplantation, especially in young recipients.