Transpl Int (2003) 16: 419–424
DOI 10.1007/s00147-003-0561-y

ORIGINAL ARTICLE

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Laparoscopic right nephrectomy for live kidney donation: functional results

Received: 14 March 2002
Revised: 2 August 2002
Accepted: 23 August 2002
Published online: 26 March 2003

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Abstract Laparoscopic live-donor nephrectomy has gained wide acceptance. However, the vast majority of surgeons perform left nephrectomies only, which may not always be in the best interest of the donor. Of 17 consecutive laparoscopic donor nephrectomies, 13 were done on the right side. The function of these grafts was compared with that of 17 kidneys previously procured by an open technique and with that of the four left laparoscopic grafts. Ischaemic damage was evaluated by post-operative nuclear scanning and urinary lysozyme, and graft function by creatinine and creatinine clearance. Results show that operating time was longer in the laparoscopic donors, but identical in right and left laparoscopic procurements. Ischaemic damage and function were similar, regardless of the side or the surgical technique. We can conclude that right laparoscopic donor nephrectomy is feasible and results in good graft function. Systematic harvesting from the left side may, therefore, not be justified.

Keywords Kidney · Living donors · Laparoscopy · Transplantation

Introduction

The persistent shortage of cadaveric kidneys available for transplantation has stimulated live donation. The excellent results obtained with both genetically related and unrelated donors [6] have increased this trend. The recent description of laparoscopic allograft harvesting [10, 16] has promoted this option even further. The benefits of the laparoscopic procedure for the donor have been extensively described, but whether the functional results in the recipient of the laparoscopically procured grafts are equivalent to those obtained by classical open methods remains controversial. Of particular concern are the results obtained with grafts harvested by coelioscopy from the right side, as most of the published data have been gained from left nephrectomies. The majority of surgeons do prefer to operate on the left because the right vein is short, and they fear thrombosis and consecutive graft loss [13]. In this single-centre study, we compare the functional outcome of grafts harvested laparoscopically from the right and from the left sides with the outcome of a previous series of grafts procured by laparotomy.

Patients and methods

Eras

As we performed our last open nephrectomy (ON) in August 1998 [2], we compare all our procurements by laparotomy since 1993 (era I) with those done laparoscopically from September 1998 to May 2001 (era II). During both eras, we used the same pre-operative criteria to assess the potential donors. In era II, nobody was denied the laparoscopic approach because of an anatomical anomaly such as a short vein or multiple arteries, and we had no preconceived preference for left or right kidney procurement. A magnetic resonance image or a spiral CT scan with three-dimensional

reconstruction was obtained for assessment of the renal vascular anatomy. Before the operation, all donors of era II were informed that laparoscopy would be converted to open surgery should any technical difficulty arise. In both eras, a pre-operative renal nuclear scan was performed on the donors, with Tc^{99m} MAG3 or, in some early cases, I^{123} Hippuran, being used; a difference in function of between 45% and 55% was regarded as normal [3]. If the function was symmetric on the nuclear scan and the vascular anatomy was standard, left nephrectomy was favoured. In the presence of multiples arteries, or early division (within 1 cm of the ostium), the side with the simpler anatomy was chosen. In asymmetrical function, the side with lesser function was taken.

Surgical techniques

Open nephrectomy was performed transperitoneally through a subcostal incision: first, we dissected the vascular pedicle, keeping away from the hilum; then the kidney and the ureter were mobilised; eventually, the ureter and the vessels were cut. The extracted kidney was perfused on a back table with cold University of Wisconsin (UW) solution.

The laparoscopic operation was also performed transperitoneally, the patient lying on the side opposite to that of the nephrectomy. The first trocar was introduced, an open technique 2–3 cm cranial to McBurney's point being used. The pneumoperitoneum was then established and electronically maintained at a pressure of 8 mmHg. Two further 10-mm trocars were introduced under visual control, one approximately 3 cm lateral and cranial to the umbilicus and the other 6–8 cm more cranially. For right nephrectomies, a 5-mm trocar was placed below the xyphoid process, to the left of the round ligament. It accommodated a static forceps, placed under the liver and grasping the diaphragm. A further 5-mm trocar was inserted in the loin to help with the handling of the kidney. Dissection was carried out with a 10-mm Ultracision Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, Ohio, USA). On the left side, an en-bloc mobilisation of the left colon, tail of the pancreas, and spleen, was performed. On the right side, the colon, the right liver lobe and the duodeno-pancreas were extensively mobilised. The renal vein was then dissected; on the right side, the inferior vena cava was also prepared from the liver to the iliac confluence. On the left side, gonadal, adrenal and, if present, lumbar veins, were ligated and divided. After dissection of the renal artery at its ostium on the left side and as far as possible behind the cava on the right, we prepared the ureter, keeping as much as possible of the surrounding areolar tissue; it was then clipped and cut at the level of the iliac vessels. Finally, the kidney was cleared from the peri-renal fat and placed in an extraction bag (Dexide bag, U.S. Surgical Corporation, Norwalk, Connecticut, USA). After heparinisation of the donor (Heparin 5,000 UI i.v.), the artery was divided distal to a clip (ChallengeTi Aesculap AG, Tüttlingen, Germany). We preferred clipping to vascular stapling to save arterial length. On stumps shorter than 5 mm, two clips were used. The kidney was allowed to empty of its blood before the vein was divided with a commercially available laparoscopic vascular stapler (ETS Ethicon Endo-Surgery). The kidney was finally extracted through a 5 to 6-cm suprapubic Pfannenstiel incision and perfused on a back table with cold UW solution. The warm ischaemia time was measured, from arterial clipping to the beginning of cold perfusion: this was recorded precisely in the laparoscopic nephrectomy (LN) group but not in the ON donors. Heparinisation was reversed with protamine, before closure of the Pfannenstiel and the 10 to 12-mm trocar incisions.

Postoperative assessment

After preparation on the back table, the grafts were transplanted extraperitoneally on the iliac vessels. All recipients received cyclosporine-based immunosuppression, with prednisone and, since 1998, induction therapy (basiliximab, Novartis, Basle, Switzerland).

We collected the data of era I retrospectively and era II prospectively. The overall data of era II were compared with those of era I; those of right LNs (RLNs) were also compared with those of left LNs (LLNs). In order to assess early graft function, we performed a nuclear scan on the recipients on post-operative day 2 or 3. The accumulation index (AI) and excretion index (EI) were recorded. The AI reflects the cortical perfusion and the EI the severity of acute tubular necrosis [3]. At this early post-operative phase, both indices correlate essentially with ischaemic graft damage, as the onset of acute rejection tends to occur later; the results were compared with those previously obtained in the donors. The urinary lysozyme was measured in both eras on post-operative day 1, as a marker of acute tubular necrosis [9]. Serum creatinine and creatinine clearance on a 24-h urine collection were measured at fixed intervals. Intra-operative and post-operative surgical complications likely to influence the outcome were recorded.

Statistics

Student's t and the chi-square tests were used where appropriate.

Results

Thirty-four consecutive renal transplants from living donors were analysed, 17 in era I; and 17 in era II. There were 13 RLNs and four LLNs. Reasons for RLNs are listed in Table 1. Demographic data of the ON and LN patients are summarised in Table 2: in both groups, the ages of the donors and recipients were similar; there

Table 1 Reasons for right donor laparoscopic nephrectomy ($n = 13$)

Reason	n
Better pre-operative function of left kidney	9
Left multiple renal arteries or early division	3
Right pyelo-ureteral stricture due to arterial compression	1

Table 2 Demographic data of the era-I (*ON*) and era-II (*LN*) donors and recipients

Parameter	ON ($n = 17$)	LN ($n = 17$)
Donors		
Age (years)	50.3 ± 11.4	48.5 ± 11.6
Male/female ratio	1.4	0.4
Right/left nephrectomy	14/3	13/4
Operating time (min)	167 ± 28	198 ± 38*
Mean warm ischaemia time (min)	–	4.1 ± 3.9
Length of stay (days)	8.2 ± 1.6	4.6 ± 1.1*
Recipients		
Age (years)	38.1 ± 12.4	45.9 ± 12.0
Male/female ratio	0.9	0.9
Genetically related/unrelated	14/3	9/8
Median (range) follow-up time (months)	55.7 (35–102)	17.8 (2–35)

*$P \leq 0.01$

were more male donors in era I than in era II; in both eras the majority of the nephrectomies were done on the right side. In era II there were more genetically unrelated recipients; the mean operating time was half an hour longer in era II, which was statistically significant. Conversion from laparoscopy to the open method was never necessary. The median warm ischaemia time was 3.0 (2.5–20) min in era II, not exceeding 3 min in our last ten cases. The warm ischaemia time was not measured in era I, although it can reasonably be assumed to have been shorter. During both eras morbidity in the donors was minimal, without significant urinary leakage, chest infection, wound pain or discharge; no blood transfusion was required; there was no mortality. In one LLN donor an upper polar artery was inadvertently cut: it had been missed by the pre-operative imaging, but successful reconstruction could be done on the back table. The same donor suffered from a post-operative haematoma of the loin. Two other vascular reconstructions had to be done on RLN grafts, one because of a double artery and the other because of a double vein. Tension-free anastomosis of the short right renal vein is achieved by the complete mobilisation of the iliac vein, with, if necessary, section of the internal iliac vein. One ON graft that had been harvested from the right side in the donor was lost immediately after transplantation, due to venous thrombosis. The ON donors stayed significantly longer in hospital. Since era-I donors were historical controls, their follow-up was longer. One ON recipient moved abroad after 1 year and was lost for later follow-up. Another era-I recipient died with a functioning graft 4 years post-operatively.

Table 3 summarises the comparison between LLN and RLN. There was no significant difference regarding age, gender of donors and recipients, genetic relationship, duration of operation, length of hospital stay and ischaemia time.

In the recipients the mean urinary lysozyme concentration at day 1 was similar in both eras; there was no difference either, in era II, between the RLN and LLN recipients (Table 4). One RLN patient needed dialysis for 1 week after transplantation due to acute tubular necrosis related to severe intra-operative hypotension. This haemodynamic event had been caused by an acute thrombosis of the superior vena cava during the transplantation, induced by a pre-operatively positioned dialysis catheter. An emergency thrombectomy under extracorporal bypass had to be performed and turned out to be successful. As this patient remained anuric for a week we were unable to assess the urinary lysozyme at post-operative day 1. The patient of era I who lost his graft due to a thrombosis of the renal vein also needed dialysis immediately after undergoing transplantation.

The nuclear scan demonstrated similar early graft function in both eras and in both subgroups of era II (Table 4), as reflected by the AI and EI. Comparing AI and EI in the donors and in the recipients, we saw evidence of an early post-operative AI decline, reflecting a poorer perfusion after transplantation. EI declined too, as we witnessed by the ischaemic damage. This early decrease in the indices was similar in both eras and in the subgroups of era II.

The levels of serum creatinine (Fig. 1) and creatinine clearance (Fig. 2) did not show significant differences between the eras.

Table 3 Comparison between LLNs and RLNs

Parameter	LLN ($n=4$)	RLN ($n=13$)
Donors		
Age (years)	58.2 ± 8.9	45.5 ± 10.6
Male/female ratio	1.0	0.3
Operating time (min)	207 ± 48	182 ± 33
Mean warm ischaemia time (min)	4.0 ± 2.4	4.2 ± 4.2
Recipients		
Age (years)	42.6 ± 8.2	46.9 ± 12.8
Male/female ratio	1.0	0.9
Genetically related/unrelated	2/2	6/7
Median (range) follow-up time (months)	28.3 (2–31)	19.6 (2–35)

Discussion

Since its initial description, the use of laparoscopic renal live donation has been spreading fast. The advantages for the donor are manifold: less pain and fewer scars, improved cosmesis, shorter hospital stay and absence from work and social activities. Although this

Table 4 Comparison of functional results: lysozyme and nuclear scanning (*POD* post-operative day)

Parameter	Era I (ON)	Era II (LN)	
	$n=17$	LLN $n=4$	RLN $n=13$
Lysozyme POD 1 (IU)	497 ± 482	439 ± 224	430 ± 378
Mean AI (donor)	8.4 ± 1.9	7.4 ± 1.2	8.7 ± 1.9
Mean AI (recipient)	6.6 ± 2.5	4.6 ± 1.4	6.2 ± 1.6
AI recipient/AI donor (%)	78	62	71
Mean EI (donor)	8.9 ± 2.8	6.3 ± 1.4	7.0 ± 2.5
Mean EI (recipient)	1.7 ± 1.4	1.4 ± 0.4	1.8 ± 1.0
EI recipient/EI donor (%)	19	18	26

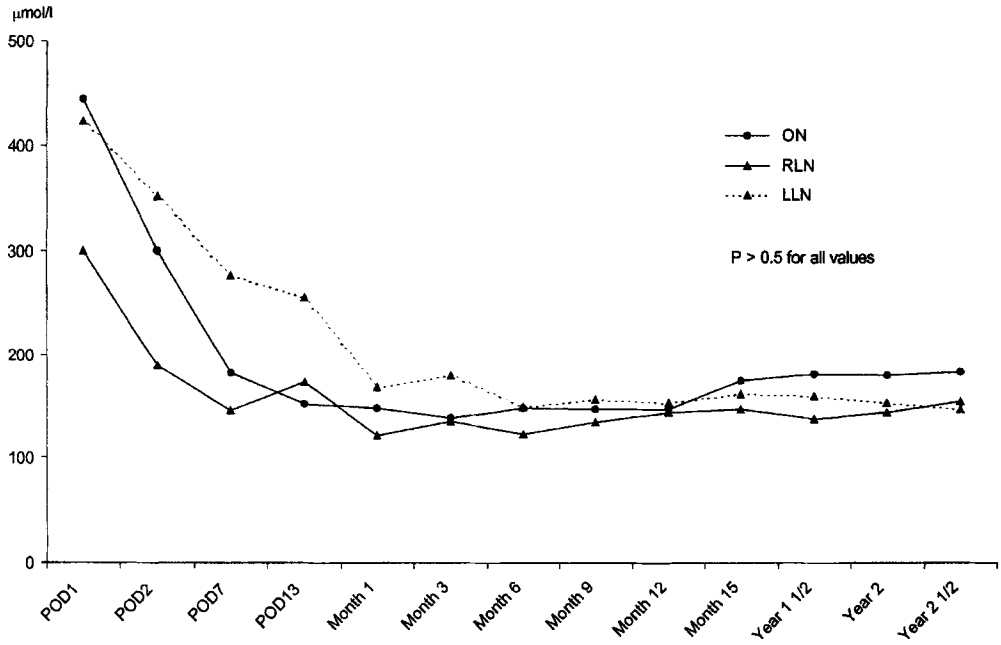

Fig. 1 Mean post-operative serum creatinine levels

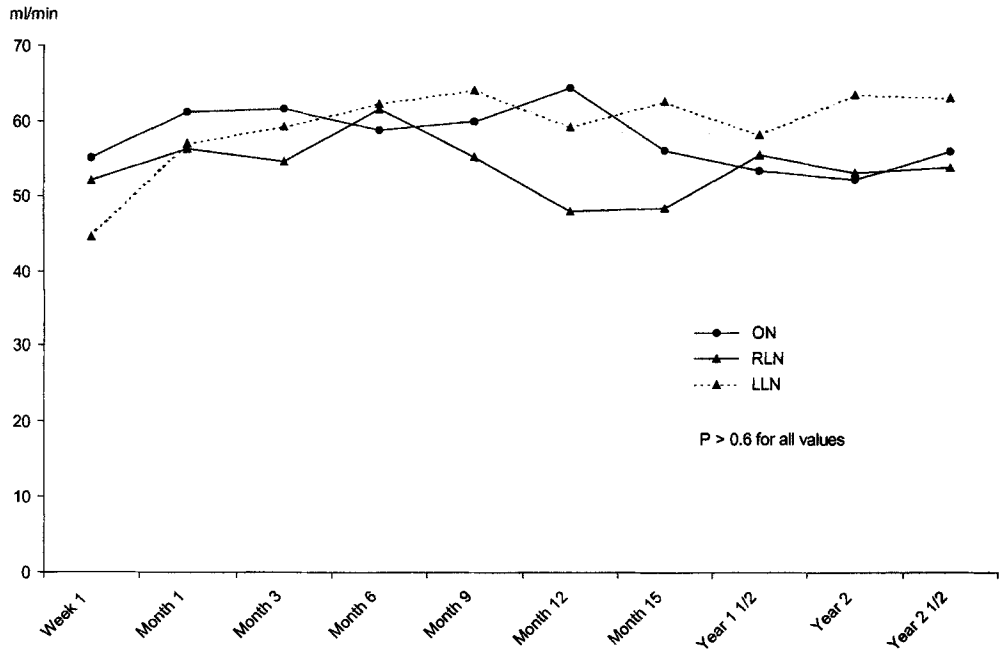

Fig. 2 Mean creatinine clearance

approach increases the rates of donation [18] and can be performed safely, it does not benefit the recipient directly. Some authors even claim that these grafts are of lower quality, as only few studies have described their function [1, 11, 17]. Laparoscopic harvesting may indeed harm the kidney in many ways: the pneumoperitoneum could impair the venous outflow; the handling of the kidney being more difficult, the organ may twist and the arterial inflow could therefore be compromised; excessive traction on the artery may induce a spasm or even a wall dissection; and the warm renal ischaemia time is increased. In addition, most groups that perform laparoscopic kidney harvesting are reluctant to operate on the right side because of the short length of the vein. The initial experience with right-sided nephrectomy of the pioneer group of Ratner was indeed disappointing, as three of eight transplantations were complicated by thrombosis [12]. This led these authors to modify their technique by performing an open division of the renal vein through a short subcostal coeliotomy. Using this

modification, they achieved nine additional successful right-sided laparoscopic nephrectomies. More recently, a retrospective North American seven-centre review of 97 right laparoscopic nephrectomies [5] also indicated that successful transplantation are able to be achieved with grafts provided by right living-donor nephrectomy. In the latter collective series, two grafts were lost, and graft function, assessed by the recipients' serum creatinine only, appeared to be similar to that of transplants procured by an open technique or by left laparoscopic nephrectomy. However, the authors did not mention the rate of delayed graft function and did not quantify the ischaemic damage. This missing information is provided by our study, as we measured the early function of the grafts by comparing nuclear scans before and shortly after transplantation. In addition, other markers of function (serum creatinine, creatinine clearance and urinary lysozyme) were also followed, allowing us to make an accurate assessment of the ischaemic insult to the graft. In this context, we found nuclear scanning particularly helpful for early assessment, as it provides reference functional indices before the organs are harvested. The decrease of the AI and EI after transplantation was similar in the ON and LN grafts; there was no difference, either, between the right and left LN transplants. Among the laparoscopic grafts, three had low post-operative indices, which could be explained by technical difficulties. In the first case, the patient sustained severe and prolonged hypotension (IA: 2.6; IE: 0.7) due to superior vena cava thrombosis during transplantation and provided, therefore, the only case of delayed graft function. The second (IA: 3.1; IE: 0.7) had required vascular reconstruction after an accidental injury to an upper polar artery during procurement. In the third graft with low post-operative indices (IA: 6.8; IE: 0.6) the extraction of the kidney was complicated by a rupture of the plastic bag, resulting in a warm ischaemia time of 20 min. Since then we have put the kidney into the plastic bag before cutting the vessels, hence reducing the manipulation of the bag during the warm ischemia time.

For the mid-term function assessment of the grafts, we relied on the follow-up of the serum creatinine level and creatinine clearance of the recipients: we demonstrated no difference between the ON and the LN, or between the RLN and LLN transplants. This is certainly very encouraging; however, we realise that we had only a few LLNs available for comparison with RLNs. In addition, we are aware that the real endpoint will be the long-term survival of the laparoscopic grafts. It is still possible that subtle alterations in the renal inflammatory response may contribute to the late development of chronic allograft nephropathy. Only very long follow-up studies will settle this issue, since the half-life of a conventionally procured live-donor graft is currently more than 12 years [7]. Although there are indications that good early function heralds long-term survival [4], we still have to wait before we understand completely the impact of the laparoscopic live-donor procedure on graft function. At the moment it can only be assumed that the coelioscopic approach per se does not harm the kidney more than open surgery does, and that right or a left procurement makes no significant difference.

In living-donor transplantation, the potential loss of a graft is a vital issue. This did not happen in our LNs, but occurred once among the historical ON series. We believe that the improved results of the present series in comparison with previous reports of right laparoscopic live-donor nephrectomies are mainly due to modifications of the operating technique. First of all, it is crucial for one to obtain full mobilisation of the right side of the inferior vena cava along its entire infra-hepatic portion; to this end, lumbar veins must be divided. The trocar location for the vascular stapler has to allow a section line parallel to the vena cava. As the right renal vein is often thin-walled, we advise the inclusion, whenever possible, of its caval ostium in the graft to provide better tissue for the anastomosis. To achieve this, the kidney must be fully mobilised, and a forceps has to stretch the renal vein so that the cut is on the attracted vena cava. Such harvesting of a caval rim does not narrow the inferior vena cava. The implantation operation is also of importance [5]: tension-free anastomoses are best achieved by surgeons who master vascular reconstructions, as these are often more complex than in conventional cadaveric kidney transplantation.

In conclusion, we feel that LN is here to stay and that procurement on the right side is as feasible and as safe as on the left. We expect our results to be confirmed by other transplant units, ideally in the setting of a randomised trial [14], but more probably by further observational studies and registries data [4, 15]. This will allow the side of the nephrectomy to be chosen in a donor-orientated manner, by the "worse" kidney being harvested, i.e. the one with the lesser function on a predonation nuclear scan. As the left kidney is usually bigger [8], we performed more right than left nephrectomies by laparoscopy, as we did in the days of open procurement. We do believe that when one offers a live-donation programme it is the surgeon's duty to respect the donor's right to keep the better kidney in case of an anatomical or functional asymmetry, irrespective of that surgeon's technical preferences.

References

1. Berney T, Malaise J, Mourad M, Morel P, Squifflet JP (2000) Laparoscopic and open live donor nephrectomy: a cost/benefit study. Transpl Int 13:35–40
2. Bettschart V, Schneider R, Berutto C, Groos R, Wauters JP, Edye M, Mosimann F (2000) A step-by-step approach to laparoscopic live donor nephrectomy. Transplant Proc 32:117–118
3. Bischof-Delaloye A, Wauters JP, Delaloye B (1982) Accumulation and elimination indices in the long term follow-up of renal transplants. In: Joekes AM, Brown NJG, Tauxe WN (eds) Radionuclides in nephrology. Academic Press, London, pp 283–288
4. Boschiero L, Foroni R, Tonini M, Ancona G (2000) An objective method for detecting time-dependent effects in graft survival. Transpl Int 13 [Suppl 1]:112–116
5. Buell JF, Edye M, Johnson M, Li C, Koffron A, Cho E, Kuo P, Johnson L, Hanaway M, Potter SR, Bruce DS, Cronin DC, Newell KA, Leventhal J, Jacobs S, Woodle ES, Bartlett ST, Flowers JL (2001) Are concerns over right laparoscopic donor nephrectomy unwarranted? Ann Surg 233:645–651
6. Cecka JM (2000) Kidney transplantation from living unrelated donors. Annu Rev Med 51:393–406
7. Collaborative Transplant Study (2001) Relationship first kidney transplant CTS-K-15103-Dec 2001. http://www.ctstransplant.org
8. Emamian SA, Nielsen MB, Pedersen JF, Ytte L (1993) Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. AJR Am J Roentgenol 160:83–86
9. Favre H, Wauters JP, Mach RS (1971) Clinical diagnostic value of lysozymuria. Adv Nephrol Necker Hosp 1:195–205
10. Flowers JL, Jacobs S, Cho E, Morton A, Rosenberger WF, Evans D, Imbembo AL, Bartlett ST (1997) Comparison of open and laparoscopic live donor nephrectomy. Ann Surg 226:483–489
11. London E, Rudich S, McVicar J, Wolfe B, Perez R (1999) Equivalent renal allograft function with laparoscopic versus open liver donor nephrectomies. Transplant Proc 31:258–260
12. Mandal AK, Kalligonis AN, Cohen C, Montgomery RA, Kavoussi LR, Ratner LE (2000) Should the right kidney be used in laparoscopic live donor nephrectomy? Transplantation 69:1116
13. Mandal AK, Cohen C, Montgomery RA, Kavoussi LR, Ratner LE (2001) Should the indications for laparoscopic live donor nephrectomy of the right kidney be the same as for the open procedure? Anomalous left renal vasculature is not a contraindiction to laparoscopic left donor nephrectomy. Transplantation 71:660–664
14. Mosimann F, Bettschart V, Schneider R (2001) Laparoscopic live donor nephrectomy for transplantation: urgent need for standardising procedures. Transpl Int 14:52–54
15. Opelz G (1997) Impact of HLA compatibility on survival of kidney transplants from unrelated live donors. Transplantation 64:1473–1475
16. Ratner LE, Ciseck LJ, Moore RG, Cigarroa FG, Kaufman HS, Kavoussi LR (1995) Laparoscopic live donor nephrectomy. Transplantation 60: 1047–1049
17. Ratner LE, Montgomery RA, Maley WR, Cohen C, Burdick J, Chavin KD, Kittur DS, Colombani P, Klein A, Kraus ES, Kavoussi LR (2000) Laparoscopic live donor nephrectomy: the recipient. Transplantation 69:2319–2323
18. Schweitzer EJ, Wilson J, Jacobs S, Machan CH, Philosophe B, Farney A, Colonna J, Jarrell BE, Bartlett ST (2000) Increased rates of donation with laparoscopic donor nephrectomy. Ann Surg 232:392–400