

## Surgical aspects of live kidney donation

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## 1. ABSTRACT

In the early 1990s live kidney donation regained popularity to meet the demand of kidney transplantation. Significant developments in the field of live kidney donation have established live donation as the potential prime source of kidney transplants in the future. Nowadays management focuses on logistic and immunological innovations, and improvements in care of the live donor. However, a flawless surgical procedure in donors and recipients is a prerequisite for further expansion of live kidney donor transplantation. From a surgical perspective the introduction of the laparoscopic approach has been a major breakthrough. Less invasive techniques to procure live donor kidneys have been held responsible for a steep increase in the number of live donors. In addition, less invasive imaging, improvements in perioperative care, and novel insights in follow-up have all improved the care of the live donor. Live kidney donation may develop as the most promising source of renal organs since artificial kidneys, xenografts and stem cell therapy for restoring intrinsic kidney function will probably not find application on large scale in the near future.

## 2. INTRODUCTION

The kidney is an essential organ, which plays a pivotal role in acid/base balance, sodium/potassium balance, calcium metabolism, regulation of blood pressure, red blood cell synthesis and excretion of metabolites. A variety of renal diseases finally results in renal insufficiency.

Kidney replacement therapy consists of dialysis and kidney transplantation. Hemodialysis and peritoneal dialysis can lead to long-term survival and may bridge patients to kidney transplantation. However, the impact of dialysis on quality of life is enormous. Kidney transplantation is considered the optimal kidney replacement therapy for many patients with end-stage renal disease (1, 2).

In the early 1950s, Rene Kuss and Joseph Murray performed the first successful kidney transplantations in France and the United States respectively (3, 4). The discovery of adequate immunosuppressive therapy in the 1960s enabled deceased donor kidney transplantation, preventing risky operations performed on healthy

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individuals. As enough deceased donors were present at that time, live kidney donor transplantation was pushed into the background.

In the late 1980s and 1990s, a discrepancy between organ demand and supply occurred because of an increasing number of patients suffering from end-stage renal disease and a stagnating number of transplants. The average waiting time for a kidney from a deceased donor increased considerably. Mainly because of mortality and worsening condition precluded transplantation. Annually, up to twenty percent is removed from the waiting list. Increasing the number of deceased donors has failed mainly due to relatives refusing donation (5). This prompted a new interest in live donor kidney transplantation amongst other alternatives.

In the last decade, the number of transplants from live donors significantly increased in the Western World (6). The revival of live kidney donation is a result of the aforementioned gap between the demand and supply of organs. Live kidney donor transplantation has created opportunities including pre-emptive and ABO-incompatible kidney transplantation that contribute to the success of live kidney donation. The expansion of live kidney donation is only possible by continuous innovations and research in screening of the donor, perioperative care and last but not least the surgical technique. These innovations have limited the discomfort to the donor and incited live donation. In this review we will focus on current surgical issues surrounding live kidney donation.

### **3. BENEFITS OF LIVE KIDNEY DONOR TRANSPLANTATION**

Live kidney donor transplantation renders some significant benefits over kidney transplantation from a deceased donor. First, the transplant usually starts functioning immediately following transplantation, as opposed to transplants derived from deceased donors. Ischemic damage to the allograft is minimal due to short ischemic time. This is important, as cold ischemic time is a well-known risk factor for delayed graft function (7). Second, transplant survival is significantly improved. Three-year survival rates are approximately 81 to 87 percent for living unrelated donors and 70 percent for cadaveric kidneys (8-10). Third, dialysis may be avoided by planning live donor kidney transplantation. This so-called pre-emptive kidney transplantation is gaining popularity. It reduces the costs of dialysis and the related operations needed to introduce a catheter or develop a shunt; furthermore such an approach may improve transplant function and survival (2). Current allocation guidelines impede pre-emptive kidney transplantation from a deceased donor. Fourth, live kidney donor transplantation turns emergent surgery into elective surgery and thereby improves surgical results without any doubt. Candidates for donation and transplantation can be carefully screened and the transplantation can be scheduled at a time when donor and recipient are well prepared for surgery. Finally, a higher degree of histoincompatibility may be accepted in live kidney donor transplantation because the grafts are derived from healthy donors and do not sustain significant

injury during the time awaiting explantation (11). Nevertheless, kidney transplantation is a surgical procedure with risks of mortality and morbidity

### **4. INNOVATIONS IN LIVE KIDNEY DONATION**

Live kidney donation has been fostered by immunologic maneuvers that can overcome biologic obstacles such as HLA disparity and ABO or cross-match incompatibility. In the classic, successful live kidney donor transplantations of the 1950s, the transplant was derived from an HLA identical individual, often a twin. Despite the rapid developments in immunosuppressive therapy, most transplants were derived from relatives until the early 1990s.

Nowadays transplants derived from genetically unrelated donors appear to provide excellent function and long-term survival is comparable with the survival of a graft derived from related donors (11). Awareness of the success of grafts from unrelated donors resulted in a spectacular increase of unrelated donors, in particular from spouses (12).

Among the genetically unrelated donors, the percentage of those without a direct relation to the recipient increases, including those participating in cross-over transplant programs, list-exchange programs and Good Samaritan kidney donor programs. (13, 14).

Cross-over transplantations (donor-paired exchange) intend to help recipients accompanied by a donor with a different, incompatible, blood group. This pair is coupled to one or two other pairs having the same problem of blood group incompatibility. However, the blood group of the donor of the first pair and the recipient of the second or third pair matches. So, donor A donates to recipient B, donor B donates to recipient C and donor C may donate to recipient A. Although the logistics are demanding and a sufficient pool is necessary to create combinations between pairs, these cross-over transplant programs or pair-wise donation may be highly successful (15).

List-exchange transplantation is relatively new. The live donor and the recipient have incompatible blood groups. The donor donates his kidney to a recipient waiting for an organ derived from a deceased donor. In exchange, the intended recipient, related to the live donor, receives priority on the deceased donor waitlist. List-exchange may be live saving, in particular for those recipients who do not find a compatible donor by a cross-over program or for whom transplantation across the blood group is not optional.

Good Samaritan kidney donors are also denoted as truly altruistic donors who do not have any relation to a recipient (14). The transplants of these donors are usually intended for recipients awaiting deceased donor transplantation.

An uncommon type of kidney donor is a patient whose kidney is removed for medical indication (i.e. iatrogenic ureteral lesions that could not be repaired, kidney stones). These donors/patients usually have another kidney that functions well and they do not require auto-transplantation. Donation to the organ pool may be an option.

Integration of all aforementioned practices would help to reduce the number of transplant candidates waiting. Recent calculations estimate that up to eleven percent of the transplanted kidneys may be recruited from this pool of formerly uncommon donors (16, 17).

Another innovative approach includes the transplantation of living donor renal allografts across blood group barriers (18, 19). This requires protocols to reduce and maintain anti-blood group antibodies at safe levels. Developments in immuno-absorption have resulted in good results for such transplantations (18).

### 5. CARE OF THE LIVE DONOR

#### 5.1. Standard care of the live donor

The crucial aspect in live kidney donor transplantation is the potential harm to the donor. From an ethical perspective live kidney donation is only justified if the harm to the donor is limited and the potential benefit to the recipient is major. The risk for the immediate and long-term health adverse consequences to the donor is therefore very important. The Amsterdam Forum has established guidelines for the (relative) contra-indications to live kidney donation: donors must have sufficient renal function (GFR more than 80 ml/min), no hypertension (less than 140/90 mm Hg), no obesity (BMI less than 35 kg/m<sup>2</sup>), negative urine analysis for protein (less than 300mg/24 hours) and erythrocytes, no diabetes, stone disease, malignancy or urinary tract infections, a minor or no cardiovascular or pulmonary risk and smoking cessation and alcohol abstinence is obligatory (20).

A multidisciplinary approach is required to optimize quality of a live kidney donation program. Disciplines have to cooperate in the screening of donors and informing relatives without exerting pressure on potential donors. Each step in the multidisciplinary approach should be optimized. Imaging of the donor kidney should be performed without any complications and the surgical procedure, while peri-operative care should be optimally organized to minimize pain and discomfort to the donor. Advances in surgical technique have improved the comfort of the donor considerably and the risks of morbidity and mortality have been minimized. Adequate follow-up may identify donors who develop hypertension early and may also aid donors from a social perspective, for example, by advising those who struggle with their recovery or experience problems resuming work (21).

Together with the solution of more donor kidneys another problem arises. The ethical aspects concerning living unrelated transplantation are even more complicated than the medical ones due to concern of commercialization. Many people consider it unethical to pay kidney donors. In developing countries this can become a problem. People are more willingly towards donation if there is a financial reward. Some advocate for a reward for donors as renal replacement therapy is much more expensive. Others suggest that establishing controlled donor compensation programs could partly solve the shortage in organs (22-24).

#### 5.2. Improvements in imaging of the donor

Imaging is of great importance in selecting donors. It determines the choice of the kidney to be donated. Donors with bilateral arterial stenosis, cysts, fibromuscular dysplasia or parenchymal tumors should be excluded from donation. To ensure sufficient renal function for the donor, the best-functioning kidney should be left to the donor. This requires techniques to rule out how both kidneys of the donor contribute to donor function. In addition to providing detailed information on the donor, radiological examinations should be safe, minimally invasive and the time for these investigations should be limited. In laparoscopic donor nephrectomy, tactile feedback to the surgeon, and thereby relatively easy discrimination of vessels by pulsatile movement, is lost. Therefore, especially for laparoscopy, preoperative planning has become increasingly important. The anatomy of the renal arteries must be visualized, as the presence of multiple arteries has been associated with increased complexity for removal and an increased rate of ureteral complications in the recipient (25). Traditionally, the renal anatomy was assessed by angiography with good results but significant consequences for the donor, including radiation and a short stay in the hospital. Magnetic resonance imaging (MRI) and computed tomography (CT) have both been reported as feasible alternatives (26-33). In our hospital, MRI has gradually replaced angiography as this technique does not cause radiation and, in addition, provides information on the venous anatomy (34). CT may help to determine renal split function (35).

Live kidney donors are healthy individuals who deserve the least invasive and the least time consuming imaging with the best predictive value. At present, none of the techniques encompasses all the features outlined. However, imaging with CT and MRI is less invasive than angiography, provides information on venous anatomy and the renal parenchyma, and does not require observation of the live donor in the hospital for several hours after the procedure. Further development of these techniques will contribute to selection and surgical planning.

#### 5.3. Improvements in surgical technique

##### 5.3.1. Laparoscopic donor nephrectomy

Traditionally, kidneys were harvested by a 15 to 25 cm flank incision that transected three layers of abdominal muscles. Resection of ribs was frequently applied to allow sufficient access to the kidney. This procedure injured the abdominal wall resulting in substantial postoperative pain, an average hospital stay of 7 days and prolonged sick leave. In the long term, some donors suffered from chronic neuralgia and incisional hernias (36).

Fortunately, renewed interest in live kidney donation occurred in an era in which minimally invasive surgery was gradually replacing conventional surgery. In 1995, Ratner and colleagues performed the first laparoscopic donor nephrectomy (37). Various alternatives to this laparoscopic approach have been presented since, including hand-assisted laparoscopic donor nephrectomy and retroperitoneoscopic donor nephrectomy. Meanwhile, the classic open approach has been refined and minimally invasive principles are more often applied in open surgery. As described above Ratner and colleagues introduced a laparoscopic technique for live kidney donation in 1995. He used a midline incision to harvest the

**Table 1.** Randomized controlled trials comparing open and laparoscopic donor nephrectomy

References	71		72		44		42		43	
	Open	Lap (hand-assisted)	Open	Lap (hand-assisted)	Open	Lap	Open (MIDN)	Lap	Open (MIDN)	Lap
Number of patients	27	23	100	100	59	63	50	50	20	20
Operative time (minutes)	125 <sup>1</sup>	206	152 <sup>1</sup>	271	140 <sup>1</sup>	180	164 <sup>1</sup>	221	147 <sup>1</sup>	232
Warm ischemia time (minutes)	1.6 <sup>1</sup>	3.1	1.8 <sup>1</sup>	8.7	1.4 <sup>1</sup>	4.3	3 <sup>1</sup>	6	2 <sup>1</sup>	4
Conversion	-	0	-	1	-	1	-	0	-	0
Hospital stay (days)	2.6 <sup>1</sup>	1.7	2.2	2.6	6.7	6.2	4 <sup>1</sup>	3	6 <sup>1</sup>	4.4
Back to normal daily activities	Longer <sup>1</sup>	Shorter	Longer <sup>1</sup>	Shorter	Longer <sup>1</sup>	Shorter	Longer <sup>1</sup>	Shorter	Longer	Shorter
Complications (minor)	4	4	27	21	4	7	6	8	7	8
Complications (major)	0	0	0	0	0	5	0	0	0	0

<sup>1</sup> = p-value less than 0.05

kidney transplant, instead of the Pfannenstiel incision we use nowadays (37). The donor is in a lateral decubitus position. The first trocar is inserted periumbilically. The abdomen is insufflated with CO<sub>2</sub>, a 30 degrees video-endoscope is introduced and three to four additional trocars are inserted (Figure 1). The right or left hemicolon is dissected from the lateral abdominal wall and mobilized medially. Gravity aids this mobilization. The kidney is located behind the hepatic or splenic flexure. The fascia of Gerota is opened and the kidney is dissected from the surrounding capsule. The renal vessels are dissected and encircled with vessel loops to facilitate identification from different directions. The venous branches of the renal vein are clipped and divided with scissors. The ureter is dissected until it crosses the gonadal vein. Then, a 5 to 8 cm horizontal suprapubic incision or Pfannenstiel incision is made as extraction site while maintaining pneumoperitoneum. An endobag is introduced via a small incision in the peritoneum. Subsequently, the ureter is clipped and divided with scissors and the renal artery and vein are divided with an endostapler. The kidney is caught with the endobag and extracted via Pfannenstiel incision. Then, the transplant is cooled down by perfusing it with a preservation solution at 4 degrees centigrade and stored on ice. This step is similar in all the techniques. The Pfannenstiel incision is sutured once the pneumoperitoneum is restored. The peritoneal cavity is checked for bleeding; the remnants of the renal vessels and the adrenal gland in particular are checked. After haemostasis is ensured, the trocars are removed under vision and the incisions are sutured.

The introduction of this technique has given rise to much discussion in the transplant society because the pneumoperitoneum, necessary to obtain vision, leads to an increased intra-abdominal pressure and thereby may affect renal perfusion with subsequent ischemia/reperfusion injury to the transplant. Recovery of transplant function would be delayed as indicated by slower declining recipient serum creatinine (38).

Subsequently, various studies have proven that there are no clinical short-term adverse effects of laparoscopic donor nephrectomy on transplant function. However, these studies either did not continuously

assess renal function during the first weeks or did not adjust serum creatinine values for possible confounders at baseline (39-41). Adjusting the fluid regimen of the donor anticipates potentially adverse effects of increased pressure and decreased perfusion (40).

Three prospective studies, comparing open with laparoscopic donor nephrectomy are listed in Table 1 (42-44). Several cohort studies from large volume centers in the United States have proven the feasibility and safety of the laparoscopic technique (45, 46). Leventhal *et al* reported a group of 500 patients with an overall rate of intra- and postoperative complications of respectively 2.8% and 3.4%. There were 9 conversions (1.8%), of which 6 were in the first 100 cases. Thirty patients experienced an intraoperative or procedure-related complication (6.0%). Only 1 recipient experienced delayed graft function, and only 1 recipient had a urological complication.

The laparoscopic live donor nephrectomy is technically more demanding than the open approach, with a prolonged learning curve (47, 48). Therefore the introduction of the laparoscopic method in small centers can be difficult.

### 5.3.2. Hand-assisted laparoscopic donor nephrectomy

Hand-assistance during laparoscopic donor nephrectomy requires an extraction incision that is little larger than the aforementioned extraction site for total laparoscopic donor nephrectomy. This allows one hand of the surgeon to enter the peritoneal cavity via a hand port. These hand ports allow introduction of, manipulation by, and removal of the hand of the surgeon while maintaining pneumoperitoneum. Some surgeons make a midline incision to place their hand port in an ergonomic position. The introduction of various trocars is similar to the conventional laparoscopic approach. Advantages of this technique include maintaining tactile sensation, the possibility to present tissues and the creation of surgical planes with the hand. In case of bleeding, it is easier to directly stop the bleeding manually and repair the injury. This technique contributes to a steeper learning curve for the hand-assisted method compared to the total laparoscopic approach (49). Potential disadvantages are higher costs because of the hand port, a worse ergonomic position of the surgeon during operation, a higher rate of wound infections and increased traumatic injury to the



**Figure 1.** Laparoscopic donor nephrectomy. A camera is introduced periumbilically (purple port). Three to four trocars are inserted.



**Figure 2.** Hand-assisted retroperitoneoscopic donor nephrectomy. The surgeon creates the retroperitoneal space with his left hand. Thereafter, the trocars are introduced and the retroperitoneal cavity is insufflated.

transplant as a consequence of manipulation. Literature on the pros and cons of either technique is scarce and inconclusive. Bargman and co-workers compared laparoscopic donor nephrectomy with and without hand-assistance (50). They found a statistically significant difference in the mean operative time for the two groups (200  $\pm$  20.8 minutes for Standard Laparoscopy vs. 219  $\pm$  28.3 minutes for Hand-Assisted Laparoscopy;  $P = 0.02$ ). No differences were observed regarding mean estimated blood loss, warm ischemia time, length of postoperative hospital stay, intravenous analgesia or pain score on postoperative day 1 and 2. Five minor complications in the laparoscopy group and three in the hand-assisted group occurred. The mean preoperative, 1-month, and 3-month postoperative QoL scores did not differ significantly between the groups. None of the recipients required postoperative dialysis, and there was no statistical difference between the two groups in serum creatinine concentration. The authors concluded that laparoscopic and hand-assisted donor nephrectomies have similar outcomes and postoperative pain, minimal complication rates and similar impact on quality of life.

### 5.3.3. Retroperitoneoscopic donor nephrectomy

Retroperitoneoscopic donor nephrectomy is a modification of the technique first described by Ratner.

In this technique the peritoneal cavity is not opened. The technique has been described with and without hand-assistance (51, 52). The retroperitoneal space is developed and insufflated with CO<sub>2</sub>. Several trocars are introduced (Figure 2). The peritoneal sac containing the bowel is mobilized medially. The dissection of the kidney and the renal vessels is similar to transperitoneal donor nephrectomy but the angle is different. The kidney is extracted via a muscle-splitting flank incision or a Pfannenstiel incision (51-54). The discussion to use or not to use hand-assistance is similar to the discussion about hand-assistance during the transperitoneal approach. Appropriately designed studies on this topic are lacking and the evidence is based on expert opinions. The potential advantage of the retroperitoneoscopic technique is that the peritoneum is not opened; also the descending colon and the splenocolic ligament are left intact, thereby avoiding injuries to these organs. Moreover, the angle at which the vessels are dissected may be preferable (51). The hand-assisted technique is claimed to offer advantages in the management of severe bleeding (49, 55, 56).

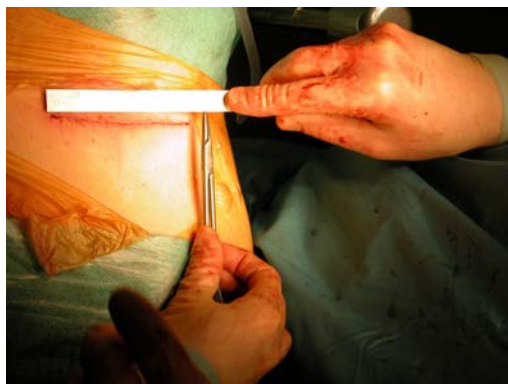
Wadstrom concluded from his first 75 cases that the retroperitoneoscopic hand-assisted method facilitates the procedure by enabling short operation times and significantly reducing the risks associated with endoscopic live donor nephrectomy (52). Bachman *et al.* concluded that retroperitoneoscopic donor nephrectomy provides comparable perioperative features, such as operation time, warm ischemia time and overall complication rate compared with open donor nephrectomy. Additionally, it does not have a negative impact on operation time of the recipient, graft ischemia and early graft function (53).

No large case series or comparative cohort studies have been published to date. In the future, the value of retroperitoneoscopic donor nephrectomy alongside the transperitoneal approaches has to be assessed. Preferably the primary endpoint should be the quality of life, with the time of the operation and complications as secondary endpoints.

### 5.3.4. Minimally invasive open donor nephrectomy

The introduction of laparoscopic approaches has also encouraged refinement of open approaches. Many centers have banned rib resections, replaced classic flank incisions by incisions at other, alternative sites, and currently apply principles of minimally invasive surgery including minimal tissue damage and limited access. These incisions have in common that the incision is located anterior and more medial compared to classic open incisions; the size of the incision is also smaller.

A minimal flank incision most closely correlates to the conventional flank incision. The retroperitoneal cavity is accessed with a smaller incision, varying from 7 cm in lean donors to 15 cm in obese individuals. The oblique and transverse abdominal muscles can be either divided or split. Mechanical retractors allow sufficient access with minimal skin incision. In addition, instruments also used in laparoscopic surgery, including endostaplers, may be used to maintain limited access in case of difficult anatomy i.e. multiple renal vessels. Most Dutch surgeons and urologists use the muscle-split approach when open donor nephrectomy is performed. Because the surgical trauma is limited, these operations result in a shorter



**Figure 3.** Mini-incision open donor nephrectomy. The incision measures less than ten centimeters (indicated by the ruler) and in erect position, the scar will lie in the natural shade of the costal margin.

hospital stay and less pain compared to conventional open surgery (41). Cosmetic outcome is excellent (Figure 3).

A similar muscle-split approach can be performed in an even more anterior position. This approach may be more difficult initially, because more organs are located between the abdominal muscles and the kidney, but the approach of the renal vessels is potentially easier. A concomitant advantage is that the intercostal nerves that innervate the oblique abdominal muscles are less likely to be injured and abdominal wall function may be superior.

A third option for minimally invasive open donor nephrectomy is a pararectal vertical skin-incision. This incision does not divide muscles but fascia only. This technique leads to superior postoperative results compared to conventional open approaches (57). The technique has only been compared to the classical open approach; there are no reports in which the technique is compared to laparoscopy or another type of mini incision donor nephrectomy (MIDN).

### 5.3.5. Evidence-based approach in the surgical management

Evidence has mounted that laparoscopic and retroperitoneoscopic approaches are superior to open surgery (58). Two European studies have been published; one from Great Britain and one from the Netherlands (42, 43). These prospective studies aimed to assess the superiority of either the laparoscopic or the minimally invasive open approach (MIDN) (Table 1). Kok *et al.* concluded that laparoscopic donor nephrectomy results in a better quality of life compared with mini-incision open donor nephrectomy with equal safety and graft function.

A comparative study between laparoscopic and traditional open donor nephrectomy by Oyen *et al.* from Norway randomized 122 live kidney donors (56). A relatively high complication rate in the laparoscopic group (including various re-operations) and minor differences with regard to postoperative pain, resulted in the cautious conclusion that the laparoscopic approach confers advantages in some donors only, but

should not be applied to all donors. The authors suggested limiting laparoscopy to donors of normal weight or mildly overweight only, as complications mainly appeared in obese donors. Longer follow-up of the same Norwegian group confirmed a shorter recovery phase after laparoscopy (59). Various non-randomized studies have led to similar conclusions (60-70). Most of these studies were aimed at the safety and feasibility of the laparoscopic approach and presented laparoscopic donor nephrectomy as an alternative rather than as the preferred technique.

Only two randomized controlled trials comparing hand-assisted laparoscopic and conventional open techniques have been published (71, 72). Both studies compared left-sided hand-assisted laparoscopic donor nephrectomy with conventional open donor nephrectomy (Table 1). In the United States, Wolf *et al.* randomized 50 donors to either hand-assisted laparoscopic donor nephrectomy or conventional lumbotomy (72). Inclusion criteria included normal weight and interest in the laparoscopic approach. The main conclusion of the authors was that the hand-assisted approach resulted in shorter hospital stays and earlier recovery. Simforoosh *et al.* performed a comparable study in Iran (71). Donors with overweight (more than 28 kg/m<sup>2</sup>) and complex renal anatomy were excluded. The donors in this study were relatively young. Again, the hand-assisted laparoscopic approach appeared favorable. The unacceptably high complication rate in the open group (n=100), including 18 donors who sustained a pneumothorax, in this study was remarkable.

Currently, the literature does not provide enough evidence whether or not to use hand-assistance at some stage during laparoscopic donor nephrectomy. About half of the surgeons perform hand-assisted laparoscopic donor nephrectomy. In our aforementioned study we compared open surgery with total laparoscopic surgery, because at that time we did not see the possible benefits of hand-assistance (42). Other authors clearly had this experience (72). A total laparoscopic approach may be even less invasive, but hand-assisted donor nephrectomy may confer benefits such as shorter operation times (71, 73). A comparative study of hand-assisted and total laparoscopic donor nephrectomy is difficult to organize. To assess potential interesting differences in a superiority study, such as the rate of conversion and wound infections, hundreds of donors must be enrolled. Only non-inferiority studies are feasible. Comparative studies assessing the role of (hand-assisted) retroperitoneoscopic kidney donation alongside laparoscopic kidney donation are warranted.

### 5.4. Improvements in perioperative care

Two factors in live kidney donation may be influenced by improvements in perioperative care. These include postoperative pain and nausea and postoperative donor and recipient creatinine clearance. At our center we currently analyze the role of preoperative infusion of fluids to maintain adequate perfusion of the kidneys of the donor during laparoscopic donor nephrectomy.

For other surgical procedures, epidural anesthesia/analgesia has been reported to significantly reduce perioperative morbidity including ileus, acute renal failure (approximately 30%) and blood loss (approximately 30%), and not only improved analgesic efficacy but also reduced opioid demand and side-effects such as nausea,

vomiting and sedation (74-77). The use of thoracic epidural analgesia (TEA) for laparoscopic procedures is becoming more common, especially with colon surgery, where TEA significantly improved early analgesia and had a significant, favorable impact on dietary tolerance and length of stay (77-79). To date, reports describing the effect of epidural analgesia during laparoscopic donor nephrectomy on postoperative pain and nausea have not been published to our knowledge.

Delayed graft function and slower initial graft function have been associated with a higher incidence of acute rejection and have been reported in the past to occur more frequently after laparoscopic donor nephrectomy (80-82). Most studies comparing laparoscopic and open donor nephrectomy observed higher serum creatinine values in recipients of laparoscopically procured kidneys in the first days to weeks following renal transplantation (38, 40, 61, 82-84). As mentioned earlier, studies that reported no differences did often not continuously assess renal function during the first weeks or did not adjust serum creatinine values for possible confounders at baseline (39, 71). Proposed mechanisms resulting in slower recovery of graft function after LDN included mechanical injury to the graft, longer operation time until nephrectomy, longer first warm ischemia time and increased abdominal pressure due to the pneumoperitoneum leading to decreased cardiac output and decreased renal blood flow (40, 85). The predictive value of these findings on graft survival remains unclear as the mean half life of a graft procured from a live donor is much longer than the time elapsed since the first laparoscopic donor nephrectomy by Ratner in 1995 (37).

Retrospective studies at our institution showed that higher recipient serum creatinine values remained present in spite of administration of a sufficient amount of intra-operative fluids (40, 83). Therefore, we hypothesized that not only intra-operative fluid management is important, but also prehydration. An adequate prehydration regimen may indeed improve donor and recipient creatinine clearance. In contrast to earlier findings, kidney function of the donor and recipient is comparable between open and laparoscopic donor nephrectomy after introduction of a fluid regimen with prehydration (86).

### 5.5. Improvements in follow-up

Fatigue and diminished quality of life may be present until one year after the donation (42, 87, 88). There is a subgroup of donors that does not return to preoperative values. Further studies to characterize these donors are warranted.

Regular follow-up may help donors who do not recover well and donors who have conflicts with their employers with regard to resumption of work. Incidentally we encounter disturbed relationships between donor and recipient. These are recognized early. Professional aid can then be offered if necessary. In our opinion, the transplant community and governmental organizations are obliged to provide help

to struggling donors, because they have significantly benefited society.

Expansion of unrelated donation other than spousal donation and non-directed donation may increase the number of disappointed live donors, as the personal advantages for the donor are usually smaller with these types of donation. Further follow-up of these groups of donors in particular is required.

With regard to medical follow-up, donors may be monitored cautiously for hypertension and proteinuria as an expression of renal disease. Although individuals with one kidney do not appear to have an increased chance to develop renal insufficiency, they have a reduced functional reserve. Although most kidney diseases will affect both kidneys, early recognition of deteriorating kidney function may be beneficial in preventing end-stage renal disease and may also be considered a minimal service of society to our kidney donors (58, 89, 90). Follow up of the donors is also needed in order to gather more data regarding the long-term consequences of kidney donation. At our institution we schedule follow-up visits at the nephrology and surgery outpatient clinics at one, three and twelve months and annually thereafter.

## 6. CONCLUSION AND FUTURE PERSPECTIVES

Live kidney donor transplantation may develop as the most important live-saving procedure and the treatment that offers the best quality of life for patients with renal insufficiency. Further expansion of non-directed kidney donation and renal transplantation across blood group barriers will help those recipients with an incompatible blood group. An increase in pre-emptive transplantation may improve results of renal transplantation and reduce the costs of dialysis. Laparoscopic donor nephrectomy may be applied in the majority of donors and offers the best outcome to the donor with regard to quality of life. Future directions include addressing the position of the retroperitoneoscopic approach, long term outcomes of live kidney donors, in particular hypertensive, older and obese donors, and increasing the number of live kidney donors without compromising safety to the donor or the graft.

## 7. ACKNOWLEDGEMENTS

The authors equally contributed to this article.

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## **Surgical aspects of live kidney donation**

**Key Words:** Living Donors, Quality Of Life, Minimally Invasive, Cost-Effectiveness, Laparoscopic Donor Nephrectomy, Cross-Over, ABO incompatibility, Review

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