REVIEW ARTICLE

Surgical aspects of living donor nephrectomy☆

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Abstract

Context: Living donor renal transplant surgery has evolved from the classical nephrectomy by lumbotomy to less invasive surgery, the laparoscopic and robotic nephrectomy currently being the most important. It is important to know the available evidence on whether nephrectomy in patients with multiple arteries, right kidney and in obese patients can be performed safely when there is a correct indication.

Objective: To perform a review of the different surgical techniques in living donor nephrectomy, adapted to the current surgical evidence and other aspects related to the indication.

Evidence acquisition: A systematic review was made in PubMed (1997–2011). This included previous reviews randomized controlled clinical studies, cohort studies, and meta-analyses of these surgical aspects of living donor nephrectomy.

Conclusions: Currently, there is sufficient evidence to consider living donor laparoscopic nephrectomy (LDLN) as the technique of choice, although the role of hand-assisted retroperitoneoscopic technique is still not totally clear. Open surgery techniques using mini-incision are an acceptable alternative for the sites that have not yet implemented laparoscopic surgery. Right kidney nephrectomy, of those cases that present multiple pedicles and in obese donors, is justified in selected cases.

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PALABRAS CLAVE

Nefrectomía de donante vivo; Laparoscopia; Resultados

Aspectos quirúrgicos actuales de la nefrectomía de donante vivo

Resumen

Contexto: La cirugía del trasplante renal de donante vivo, ha evolucionado desde la clásica nefrectomía por lumbotomía a una cirugía menos invasiva, imponiéndose en la actualidad la nefrectomía laparoscópica y robótica. Resulta importante conocer la evidencia disponible acerca de si la nefrectomía en pacientes con múltiples arterias, riñón derecho y en pacientes obesos puede realizarse de manera segura ante una indicación correcta.

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Objetivo: Realizar una revisión de las diferentes técnicas quirúrgicas en nefrectomía de donante vivo, adaptada a la evidencia científica actual, y de otros aspectos que rodean la indicación.

Adquisición de la evidencia: Se realizó una revisión sistemática en PubMed (1997–2011), que incluye revisiones previas, estudios clínicos aleatorizados controlados, estudios de cohortes, y metanálisis de los aspectos quirúrgicos de la nefrectomía de donante vivo.

Conclusions: Actualmente existe suficiente evidencia para considerar la nefrectomía laparoscópica de donante vivo (NDLV) como técnica de elección, aunque el papel de la técnica mano-assistida y la retroperitoneoscopía todavía no están del todo claros. Las técnicas de cirugía abierta por mini-incisión representan una alternativa aceptable para los centros que no hayan implementado todavía la cirugía laparoscópica. La nefrectomía de riñón derecho, de aquellos casos que presentan pedículos múltiples y en los donantes obesos esta justificada en casos seleccionados.

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Introduction

The living donor kidney transplant (LDKT) is the treatment of choice for patients with terminal renal failure. Taking into account that it is an altruistic procedure in healthy people, it is essential that the intervention is a safe procedure and allows the individual to quickly regain normal activity. 40% of all kidney transplants performed in the U.S. and 20% of those carried out in Europe come from a living donor. In the case of countries where the rate of cadaveric donors is very low, up to 75% of transplants are from living donors. The continuous increase in living donation is due, in large part, to the better short- and long-term results in relation to the cadaveric donor (93.9 and 86.2% survival at 1 and 3 years vs. 87.6 and 76.7%, respectively), as well as less aggressive immunosuppressive regimens, better HLA matching, shorter cold ischemia times, and avoiding waiting lists, which in the case of Spain they can be of up to 2 years. They represent relative contraindications for donation, presence of a chronic active infection (TB, B/C hepatitis, or parasites), obesity, and some psychiatric disorders. Absolute contraindications are listed in Table 1.

Surgical techniques have evolved from the classical lumpectomy and open-approach muscle-splitting minicision to the current minimally invasive techniques including classical laparoscopy, hand-assisted one, hand-assisted retroperitoneoscopy, pure retroperitoneoscopy, NOTES (Natural Orifice Transluminal Endoscopic Surgery) or LESS (Laparoendoscopic Single SiteSurgery) and robotic nephrectomy. Thus, many of the disadvantages of living donation have improved, such as, faster postoperative recovery, less bleeding, and less need for analgesia.

Other major surgical factors to consider are the proper selection of the kidney to be removed, specific considerations in obese patients, and the management of multiple pedicles. Although conventionally, and still at present, the trend in many centers is to choose the left kidney with simple pedicle, of young individuals with a suitable body mass index and ASA I, we increasingly tend to pick individuals with isolated alterations, such as HBP or obesity, if the renal function is correct.

Donor assessment

General aspects

The evaluation of a potential living donor may be performed by an independent physician, followed by a nephrologist, psychiatrist, and surgical team of urologists. Initial studies should include: history and complete physical examination, HLA typing, blood tests (urea, creatinine, electrolytes, calcium, phosphorus, albumin), coagulation tests, serological test for HIV, cytomegalovirus, varicella virus, herpes virus, Epstein Barr virus, B/C hepatitis virus, RPR, FTA, and PPD (purified protein derivative), electrocardiogram, chest X-ray, and CT with urographic and vascular phase. In men, testicular exploration is included, and in those older than 50, PSA and DRE. In women, breast screening is also included, and in those over 40, mammography. Now, if there is a history of breast cancer in premenopausal age in first-degree relatives, the age for mammography should be below 35 years.

Choice of kidney

It is mandatory that the living donor maintains the kidney with the best conditions. The renal anatomy has to be assessed by means of multidetector CT and angiography/urography with reconstructions. In the cases in which both kidneys have similar characteristics, it is chosen to remove the left kidney, which is the one with the longest renal vein and will facilitate implantation.

<table>
<thead>
<tr>
<th>Table 1 Absolute contraindications for living donor kidney transplant.</th>
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<tbody>
<tr>
<td>Age &lt;18 years</td>
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<tr>
<td>Uncontrolled HBP</td>
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<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Proteinuria &gt;300 mg/24 h</td>
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<tr>
<td>Abnormal glomerular filtration for age</td>
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<tr>
<td>Microscopic hematuria</td>
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<tr>
<td>High risk of thromboembolism</td>
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<tr>
<td>Severe disease (chronic pulmonary disease, recent malignancy, heart disease)</td>
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<tr>
<td>History of bilateral renal calculi</td>
</tr>
<tr>
<td>HIV infection</td>
</tr>
</tbody>
</table>
The right nephrectomy has been attributed a greater number of complications such as venous thrombosis, greater delay in functional recovery, and, in general, greater number of implant loss due to technical difficulties during the vascular anastomosis; however, recent studies suggest that although there is a minimal increase in the risk of graft failure, it is considered as a perfectly acceptable option in donors in whom left nephrectomy is contraindicated (Table 2).

### Table 2
<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Type of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left vs right</strong></td>
<td>1b</td>
</tr>
<tr>
<td>Multiple pedicles</td>
<td>III</td>
</tr>
<tr>
<td>Obese vs non obese</td>
<td>III</td>
</tr>
</tbody>
</table>

### Multiple pedicles

The choice of kidneys with multiple pedicles has also been a controversial issue. We tried to avoid them, in order to minimize the vascular and ureteral complications. However, when the choice of the right kidney arises, many centers prefer to use the left kidney despite having a multiple pedicle. Abnormalities such as circumaortic veins, retroaortic veins, early bifurcation of the renal artery, multiple veins, or large lumbar veins, are not usually a problem for the donation. Although all the studies include a small number of patients with multiple pedicles, globally, it is considered to be feasible and safe. Only in 2 studies have they been associated to more ureteral complications in the receptor, especially with lower polar arteries (Table 2).

### Obesity

Regarding obesity, several studies have shown that laparoscopic nephrectomy in selected patients is safe. Besides instrumentation and special position needs, a higher incidence of anesthetic complications has been observed and postoperatively. Obese patients have an increased filtration fraction, which is an independent predictor of HBP, which can influence long-term renal function (Table 2).

Overall, patient assessment for living donor laparoscopically or robotically is similar to the open approach. The only relative contraindication for laparoscopic surgery, which does not exist in the open procedure, is a history of major upper abdominal surgery that might have led to dense adhesions so that the laparoscopic surgery may not be safe.

### Open nephrectomy

It can be performed by classical transperitoneal approach, through an incision in the midline or left or right subcostal, under sub or supracostal left or right extraperitoneal, and dorsal lumbar below the 12th rib, with resection thereof, or above (extraperitoneal, extrapleural). Although some authors have preferred the transperitoneal approach to ensure better access to the vessels, the many advantages of the extraperitoneal surgery have eventually made it the standard technique.

The objectives of nephrectomy include removal of the kidney with minimal anatomical and physiological damage, as well as minimal warm ischemia, avoiding trauma to the renal parenchyma and preserving an adequate length of the artery, vein, and ureter that allows to perform a safe anastomosis without endothelial damage, and atraumatic ureteral reimplantation maintaining vascularization. The result of these premises should translate into an immediate graft function in the host with a low rate of vascular and ureteral complications.

The literature review concludes that, overall, major complications have occurred in 3% of donors who underwent open surgery, most of which were resolved without permanent sequelae, and minor complications in 10% of patients. Most of the studies reviewed share the fact that delayed graft function, thrombosis, and ureteral fistulas are rare events that appear in 1–2% of the cases.

Also, the overall hospital stay is 5–7 days. In long-term follow-up, in a review of 524 donors with a follow-up of 15 years, only 4% were dissatisfied with the donation, and regretted having undergone surgery. Regarding the surgical wound pain, 84% reported no pain present, or medium intensity pain.

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The advent of laparoscopic LDKT has stimulated the development of minimally invasive open surgery techniques. These techniques have shown excellent results in terms of recovery, cost-effectiveness, safety, and cosmetically. The fascias of the external oblique muscles, internal and transverse abdominal are separated with scissors miophylactically without being cut. We can also make an anterior vertical mini-incision, in which, with
the patient in supine position, an anterior vertical incision is made, 6–10 cm lateral to the rectum below the costal arch. The abdominal muscles are separated into layers, and the peritoneum is separated medially to expose the kidney in a retroperitoneal position.21–23

Other minimally invasive techniques are finger-assisted living donor nephrectomy, which is performed with the patient in lateral decubitus and table at maximum deflection, using a 4-cm transverse incision and anterior to the tip of the 11th rib. All the muscle layers and the fascia of the lumbar muscle are separated in line with the incision.24 In minimally invasive nephrectomy through a transverse incision, the patient is placed in a semilateral position, with 20° flexion, performing an 8–10 cm transverse incision anterior to the 11th lateral rib on the edge of the rectum. The transversalis fascia is incised laterally, and the peritoneum is rejected medially using the Omnitrac retractor.25

In microinvasive nephrectomy, the patient is placed in lateral decubitus and the incision is made 6–8 cm from the tip of the 10th rib to the rectum, with the table flexed 30° and placed 20° in Trendelenburg.26 In the mini-nephrectomy through a posterior transcostal incision, the patient is placed in lateral decubitus, palpating the 12th rib. A 6–8 cm incision is made along the rib starting 2–3 cm anterior to the lateral edge of the sacrospinalis muscle. The latissimus dorsi and the serratus posterior have to be sectioned, in order to expose the 12th rib.27 Finally, in video-assisted mini-laparotomy, a 5–7 cm lateral incision is made and a 10-mm trocar is placed between the peritoneum. The 30° optics makes it possible to maximize the vision.28

Laparoscopic live donor nephrectomy

Globally, it has been shown that laparoscopic live donor nephrectomy (LLDN) has advantages over open surgery in terms of analgesic requirements, hospital stay, cosmetic result, and return to the work activity.29,30 We have not seen that the graft function is affected by the positive pressure of the pneumoperitoneum, being comparable to the open approach.31

The LLDN technique has evolved over time, and although it can be performed both transperitoneally and retroperitoneally, in most centers, it is performed transperitoneally due to the lower limitation of the surgical field and the possibility of removing the kidney through a midline or Pfannenstiel incision.32 The technique is performed in modified lateral decubitus position, with the hips rotated back for easy access to the bottom of the midline and to remove the kidney. 3 5-mm laparoscopic accesses are performed, separated 4 fingers in supraumbilical pararectal position. The first of them, caudal to the 12th rib and using 30° optics. It is started by rejecting the peritoneum along the avascular Toldt’s line. The dissection follows the existing plane between Gerota’s fascia and the mesentery of the descending colon, until the left gonadal vein is identified.

Dissection of the middle part of the gonadal vein should be limited to avoid devascularization of the ureter. En bloc elevation of the gonadal vein, the ureter, and the lower pole of the kidney is generally useful in anterolateral direction with regard to the psoas muscle to facilitate exposure of the pedicle. For the section of the pedicle, we use an Endo-GIA stapling device, with vascular load through access via 5-cm Pfannenstiel incision by which we will subsequently extract the kidney by endobag.32

In the case of removing the right kidney, additional access in the lumbar fossa for anterior retraction of the liver lobe and increasing the length of the renal vein, which with the Endo-GIA causes the loss of 1–1.5 cm, may be required. A 6-cm transverse incision could also be made above the confluence of the right renal vein and the inferior vena cava for the open section of the renal vasculature. Alternatively, reconstruction can be performed using saphenous vein graft of the receptor.34

Hand-assisted laparoscopic nephrectomy

Both transperitoneal and retroperitoneal hand-assisted laparoscopic nephrectomy (HALN) has been described. The use of the hand can be performed throughout the procedure, or only at the time of the section of the pedicle and kidney extraction.35 The incisions can be periumbilical, supra- or infraumbilical in the midline, or Pfannenstiel.35,36 The advantages of hand-assisted laparoscopy compared to conventional laparoscopy are primarily the ability to digitally control a possible bleeding and allow for better exposure of the pedicle.37 This would make it possible to have shorter warm ischemia and surgical times.38–40 With the retroperitoneal approach, it is less likely to damage intra-abdominal organs.

Comparison between techniques

Laparoscopic nephrectomy and hand-assisted laparoscopic nephrectomy

Most studies conclude that the hand-assisted technique (transperitoneal) has shorter operative time, blood loss, warm ischemia, and hospital stay. The complications, analgesic requirements, and graft survival are similar in both.38–41 It should be borne in mind that these studies include a limited number of patients, with a low level of evidence, so the definitive role of the HALN is not yet fully defined (Table 3).

Open nephrectomy and laparoscopic nephrectomy

Globally, several meta-analyses have concluded that although the operative time and the warm ischemia time are more favorable for the open approach, the LLDN has a shorter hospital stay, faster recovery, less pain, less blood loss, faster return to work, and better quality of life compared to the open approach. Most of these studies present the hand-assisted as an alternative rather than as the technique of choice.19,30,42–44

Via open surgery, it is easier to control intraoperative bleedings, and in the postoperative period; although the rate of reoperation for bleeding is similar in both groups (1.7 vs 0.7%), in a recent work by Friedman et al.,45 we saw that massive hemorrhages are associated to a greater extent to the use of surgical Hem-o-locks (more frequently in the laparoscopic approach) than with other methods of renal pedicle control.

Although laparoscopy has a longer warm ischemia time, several studies have shown that this does not translate
### Surgical aspects of living donor nephrectomy

#### Table 3  Levels and types of evidence in the comparison of different techniques in live donor nephrectomy.

<table>
<thead>
<tr>
<th>Level of evidence</th>
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<tbody>
<tr>
<td>Open mini-incision</td>
<td>III Prospective studies&lt;sup&gt;31,51&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mini-incision vs LLDN</td>
<td>Retrospective studies&lt;sup&gt;20,22&lt;/sup&gt;</td>
</tr>
<tr>
<td>LLDN vs HALN</td>
<td>Randomized clinical trials&lt;sup&gt;59&lt;/sup&gt;</td>
</tr>
<tr>
<td>Robotic vs open</td>
<td>Prospective studies&lt;sup&gt;54&lt;/sup&gt;</td>
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into increased graft dysfunction.<sup>46,47</sup> The incidence of complications remains lower in the laparoscopic group (14 vs 16%).<sup>46</sup> Apart from the pain of surgical wound, which is longer in the open surgery group, there are no differences in other major or minor specific complications.

In the case of specifically comparing the transperitoneal approach and retroperitoneoscopy within laparoscopy, we have seen that the transperitoneal approach presents fewer lung lesions, hernias, and surgical wound pain than the retroperitoneal approach.<sup>48,49</sup>

Doubts regarding follow-up, complications, and safety of the donor and receptor have been solved over time. LLDN is currently the standard technique in most centers with experience in laparoscopy.<sup>50</sup>

### Laparoscopic nephrectomy and mini-incisional open nephrectomy

The existing randomized studies have concluded that the LLDN presents better quality of life compared to the mini-incision with equal functionality to the graft.<sup>51</sup> Overall, compared to the mini-incision, the LLDN has a longer surgical time and less blood loss, without differences in terms of complications. The LLDN has fewer analgesic requirements and a shorter hospital stay.<sup>51,52</sup> Now, the LLDN is technically more demanding with a longer learning curve. Because of this, many smaller centers have opted for mini-incisional approaches.

Lewis et al.<sup>53</sup> conducted a study comparing the open approach, laparoscopy, and mini-incision. The operative time and warm ischemia were longer for the mini-incision and laparoscopy. Blood loss, hospital stay, and recovery of normal activity were significantly lower in laparoscopy. The analgesic requirements were similar (Table 3).

### Follow-up of the receptor

Globally, no significant differences were seen in overall or graft survival, need for dialysis, incidence of technical complications (ureteral or vascular), incidence, time or severity of graft rejection, and immediate or long-term function between the receptors made by open or laparoscopic approach.<sup>53</sup>

Theoretically, the pneumoperitoneum required for laparoscopic surgery would reduce the blood supply to the kidney, causing a decrease in its function; however, hyperhydration significantly helps maintain the rhythm of diuresis. The patients must be hydrated with 5–7 l of crystalloids during surgery, and 25 mg of mannitol administered to encourage diuresis. After the transplant, the decrease in creatinine levels in the laparoscopic group indicates an immediate recovery of the renal function.<sup>54</sup>

Although the creatinine nadir is reached earlier in the open surgery group (third vs. fourth postoperative day), clinical significance has not been appreciated. The average hospital stay is around 7 days for both groups, and there are no significant differences in terms of ureteral complications.<sup>55</sup> Survival after one year of the laparoscopic and open (100 vs. 97%) and graft group (93.5 vs 91.1%) were similar in both groups.<sup>54,55</sup>

### Developing surgical techniques

The literature in this field is limited, although the theoretical advantages of the robot would be the scanned image in combination with the advances in microsurgery.<sup>56</sup> There is a study comparing the robot to the open approach, in which the operative time and warm ischemia are greater in the robot, with equivalent graft function, similar complications, and shorter hospital stay for the robot.<sup>57</sup> Similarly, new minimally invasive surgical techniques such as robotic-assisted nephrectomy and NOTES or LESS, whose results so far are preliminary, are recently being introduced.<sup>58,66</sup>

### Conclusions

Currently, there is sufficient evidence to consider the LLDN as the technique of choice, although the role of the hand-assisted technique and retroperitoneoscopy are still not entirely clarified. The techniques of mini-incisional open surgery techniques represent an acceptable alternative for the centers that have not yet implemented laparoscopic surgery. The right kidney nephrectomy, multiple pedicles, and in obese patients is justified in selected cases.

### Conflict of interest

The authors declare that they have no conflict of interest.

### References


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