ORIGINAL ARTICLE

Laparoscopic partial nephrectomy: An experience in 227 cases

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Abstract
Objective: To evaluate our long-term experience with laparoscopic partial nephrectomy (LPN) and to review the literature.

Material and methods: We performed a retrospective chart review, evaluating 227 consecutives laparoscopic partial nephrectomies performed between June 1995 and June 2010. Perioperative data were recorded along with clinical a oncological outcomes.

Results: Mean age was 56.4 years (18–87) and clinical stages were T1a, T1b and T2 in 90.74% (206/227), 7.48% (17/227) and 1.76% (4/227), respectively. Median blood loss was 250 ml (10–1800). The mean operative time was 108.42 min (30–240) and median warm ischemia time was 25 min (10–60). The intraoperative complication rate was 2.64% (6/227), 5 (2.2%) secondary to bleeding. The postoperative complication rate was 5.72% (13/227) and bleeding is also the most frequent in 3% (7/227) of the cases. According to the Clavien classification, 1.32% (3/227), 0.88% (2/227) and 3.52% (8/227) were grade i, ii and iii, respectively. The mean hospital stay was 3.66 days (1–12).

Clear cell carcinoma was the most common histological finding in 74.6% (150 patients). TNM classification was T1a, T1b and T2 in 90.74% (206/227), 7.48% (17/227) and 1.76% (4/227), respectively. No conversion or mortality was reported. Positive surgical margins were found in 4 patients (2.7%), with no local recurrence after long-term follow-up. At a mean follow up of 27 months, one patient had port site and peritoneal recurrence.

Conclusion: Laparoscopic partial nephrectomy is a safe and viable alternative to open partial nephrectomy, providing equivalent oncologic outcomes and comparable morbidity to the traditional approach in experienced centers.

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PALABRAS CLAVE
Carcinoma renal; Laparoscopia; Nefrectomía parcial; Operaciones laparoscópicas; Nefrectomía parcial.

Nefrectomía parcial laparoscópica: experiencia en 227 casos consecutivos

Resumen
Objetivo: Analizar nuestra experiencia a largo plazo con la técnica de nefrectomía parcial laparoscópica (NPL) y revisar la literatura.


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Cirugía conservadora de nefronas

**Material y métodos**: Entre junio de 1995 y junio de 2010 se efectuaron 227 nefrectomías parciales laparoscópicas. Los datos fueron registrados en forma prospectiva y se realizó una revisión retrospectiva de los datos demográficos y quirúrgicos, complicaciones perioperatorias, estancia hospitalaria, tasa de márgenes positivos y de recurrencia, y hallazgos histopatológicos.

**Resultados**: La edad promedio fue de 56,4 años (18-87). El sangrado intraoperatorio promedio fue de 250 ml (10-1.800). El tiempo operatorio medio fue de 108,42 min (30-240) y la mediana de tiempo de isquemia caliente fue de 25 min (10-60). La tasa de complicaciones intraoperatorias fue de 2,64% (6/227), de las cuales 5 (2,2%) fueron por sangrado. La tasa de complicación postoperatoria fue de 5,72% (13/227), siendo también el sangrado la más frecuente en un 3% (7/227) de los casos. Según la clasificación de Clavien, el 1,32% (3/227), el 0,88% (2/227) y el 3,52% (8/227) fueron grado I, II y IIIb, respectivamente. La estancia hospitalaria media fue de 3,66 días (1-12).

El carcinoma de células renales fue el hallazgo histopatológico más frecuente en el 74,6% (150 pacientes), presentando estadíos clínicos T1a, T1b y T2 en el 90,74% (206/227), el 7,48% (17/227) y el 1,76% (4/227), respectivamente. No hubo conversión ni mortalidad relacionada con la cirugía. Hubo margen quirúrgico positivo en 4 pacientes (2,7%), sin recurrencia a largo plazo. En un seguimiento promedio de 27 meses hubo solo un caso de metástasis en los puertos y carcinomatosis peritoneal.

**Conclusión**: La NLP es una alternativa segura y viable a la nefrectomía parcial abierta, entregando resultados oncológicos equivalentes y una morbilidad comparable a la cirugía tradicional en centros con experiencia.

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**Introduction**

Since 1990, 2 advances significantly changed the approach to treat renal masses. One of them was the advancement of minimally invasive surgery. In 1991, Clayman et al. performed the first laparoscopic nephrectomy and since then a lot of researchers have reported their experience with laparoscopic nephrectomy using a variety of approaches. The other development was the acceptance of nephron-sparing surgery as a management alternative for small renal masses in patients with a normal contralateral kidney. Partial nephrectomy initially proved to be effective for the treatment of renal tumors when preservation of the renal function was essential. In this sense, we achieved excellent local control for small renal tumors treated with this technique. Then, new research allowed for the dissemination of the role of partial nephrectomy in patients with normal contralateral kidney.

Laparoscopic partial nephrectomy (LPN) combines these two advantages, offering in the same procedure the benefit of reducing morbidity linked to laparoscopy, while preserving renal function secondary to partial nephrectomy.

Since its introduction in 1993, the LPN has gained acceptance as a viable alternative for the management of small renal tumors. The LPN has the advantage of having a faster recovery profile, but when compared with open partial nephrectomy, it was initially associated with a longer ischemia time and greater complications. During the last decade, the LPN technique has continued to evolve, delivering better results and gaining more and more followers within the urological community.

The aim of this work is to publish our experience on LPN after 15 years and to carry out a review of the contemporary literature on LPN.

**Material and methods**

In this study, we evaluated 227 LPNs consecutively performed by the same surgeon (OAC) over a period of 15 years, from June 1995 to June 2010. There was not a strict criterion for the selection of patients, since at the beginning only small tumors and primarily exophytic were selected, increasing the complexity based on the acquisition of experience. All the procedures were performed using a similar technique. The installation of ports and the surgical technique used have been described in detail above, so we will not go into detail in this area. We mainly used the transperitoneal approach, using 4 ports placed in a rhomboidal shape, except for the right side, where a fifth port was added for placing a clamp to separate the liver.

Vascular control varied in the evolution of the series mainly due to the availability of resources according to the time. Initially, we used hand-assisted surgery, in which the surgeon’s hand performed manual compression of the renal parenchyma, without renal pedicle control; then vascular control was used with open-surgery bull-dog inserted through a working port; we continued with vascular control with Rumel using the technique described by Rosales et al.; then we used laparoscopic Satinsky (Storz Medical®), and finally the laparoscopic bull-dogs (Aesculap®). For the tumor resection, we used the cold scissors section. The parenchyma was sutured in a close-up of 3-0 Vycril with continuous suture (calyceal-vascular plane), and the background with 2-0 Vycril to separate stitches or continuous suture on Surgicell (Ethicon®) matrix. Routinely, we left suction drainage. No ureteral catheter was used to identify calyces opening.

The database was produced prospectively and we retrospectively analyzed the following demographic data: age,
sex, body mass index; perioperative data such as operative time, ischemic time, and conversion rate. In addition, we evaluated the perioperative complications according to the modified Clavien classification, 

Results

Over a period of 15 years, 227 consecutive LPNs were performed. The demographic data of the series are summarized in Table 1. The average age was 56.4 years, with a range of 18–87 years.

The transperitoneal approach was the most used (Table 2). 21.5% (49/227) of the LPNs were performed with manual assistance, all of them at the beginning of the series. In relation to the operative side, there was a slight predominance of the right side in 52.8% (120/227). The mean intraoperative blood loss was 250 (10–1800) ml and the mean operative time was 108.42 (30–240) min. In the patients who underwent vascular control of the renal pedicle (178 out of 227 cases, or 78.4%), the median ischemic time was 25 (10–60) min. In no case was it required to convert to open surgery. 2 patients (0.88%) underwent ipsilateral adrenalectomy due to a tumor-like lesion present in preoperative studies.

Perioperative complications were divided into intraoperative and postoperative complications (Table 3). Intraoperative complications occurred in 6 patients (2.64%): one patient (0.44%) had renal pelvis injury due to the proximity of the tumor and 5 patients (2.2%) had intraoperative bleeding (one patient with renal vein injury). In 2 out of these 5 patients, it was required to perform laparoscopic nephrectomy without conversion to open surgery. Postoperative complications occurred in 13 patients (5.72%), in 7 of them it was due to postoperative bleeding secondary to arteriovenous fistula. Of these 7 patients, only one (0.44%) required a laparoscopic nephrectomy and the remaining 6 were successfully treated by angiography and embolization. One patient had urinary fistula and secondary urinoma evolving satisfactorily by placing a double J ureteral catheter and percutaneous nephrostomy. The other postoperative complications are listed in Table 3, being treated successfully by medical treatment and watchful waiting. When applying the modified Clavien classification, 12 most of the patients had complications lower than or equal to grade III. The transfusion rate was 7% (16/227) and the mean hospital stay was 3.6 (1–12) days.

Mean tumor size was 2.9 (1–9) cm. The histopathological findings are detailed in Table 4. There were positive margins in 4 out of 150 patients (2.7%), all of them in the group of patients with manual assistance and without vascular control. None of these patients had local recurrence, with a mean follow-up of 52 months. Of the 150 patients

### Table 1 Demographic data of the 227 laparoscopic partial nephrectomies.

<table>
<thead>
<tr>
<th>Demographic characteristics of the patients</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/female (percentage)</td>
<td>2/1 ratio</td>
</tr>
<tr>
<td>Age (years)</td>
<td>56.4 (18–87)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>28.2 (18.6–41.5)</td>
</tr>
</tbody>
</table>

### Table 2 Perioperative data of the series.

<table>
<thead>
<tr>
<th>Approach</th>
<th>217 (95.6%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transperitoneal</td>
<td>10 (4.4%)</td>
</tr>
<tr>
<td>Retropertioneal</td>
<td>1/1 ratio</td>
</tr>
<tr>
<td>Manual assistance</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>49 (21.5%)</td>
</tr>
<tr>
<td>No</td>
<td>178 (78.5%)</td>
</tr>
<tr>
<td>Intraoperative bleeding (mean)</td>
<td>250 ml (10–1800)</td>
</tr>
<tr>
<td>Operative time (mean)</td>
<td>108.42 min (30–240)</td>
</tr>
<tr>
<td>Ischemia time (median)</td>
<td>25 min (10–60)</td>
</tr>
<tr>
<td>Transfusion rate</td>
<td>16 (7%)</td>
</tr>
</tbody>
</table>

### Table 3 Perioperative complications of the series.

<table>
<thead>
<tr>
<th>Perioperative complications of the series</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative</td>
<td>6 2.64</td>
</tr>
<tr>
<td>Renal pelvis injury</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Intraoperative bleeding</td>
<td>5 2.2</td>
</tr>
<tr>
<td>Postoperative</td>
<td>13 5.72</td>
</tr>
<tr>
<td>Postoperative bleeding</td>
<td>7 3.3</td>
</tr>
<tr>
<td>Urinary fistula</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Pneumony</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Wound seroma</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>1 0.44</td>
</tr>
<tr>
<td>Lymphorrhrea</td>
<td>1 0.44</td>
</tr>
</tbody>
</table>

### Table 4 Histopathological findings of a total of 205 patients of the series assessed.

<table>
<thead>
<tr>
<th>Renal cell carcinoma</th>
<th>137</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear cell</td>
<td>8</td>
</tr>
<tr>
<td>Cromophobe</td>
<td>5</td>
</tr>
<tr>
<td>Papillary type 1</td>
<td></td>
</tr>
<tr>
<td>Cystic lesions</td>
<td>34</td>
</tr>
<tr>
<td>Oncocitoma</td>
<td>14</td>
</tr>
<tr>
<td>Adenoma</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>1</td>
</tr>
<tr>
<td>Pseudoinflammatory tumor</td>
<td>1</td>
</tr>
<tr>
<td>MEST</td>
<td>1</td>
</tr>
<tr>
<td>Calyceal diverticulum</td>
<td>1</td>
</tr>
<tr>
<td>Metastasis of thyroid carcinoma</td>
<td>1</td>
</tr>
</tbody>
</table>

MEST: mixed epithelial and stromal tumor.
diagnosed with renal cell carcinoma, follow-up was completed in 127. The mean follow-up time of the series was 28 (3–132) months. During this time, there was a recurrence (0.44%) at peritoneal level and of the ports 3 months after the surgery. The patient had been operated for a pT1a stage and Fuhrman grade 3 RCC, and the margins were negative. Unfortunately, he died a few days after the diagnosis.16

Discussion

After the first LPN performed by Winfield et al.,8 LPN viability has been published by various authors.16–18 However, it has not established itself as the standard for tumors smaller than 4 cm. The guidelines of the American Association of Urology recommend both the open and the laparoscopic approaches for the management of the tumors smaller than 4 cm, but the latter only in experienced hands. Some initial publications showed that the LPN had increased warm ischemia time and postoperative complications, such as bleeding and urinary fistula.19 However, over time, the surgical technique was refined hand in hand with an improvement of the laparoscopic instruments. One of these advances was the early renal pedicle unclamping after the suture of the calicovascular plane,20,21 showing a reduction of more than 50% of the warm ischemia time.20 Gill et al.22 published their experience in 800 LPNs carried out in 9 years. In this study, the surgeries were divided into 3 groups: group 1 corresponded to the first 276 LPNs, group 2 to the next 289 LPNs, and group 3 to the latest 235LPNs. In all cases, the same technique was performed, except for group 3, where early renal pedicle unclamping was performed. Although the tumors of the patients in group 3 were more complex (size and location), the ischemic time was shorter for this group (31.9, 31.6, and 14.4 min for groups 1, 2, and 3, respectively; p < 0.0001). Group 3 also had a lower rate of postoperative complications (22.1, 12.5, and 8.5%, respectively; p < 0.0001), and a lower rate of postoperative bleeding (6.5, 3.5, and 2.1% of cases; p = 0.035), although the rate of urinary fistula was similar in all 3 groups (3.6, 1.7, and 1.7%, respectively). The negative surgical margins and conversion rates were similar in all 3 groups (99, 99, and 99.4% of the cases, respectively). With regard to the postoperative value of blood creatinine, group 3 had the lowest elevation (28.4, 28.8, and 17.4%, respectively; p = 0.23). In a mean follow-up period of 3.2 years and out of a total of 744 patients assessed by their histopathology, cancer-specific and recurrence-free survival at 5 years was 90, 99, and 97%, respectively. The authors conclude that, despite the increased complexity of the tumors in group 3, the ischemia time, complications, and renal function improved significantly.

Another study published by Lifshitz et al.,23 which evaluated the evolution of the LPN technique, compared the surgical and functional results. The same surgeon performed a total of 184 LPNs in a period of 6 years and they were divided into the first 50 (group 1) and the last 50 (group 2) surgeries. The variations in the surgical technique for group 2 were: ureteral catheter according to the case, vascular control of artery and vein in all cases to decrease bleeding, better identification of the excretory system, closure of the surgical site at 2 levels, one for the vascular-calciﬁc level, and another one of the parenchyma, early unclamping. 95% of the cases were approached transperitoneally. Both groups had similar demographic characteristics, except that group 2 had more central and larger tumors, the average size being 2.4 cm for group 1 and 3 cm for group 2. The mean ischemia time was similar for both groups (30 and 27 min, respectively; p = 0.3), as well as the rate of complications. The rate of positive margins was 2 and 4% for groups 1 and 2, respectively (p = 0.6). They observed no local or distant recurrence after 18 months of mean follow-up. The authors conclude that the LPN may be indicated for central and larger tumors as experience increases and surgical techniques improve.

In many centers, the LPN has been acquired as a first-line alternative for tumors smaller than 4 cm.24–29 In them, the choice of the approach, transperitoneal or retroperitoneal, depends on the experience of the surgeon, the location and size of the tumor.28,29 In an attempt to decrease the rate of postoperative complications, several hemostatic substances have been released which have validated their effectiveness.30–33 One of these substances is FloSeal® (Baxter, Deerfield, Illinois, USA), consisting of a gelatinous matrix of thrombin. Its use in LPN was assessed by Gill et al.,34 who compared a group with FloSeal® vs. another one which did not use the hemostatic agent. Both groups were comparable in demographic and perioperative terms. However, the complication rate was signiﬁcantly lower for the FloSeal® group (37% versus 16%; p = 0.008), with less tendency to bleeding complications (12% versus 3%), although this was not statistically signiﬁcant (p = 0.08). The authors conclude that the use of FloSeal® decreased the rate of complications, so they recommend its routine use in LPN.

Because the LPN and laparoscopic radical nephrectomy (LRN) present comparable oncological results for tumors smaller than 4 cm, the indications for LPN for tumors larger than 4 cm were expanded.35,44 Simmons et al.35 compared the perioperative outcomes of 35 patients undergoing LPN vs. 75 patients undergoing LRN for tumors larger than 4 cm (T1b). No differences were found in estimated intraoperative bleeding, in the complication rate or positive margins. At a mean follow-up of 57 (27–79) months for the LRN group and 44 (27–85) months for the LPN group, the overall mortality rate (11% vs. 11%), specific mortality (3% vs. 3%), and recurrence (3% vs. 6%) were equivalent in both groups (p = 0.4). In addition, the decline in the glomerular filtration rate was lower in patients undergoing LPN (13 and 24 ml/min, respectively; p = 0.03). The authors conclude that in selected patients with tumors larger than 4 cm, the LPN presents similar oncologic outcomes and reduced renal function impairment compared with LRN. Lifshitz et al.36 compared 149 patients with T1a stage tumors versus 35 patients with T1b stage tumors undergoing LPN. They found no differences either in mean operative time, ischemia time, estimated intraoperative bleeding, and intraoperative complications. However, they did show increased postoperative complications in the group with stage T1b (26% vs. 12%; p = 0.001). As evidenced by these publications, the LPN can be used for tumors greater than 4 cm; however, in some situations, a deeper resection of the renal parenchyma is necessary, as well as making a larger reconstruction, which leads to longer ischemia time and postoperative complications compared with tumors smaller than 4 cm.19

Gill et al.37 published a comparison of perioperative and renal function outcomes between the initial LPNs and open
Laparoscopic partial nephrectomies (OPNs) in patients with clinical stage T1 (<7 cm). The study was conducted in 1800 patients of 3 different centers with high surgical volume. 771 patients undergoing LPN and 1029 OPN were included. The surgical technique of both procedures was similar, as well as the renal pedicle control (91.5% for LPN and 99% for OPN). 78.5% of the LPNs were approached transperitoneally. Postoperative complications were classified as urological (bleeding, when there was need for surgical reoperation or transfusion greater than or equal to 3 units of red blood cells; urinary fistula, drainage greater than 50 ml/day for more than a week with biochemical study compatible with urine), acute renal failure (any dialysis, ureteral obstruction, or renal loss) or non-urological complications (cardiac, gastrointestinal, thromboembolism, etc.). The average warm ischemia time was 30.7 and 20.1 min for LPN and OPN, respectively. However, the multivariate analysis (it included the different demographic and tumor variables) showed that the warm ischemia time was 1.69 times higher for LPN (95% CI: 1.62–1.77) compared with the patients with similar characteristics undergoing OPN (p < 0.0001). The mean operative time was 3.3 h for LPN and 4.3 h for OPN. The multivariate analysis showed that for LPN, it was 0.78 times lower compared with OPN (95% CI: 0.75–0.81; p < 0.0001). The average intraoperative blood loss was 300 ml and 376 ml for LPN and OPN, respectively. The multivariate analysis was in favor of LPN (0.80 times; 95% CI: 0.74–0.87; p < 0.0001). The transfusion rate was 4.5% for LPN and 5.1% for OPN. The rate of intraoperative complications was similar in both groups; however, the patients undergoing LPN had a higher rate of postoperative complications, particularly urological (p < 0.0001). The hospital stay was 0.59 times lower for LPN, 3.5 vs. 5.8 days (95% CI: 0.56–0.61; p < 0.0001). The renal function was similar for both groups 3 months after being assessed. The cancer-specific survival at a mean follow-up of 3 years for patients with renal cell carcinoma (pT1N0M0) was 99.3% after LPN and 99.2% after OPN. The authors conclude that LPN for tumors smaller than 7 cm offers the advantages of shorter operative time, less intraoperative bleeding, and shorter hospital stay; however, it has increased ischemia time and postoperative complications (urological) compared with OPN. The oncologic and functional results were similar to OPN. It is important to highlight that this comparative study was among the first LPNs performed in 3 different centers compared with OPNs; therefore, techniques to reduce the warm ischemia time and the rate of postoperative bleeding complications were not implemented.20,21

The extensive review of the literature presented in this discussion reflects not only the complexity of LPN, but also its good results in experienced centers and patient volume. The most important limitation of this study is that it is a retrospective series, at a center of medium volume of patients, through a long period of time. This is reflected mainly in the variations of the surgical technique, in the inclusion of tumors of greater complexity in time and in the complications. In the first 49 cases, vascular control was not performed, because of lacking the necessary equipment to do it (the series started in 1995). However, despite having selected only patients with small and exophytic tumors, it was in this unique group of patients where there were positive surgical margins (4 cases) and the highest rate of bleeding complications. This meant a radical change in our surgical approach, as we believe that good vascular control is essential, both to achieve an adequate margin of healthy tissue and to perform a better suture both of the vascular-calicilar level and of the renal parenchyma. Good vascular control also makes it possible, and to the extent of the experience gained, to perform LPN in more complex tumors. To the extent of the experience gained, those who are introduced in this surgical technique may, as we do today, perform early unclamping once the primary renal level is sutured, perform selective control of secondary arterial branches avoiding the renal pedicle clamping, only perform vascular control of the artery and not the vein, especially to the left (to the right it is not advisable because of greater retrograde venous flow). It has been established that the acceptable warm ischemia time is 30 min, but in our opinion, this is an arbitrary limit, since ‘every minute counts’.

We estimate that, currently, the use of any index that quantifies the tumor anatomical complexity13–15 will enable us to better select the cases for partial nephrectomy according to the surgeon’s experience and the potential risk of complications. In our opinion, in centers with a low volume of patients, the hand-assisted surgical technique and with associated vascular control will shorten the learning curve and have a lower complication rate.

Conclusion

LPN is a safe and viable alternative to OPN, delivering equivalent oncological outcomes and a morbidity comparable to traditional surgery in experienced centers.

Conflict of interests

The authors declare that they have no conflict of interest.

References