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# Comparative Analysis of Robot-Assisted versus Traditional Laparoscopic Retroperitoneal Partial Nephrectomy

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**Abstract**

**Introduction:** This study aimed to assess the effectiveness of laparoscopic retroperitoneal partial nephrectomy (LRPN) and robot-assisted retroperitoneal partial nephrectomy (RRPN) in managing renal tumors, with a focus on perioperative efficiency, oncological safety, and preservation of renal function.

**Materials and Methods:** The cohort comprised 80 patients who underwent partial nephrectomy (PN), (centre A-LRPN =26, centre B-RRPN=54), excluding those with prior renal surgeries or conditions complicating renal function. Perioperative, postoperative, oncologic, and renal functional data were compared between the two surgical techniques. Tumor complexity was evaluated using the RENAL scoring system and surgical success was assessed using the margin, ischemia, and complication (MIC) scoring system.

**Results:** The median tumor size (4 vs. 2.5 cm) and RENAL scores (6 vs. 4) were significantly higher in the RRPN group ($p<0.05$). Trocar placement and operation times were significantly lower in the LRPN group ($p<0.05$). In terms of mean estimated blood loss, postoperative renal function, and reduction in hemoglobin levels, no significant differences were observed between the groups. The oncological outcomes were comparable between the groups, with no significant differences observed in positive surgical margin rates.

**Conclusion:** In minimally invasive partial nephrectomy, both robotic and laparoscopic approaches have their advantages. LRPN is a feasible method in less complicated tumors with its shorter trocar placement time and shorter operation time. Although RRPN can be applied in larger and more complex tumors, its oncological and functional results are similar to LRPN. This suggests that while the robotic approach is potentially more suitable for complex cases, it does not compromise patient safety or effectiveness.

**Key words:** Laparoscopic; nephrectomy; partial; retroperitoneal; robotic.

## Introduction

Renal tumors present a complex clinical challenge, necessitating surgical interventions that meticulously balance tumor excision efficacy with the preservation of renal function (1). The field of minimally invasive surgical techniques, including robot-assisted and laparoscopic procedures, has made significant progress in the therapy of renal tumors in recent years (1, 2). Many criteria, such as the tumor's stage, location, size, depth, and proximity to the renal vasculature, influence the treatment decision, which can involve either a partial or radical nephrectomy. PN is the recommended approach for managing T1a-b renal tumors if possible (1-3). Transperitoneal or retroperitoneal methods can be used for minimally invasive PN (1, 2, 4).The retroperitoneal approach has gained attention due to its subtle advantages, especially in the treatment of tumors in the posterior part of the kidney (4, 5). This tailored approach streamlines access to posterior tumors and facilitates a rapid and direct route to the renal hilum, offering an appealing alternative to the transperitoneal approach (4, 6). This approach minimizes the risk of injury to adjacent organs by preventing intervention in intra-abdominal structures. Additionally, the shortened trajectory to the renal hilum through the retroperitoneal approach allows for expedited surgical access, potentially resulting in reduced operative times (6). Robotic-assisted PN has emerged as a promising approach, offering potential benefits over traditional laparoscopic methods. It has provided surgeons a three-dimensional, high-definition field of view, and reduced

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intraoperative bleeding in transperitoneal partial nephrectomy (7). In the era of personalized medicine, where the emphasis on renal preservation has never been more critical, understanding the benefits of the retroperitoneal approach is imperative. Previous reports have indicated comparable outcomes between transperitoneal and retroperitoneal robotic PN, but few studies have directly compared the efficiency of RRPN and LRPN (8). Additionally, concerns regarding oncological and functional results and overall complication rates between these approaches warrant thorough investigation. In the light of these considerations, this retrospective study aimed to compare the oncological and functional results of RRPN and LRPN.

## Materials and Methods

**Study design and patients:** A retrospective cohort design was used in this two-center study to compare the results of consecutive patients treated with LRPN by a single surgeon in center A and RRPN by a single surgeon in center B. Both surgeons had over 15 years of experience in laparoscopic surgery and uro-oncology. The robotic surgeon also had 8 years of experience in robotic surgery. Patients with bilateral renal tumors and multiple tumors, missing data, previous renal surgery at the tumor site, or renal stones requiring further renal surgery were excluded from the study. Between January 2019 and November 2023, a total of 80 patients, 26 undergoing LRPN (group 1) and 54 undergoing RRPN (group 2), were included in the study. Perioperative, postoperative, oncologic, and renal functional data were assessed. Variables including length of hospital stay, mean operative time, warm ischemia time, estimated blood loss, postoperative complications, and changes in renal function were evaluated. The surgical difficulty in PN was determined using the R.E.N.A.L. scoring system (9). MIC score positivity is defined as a negative surgical margin (SM), renal ischemia time of less than 20 minutes, and absence of complications and it was used to define surgical success (10). The collected data were compared between the two groups to assess differences in outcomes.

The study was conducted in accordance with ethical rules and necessary permissions were obtained from the institutional ethics committee. Patient confidentiality and data protection were ensured throughout the study.

**Surgical techniques:** Both laparoscopic and robotic procedures were performed under general anesthesia at the lateral decubitus position with the tumor side up. The operating table was bent into an inverted V shape to widen the space between the iliac crest and the 12th rib. A standard retroperitoneal 3-port configuration was employed in the LRPN group (11). After the port placement, the kidney was released from the surrounding tissues, the renal hilum was found and the renal artery was dissected and separated. The renal tumor was identified after the Gerota's fascia incision and enucleated from the kidney. Two-layer suture renography was performed with a 3-0 monofilament barbed suture and a 2-0 polyglactin suture using the sliding clip technique.

The Da-Vinci Xi ® (Intuitive Surgical, Sunnyvale, CA, USA) surgical platform was used in RRPN group. A standard robotic retroperitoneal 4-port configuration was employed with an additional assistant port (12). After the docking of the robotic arms, the fundamental surgical steps of the PN and suture renography were performed as told in LRPN. Unlike the LRPN group, suture renography was not performed in patients who achieved hemostasis with robotic monopolar and bipolar electrocoagulation.

**Ethical approval**: The protocol for this research project has been approved by the ethics committee on human research of Antalya Training and Research Hospital (No. 16/7, Dated 23/11/2023, retrospectively registered), and it conforms to the provisions of the Declaration of Helsinki.

**Statistics analis:** Statistics were analyzed using SPSS 22.0 for Windows (SPSS, Inc., Chicago, IL, USA). Student's t-test was used for comparison of results for continuous variables with normal distribution. Continuous variables with a non-normal distribution were reported as the median (interquartile range) and were compared using the Mann-Whitney U test. Categorical variables were reported as numbers (percentages) and Pearson's chi-squared test was used to compare outcomes. A value of $p < 0.05$ (two-tailed) was considered to be statistically significant.

## Results

The sex distribution, mean BMI and presence of chronic diseases such as diabetes mellitus and/or hypertension were similar in both groups. In comparison to group 2, group 1's patient mean age was significantly lower (p=0.039). In group 1, the majority of the tumors were located on the left side, whereas in group 2, the tumors were mostly on the right side (p=0.007). There was no difference between the groups in terms of the anterior and posterior renal surface location of the tumors (p>0.05). It was observed that RRPN was

**Table 1:** Patients-tumor characteristics, surgical and functional results

| | | Group 1 (n 26) | Group 2 (n 54) | p Value |
|---|---|---|---|---|
| Age | | 51.50 ±13.33 | 57.67±12.99 | 0.039 |
| Gender | Female (n,%) | 10 (38.5) | 16 (29.6) | 0.430 |
| | Male (n,%) | 16 (61.5) | 38 (70.4) | |
| BMI (kg/m2) | | 28 (16-35) | 27 (20-42) | 0.765 |
| Chronic ilness (n,%) | | 12 (46.2) | 26 (48.1) | 0.867 |
| Tumor side | Right (n,%) | 7 (26.9) | 32 (59.3) | 0.007 |
| | Left (n,%) | 19 (73.1) | 22 (40.7) | |
| Tumor Location | Anterior (n,%) | 8 (30.8) | 10 (18.5) | 0.219 |
| | Posterior (n,%) | 18 (69.2) | 44 (81.5) | |
| Tumor size (cm) | | 2.5 (1.2-5) | 4 (2-6.5) | 0.003 |
| R.E.N.A.L. score | | 4 (4-7) | 6 (4-10) | <0.001 |
| R.E.N.A.L. score group | Low (n,%) | 25 (96.2) | 28 (51.9) | |
| | Mid (n,%) | 1 (3.8) | 23 (42.5) | <0.001 |
| | High (n,%) | 0 | 3 (5.5) | |
| Trocar placement time (min) | | 15 (10-28) | 22 (12-40) | <0.001 |
| Operation time (min) | | 115 (80-181) | 140 (75-270) | 0.008 |
| Off-Clamp (n,%) | | 13 (50.0) | 36 (66.7) | 0.152 |
| Renography time (min),(n) | | 20 (15-30) (26) | 19 (5-37) (38) | 0.041 |
| Ischemia time (min, n) | | 19.54 ±5.79 (13) | 24.89±9.26 (18) | 0.349 |
| Estimated blood loss (ml) | | 150 (100-450) | 135 (30-500) | 0.216 |
| Preoperative Hb level (gr/dl) | | 14.43±1.57 | 14.05±1.70 | 0.348 |
| Postoperative Hb level (gr/dl) | | 13.00±1.63 | 12.75±1.72 | 0.548 |
| Preoperative creatinine level (mg/dl) | | 0.85±0.20 | 1.00±0.19 | 0.001 |
| 3rd month creatinine level (mg/dl) | | 0.89±0.19 | 1.01±0.19 | 0.012 |
| Preoperative eGFR (ml/min) | | 97.34±23.06 | 78.61±16.85 | <0.001 |
| Postoperative 3rd month eGFR (ml/min) | | 93.19±18.85 | 76.67±17.35 | <0.001 |
| Positive surgical margin (n,%) | | 3 (11.5) | 6 (11.1) | 1.0 |
| Malign (n,%) | | 15 (57.7) | 44 (81.5) | 0.024 |
| Clear cell | | 8 | 31 | |
| Papillary | | 4 | 8 | 0.096 |
| Oncocytic-Chromophobe | | 3 | 5 | |
| MIC score positivity (n,%) | | 21 (80.8) | 42 (77.8) | 0.759 |
| Follow-up (month) | | 35 (3-72) | 14.5 (3-63) | 0.105 |
| Recurrence | | 2 | 2 | * |
| Drain removal time | | 2 (1-5) | 3 (1-35) | <0.001 |
| Length of hospital stay | | 4 (3-8) | 3 (2-10) | <0.001 |
| Clavien-Dindo grade III or higher complication | | 1 | 2 | * |
| Red blood cell suspension transfusion | | 0 | 3 | * |

**BMI:** body mass index, **eGFR:** estimated glomerular filtration rate, **MIC:** Margin, ischemia and complication.
***** Not suitable for statistics

applied in more complex tumors. The median tumor size (2.5 cm vs 4 cm) and RENAL scores (4 vs 6) were significantly lower in group 1 (p=0,003). Group 1 included 96.2% of tumors with low RENAL scores, whereas Group 2 included 51.9% of tumors with low RENAL scores (p<0.001). (Table 1). Operative outcomes revealed a significant advantage for LRPN in terms of trocar placement and operative times. LRPN demonstrated a considerably shorter trocar placement and operative times compared to RRPN (p<0.001). The off-clamp technique ratio was 50.0% of LRPN and 66.7% of RRPN. In group 1, all patients underwent suture renography, while in group 2 thirty eight patients underwent suture renography. Suture renography was not performed in 16 patients in the RRPN group because the hemostasis was achieved by electrocoagulation. The median renography times and the mean ischemia times were similar in both groups (p>0.05) (Table 1). Median estimated blood loss was similar in both groups and was 150 (100-450) ml and 135 (30-500) ml in groups 1 and 2, respectively (p>0.05). Both groups' mean hemoglobin levels before and after surgery were similar. Mean postoperative hemoglobin levels decreased by approximately 1 gr/dl in both groups compared with preoperative levels. Preoperative renal function tests of patients in group 1 were better than in group 2. The mean preoperative creatinine levels were 0.85±0.20 mg/dl and 1.00±0.19 mg/dl in groups 1 and 2, respectively ($p<0.05$). Mean preoperative eGFR was significantly higher in group 1 compared to group 2 (97.34±23.06 vs. 78.61±16.85), ($p<0.05$). Between the preoperative and 3-month postoperative periods, neither group's renal function tests showed a statistically significant decrease. (Table 1). In groups 1 and 2, positive surgical margin rates were 11.5% and 11.1%, respectively. While 57.7% of the renal tumors in group 1 were malignant, 81.5% of those in group 2 were malignant ($p<0.05$). For Group 1, the median follow-up duration was 35 (3–72) months, while for Group 2, it was 14.5 (3-63) months. Local recurrence was detected in two patients in each group. The mean drain removal time was shorter in group 1, and the mean length of hospital stay was shorter in group 2 ($p<0.001$). Complications of Clavien-Dindo grade III or higher occurred in 3 of all patients. Postoperative prolonged urinary leakage was detected in 1 patient in each group and treated by D-J stent insertion. Intraoperative ureter injury occurred in 1 patient in Group 2 and was repaired. None of the patients in Group 1 received blood suspension transfusion postoperatively, whereas 3 patients in Group 2 received 1 unit of red blood cell suspension transfusion. Pathological tumor sub-groups were similar between the groups. While 73.1% of patients in group 1 had pT1a disease, 53.7% of patients in group 2 had pT1a disease. MIC score positivity rates were 80.8% and 77.8% in groups 1 and 2, respectively (Table 1).

## Discussion

PN, particularly under laparoscopy, has historically posed challenges, including prolonged warm ischemia time and heightened risk of hemorrhage (13). Robot-assisted approaches have aimed to address these challenges. Robotic systems offer a 3-D magnified vision and enhanced instrument flexibility, aiding tumor excision and suturing. This may shorten the duration of renal ischemia and operation time (14, 15). The application of an extra arm in robotic surgery can help to treat large-sized (T1b cases) and hilar-located tumors (15). While the narrow surgical field in retroperitoneal PN makes it difficult to place more trocars, will robotic systems overcome this disadvantage by providing more flexible intracorporeal movement? In the presented study, the trocar placement and operation time were significantly longer in the RRPN group. The BMIs of the patients were similar in both groups, but the difference in trocar placement time may be even greater in obese patients with narrow lumbar angles. The impact of ischemia on renal function and the potential benefits of zero-ischemia in preserving renal function are well known (1, 16). Furthermore, tumor depth, size, location, and proximity to the renal vascular system or urinary collection system may affect surgical risks, especially long ischemia time, urine leakage, and excessive bleeding (17). The presented study evaluated the effects of these factors on perioperative and postoperative outcomes using the R.E.N.A.L. scoring system (9). Although the patients in the RRPN group had larger renal tumors and higher R.E.N.A.L. scores, MIC scores, renography times, and EBL were similar between the groups. Even though the RRPN group's tumors were larger, the assistance attractor's ability to create a clean surgical field that made thin layer excision around the tumor easier and consequently reduced intraoperative bleeding during robotic surgery may have contributed to an EBL similar to that of the LRPN group. Furthermore, robotic systems are far superior at identifying the border of healthy renal tissue and differentiating the tumor capsule (8). The flexible robotic arms help the surgeon adjust the suture to the optimal position. In laparoscopic PN, some angles are unreachable, making suturing difficult and prolonging the ischemia time (8). In the RRPN group, renal ischemia was applied at a relatively lower rate despite the more complex tumors, but the ischemia duration was relatively longer when it was applied. Preoperative renal function tests were lower in the RRPN group, but there was no significant decrease in postoperative renal function tests in both groups compared with the preoperative period. Although both groups consisted of consecutive random patients from two different centers, the RRPN group included more complex tumors and ischemic technique application rates were lower in the RRPN group. Almost all of the patients in the LRPN group were in the low RENAL score (4-6) subgroup, whereas nearly half of the patients in the RRPN group were in the intermediate RENAL score (7-9) subgroup. The robotic technique also enabled PN in patients in the high RENAL score (10-12) subgroup. These findings support that robotic systems may encourage surgeons to dare to perform PN in larger and more complex tumors (15). Drain removal time was significantly shorter in LRPN group, and the length of hospital stay was significantly shorter in RRPN group. This may have varied according to differences in surgeons' perceptions of surgical safety. The analysis of oncological outcomes during the follow-up period did not reveal significant differences between RRPN and LRPN. Both approaches demonstrated comparable rates of disease recurrence and progression in a short period.

**Study limitations:** The limitations of this study include the non-comparability of the surgeons' experiences across groups, which could influence the outcomes. Additionally, the retrospective design and small sample sizes with the lack of homogeneity within and between the groups a significant limitations. These factors likely influenced the results and should be considered when interpreting the findings.

## Conclusion

The comparative analysis of RRPN and LRPN involves various factors, including duration of renal ischemia and operation time, postoperative recovery, oncologic outcomes, and renal functional data. The choice of surgical approach, ischemia management, tumor size, and surgical techniques all play a crucial role in determining the overall success and patient outcomes in these procedures. Comparable oncological and functional outcomes between RRPN and LRPN support the feasibility and effectiveness of both techniques in PN. However, the robotic approach may be a good companion for the surgeon in larger and more complex tumors in retroperitoneal PN. Comparison of more homogenous groups in future studies will facilitate a more meaningful comparison of the results of both techniques.

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**Ethical consent:** The protocol for this research project has been approved bythe ethics committee on human research of Antalya Training and Research Hospital (No. 16/7, Dated 23/11/2023, retrospectively registered) and it conforms to the provisions of the Declaration of Helsinki.

**Written informed consent: Written informed consent was obtained from all patients in this study:**

**Conflict of interest:** The authors report no conflict of interest

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**Availability of data:** The data supporting the results of this study have not been shared openly to protect the privacy of the participants, but are available from the corresponding author upon reasonable request.

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