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Comparison of Laparoscopic Partial Nephrectomy vs. Radical Nephrectomy for Renal Tumors with a Renal Nephrometry Score ≥10: A Propensity Score Matched Analysis

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Abstract

Objective: The aim of this study was to assess the oncologic and functional outcomes associated with laparoscopic partial nephrectomy (LPN) in patients diagnosed with high-complexity renal tumors.

Materials and Methods: From November 2009 to October 2018, 399 patients underwent LPN, while 307 patients underwent laparoscopic radical nephrectomy (LRN). Employing propensity score matching to mitigate potential selection bias, individuals were matched on the basis of age, gender, clinical tumor stage, tumor size, baseline renal function, comorbidities, and final tumor pathology. A comparative analysis of functional and oncological outcomes was subsequently conducted across the two groups.

Results: After conducting propensity score analysis, a cohort of 39 patients who underwent LPN was meticulously matched with an equivalent number from the LRN group. The LPN group exhibited a postoperative major complication rate of 10.3%. In the year following surgery, the LRN group demonstrated a notably higher relative decline in renal function compared with the LPN group (-26% vs. -11%, p=0.001). Nevertheless, the two groups displayed similar levels of overall survival (94.9% vs. 82.1%, p=0.545) and recurrence-free survival (97.4% vs. 87.2%, p=0.227).

Conclusions: Although LPN is linked to heightened postoperative complication risks, it may yield superior functional outcomes and maintain comparable oncological outcomes, particularly within proficient medical institutions, for patients grappling with high-complexity renal tumors.

Keywords: Laparoscopic surgery, nephrectomy, patient outcome, propensity score, renal tumor

Introduction

Given the expanding use of cross-sectional imaging for assessing nonspecific issues, a significant proportion of renal tumors are incidentally detected (1).

While partial nephrectomy (PN) remains the preferred approach for patients with clinical T1a tumors, the inclination toward radical nephrectomy (RN) is progressively growing because of the escalation in tumor size and/or complexity in the management of such cases (2). Significant factors that impact treatment decisions encompass the surgeon's proficiency, the clinic's annual case volume, and the effective and widespread use of minimally invasive interventions. Although laparoscopic radical nephrectomy (LRN) has established its efficacy in addressing intricate renal tumors, the existing literature offers only a limited selection of retrospective studies on robotic-assisted PN for this patient cohort (2,3). Conversely, the safety and efficacy of laparoscopic partial nephrectomy (LPN) for high-complexity renal tumors remain inadequately elucidated.

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This study explored the justification for employing LPN in patients diagnosed with high-complexity renal tumors, with a particular focus on assessing both oncological and functional outcomes.

Materials and Methods

The study protocol received scrutiny and approval from the Ondokuz Mayıs University Clinical Research Ethics Committee (decision no: KAEK 2019/538, date: 11.07.2019). All participants provided informed consent upon enrollment and adhered to the tenets of the Declaration of Helsinki. Furthermore, the study has been registered under the identifier NCT04933604 on ClinicalTrials.gov.

We retrospectively analyzed prospectively collected data encompassing 399 cases of LPN and 307 cases of LRN performed between November 2009 and October 2018. Among the LPN group, 41 patients (10.2%) had complete data and each had a radius of the tumor size, exophytic, nearness to collecting system, anterior, location (RENAL) nephrometry score (RNS) of ≥10. In the LRN group, 265 patients (86.3%) had complete data and were consecutively included, with a minimum follow-up period of one year.

To mitigate selection bias, a meticulous 1:1 propensity score-matched analysis was conducted, aligning variables including age, gender, clinical tumor stage, tumor size, baseline renal function, American Society of Anesthesiologists (ASA) score, and pertinent comorbidities such as diabetes mellitus (DM), hypertension (HT), coronary artery disease (CAD), and final tumor pathology of renal cell carcinoma (RCC) (4,5). The final analysis comprised 78 patients, evenly divided into 39 in the LPN group and 39 in the LRN group.

Clinical diagnoses and tumor anatomical characteristics were established using magnetic resonance imaging and/or contrast-enhanced computed tomography. The Urology Review Board was responsible for determining the treatment modality and specific surgical approach for all patients. Both LPNs and LRNs were conducted exclusively by a single surgeon (EO). Pertinent preoperative variables including age, gender, body mass index, hemoglobin levels, serum creatinine, estimated glomerular filtration rate (eGFR), and comorbidities such as DM, HT, CAD, and tumor size were meticulously documented. The complexity of tumors in both cohorts was evaluated using the RNS score (6).

Intraoperative and postoperative variables encompassing operation time (OT), estimated blood loss (EBL), warm ischemia time (WIT) in the LPN group, perioperative complications, postoperative complications, hospitalization duration, renal functional advancements, ultimate tumor pathology, follow-up duration, and the occurrence of metastatic recurrence were meticulously documented. Postoperative complications were stratified using the modified Clavien-Dindo classification system (Grades 1-5) (7). The evaluation of renal function involved the application of the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation to eGFR both before and one year following the surgical procedure (8). The achievement of optimal surgical outcomes in the LPN group was evaluated through the application of trifecta criteria, which encompassed negative surgical margins, WIT of 20 min, and the absence of major complications (≥ Clavien grade 3) (9).

Statistical Analysis

The dataset was subjected to analysis using IBM SPSS Statistics Package version 24 (IBM SPSS®, Armonk, NY). Normal distribution conformity was assessed using the Shapiro-Wilk test, with the comparison of normally distributed data performed using the independent samples t-test. In cases where the normal distribution was not met, the Mann-Whitney U test was employed. For categorical data, the chi-square test was applied, and Fisher's exact test was used when cell counts were less than 5. Analytical outcomes are presented as mean ± standard deviation for quantitative data, and categorical data are expressed as frequency (percentage). A significance level of $p<0.05$ was considered significant. The computation of overall survival and recurrence-free survival was conducted using Kaplan-Meier analysis.

Results

In the LPN group, RNS exhibited a mean of 10.23±0.42 (range: 10-11), indicating that 17 tumors (43.6%) were entirely endophytic, 13 tumors (33.3%) were less than 50% exophytic, and 9 tumors (23.1%) were more than 50% exophytic. The mean WIT was 18.28±5.48 min (range: 8-28). Table 1 presents the preoperative demographics and clinical characteristics of the tumors, both before and after propensity score matching.

The LPN group displayed significantly longer mean operation time (111 vs. 88 min., p=0.001), greater mean EBL (166 vs. 124 mL, p=0.020), and elevated rates of postoperative complications (23.1% vs. 10.3%, p=0.045). Each group had one patient who required postoperative transfusion (Clavien grade 2). Additionally, within the LPN group, two patients experienced pseudoaneurysms, leading to angioembolization (Clavien grade 3a) at 2 and 3 weeks post-LPN, respectively. Likewise, two other LPN patients required double J stenting (Clavien grade 3a) because of urine leakage.

Consequently, patients who underwent LPN exhibited superior preservation of renal function. Specifically, the LPN group demonstrated a mean decrease in the eGFR of 11.18±10.77 mL/min/1.73 m^2 one year post-surgery, in contrast to 26.46±18.11 mL/min/1.73 m^2 in the LRN group (p=0.001). The LPN group also displayed a notably lower relative change in renal function (ΔeGFR) compared to the LRN group (-11% vs. -26%, p=0.001). Furthermore, patients who underwent LRN experienced a substantially higher rate of CKD stage-upgradation 1year post-surgery. A detailed overview of the intraoperative and postoperative outcomes is presented in Table 2.

The mean duration of follow-up in the LPN and LRN groups was 28.43±15.95 months and 56.05±31.72 months, respectively. Among patients who underwent LPN, favorable outcomes were observed, with 97.4% achieving negative surgical margins, 89.7% experiencing no major complications, 66.7% having a WIT of 20 min, and 56.4% meeting the criteria for trifecta success. Additionally, within the same LPN cohort, 38.5% exhibited an upgrade in their CKD stage and 48.5% preserved ≥90% of their eGFR.

The analysis of overall survival revealed comparable rates between the LPN and LRN groups, with values of 94.9% and 82.1% respectively (p=0.545). Similarly, recurrence-free survival demonstrated comparable outcomes, with rates of 97.4% in the LPN group and 87.2% in the LRN group (p=0.227). A graphical representation of overall survival is presented in Figure 1, along with additional details in Table 3. Similarly, Figure 2 illustrates recurrence-free survival, which is complemented by supporting information in Table 4.

Discussion

This study demonstrates that LPN yields comparable oncological outcomes and superior functional outcomes compared with LRN for patients afflicted with high complexity renal tumors (RNS ≥10).

Within the decision-making framework for PN in patients with complex renal tumors, tumor size alone does not inherently serve as a definitive constraint. The interplay of patient demographics, clinical tumor attributes, and surgeon proficiency collectively influences the choice of pursuing PN. Of these factors, tumor complexity is potentially the most influential determinant (10). Although the proportion of patients with cT1a tumors was consistent at 59% in both groups within this study, those patients exhibited a higher RNS. Additionally, the tumors displayed distinct characteristics, with 43.6% (n=17) being entirely endophytic and 69.2% (n=27) located centrally.

Moreover, several nephrometry scoring systems, such as RENAL, PADUA, and C-index, which provide comprehensive insights into tumor anatomy based on preoperative imaging, serve as valuable instruments for anticipating surgical challenges, predicting complications, and informing the decision-making process (11). Correlative investigations have consistently revealed a direct relationship between elevated nephrometry scores and increased risks of prolonged WIT, extended OT, greater EBL, heightened complication rates, and the potential for conversion to RN (12,13). A study conducted by Borgmann et al. (14) proposed that RNS exhibited a stronger association with favorable surgical outcomes and perioperative variables, including OT, EBL, WIT, and LOS. Furthermore, it has been observed that patients with higher nephrometry scores are likely to achieve optimal surgical outcomes at a comparatively

Table 1. Pre-operative clinical and demographic characteristics

	Before propensity score matching			After propensity score matching		
Variables*	**LPN (n=41)**	**LRN (n=265)**	**p value**	**LPN (n=39)**	**LRN (n=39)**	**p-value**
Age, year	51.34±14.41	59.32±13.0	0.001	52.26±13.97	54.15±15.33	0.570[a]
Sex, n (%)			0.164			0.591[b]
Male	24 (58.5)	184 (69.4)		23 (59)	23 (59)	
Female	17 (41.5)	81 (30.6)		16 (41)	16 (41)	
DM, n (%)	5 (12.2)	55 (20.8)	0.199	5 (12.8)	8 (20.5)	0.362[b]
HT, n (%)	13 (31.7)	126 (47.5)	0.058	13 (33.3)	14 (35.9)	0.812[b]
CAD, n (%)	2 (4.9)	27 (10.2)	0.280	2 (5.1)	2 (5.1)	0.692[b]
BMI, kg/m^2	28.12±4.56	26.95±3.75	0.129	28.36±4.61	27.27±3.79	0.339[a]
ASA score			0.001			0.517
1	22 (53.7)	68 (25.7)		20 (51.3)	16 (41)	
2	16 (39)	161 (60.8)		16 (41)	21 (53.8)	
3	3 (7.3)	36 (13.6)		3 (7.7)	2 (5.1)	
Baseline Cr, mg/dL	0.83±0.20	1.21±1.19	0.043	0.83±0.21	0.94±0.61	0.316[a]
Baseline eGFR	99.73±28.37	80.83±30.99	0.001	94.55±17.98	89.85±23.63	0.326[a]
Tumor size	38.71±16.0	62.65±28.9	0.001	38.90±16.27	44.44±22.74	0.220[a]
RENAL score	10.21±0.41	10.72±1.07	0.003	10.23±0.42	10.46±0.68	0.77[a]
Tumor stage			0.001			0.386[b]
T1a	25 (61)	54 (20.5)		23 (59)	23 (59)	
T1b	15 (36.6)	88 (33.3)		15 (38.5)	14 (35.9)	
T2a	1 (2.4)	50 (18.9)		1 (2.6)	2 (5.1)	
T2b	0	27 (10.2)		0	0	
T3a	0	30 (11.4)		0	0	
T3b	0	5 (1.9)		0	0	
T4	0	10 (3.8)		0	0	

ASA: American Society of Anesthesiologists, BMI: Body mass index, CAD: Coronary artery disease, Cr: Serum creatinine, DM: Diabetes mellitus, eGFR: Estimated glomerular filtration rate, LPN: Laparoscopic partial nephrectomy, LRN: Laparoscopic radical nephrectomy, n: Number
*Continuous variables are presented as the mean ± standard deviation, categorical variables as number (%)
[a]t-test, [b]chi-square test

lower rate than individuals with tumors characterized by lower complexity (9).

It has been reported that almost 80% of patients with T1b renal tumor undergo RN or only robotic PN in high-volume centers by experienced surgeons (2,9). Conversely, the sole randomized clinical trial, EORTC 30904, did not establish an overall survival advantage, despite observing improved functional and comparable oncological outcomes with PN in contrast to RN for patients with localized, solitary renal tumors measuring less than 5 cm (15). While the present guidelines recommend considering PN when technically viable for patients with renal tumors, the impact of renal mass size and complexity on post-PN functional outcomes remains a subject of debate, primarily due to the diversity inherent in retrospective studies (16).

Table 2. Perioperative and postoperative variables

Variables*	LPN (n=39)	LRN (n=39)	p-value
Operation time, min	111.15±35.99	88.08±24.21	0.001[a]
Blood loss, mL	166.15±78.99	124.62±74.75	0.020[a]
Hospital stays, day	4.05±2.60	4.29±6.45	0.832[a]
Positive surgical margin, n (%)	1 (2.6)	0	
∆eGFR	11.18±10.77	26.46±18.11	0.001[a]
%∆eGFR	-11	-26	0.001[a]
Postoperative complication rate			0.045[b]
Clavien 1	3(7.7)	0	
Clavien 2	2 (5.1)	4 (10.3)	
Clavien 3a	4 (10.3)	0	
Total	9 (23.1)	4 (10.3)	
Baseline CKD stage			0.296[b]
1	30 (76.9)	22 (56.4)	
2	7 (17.9)	13 (33.3)	
3a	1 (2.6)	2 (5.1)	
3b	1 (2.6)	2 (5.1)	
CKD stage 1 year after surgery			0.001[b]
1	16 (41)	2 (5.1)	
2	20 (51.3)	17 (43.6)	
3a	2 (5.1)	12 (30.8)	
3b	1 (2.6)	6 (15.4)	
4	0	1 (2.6)	
5	0	1 (2.6)	
RCC grade			0.530[b]
Low (1-2)	34 (87.2)	32 (82.1)	
High (3-4)	5 (12.8)	7 (17.9)	
Follow-up, month	28.43±15.95	56.05±31.72	0.001[a]

CKD: Chronic kidney disease, EBL: Estimated blood loss, eGFR: Estimated glomerular filtration rate, LOS: Length of hospital stay, LPN: Laparoscopic partial nephrectomy, LRN: Laparoscopic radical nephrectomy, PSM: Positive surgical margin, RCC: Renal cell carcinoma
*Continuous variables are presented as the mean ± standard deviation, categorical variables as number (%)
[a]t-test, [b]chi-square test

Recent literature has revealed the comparability of PN and RN in relation to oncological and functional outcomes, even in cases of complex tumors. Yang et al.'s (17) recent study suggested that patients undergoing LPN exhibited superior renal functional and oncological outcomes when compared with those who underwent LRN. In line with this, a recent meta-analysis encompassing 21 case-control studies underscores that PN provides comparable oncological outcomes while affording enhanced functional preservation in contrast to RN. The analysis further observed a correlation between increased tumor size, heightened risk of bleeding and complications, and reduced disease recurrence and cancer-specific mortality among patients with PN (18). Our results are consistent with those of the existing literature, demonstrating that OT, EBL, and the rate of complications were elevated in the LPN group. It is important to note that the current study design does not pertain to a specific subgroup within the PN patients, but rather compares the perioperative variables of patients who underwent RN. As anticipated, the extended surgical duration and increased blood loss observed in the LPN group were inherent to the need for

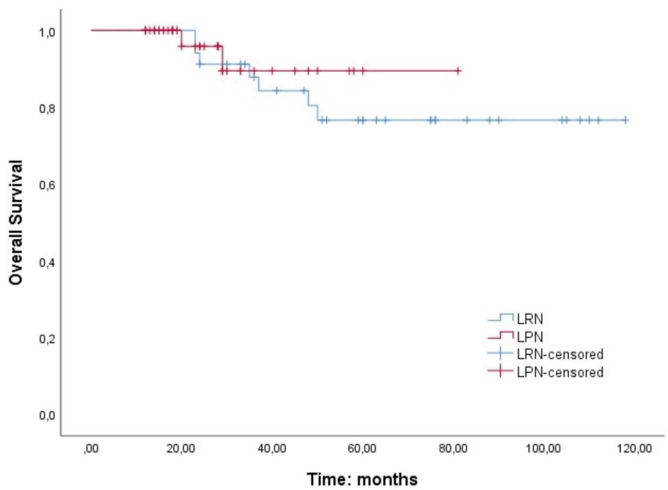

Figure 1. Kaplan-Meier analysis for overall survival

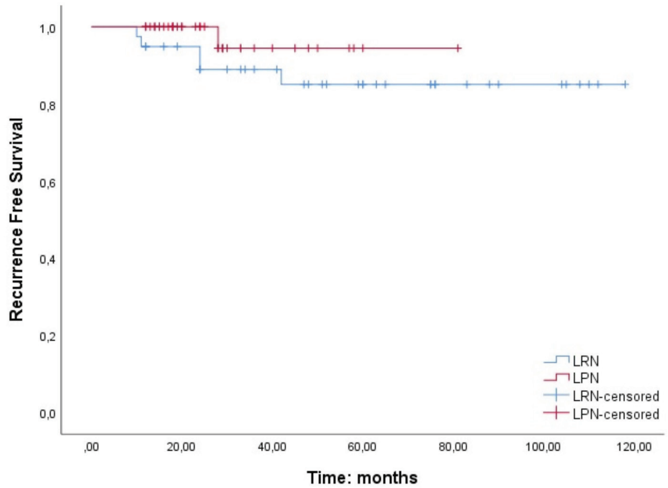

Figure 2. Kaplan-Meier analysis for recurrence free survival

Table 3. Kaplan-Meier analysis for overall survival

	Mean (95% CI)	p-value*
LRN	98.7 (86.1-111.3)	0.545
LPN	75.1 (67.3-82.9)	
Overall	100.9 (90.7-111.1)	

*Log rank, LRN: Laparoscopic radical nephrectomy, LPN: Laparoscopic partial nephrectomy, CI: Confidential intervals

Table 4. Kaplan-Meier analysis for recurrence free survival

	Mean (95% CI)	p-value*
LRN	104 (92.6-115.4)	0.227
LPN	78.1 (72.4-83.7)	
Overall	107.6 (99.6-115.6)	

*Log rank, LRN: Laparoscopic radical nephrectomy, LPN: Laparoscopic partial nephrectomy, CI: Confidential intervals

vascular control, tumor excision, and renorrhaphy during the procedure.

Contemporary literature presents limited evidence regarding LPN for high-complexity renal tumors. This scarcity can be attributed to the increasing adoption of robotic-assisted PN, even for intricate renal tumors, alongside the challenging learning curve associated with pure LPN. In our study, the substantial difference in follow-up duration between the two groups stems from the requisite learning curve for acquiring experience in LPN for patients with complex renal tumors. Nonetheless, our analysis reveals that perioperative outcomes within the LPN cohort, encompassing variables such as OT, WIT, EBL, and rates of postoperative complications, align closely with outcomes reported in prior robotic series (19,20,21).

Even though most complications were minor, tumors with a high-complexity rating have been reported to be directly related to the likelihood of development of increased postoperative complication rates in previous studies (22). In a retrospective cohort study across multiple institutions, Tanagho et al. (23) demonstrated that anatomically classified low-complexity tumors (RNS: 4-6), intermediate-complexity tumors (RNS: 7-9), and high-complexity tumors (RNS: 10-12) exhibited escalating rates of postoperative complications (9%, 15.8%, and 18%, p=0.016, respectively). Similarly, Volpe et al. (19) documented comparable findings, with the reported rates of 22.7% for overall complications and 9.1% for major complications. Our findings are consistent with these investigations. Within our study cohort, the aggregate rate of postoperative complications was 21%. Among these, instances necessitating angioembolization due to bleeding (n=2, grade 3a) and cases requiring double-J stent placement to address urine leakage (n=2, grade 3b) accounted for 10.3% (n=4) of the cases.

Study Limitation

This study was constrained by its retrospective design, a relatively modest patient population representing the experience of a EO, and variations in follow-up durations. Given the necessity for an increased depth of experience in the realm of LPN for complex renal tumors, a disparity in follow-up durations emerged between the LPN and LRN cohorts. The similarity in patients with renal cell carcinoma in the final pathology contributes to the relatively modest sample size. Non-etheless, this study employed a propensity score-matched analysis to mitigate potential selection bias.

Conclusion

Although LPN carries a heightened risk of postoperative complications, it demonstrates the potential for improved functional outcomes and comparable oncological results, particularly within experienced medical centers for patients with high-complexity renal tumors. Vigilant postoperative monitoring is advised, with special attention to potential bleeding and urine leakage.

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Ethics

Ethics Committee Approval: The study protocol received scrutiny and approval from the Ondokuz Mayıs University Clinical Research Ethics Committee (decision no: KAEK 2019/538, date: 11.07.2019).

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