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Comparison of perioperative outcomes between robot-assisted partial nephrectomy and laparoscopic partial nephrectomy in obese patients

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Abstract. – OBJECTIVE: The primary surgical techniques used to treat localized renal tumors are laparoscopic partial nephrectomy (LPN) and robot-assisted partial nephrectomy (RAPN). Obese patients have more intra-abdominal fat accumulation, which may make the localization and operation in minimally invasive surgery more complicated. Currently, limited research has been conducted on which method is more suitable for performing a partial nephrectomy on obese individuals. The aim of our investigation was to analyze and compare the perioperative results associated with both approaches to offer valuable information about the selection of LPN or RAPN as an optimal choice when performing a partial nephrectomy in obese patients.

PATIENTS AND METHODS: We retrospectively collected clinical data from 78 cases of obese individuals [Body mass index (BMI) > 28] who underwent RAPN, as well as 50 cases of obese individuals (BMI > 28) who underwent LPN. The analysis covered various aspects, including initial patient characteristics, glomerular filtration rate (GFR), warm ischemia time (WIT), operation time, volume of blood loss during the surgical procedure, time taken to recover bowel function, positive surgical margin rate, incidence of postoperative complications, and postoperative hospital stay.

RESULTS: We observed that RAPNs exhibited shorter warm ischemia time and reduced intraoperative blood loss in obese patients, along with decreased postoperative duration of abdominal drainage and hospitalization periods compared to LPNs.

CONCLUSIONS: In obese patients, RAPN demonstrates advantages over LPN in minimizing intraoperative blood loss, WIT, and facilitating postoperative recovery. These findings may serve as valuable evidence when considering the choice between LPN or RAPN for partial nephrectomy in obese individuals.

Key Words:
Obese patients, Renal neoplasm, Robot-assisted partial nephrectomy, Laparoscopic partial nephrectomy.

Introduction

Renal cell carcinoma (RCC) is a common cancer in the field of urology, particularly affecting males, accounting for 3% of the total number of cancer instances[1]. RCC arises from epithelial cells that surround the renal tubules, with clear cell carcinoma being its most prevalent histological subtype[2]. The prevalence of RCC continues to increase without interruption, with mortality rates ranging from 30-40%[3]. Currently, owing to progressive advances in technological modalities, the mortality associated with RCC is precipitously declining[4]. According to previous guidelines[5], surgery has emerged as the most efficacious modality for the treatment of localized renal cell carcinoma. Minimally invasive

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surgical approaches, including robot-assisted partial nephrectomy (RAPN) or laparoscopic partial nephrectomy (LPN), have been universally embraced, essentially replacing traditional open procedures worldwide. To preserve a greater number of renal units and safeguard kidney function, for RCC with a tumor diameter of < 7 cm, the recommended approach involves partial nephrectomy (PN), resulting in curative efficacy for tumor eradication[1,6-8].

LPN and RAPN have emerged as the main surgical modalities for renal parenchymal tumors. Comparative investigations indicate that LPN exhibits greater cost-effectiveness than RAPN. Recently, Gu et al[9] conducted a comparative analysis to assess the perioperative outcomes of LPN and RAPN in patients with localized renal neoplasm. The findings suggested that no notable differences were observed between the two cohorts regarding surgical duration, estimated blood loss, postoperative complications, WIT, positive surgical margin (PSM) rate, and other pertinent variables. However, LPN is associated with lower costs. Bray et al[10] conducted a retrospective study to compare tumor characteristics and perioperative and postoperative outcomes of patients who received partial nephrectomies performed by a surgeon experienced in both laparoscopic and robotic procedures for a duration of 7 years. The findings revealed that robotic-assisted partial nephrectomies exhibited notable advantages over laparoscopic, including a significant reduction in warm ischemia time (2.6 minutes), shorter hospital stays (1.3 days less), and an impressive 55% decrease in acute renal dysfunction incidence[10]. Choi et al[11] conducted a comprehensive analysis of 2,240 patients. The RAPN group did not show differences compared to the LPN group in terms of complications, renal function changes, surgical duration, estimated blood loss, and PSM. However, the RAPN group showed a significantly better outcome in conversion to open surgery and radical nephrectomy, WIT, changes in the estimated glomerular filtration rate, and length of hospitalization. The aforementioned research and findings indicate that each of the two surgical approaches possesses its own strengths and weaknesses.

Patients with obesity often exhibit a higher volume of adipose tissue, potentially leading to increased surgical complexities. This is particularly evident in minimally invasive procedures, where obese patients tend to have greater intra-abdominal fat accumulation, resulting in more intricate positioning and operation requirements. Additionally, perioperative management for obese individuals may present additional hurdles, such as challenging ventilation and heightened difficulty in intravenous catheterization. Currently, there is limited research or literature on the choice between LPN and RAPN procedures for partial nephrectomy in obese patients. In this research, our objective was to assess and compare the perioperative results of LPN *vs.* RAPN to treat RCC in a tertiary medical center. This may provide substantial evidence to guide the choice between LPN and RAPN procedures for partial nephrectomy in obese patients.

Patients and Methods

Patients

We conducted a retrospective examination of the medical documentation for kidney cancer patients who received LPN and RAPN at the Urology Department of the First Affiliated Hospital, Anhui Medical University, from January 2015 to January 2024. Inclusion criteria included patients with BMI > 28, a preoperative diagnosis of renal tumor, absence of other organ metastases, being in the T1bN0M0 stage, and preoperative assessment of renal tumors based on the RENAL scoring systems[12].

Procedures

Both LPN and RAPN were conducted by skilled urologists at the First Affiliated Hospital of Anhui Medical University, utilizing either a transperitoneal or retroperitoneal approach, employing the techniques described[13-15]. LPN involved the use of four ports, while RAPN utilized four ports from the Da Vinci (IS4000) (Sunnyvale, CA, USA) device along with two additional ports *via* a transperitoneal approach or one port *via* a retroperitoneal approach. Vascular occlusion clamps were employed to block renal arteries in all cases, followed by resection of at least 1 cm of normal renal parenchyma surrounding the tumor. Continuous suturing was performed on both the tumor base and renal wound surface to effectively control bleeding.

Assessments

The surgical information included operation time, WIT, intraoperative blood loss, postoperative fasting time, PSM, postoperative infection,

and other complications. Postoperative follow-up included routine evaluations of hematuria, renal function, b-mode ultrasound, and CT imaging. The postoperative follow-up was 90 days.

Statistical Analysis

Statistical analysis was performed using SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Quantitative data were presented as mean ± standard deviation, quartiles, etc. Group comparisons were performed using the *t*-test or Fisher's exact test. A statistical significance was determined when the *p*-value was lower than or equal to 0.05.

Results

Characteristics of the Patient

Characteristics of the patient population are displayed in Table I. The patients had a BMI greater than 28.0 kg/m^2, with a median age of 52 years. The RAPN group exhibited higher ASA scores compared to the LPN group, while no notable differences were observed in terms of BMI, age, Pre-op GFR, NERAL (Nephrometry score system) score, and Charlson's comorbidity index (CCI) score between the two groups. The 128 patients diagnosed with T1bN0M0 renal tumors were included in this study and successfully underwent RAPN or LPN (Table I). None of the cases required radical nephrectomy or open surgery. No intraoperative blood transfusions or complications were documented during the procedure.

Surgical and Pathological Results

The results of the surgical procedures performed on the participants are presented in Table II. RAPN was performed in 78 patients (representing 60.9%), while LPN was performed in 50 patients (representing 39.1%). Statistically, the warm ischemia time (18.78 ± 3.93 *vs.* 21.52 ± 5.69) and intraoperative blood loss (36.95 ± 33.67 *vs.* 44.95 ± 28.57) in the RAPN groups were significantly shorter than those in the LPN groups, but the average operation time (165.54 ± 64.77 *vs.* 158.42 ± 59.27) was slightly longer in the RAPN group. The pathological findings observed in this study are presented in Table II. Among the enrolled individuals, RCC was diagnosed in 14 cases (10.9%), clear cell renal cell carcinoma in 87 cases (67.9%), angiomyolipoma in 20 cases (15.6%), renal hamartoma in one case (0.7%), epithelial and mesothelial mixed renal tumor in one case (0.7%), eosinophilic adenoma in two cases (1.4%), renal carcinoid in one case (0.7%), renal squamous cell carcinoma in one case (0.7%) and renal chromophobe cell carcinoma was also observed once (0.7%).

Table I. Patients' characteristics.

	RAPN	LPN	*p*
BMI, kg/m^2, median (range)	29.42 (28.41-31.31)	28.97 (28.38-30.62)	0.153
Age, years, median (range)	55 (42-60)	49.50 (45-58)	0.492
Gender, n (%)			0.849
Male	51 (65.4%)	32 (64.0%)	
Female	27 (34.6%)	18 (36.0%)	
ASA score, n (%)			0.008
1-2	48 (61.5%)	41 (82.0%)	
3-4	30 (38.5%)	9 (18%)	
CCI score, n (%)			0.660
0-1	26 (33%)	22 (44%)	
≥ 2	52 (67%)	28 (56%)	
Tumor laterality, n (%)			0.016
Left	45 (57.7%)	18 (36.0%)	
Right	33 (42.3%)	32 (64.0%)	
Tumor size, cm, median (range)	4.0 (3.0-5.0)	4.0 (2.5-5.0)	0.215
Pre-op GFR (mL/min/1.73 m^2), Mean, SD	100.71 ± 22.41	98.64 ± 22.13	0.442
R.E.N.A.L. score, median (range)	7.0 (6.0-8.0)	6.0 (6.0-8.0)	0.070

Body mass index (BMI); Charlson's comorbidity index (CCI); Nephrometry score system known as R.E.N.A.L.; Robot-assisted partial nephrectomy (RAPN); Laparoscopic partial nephrectomy (LPN). The data is presented either as numbers accompanied by percentages within parentheses, mean ± SD, or as median and range values. Statistical significance is indicated by $p < 0.05$.

Table II. Comparison of intraoperative and pathological results between RAPN and LPN.

	RAPN	LPN	*p*
Warm ischemia time (WIT) (min) Mean, SD	18.78 ± 3.93	21.52 ± 5.69	0.004
Surgery time (min), Mean, SD	165.54 ± 64.77	158.42 ± 59.27	0.532
Estimated blood loss (mL) Mean, SD	36.95 ± 32.67	44.95 ± 28.57	0.029
Intraoperative blood transfusion volume (ml)	0 (0%)	0 (0%)	
Conversion to laparotomy	0 (0%)	0 (0%)	
Negative surgical margin (number, %)	78 (100%)	50 (100%)	
Pathological type, n (%)			0.012
Renal cell carcinoma	10 (12.8%)	4 (8%)	
Clear cell carcinoma of kidney	55 (70.5)	32 (64%)	
Angiomyolipoma	10 (12.8%)	10 (20%)	
Hamartoma of kidney	1 (1.3%)	0 (0%)	
Mixed epithelial and mesothelial tumors of the kidney	0 (0%)	1 (2%)	
Renal carcinoid	1 (1.3%)	1 (2%)	
Squamous cell carcinoma of kidney	0 (0%)	1 (2%)	
Chromophobe cell carcinoma of kidney	0 (0%)	1 (2%)	
Eosinophilic adenoma	0 (0%)	1 (2%)	

The data are presented as average and standard deviation (SD), numerical values, with percentages shown in parentheses. Statistical significance is indicated by $p < 0.05$. Robot-assisted partial nephrectomy (RAPN); Laparoscopic partial nephrectomy (LPN).

Comparative Analysis of Outcomes Between RAPN and LPN in Obese Patients

All 128 obese patients in both groups successfully completed partial nephrectomy. Postoperative parameters (Table III), including abdominal drainage time (RAPN *vs.* LPN: 4.53 ± 0.98 *vs.* 5.42 ± 2.71 days, $p = 0.029$), and postoperative hospital stay (RAPN *vs.* LPN: 5.72 ± 1.23 *vs.* 8.22 ± 4.64 days, $p < 0.001$), showed a notable advantage in the RAPN group when compared to the LPN group. There were no significant differences in indwelling catheterization time (3.97 ± 0.85 *vs.* 4.18 ± 1.30 days, $p = 0.326$), fasting time (3.19 ± 0.76 *vs.* 3.40 ± 0.88 days, $p = 0.158$) and post-op GFR (85.50 ± 23.27 *vs.* 85.24 ± 22.29, $p = 0.925$) between the two groups. The postoperative histopathological evaluation of the tissues revealed that both groups of patients had negative results for positive surgical margins (Table II). Postoperative complications occurred in 3 patients (Table III). Redness and swelling (no purulent discharge) occurred in 2 patients with RAPN, and the incision healed after 10 days of surgical incision dressing change. Incision infection (incision swelling with purulent secretion) occurred in 1 patient in the LPN group, and the incision healed after 1 week of oral antibiotics (cefdinir dispersible tablets) and 15 days of surgical incision dressing change. After 90 days of follow-up, no instances of recurrence or distant metastases were observed in either the RAPN group or the LPN group among patients.

Table III. Comparison of postoperative outcomes between RAPN and LPN.

	RAPN	LPN	*p*
Postoperative complication, n (%)	2 (2.6%)	1 (2%)	
Post-op GFR (mL/min/1.73 m^2), Mean, SD	85.50 ± 23.27	85.24 ± 22.29	0.925
Abdominal drainage time (day), Mean, SD	4.53 ± 0.98	5.42 ± 2.71	0.029
Indwelling catheterization time, Mean, SD	3.97 ± 0.85	4.18 ± 1.30	0.326
Fasting time (day), Mean, SD	3.19 ± 0.76	3.40 ± 0.88	0.158
Postoperative hospital stay (day), Mean, SD	5.72 ± 1.23	8.22 ± 4.64	< 0.001
Tumor recurrence or distant metastasis	0 (0%)	0 (0%)	

The data are presented as average and standard deviation (SD), numerical values, with percentages shown in parentheses. Statistical significance is indicated by $p < 0.05$. Robot-assisted partial nephrectomy (RAPN); Laparoscopic partial nephrectomy (LPN), glomerular filtration rate (GFR).

Discussion

The surgical treatment of localized renal cell carcinoma is increasingly focused on preserving renal units and function. Minimally invasive procedures, such as RAPN and LPN, are increasingly used in patients with these characteristics. Compared to open surgery, both RAPN and LPN produce superior postoperative outcomes. In addition, the implementation of robotic surgical systems empowers surgeons to overcome the technical constraints encountered in laparoscopic surgery[16,17]. In this retrospective analysis, we evaluated the perioperative results of people with obesity (BMI > 28) who underwent LPN and RAPN. Our results indicated that the RAPN group exhibited reduced intraoperative blood loss, shorter duration of postoperative abdominal drainage, and shorter hospital stay compared to the LPN group. However, no notable disparities were observed in the majority of other intraoperative and postoperative outcomes.

In our research, we demonstrated the comparability of RAPN and LPN in obese patients (BMI > 28), with some endpoints showing significant advantages. We found that RAPN reduced intraoperative blood loss and reduced the time of warm ischemia. These intraoperative benefits align with the findings of another research. Benway et al[18] emphasized the potential of RAPN to significantly decrease WIT, with a difference of 9.9 minutes observed in their study (15.3 minutes *vs.* 25.2 minutes), which is significantly greater than the findings from our research. Their research findings[18] also revealed a considerably more pronounced decrease in blood loss, much larger than the difference observed in our study. These advantages can be ascribed to the benefits provided by robotic assistance. In the constrained operating space of obese patients, the superior image magnification, 3D imaging, wrist-like articulation, and tremor filtering provided by robotic systems are advantageous[19]. The RAPN group exhibited a significantly shorter length of hospital stay and postoperative abdominal drainage time compared to the LPN group. We attribute this result to shorter intraoperative blood loss and WIT in the RAPN groups, leading to less intraoperative damage and facilitating postoperative recovery. Postoperative pathological examinations for both groups revealed no tumor cells at the surgical margins, suggesting that the RAPN and LPN procedures are adequate to remove all positive tumor lesions, consistent with findings from other studies[20,21].

In the present study, surgical procedures were performed exclusively by a consistent surgical team, thus minimizing any potential bias in the execution of the procedures. However, a drawback of this study is the limited number of participants, which could potentially lead to biased findings. The sample size poses an inherent challenge due to the constraints imposed by obesity. While the current size of our sample was deemed sufficient to perform statistical analysis, the inclusion of larger samples has the potential to enhance the overall quality of this article. Additionally, a notable constraint lies in the absence of long-term follow-up outcomes pertaining to these patients. Despite achieving negative surgical margins, prospective studies with more patients and longer follow-up times are needed to further assess postoperative tumor safety, given the natural history of RCC. Our follow-up time was insufficient to assess the possibility of delayed recurrence after robotic and laparoscopic surgery. Therefore, a longer follow-up time is necessary.

Conclusions

In our study, RAPN showed a reduction in WIT and intraoperative blood loss in obese patients compared to LPN. Furthermore, RAPN demonstrated advantages in postoperative recovery, including a decrease in abdominal drainage time and length of hospital stay. There were no significant differences in other aspects, such as surgical time and postoperative complications. Our findings may provide strong evidence for the selection of LPN or RAPN procedures for partial nephrectomy in obese patients.

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Authors' Contributions

Conception of the study: Xianguo Chen and Changsheng Zhan. Acquisition and analysis of data for the study: Xianhong Liu and Wenming Ma. Writing the manuscript: Jian Song and Cheng Zhang. All the authors have thoroughly reviewed and approved the final version of the manuscript.

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Availability of Data and Materials

The corresponding author can provide the data supporting the findings of this study upon reasonable request.

Ethics Approval

This study was conducted in accordance with the guiding principles of the Declaration of Helsinki and was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University on March 12, 2024 (approval No.: PJ2024-03-26).

Conflict of Interest

The authors declare that there are no competing interests.

Informed Consent

Due to the retrospective nature of this study, the need for informed consent was waived.

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