Long-term outcomes of minimally invasive surgeries in partial nephrectomy. Robot or laparoscopy?

Mehmet Salih Boga[1], Mehmet Giray Sozmez[2], Kaan Karamık[3], Cagatay Ozsoy[3], Arif Aydin[2], Murat Savas[3], and Mutlu Ates[3]

[1]University of Health Sciences Antalya Training and Research Hospital
[2]Necmettin Erbakan University Meram Medical Faculty Hospital
[3]Antalya Training and Research Hospital

August 4, 2020

Abstract

Background: To compare long-term oncological and renal functional outcomes of laparoscopic and robotic partial nephrectomy for small renal masses. Methods: A total of 103 patients who underwent laparoscopic (n= 31) and robotic (n= 72) partial nephrectomy between April 2015 and November 2018 were included in the study. Perioperative parameters, long-term oncological and functional outcomes were compared between the laparoscopic and robotic groups. Results: No significant differences were found in terms of age, tumor size, RENAL and PADUA scores, preoperative estimated glomerular filtration rate (eGFR), and presence of chronic hypertension and diabetes (p=0.479, p=0.199, p=0.120 and p=0.073, p=0.561 and p=0.082 and p=0.518, respectively). Only estimated blood loss was significantly higher in the laparoscopic group in operative parameters (158.23±72.24 mL vs 121.11±72.17 mL; P=0.019), but transfusion rates were similar between the groups (p=0.33). In the laparoscopic group, two patients (6.5%) required conversion to open, while no conversion was needed in the robotic group (p=0.89). There were no differences in terms of positive surgical margin and complication rates (p=0.636 and p=0.829, respectively). No significant differences were observed in eGFR changes and postoperative new-onset chronic kidney disease at one year after the operation (p=0.768, p=0.614, respectively). The overall mean follow- up period was 36.07±13.56 months (p=0.007). During the follow-up period, no cancer-related death observed in both group and non-cancer specific survival was 93.5% and 94.4% in laparoscopic and robotic groups, respectively (p=0.859). Conclusions: In this study, perioperative and long-term oncological and functional outcomes seems to be comparable between laparoscopic and robotic partial nephrectomies.

Introduction

Renal cell carcinoma (RCC) is one of the most common cancer in western countries with a rate of approximately 3% among all cancers. Partial nephrectomy (PN) also known as nephron-sparing surgery is recommended in small size tumors due to its contribution to renal functions (RFs) with similar oncological results with radical nephrectomy (RN)[1]. The utilization of PN has become widespread, especially with the increase in the diagnosis of small size tumors.

Recently, the use of PN has also been increasing in high-risk kidney tumors due to its contribution to morbidity and mortality by reducing deterioration in RFs [2,3]. The main expectations of an ideal PN are surgical margin negativity, minimal deterioration in RF, and any surgical complication [4,5].

Minimally invasive techniques such as laparoscopic partial nephrectomy (LPN) and robot-assisted partial nephrectomy (RPN) are superior to open partial nephrectomy (OPN) in terms of shorter length of hospital stays (LOS), less postoperative pain and better cosmetic results[6]. Although studies have reported that RPN is superior to LPN in parameters such as short operation time (OT), low warm ischemia time (WIT), and fewer changes in RF, there is no complete consensus in this regard. Also the number of studies with long term oncologic and functional outcomes between RPN and LPN is limited.

In this study, we aimed to compare the renal functional changes between the LPN and RPN at 1 year after the surgery as a primary endpoint, then compare the perioperative variables and survival rates during the follow-up period.

Material and Methods

After institutional ethical committee approval obtained, the data of patients who underwent LPN or RPN in our center between April 2015 and November 2018 were evaluated for this study. Patients with a solitary kidney, zero ischemic PNs, retroperitoneal PNs, and who had a follow-up period of less than 1 year or with missing data were excluded from the study.

A total of 103 patients who underwent LPN (n = 31) and RPN (n= 72) were included in the study. Contrast-enhanced tomography (CT) or magnetic resonance imaging (MRI) was used to evaluate renal masses. Additional comorbidities such as chronic hypertension (HT) and diabetes mellitus (DM) that could affect RFs were recorded. Nephrometry risk scoring of renal masses was made according to RENAL (R (radius), E (exophytic/ endophytic), N (nearness), A (anterior), and L (location)) and PADUA (Preoperative Aspects and Dimensions Used for an Anatomical) scoring systems. The RENAL and PADUA scores were calculated by evaluating each anatomical parameter and tumor size according to described before[7,8].

The mean OT, WIT, estimated blood loss (EBL), conversion to open and conversion to RN, remove of lodge drain time, and LOS were recorded as perioperative data. The OT recorded as the time between the first skin incision and the suturing of the incision site. The WIT was recorded as the time period between placing the bulldog clamp in the renal artery and opening this clamp.

For pathological parameters, histological subtypes, pathological stage, Furhman grade, and positive surgical margin (PSM) rates were recorded. Pathological staging was performed according to TNM classification. Preoperative and 1 year postoperative estimated glomerular filtration rate (eGFR) values were calculated using the Modification of Diet in Renal Disease (MDRD) formula using age, gender, and ethnicity[9]. The changes between the two eGFR values were recorded.

Surgical Technique

A transperitoneal approach was applied to all patients. LPN was carried out as we described previously [10]. Briefly, following general anesthesia, the left or right lateral decubitus position was performed according to the side of the tumor. Pneumoperitoneum was created with an intra-abdominal pressure of 12-15 mmHg by inserting a Veress needle 1-2 cm superior to the umbilical level from the lateral of the rectus muscle. The optic port was placed at this point where the pneumoperitoneum was created. A total of 4 ports were placed for LPN, one for the camera, one for the right (12mm), and one for left (5mm) hand due to dissection and one for the retraction (5mm) port. If necessary, one more port (5mm) was placed for retraction or traction.

RPN performed by using a four-arm da Vinci XI robotic system (Intuitive Surgical, CA, USA). First, an 8 mm camera port was placed lateral to the rectus muscle. Three robotic working ports (8 mm) and an assistant port were then placed. The robotic system was docked from the back of the patient, and the robotic arms were docking to the ports on the front of the patient. The assistant was involved in the replacement of robotic instruments, the use of aspirators, and the delivery of suture material in the anterior-lateral part of the patient.

The colon deviated medially from the Toldt line. Following the dissection of the hepatorenal or splenorenal ligament, ureter, and gonadal vein identified on the psoas, renal hilum was revealed by followed cranial dissection. The renal artery, vein, and hilum dissected separately. Perinephric adipose tissue was released from the capsule except the adipose tissue covering the tumor. Then the tumor was resected with a cold scissor leaving an approximately 5 mm safety margin after clamping the renal artery. The collector system and vascular structures in the tumor bed were sutured with 3/0 V-Lock with fixed a Hem-o-Lok clip at the end. Than renorrhaphy was completed using 2/0 Vicryl and 2/0 Monocryl suture material fixed with Hem-o-Lok clip to bring the renal parenchyma closer. The bulldog clamps were opened and warm ischemia was terminated. This procedure was applied similarly to both LPN and RPN.

Results

Demographic features and tumor characteristics of the patients are shown in Table 1. A total of the 103 patients, 31(30.09%) underwent LPN, 72 (69.90%) RPN. The overall mean (±SD) age, tumor diameter, RENAL score, PADUA score, and preoperative eGFR were 58.85 ±12.01 years, 3.76 ± 1.56 cm, 6.86 ± 1.48, 8.37±1.53 and 77.89 ± 17.87 mL/min/1.73 m2, respectively. There was no statistical difference between the groups for these variables (p=0.479, p=0.199, p=0.120, p=0.073, p= 0.561, respectively). Overall, tumors were on the right side in 48.5% of the patients and on the left side in 51.5% of the patients. The tumor side was more on the right in LPN, while RPN was more on the left side (p=0.03).

The overall mean (±SD) WIT, OT, and LOS values were 26.22 +- 6.34, 151.89 +- 41.74 and 3.44 +- 0.95, respectively. In these variables, there was no statistical difference between the groups (p=0.119, p=0.216, p=0.580, respectively). Only EBL was higher in LPN (121.11 +- 72.17 vs 158.23+- 72.24, LPN and RPN, respectively, p=0.019). There was no statistical difference between the two groups in terms of blood transfusion requirement (p= 0.694). No significant differences were observed in PSM rates between the groups (6.5% vs 4.2%, RPN and LPN, respectively, p=0.636).

The conversion to open was seen in 2 patients (6.45%) in the LPN group, while in RPN was not observed (p=0.89). There was no conversion to RN in either group. The patients were generally discharged the next day after the loge drain was removed. The overall mean removal of log drain time and LOS were 2.4 (p=0.351) and 3.4 (p=0.580) days, respectively. Perioperative outcomes of the groups are shown in Table 2.

Intraoperative bowel injury was observed in 1 patient in the RPN group, the primary repair was performed, and no additional problems were observed for this patient in the follow-up period. In the LPN group, 2 patients had intraoperative complications, 1 was renal vein injury and the other was ureter injury. In the ureter injury, a 4.8 f JJ stent was placed and removed at the 3rd postoperative week. In renal vein injury, the primary repair was performed and PN was completed laparoscopically.

The mean 1-year eGFR decrease was -5.91 ml/min/1.73m2 (7.59%) in the overall cohort, while it was -5.06 ml/min/1.73m2 (6.63%) vs -6.28 ml/min/1.73m2 (7.93%) for LPN and RPN, respectively. No statistical difference was observed between the groups in eGFR change (p= 0.503). The overall preoperative stage 3 or stage 4 CKD (eGFR< 60 ml/min/1.73m2) rate was 12.6%, and the new onset stage 3 or stage 4 CKD rate was 4.9% in 1 year postoperatively. There was no statistical difference between the groups in the preoperative stage 3 or stage 4 CKD and postoperative new-onset stage 3 or stage 4 CKD rates (p=0.750, p=0.614, respectively) (Table 3). Complications were observed in 9.7% of LPN patients and 11.1% of RLN in the postoperative early period (0-30 days). All of the complications were minor (Clavien 1-2) complications. Late period (31-90 days) complications were not observed in either group.

The mean follow-up time was 36.07 +- 13.56 months (42.81+- 17.55 for LPN and 33.17 +- 10.28 for RPN, p=0.007). During the follow-up period, cancer-related death was not observed in either group, while non-cancer specific survival was 93.5% in the LPN group and 94.4% in the RPN group. Postoperative pathological, complication and survival outcomes are presented in Table 4.

Discussion

The importance of nephron-sparing surgery in small renal mass has become more prominent by the demonstration of a direct correlation between RF impairment and cardiovascular disease [11]. While PN has been applied to T1a / b stage tumors until recently, now it is also successfully applied to high-risk kidney tumors in developed centers. The advantages of robotic surgery with its 3D image quality and ergonomic arm structure were provided to the use of PNs in high-risk renal tumors [12]. In addition to this advantage of RPN, the lack of tactile sense and its high cost are the most important disadvantages.

In studies on cost-effectiveness, RPN has been shown to be more expensive than LPN or OPN [6,13]. Although Hyams et al reported that the price difference per case between RPN and LPN decreased from $ 1066 to $ 333 during the period from the start-up to the ideal utilization of the robot, Yu et al. reported the median costs $15,724 for RPN, $12,401 for LPN and $11,817 for OPN in per case according to the surgical approach in the USA. Therefore, the superiority of the two surgical methods to each other is still an important research topic.

Aboumarzok et al. [14] and Zhang X et al.[15] reported that RPN had similar perioperative outcomes with LPN in terms of OT, EBL, conversion rates, LOS, PSMs and complication rates, only WIT was statistically shorter favor to RPN arm in their review and meta-analysis. They didn't report outcomes of the change in renal functions between the groups. The differences in surgical techniques and comparison criteria between the groups were the important limitations of the studies.

Ji Eun Choi et al. [16] reported that RPN is associated with more favorable results than LPN in terms of conversion rates, lower WIT, shorter LOS, and change of eGFR in their review and meta-analysis of RPN and LPN outcomes. No significant difference was reported in terms of complications, change of serum creatinine, OT, EBL, and PSMs. However, the studies in this review included heterogeneous groups and methodologically different or not specified.

In the current study, we didn't find any statistical difference between the groups in tumor size (p=0.199), RENAL and PADUA score (p=0.120 and p= 0.073), OT (p= 0.216), WIT (p=0.066), LOS (p=0.580), PSMs (p= 0.636) and complication rates (p=0.969) between the groups. Only EBL was less in RPN group (p=0.027).

The main purpose of PN is to preserve the RFs. Some studies reported that RPN is superior to LPN in the preservation of RF, while some studies reported no difference between groups. Kim et al.[17] reported that eGFR decline rates were similar between RPN and LPN in the early period, but long term recovery in renal function was a favor to RPN. Although they reported that warm ischemia time was significantly shorter in the RPN group, while WIT was an acceptable range in the RPN (23.82 +- 12.03 minutes) compared to literature, in the LPN arm (34.47 +- 11.63 minutes) was higher than the recommended value.

Li et al. [18] evaluated the postoperative split renal function (SRF) between RPN and LPN approaches in Taiwanese patients. They assessed both kidney functions by scintigraphy. They reported advantages of RPN with shorter operation time and WIT, and better SRF at 6 months after the operation. They reported that WIT was associated with a decrease in renal function postoperatively.

In this study, although deterioration renal function was less in the RPN group, there was a significant difference between the groups in terms of WIT, EBL, and OT. Also these values in the LPN arm (43.3 +- 23.5 minutes) were significantly higher than the recommended value in literature.

WIT is the leading factor that affecting the renal functions after PN. Ko et al. reported the predictive factors of prolonged WIT ([?]30 minutes) in PN. Surgeon experience, tumor size, and PADUA score were found as predictive factors that prolonged WIT after RPN or LPN. Surgical experience was the most important factor for preventing prolonged WIT, among these factors [19]. Therefore, in studies comparing LPN and RPN in experienced centers, although WIT was shorter in the RPN group than LPN, the change in postoperative renal functions was not statistically significant between the groups if WIT was less than 30 minutes [20,21] in both groups.

Some authors advocated that WIT should be kept less than 30 minutes to the preservation of renal function, while some authors reported that WIT increased deterioration of long-term renal function every minute after 25 minutes [22]. Alimi et al.[23] showed that there was no difference in early eGFR changes between groups in LPN and RPN when performed by highly experienced surgeons. In their study, although WIT less in RPN arm, WIT was under 25 minutes in both groups. Their results supported that a

reasonable WIT will contribute to the preservation of renal functions to the operated kidney. Banapour et al. [24]reported that the postoperative eGFR decline was lower in the RPN group compared to OPN, but they did not report a statistical difference between RPN and LPN in their study comparing the perioperative results of RPN, LPN, and OPN, matched for nephrometry scores. In their study, while WIT was lower than 30 minutes in RLN and LPN groups, it was higher than 30 minutes in the OPN group.

In the current study, WIT time was less than 30 minutes in both groups and comparable to the recommended values in the literature. We did not find any statistical difference between the groups in pre- and postoperative mean eGFRs and eGFR changes at 1 year after the operation (p=0.561, p=0.803, p=503, respectively). We think that such a comparison with similar WIT between the groups will give more accurate results in showing whether the change in RFs will depend on the surgical approach.

Kızılay et al. [25] showed a similar result in terms of OT, EBL, LOS, and PSM in the study of compared the long-term oncological and functional outcomes between the RPN and LPN groups. In this study, however WIT was statistically shorter in the RPN group, WIT was under 25 minutes in both groups. They did not report any difference in eGFR changes 1 year after surgery, similar to our study. In this study, there was no difference in tumor size between groups, whereas RPN consisted of more risky patients in terms of tumor complexity.

The number of studies comparing LPN and RPN with long-term oncological outcomes as well as renal functional outcomes is limited. Kızılay et al.[25] also reported no differences between the groups in long-term (5 years) recurrence-free survival (85.9% vs 90.1%, p=0.710) and overall survival (84.8% vs 82.6, p=0.561) rates between the LPN and RPN, respectively. In the current study, cancer-related death was not observed in either group, while non-cancer specific survival was 93.5% in the PLN group and 94.4% in the RPN group during the follow-up period. However, they reported that the overall survival rates were slightly lower in their study because the patients had more complications and had a higher mean age. Also, we think that the difference in the survival rates between this study and our study could depend on our follow-up period was shorter compared to theirs.

We had some limitations for this study. First, our study was a retrospective and non-randomized. Second, although most of the cases were performed by two experienced surgeons, the experience of the surgeons is an important factor that could affect the outcomes. Third, our case number was relatively low due to cases with less than 1 year of follow-up or missing data were excluded from the study.

Conclusion

LPN and RPN can be used safely in PN in terms of preserving long-term RFs considered as a minimally invasive approach. When evaluated together with cost-efficacy, we think that LPN has maintained its place as an important preference reason for selected cases in experienced hands with long-term oncological and functional results similar to RPN.

Author contributions MSB: project development, data management, data analysis, and manuscript writing. MGS: statistical analysis and interpretation, and manuscript editing. KK: data collection. CO: data collection. AA: data analysis. MS: data analysis. MA: protocol/project development and manuscript editing.

Acknowledgements

- This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
- Written informed consent of each patient was obtained before the surgery, and our study was conducted according to the principles of Helsinki Declaration. Institutional ethics committee approval (No. 21/4) was obtained on September 26, 2019 for this retrospective study.

Conflict of interest

The authors declare that they have no conflict of interest.

ORCID

Mehmet Salih Boga, https://orcid.org/0000-0001-7979-8075

References

1. Ljungberg B, Albiges L, Abu-Ghanem Y, Bensalah K, Dabestani S, Fernández-Pello S, et al. European association of urology guidelines on renal cell carcinoma: the 2019 update. Eur Urol. 2019;75(5): 799-810.
2. Bertolo R, Autorino R, Simone G, Derweesh I, Garisto JD, Minervini A, et al. Outcomes of robot-assisted partial nephrectomy for clinical T2 renal tumors: A multicenter analysis (ROSULA Collaborative Group). Eur Urol 2018;Aug; 74(2):226-32.
3. Mir MC, Derweesh I, Porpiglia F, Zargar H, Mottrie A, Autorino R. Partial nephrectomy versus radical nephrectomy for clinical T1b and T2 renal tumors: a systematic review and meta-analysis of comparative studies. Eur Urol 2017;71: 606–17.
4. Carneiro A, Sivaraman A, Sanchez-Salas R, Di Trapani E, Barret E, Rozet F. Evolution from laparoscopic to robotic nephron sparing surgery: a high-volume laparoscopic center experience on achieving "trifecta" outcomes. World J Urol 2015;33: 2039–44.
5. Khalifeh A, Autorino R, Hillyer SP, Laydner H, Eyraud R, Panumatrassamee K. Comparative outcomes and assessment of trifecta in 500 robotic and laparoscopic partial nephrectomy cases: a single surgeon experience. J Urol 2013;189: 1236– 42.
6. Yu HY, Hevelone ND, Lipsitz SR, Kowalczyk KJ, Hu JC. Use, costs and comparative effectiveness of robotic assisted, laparoscopic and open urological surgery. J Urol 2012;187:1392–1398.
7. Kutikov A, Uzzo RG. The R.E.N.A.L. Nephrometry Score: A comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 2009;182:844-53.
8. Ficarra V, Novara G, Secco S, Macchi V, Porzionato A, De Caro R, et al. Preoperative aspects and dimensions used for an anatomical (PADUA) classification of renal tumours in patients who are candidates for nephron-sparing surgery. Eur Urol. 2009;56:786–93.
9. Levey AS, Bosch JP, Lewis JB, Greene T, Rogers N, Roth D. A more accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. Modification of Diet in Renal Disease Study Group. Ann Intern Med 1999;130(6):461-70.
10. Boga MS, Savaş M, Islamoğlu ME, Sönmez MG, Yılmaz K, Ölçücü MT, et al. Laparoscopic Partial Nephrectomy in T1a/T1b Stage Renal Tumors: Where We Are? Endourology Bulletin 2020;12(1), 24-30.
11. Go AS, Chertow GM, Fan D, McCullochCE, HsuCY. Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. N Engl J Med 2004;351:1296–1305.
12. Fero K, Hamilton ZA, Bindayi A, Murphy JD, Derweesh IH. Utilization and quality outcomes of cT 1a, cT 1b and cT 2a partial nephrectomy: analysis of the national cancer database. BJU Int. 2018;121(4), 565-574.
13. Hyams E, Pierorazio P, Mullins JK, Ward M, Allaf M. A comparative cost analysis of robot-assisted versus traditional laparoscopic partial nephrectomy. J Endourol. 2012;26:843-847.
14. Aboumarzouk OM, Stein RJ, Eyraud R, Haber GP, Chlosta PL, Somani B. Robotic versus laparoscopic partial nephrectomy: A systematic review and meta- analysis. Eur Urol 2012;62:1023–1033.
15. Zhang X, Shen Z, Zhong S, Zhu Z, Wang X, Xu T. Comparison of perioperative outcomes of robot-assisted vs laparoscopic partial nephrectomy: A meta-analysis. BJU Int 2013;112:1133–1142.
16. Choi JE, You JH, Kim DK, Rha KH, Lee SH. Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: a systematic review and meta-analysis. Eur Urol. 2015;67(5), 891-901.
17. Kim JH, Park YH, Kim YJ, Kang SH, Byun SS, Kwak C, et al. Perioperative and long-term renal functional outcomes of robotic versus laparoscopic partial nephrectomy: a multicenter matched-pair comparison. World J Urol. 2015;33(10), 1579-1584.
18. Li HK, Chung HJ, Huang EY, Lin AT, Chen KK. Impact of warm ischemia time on the change of split renal function after minimally invasive partial nephrectomy in Taiwanese patients. J Chin Med Assoc. 2015;78(1), 62-66.
19. Ko KJ, Choi DK, Shin SJ, Ryoo HS, Kim TS, Song W, et al. Predictive factors of prolonged warm ischemic time ([?] 30 minutes) during partial nephrectomy under pneumoperitoneum. Korean J Urol,

2015;56(11), 742-748.
20. Becker F, Van Poppel H, Hakenberg OW, Stief C, Gill I, Guazzoni G, et al. Assessing the impact of ischaemia time during partial nephrectomy. Eur Urol 2009;56:625-34. 6.
21. Godoy G, Ramanathan V, Kanofsky JA, O'Malley RL, Tareen BU, Taneja SS, et al. Effect of warm ischemia time during laparoscopic partial nephrectomy on early postoperative glomerular filtration rate. J Urol 2009;181:2438-43.
22. Thompson RH, Lane BR, Lohse CM, Leibovich BC, Fergany A, Frank I, et al. Every minute counts when the renal hilum is clamped during partial nephrectomy. Eur Urol 2010;58(3):340–345.
23. Alimi Q, Peyronnet B, Sebe P, Cote JF, Kammerer-Jacquet SF, Khene ZE, et al. Comparison of short-term functional, oncological, and perioperative outcomes between laparoscopic and robotic partial nephrectomy beyond the learning curve. J. Laparoendosc. Adv. Surg. Tech. 2018;28(9), 1047-1052.
24. Banapour P, Abdelsayed GA, Bider-Canfield Z, Elliott PA, Kilday PS, Chien GW. Nephrometry score matched robotic vs. laparoscopic vs. open partial nephrectomy. J.Robot. Surg. 2018;12(4), 679-685.
25. Kızılay F, Turna B, Apaydın E, Semerci B. Comparison of long-term outcomes of laparoscopic and robot-assisted laparoscopic partial nephrectomy. Kaohsiung J Med Sci. 2019;35(4), 238-243.

Hosted file

`Table 1.docx` available at https://authorea.com/users/348696/articles/473909-long-term-outcomes-of-minimally-invasive-surgeries-in-partial-nephrectomy-robot-or-laparoscopy

Hosted file

`Table 2.docx` available at https://authorea.com/users/348696/articles/473909-long-term-outcomes-of-minimally-invasive-surgeries-in-partial-nephrectomy-robot-or-laparoscopy

Hosted file

`Table 3..docx` available at https://authorea.com/users/348696/articles/473909-long-term-outcomes-of-minimally-invasive-surgeries-in-partial-nephrectomy-robot-or-laparoscopy

Hosted file

`Table 4..docx` available at https://authorea.com/users/348696/articles/473909-long-term-outcomes-of-minimally-invasive-surgeries-in-partial-nephrectomy-robot-or-laparoscopy