Comparison of Laparoscopic and Open Partial Nephrectomy in the Treatment of T1 Renal Tumor: a Systematic Review and Meta-analysis

Yuanming Sui
Affiliated Hospital of Medical College Qingdao University  https://orcid.org/0000-0002-7417-966X

Zongliang Zhang
Affiliated Hospital of Medical College Qingdao University

Huqing Sun
Affiliated Hospital of Medical College Qingdao University

Kai Zhao
Affiliated Hospital of Medical College Qingdao University

Zhenlin Wang
Affiliated Hospital of Medical College Qingdao University

Yulian Zhang
Affiliated Hospital of Medical College Qingdao University

Chunhua Lin
Qindao University Medical College Affiliated Yantai Yuhuangding Hospital

Jiaming Guo
Affiliated Hospital of Medical College Qingdao University

Chen Li
Affiliated Hospital of Medical College Qingdao University

Xueyu Li
Affiliated Hospital of Medical College Qingdao University

Haitao Niu
Affiliated Hospital of Medical College Qingdao University

Ke Wang  wangke6910@sina.com

Research

Keywords: Laparoscopic, partial nephrectomy, Open partial nephrectomy, Renal tumor

DOI: https://doi.org/10.21203/rs.3.rs-48507/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

Objective: Different surgical approaches may bring different treatment results for one disease. We thus determined to gather the current evidence to evaluate the effect of laparoscopic partial nephrectomy (LPN) and open partial nephrectomy (OPN) in the treatment of T1 renal tumor.

Methods: We comprehensively researched PubMed, Embase, Google Scholar and Clinicaltrials.gov to find all referring studies (published between Jan 1, 2015, and Jan 1, 2020 without language restrictions). We calculated the odds ratios (OR) and standard mean difference (SMD), and analyzed their heterogeneity with RevMan 5.3 software.

Results: Six studies were included finally. Comparing open partial nephrectomy, the pooled SMD of operative time was 0.14, (95% confidential index CI = [-0.11, 0.38]), the pooled SMD of estimated blood loss was -0.14, (95% CI = [-0.58, 0.31]), the pooled SMD of ischemia time was 0.57, (95% CI = [-0.02, 1.16]), the pooled SMD of length of stay was -0.55, (95% CI = [-1.12, 0.02]), and the pooled OR of positive margin was 1.02, (95% CI = [0.39, 2.68]), the pooled OR of postoperative complications was 0.74, (95% CI = [0.41, 1.36]).

Conclusions: LRN had advantages on decreasing postoperative complications rate but the ischemia time of OPN was much shorter.

Introduction

Partial nephrectomy (PN) has become the standard surgical treatment for T1a renal tumors (< 4 cm), and for T1b tumors whenever feasible[1]. PN is preferred over radical nephrectomy (RN) for localized T1 renal cell carcinoma, as PN better preserves renal function with comparable oncologic outcomes[2]. Furthermore, RN can increase chronic kidney disease and cardiovascular mortality[3].

OPN has been considered as the “gold standard” approach for many years. With the advancement of surgeon’s skills and medical equipment, laparoscopic technique has been gradually promoted in the field of urology. Laparoscopic surgery has the advantages of a small surgical incision, fast postoperative recovery, and small intraoperative blood loss, as well as tumor treatment effectiveness similar to that with open operations[4, 5]. However, LPN puts higher requirements for surgeon’s operating skills and clinical experience. The long learning curve makes LPN available only in large medical centers.

We summarized data for the past five year on operative time, blood loss volume, ischemia time, length of hospital stay, margin positive rate and postoperative complications rate to compare effects of LPN and OPN on T1 renal tumor patients. We hope it can provide guidance for the clinical application of the surgical approaches.

Methods
Search strategy

We comprehensively researched PubMed, Embase, Google Scholar and Clinicaltrials.gov to find all referring studies, published between Jan 1, 2015, and Mar 1, 2020 without language restrictions. We did the research with keywords “T1 renal tumor”, “partial nephrectomy”, “laparoscopic”, “open”, “LPN”, “OPN”. The systemic reviews and meta-analysis was reported in accordance with the PRISMA guidelines.

Study selection

We searched and read literature matching keywords carefully. Studies were eligible for enrollment only if they met the following criteria: (1) those that conducted LPN versus OPN comparative trials; (2) those whose study subjects were patients at T1 stage; (3) those the data of operative time, blood loss volume, ischemia time, length of hospital stay, margin positive rate and postoperative complications rate were reported. Exclusion criteria were as follows: (1) Patients in the study had significant illnesses that could affect the surgery itself; (2) The research data didn’t match our target, or recorded data were incomplete and were not suitable for meta-analysis.

Data extraction

Two independent investigators collected literature titles and abstracts, and studies that matched the inclusion criteria were considered as candidates. We extracted the following data from each selected study: study characteristics (authors of the literature, the year of the publication, the study type, basic information of study participants), operative time, blood loss volume, ischemia time, length of hospital stay, margin positive rate and postoperative complications rate. If there was a deviation between the extracted data, the two investigators would discuss and re-extract the relevant data. If there were still differences, it would be referred to a third investigator for judgment.

Data analysis

We calculated pooled estimates of the standard mean differences with 95% confidence intervals in operative time, blood loss volume, ischemia time and length of hospital stay. We calculated pooled estimates of odds ratios with 95% confidence intervals in margin positive rate and postoperative complications rate. We also did I² testing to assess the magnitude of the heterogeneity between studies, with values greater than 50% regarded as being indicative of moderate-to-high heterogeneity [6]. We performed sensitivity analysis to the data whose I² > 50%. All data were analyzed by Revman (version 5.3).

Results

We identified 325 studies. After careful selection, 6 trials satisfied to the inclusion criteria were included to our study (Fig. 1). All trials were published between 2015 and 2020 (Table 1). Two were prospective studies, one of which was multicenter observational. Four were retrospective studies, one of which wasn’t an RCT.
Table 1
Characteristics of included studies

| Country       | Study Type     | Ages             | Group | Male/female |
|---------------|----------------|------------------|-------|-------------|
| Bravi 2019    | Italy Prospective | 63(55–71)       | LPN   | 421/204     |
|               |                | 66(56–73)        | OPN   | 438/244     |
| Mehra 2019    | India Retrospective | 48.5(19–58)     | LPN   | 8/6         |
|               |                | 49(29–80)        | OPN   | 16/10       |
| Choi 2019     | Korea Retrospective | 53.1(45-60.5)   | LPN   | 74/22       |
|               |                | 54.6(46–64)      | OPN   | 212/73      |
| Banapour 2018 | USA Retrospective | 57               | LPN   | 431/255     |
|               |                | 59.1             | OPN   | 101/75      |
| Luciani 2016  | Italy Prospective | 62.9(56-69.5)   | LPN   | 42/28       |
|               |                | 65(54.7–72.6)    | OPN   | 51/22       |
| Porpiglia 2015| Italy Retrospective(RCT) | 60           | LPN   | 42/15       |
|               |                | 62.3             | OPN   | 87/46       |

Age is exhibited as the median ± IQR

The operative time was reported in 4 studies(Fig. 2A). The pooled SMD of these 4 studies was 0.14 (95% CI = [-0.11, 0.38], P = 0.0005, I² = 83%). Considering its high heterogeneity, we used random effect model and performed a sensitivity analysis(Fig. 2B). We found that the main cause of heterogeneity was the study of Luciani 2016. The pooled SMD from these 3 studies was 0.02 (95% CI = [-0.07, 0.11], P = 0.51, I² = 0%), which showed no heterogeneity. According to our analysis, there was no significant difference (P = 0.63) on operative time between LPN and OPN.

The estimated blood loss volume was reported in 5 studies(Fig. 3A). The pooled SMD of these 5 studies was −0.14 (95% CI = [-0.58, 0.31], P = 0.00001, I² = 96%). We performed a further sensitivity analysis between Choi 2019 and Porpiglia 2015(Fig. 3B). The pooled SMD from these 2 studies was −0.04 (95% CI = [-0.22, 0.15], P = 0.76, I² = 0%). The analysis showed no significant difference (P = 0.68) on estimated blood loss volume between LPN and OPN.

The ischemia time was reported in 5 studies(Fig. 4A). The pooled SMD of these 5 studies was 0.57 (95% CI = [-0.02, 1.16], P = 0.00001, I² = 98%). The performed a sensitivity analysis between Luciani 2016 and Porpiglia 2015(Fig. 4B). The pooled SMD from these 2 studies was 1.40 (95% CI = [1.14, 1.67], P = 0.00001, I² = 9%). The data demonstrated a significant statistic difference (P = 0.00001) on ischemia time between LPN and OPN. The ischemia time of OPN was much shorter than LPN.
The length of stay was reported in 2 studies (Fig. 5). The pooled SMD of these 2 studies was −0.55 (95% CI = [-1.12, 0.02], P = 0.002, I² = 89%). We didn’t find a difference (P = 0.06) on the length of stay between LPN and OPN.

The positive margin rate was reported in 4 studies (Fig. 6). The pooled OR of these 4 studies was 1.02 (95% CI = [0.39, 2.68], P = 0.29, I² = 19%). According to the data, we thought that there was no statistical difference (P = 0.97) on positive margin rate between LPN and OPN.

The postoperative complications rate was reported in 4 studies (Fig. 7A). The pooled OR of these 4 studies was 0.74 (95% CI = [0.41, 1.36], P = 0.08, I² = 56%). We also performed a sensitivity analysis and found out that the heterogeneity was mainly causes by Luciani 2016. The pooled OR of these 3 studies was 0.56 (95% CI = [0.33, 0.94], P = 0.29, I² = 18%) (Fig. 7B). According to the data, there was a significant difference (P = 0.03) on postoperative complications rate between LPN and OPN. LPN hold a lower incidence of postoperative complications.

**Discussions**

PN is the reference standard of care for small renal masses and is preferred over radical nephrectomy because of its equivalent oncological outcomes and superior renal functional preservation [12–14]. With the prevalence of minimally invasive surgery, LPN becomes common. LPN has several advantages such as accurate tumor dissection, easy intracorporeal suturing, and better perioperative outcomes compared to OPN. In 2003, Gill was the first to compare the advantages and disadvantages of LPN and OPN in the treatment of renal tumours [15]. With the continuous progress of LPN technique, we believe that the data of the past five years are more representative.

In our study, we compared operative time, blood loss volume, ischemia time, length of hospital stay, margin positive rate and postoperative complications rate. Our results demonstrated that WIT (warm ischemia time) was shorter in OPN compared with LPN, which was consistent with many published studies [15, 16]. One challenge of LPN is to shorten intraoperative WIT as much as possible, to ensure that postoperative residual kidneys maintain good renal function and to reduce the risk of postoperative acute and chronic renal failure. The consensus in the field is that a WIT of 25 minutes is the most appropriate inflection point for short-term or long-term renal function damage [17]. While a retrospective study by Marszalek et al reported the opposite results and stated that WIT was shorter in LPN compared with OPN [18]. We believe that the reason OPN has a shorter WIT are based on that OPN has lower operational requirements compared with LPN. Theoretically, LPN has very high requirement for microscopic cutting and suture of tumors, although it could be expected that LPN might be beneficial regarding WIT because of pneumoperitoneum. It should be noted that the surgeon’s expertise and tumor accessibility are two important factors that may influence ischemia time [19].

Our study shows that there is no significant difference on operative time and estimated blood volume between LPN and OPN. Although we know that LPN has several advantages like reducing bleeding owing to pneumoperitoneum, providing accurate tumor cutting and suturing under magnified vision, improving
patient's postoperative quality through smaller and beautiful surgical incision, and facilitating the coagulation of small vessels [12]. According to our analysis, the perioperative success with LPN solely depends on the surgeon's experience. The information of this study comes from different doctors all over the world. Different doctors use different surgical techniques to deal with different patients. This may be the reason that LPN doesn't have advantages in the results of surgical operation.

In our study, we found that LRN had no advantages on length of hospital stay and postoperative positive margin rate. LPN is an advancement in surgical methods. It uses a minimally invasive approach to cut the tumor in essence, and there is no change in the surgical method. So, there are not much difference on these two outcomes, which is also in line with our expectations.

According to our analysis, LPN had advantages on decreasing postoperative complications rate, which is contrary to many published conclusions. In the past, the data trends to that there was no obvious difference between OPN and LPN regarding the postoperative complications rate [20, 21]. According to our observations, the more stale (out of five years) data trends to support OPN. The literature in the past three years almost tends to support that LPN has advantages on decreasing postoperative complications rate. We believe that this is due to the development of LPN technique in recent years and the gradually accumulated clinical experience of doctors in large medical institutions. LPN avoids the huge trauma caused by OPN on the patient, and the precise operation under the microscope can avoid damage to adjacent tissues and small blood vessels. Pneumoperitoneum also helps patients avoid gastrointestinal function damage. We believe that LPN can show its full superiority with enough experience.

A limitation of this analysis is that we lack analysis of postoperative oncology and biochemical outcome. After careful data extraction, we found that our statistical literature either lack of relevant data or the data we need were not published under same standards. Second, the sample size is insufficient. There are few relevant literatures in the past five years and the selection bias is inevitable. Additionally, we were not able to ruled out the effect of surgeon's learning curves on the end results. There was insufficient information on surgeons' experience to perform a sensitivity analysis exploring the impact of the learning curve on end results [22].

**Conclusions**

Although further studies are needed to confirm that our conclusions are the best clinical applications path, our study clearly lend support to that LRN has advantages on decreasing postoperative complications rate and the ischemia time of OPN was much shorter on T1 renal tumor at this stage. Considering the continuous improvement of surgeon's LPN proficiency, we can expect that LPN have a long-term development in the future.

**Declarations**

**Acknowledgements**
None.

**Disclaimers**

None. It is never been presented/published before in any form.

**Funding**

Not applicable.

**Availability of data and materials**

The data used and analyzed in this research can be obtained from the corresponding author with a reasonable request.

**Authors’ contributions**

KW is the corresponding author of the article. YMS is the first author. KW designed the research, interpreted the data, and revised the paper. YMS, ZLZ, KZ, HQS, ZLW, CHL, YLZ, JMG, CL and XYL performed the data extraction. YMS drafted the paper. ZLZ, HTN and KW revised the paper. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

All patients in our research provided informed consent before the treatment.

All procedures in this research were performed in accordance with the principles of the Research Ethics Committee of the Affiliated Hospital of Qingdao University and with the 1964 Helsinki Declaration and its amendments.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

**References**

1. Lee CT, Katz J, Shi W, Thaler HT, Reuter VE, Russo P. Surgical management of renal tumors 4 cm. or less in a contemporary cohort. J Urol. 2000;163: 730-736.

2. Motzer RJ, Jonasch E, Agarwal N, et al. Kidney cancer, version2.2017, NCCN Clinical Practice Guidelines in Oncology. J Natl Compr Canc Netw. 2017;15:804-834.
3. Thompson RH, Boorjian SA, Lohse CM, et al. Radical nephrectomy for pT1a renal masses may be associated with decreased overall survival compared with partial nephrectomy. J Urol. 2008;179:468-471.

4. Ljungberg B, Bensalah K, Canfield S, Dabestani S, Hofmann F, Hora M, et al. EAU guidelines on renal cell carcinoma: 2014 Update. Eur Urol 2015; 67:913-24.

5. Campbell SC, Novick AC, Belldegrun A, Blute ML, Chow GK, Derweesh IH, et al. Guidelines for management of the clinical T1 renal mass. J Urol 2009; 182:1271-9.

6. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002; 21: 1539–58.

7. Bravi CA, et al. Perioperative Outcomes of Open, Laparoscopic, and Robotic Partial Nephrectomy: A Prospective Multicenter Observational Study (The RECORd 2 Project). Eur Urol Focus (2019), https://doi.org/10.1016/j.euf.2019.10.013.

8. Mehra K et al. Trifecta outcomes in Open, Laparoscopy or Robotic partial nephrectomy: Does the surgical approach matter? J Kidney Cancer VHL 2019;6(1): 8–12.

9. Choi SY, Jung H, You D, et al. Robot-assisted partial nephrectomy is associated with early recovery of renal function: Comparison of open, laparoscopic, and robot-assisted partial nephrectomy using DTPA renalscintigraphy. J Surg Oncol. 2019;1-8.

https://doi.org/10.1002/jso.25429.

10. Banapour P, Abdelsayed GA, Bider-Canfield Z et al. Nephrometry score matched robotic vs. laparoscopic vs. open partial nephrectomy. [J]. J Robot Surg, 2018, 12: 679-685.

11. Luciani LG, Chiodini S, Mattevi D et al. Robotic-assisted partial nephrectomy provides better operative outcomes as compared to the laparoscopic and open approaches: results from a prospective cohort study. [J]. J Robot Surg, 2017, 11: 333-339.

12. Porpiglia F, Mari A, Bertolo R et al. Partial Nephrectomy in Clinical T1b Renal Tumors: Multicenter Comparative Study of Open, Laparoscopic and Robot-assisted Approach (the RECORd Project). [J]. Urology, 2016, 89: 45-51.

13. Huang WC, Elkin EB, Levey AS, et al. Partial nephrectomy versus radical nephrectomy in patients with small renal tumors— is there a difference in mortality and cardiovascular outcomes? J Urol 2009, 181:55–61; discussion 61–66.

14. Weight CJ, Lieser G, Larson BT, et al. Partial nephrectomy is associated with improved overall survival compared to radical nephrectomy in patients with unanticipated benign renal tumours. Eur Urol 2010, 58:293–298.
15. Gill IS, Matin SF, Desai MM, Kaouk JH, Steinberg A, Mascha E, et al. Comparative analysis of laparoscopic versus open partial nephrectomy for renal tumors in 200 patients. J Urol 2003; 170:64-8.

16. Porpiglia F, Volpe A, Billia M, Scarpa RM. Laparoscopic versus open partial nephrectomy: analysis of the current literature. Eur Urol. 2008;53:732-42; discussion 42-3.

17. Patel AR, Eggener SE. Warm ischemia less than 30 minutes is not necessarily safe during partial nephrectomy every minute matters. Urol Oncol 2011; 29:826-8.

18. Marszalek M, Meixl H, Polajnar M, Rauchenwald M, Jeschke K, Madersbacher S. Laparoscopic and open partial nephrectomy: a matched-pair comparison of 200 patients. Eur Urol. 2009;55:1171-8.

19. Minervini A, Siena G, Antonelli A, et al. Open versus laparoscopic partial nephrectomy for clinical T1a renal masses: a matched-pair comparison of 280 patients with TRIFECTA outcomes (RECOrd Project). World J Urol. 2014;32:257-63.

20. Becker A, Pradel L, Kluth L, Schmid M, Eichelberg C, Ahyai S, et al. Laparoscopic versus open partial nephrectomy for clinical T1 renal masses: no impact of surgical approach on perioperative complications and long-term postoperative quality of life. World J Urol. 2015;33:421-6.

21. Rezaetalab Gholam Hossein., Karami Hormoz., Dadkhah Farid., Simforoosh Nasser., Shakhssalim Nasser.(2016). Laparoscopic Versus Open Partial Nephrectomy for Stage T1a of Renal Tumors. Urol J, 13(6), 2903-2907.

22. Choi JE, You JH, Kim DK et al. Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: a systematic review and meta-analysis. Eur Urol., 2015, 67: 891-901.

**Figures**
Figure 1

Study selection process.
Figure 2

The forest plot for the operative time between LPN and OPN(A); sensitivity analysis(B).
Figure 3

The forest plot for the estimated blood loss volume between LPN and OPN (A); sensitivity analysis (B).
Figure 4

The forest plot for the ischemia time between LPN and OPN(A); sensitivity analysis(B).

Figure 5

The forest plot for the length of stay between LPN and OPN.
Figure 6

The forest plot for the positive margin rate between LPN and OPN.

A

B

Figure 7

The forest plot for the postoperative complications rate between LPN and OPN (A); sensitivity analysis (B).