Robotic versus Laparoscopic Partial Nephrectomy: A Systematic Review and Meta-Analysis of Randomised Trials

Benjamin Buckland, B. Med, M. Surg[1,2,3]
Conjoint Fellow

Bridget Heijkoop, MBBS (Hons)[1]
Urology Registrar

Kevin Tree, MBBS[4]
Conjoint Associate Lecturer

Tharindu Senanayake, B. Med, M. Surg[3]
Conjoint Fellow

Oliver Best, MBBS (Hons)[1]
Urology Registrar

Marcus Handmer, MBBS (Hons), FRACS (Urol)[1,2]
Head of Department

[1]Urology Department, John Hunter Hospital, Newcastle, Australia
[2]School of Medicine and Public Health, University of Newcastle, Newcastle, Australia
[3]Surgical and Perioperative Care Research Group, Hunter Medical Research Institute, Newcastle, Australia
[4]Department of Surgery, Lismore Hospital, Gosford, Australia

ABSTRACT

Introduction: The objective of this article is to compare outcomes of robotic-assisted partial nephrectomy (RAPN) versus laparoscopic partial nephrectomy (LPN) for surgical management of renal tumours by performing a systematic review.

Materials and Methods: Prospective randomised controlled trials comparing robotic to laparoscopic partial nephrectomy were included in this analysis. No date or language restriction was imposed. Studies on paediatric patients (<16 years old) were excluded. No specific outcomes were required for inclusion in the analysis. The authors independently extracted data and assessed the risk of bias using the risk of bias tool (RoB 1). Meta-analysis was performed using ReviewManager (RevMan) Software (Cochrane Collaboration, London, United Kingdom).

Results: Two prospective randomised controlled trials involving 190 participants were included. A comparative analysis of 190 patients undergoing partial nephrectomy showed no significant difference in overall complication rates. However, RAPN was associated with a reduced risk of minor complications (Clavien-Dindo grade 1-2). Operatively, LPN demonstrated a marginally shorter duration; whereas, RAPN showed a slight advantage in warm ischemia time. Regarding renal function, RAPN resulted in a less pronounced increase in serum creatinine levels six months postoperatively. In contrast, changes in estimated glomerular filtration rate did not significantly differ between the groups. Length of hospital stay and positive surgical margin rates were comparable between approaches.

Conclusion: There is limited low-quality evidence in small-scale trials that may indicate robotic partial nephrectomy is comparable to laparoscopic partial nephrectomy. RAPN has lower minor complication rates, with potential advantages in warm ischemia time and complication rates.

INTRODUCTION

Partial nephrectomy (PN) is currently considered the gold-standard treatment option for small renal masses, as it helps preserve renal function while maintaining oncological control.[1] Initially, open partial nephrectomy (OPN) was the standard treatment method. However, with the advancement of minimally invasive techniques, laparoscopic partial nephrectomy (LPN) and robot-assisted partial nephrectomy (RAPN) have become popular.[2] Minimally invasive surgery has theoretical advantages over OPN, such as shorter postoperative recovery time, decreased morbidity, and decreased pain.[3] Robotic surgery has further theorised benefits over laparoscopic surgery. These benefits may include image quality, increased instrument dexterity, 3D visualisation, improved surgeon comfort, increased precision, and range of motion.[4] Due to these benefits, robotic surgery has become the gold standard technique in other urological operations, such as radical prostatectomy.[5,6] RAPN was first described in 2004.[7] However, there has been an explosion in the use of robotics for RAPN, with up to 54% of patients undergoing partial nephrectomy in the United States having robotic surgery.[8] With the increasing availability and use of robotic surgery as an alternative method to laparoscopic surgery,[9] the best approach for minimally invasive partial nephrectomy remains to be determined. Early experience with RAPN shows it to be a safe alternative to LPN.[10]

Recent studies have examined RAPN and LPN, focusing on various perioperative outcomes mainly in retrospective series. Retrospective studies provide valuable insights, especially in surgical procedures like RAPN and LPN.[10,11] However, these studies have some limitations regarding data quality and potential bias.[12] To address these limitations, this systematic review will only include prospective randomised controlled trials (RCTs), considered the gold standard in clinical evidence. We have decided to ensure the highest quality of evidence and provide reliable insights into the comparative effectiveness and safety of RAPN versus LPN. The primary goal of this review is to offer a robust and evidence-based guide for clinical decision-making by focusing on prospective RCTs and drawing conclusions from the most rigorous scientific data available.

MATERIALS AND METHODS

Eligibility criteria

We included only prospective RCTs with patients over 16 years of age. Other study designs were excluded. We compared robotic partial nephrectomy to laparoscopic partial nephrectomy.

Information sources

We conducted a comprehensive and systematic literature review by searching the Cochrane Library, Cochrane Central Register of Controlled Trials, MEDLINE, and EMBASE. Our search strategy is detailed in the Appendix. We did not set any restrictions on the search timeframe and searched up to August 2023. All languages were included. We also looked for unpublished or ongoing studies in various clinical trial registries, including databases such as the Australia and New Zealand Clinical Trials Registry, the WHO International Clinical Trials Registry, and Clinicaltrials.gov. To ensure we capture the most recent and relevant advancements in urological surgery, we also reviewed conference abstracts from prominent urology associations over the past two years and engaged with subject matter experts. We also meticulously examined the reference lists of all studies selected for inclusion to ensure that we covered all supplementary research.

Selection process

Two reviewers independently conducted the study selection using Rayyan,[13] a specialised software program designed to examine research studies. Initially, titles and abstracts from the search results were screened. Both reviewers evaluated the full texts for the potentially suitable articles to determine their suitability for inclusion. They marked the texts as either excluded, included, pending (if awaiting full-text access), or ongoing if the text was incompletely reviewed. They recorded the reasons for exclusions with specific rationales. If there were any disagreements, they resolved them through consultation with a third reviewer. The PRISMA flow chart depicts this selection process. A Kappa statistic was calculated at 0.63, indicating good inter-rater variability.

Data collection process/items

The author (BB) created a specialised data extraction form. Two authors (BB and KT) independently utilised this form to gather the required information. The authors discussed the issue in case of disagreement, and a third author (OB) settled any unresolved inconsistency.

The review did not exclude any studies based on the non-reporting of outcomes of interest. The primary outcome evaluated was the conversion to open surgery. The secondary outcomes assessed were the conversion to radical nephrectomy, length of stay, complication rate, operative time, estimated blood loss, warm ischemia time, and the change in estimated glomerular filtration rate.

The study data collected included the study design, protocol, country, language, dates, inclusion/exclusion criteria, participants per group, intervention, and funding source.

Study risk of bias assessment

Two reviewers (BB and BH) independently evaluated study bias utilising the RoB 1.0 tool from the Cochrane Collaboration.[14] The risks were categorised as low, unclear, or high for each domain. Any discrepancies between the two were initially discussed and resolved, and a third reviewer (TS) resolved any persisting disagreements. The domains assessed included:

- Sequence generation and allocation concealment to address selection bias.
- Blinding of participants/personnel and outcome assessment to address performance and detection biases, respectively.
- Evaluation of attrition and selective reporting for potential attrition and reporting biases.
- Examination for any additional biases.

To ensure the accuracy of the results, we evaluated each trial separately. We examined the randomisation process and blinding methods to assess selection and performance bias. We also evaluated outcomes and reported bias for each specific outcome. To do this, we distinguished between objective outcomes that are less likely to be influenced by detection bias and subjective outcomes that are more likely to be influenced by detection bias.

We planned to focus the primary analysis on studies with a low risk of bias, followed by a sensitivity analysis to explore the impact of study quality on the review's findings.

Effect measures

The study presented data from continuous variables as mean differences (MD) and 95% confidence intervals (CIs). For dichotomous data, the results were expressed in terms of risk ratios (RR) with 95% CIs. The findings were combined using a random-effects model, considering the full range of effect sizes and controlling for heterogeneity. We followed the procedures in the Cochrane Handbook for Systematic Reviews of Interventions. We used the Mantel-Haenszel method to analyse dichotomous data; whereas, we employed the inverse variance method for continuous data. The Review Manager 5 (RevMan 5; Cochrane Collaboration, London, United Kingdom) software aided us in carrying out these analyses.[15]

Synthesis methods

Missing data

Our approach to addressing missing data involves contacting the authors of the studies. We employ an intention-to-treat methodology for the analysis and avoid imputing any missing data.

Statistical heterogeneity

We will visually inspect forest plots and quantify them using the I2 statistic to assess heterogeneity. Values exceeding 75% will indicate substantial heterogeneity.

Subgroup analysis

No subgroup analysis was planned.

RESULTS

After an extensive search of electronic databases, 796 records were initially identified, with 45 additional records uncovered by trial registers or other methods. After removing duplicates, 779 records underwent a thorough screening process. Following the title and abstract review, 742 records were excluded. Subsequently, 37 full articles were carefully reviewed for suitability, excluding 19 studies due to incorrect study type and 11 studies due to an unsuitable intervention. Additionally, four articles were identified as review articles, and one study contained insufficient data. Ultimately, two eligible studies were identified and included in the analysis (Fig. 1).[16]

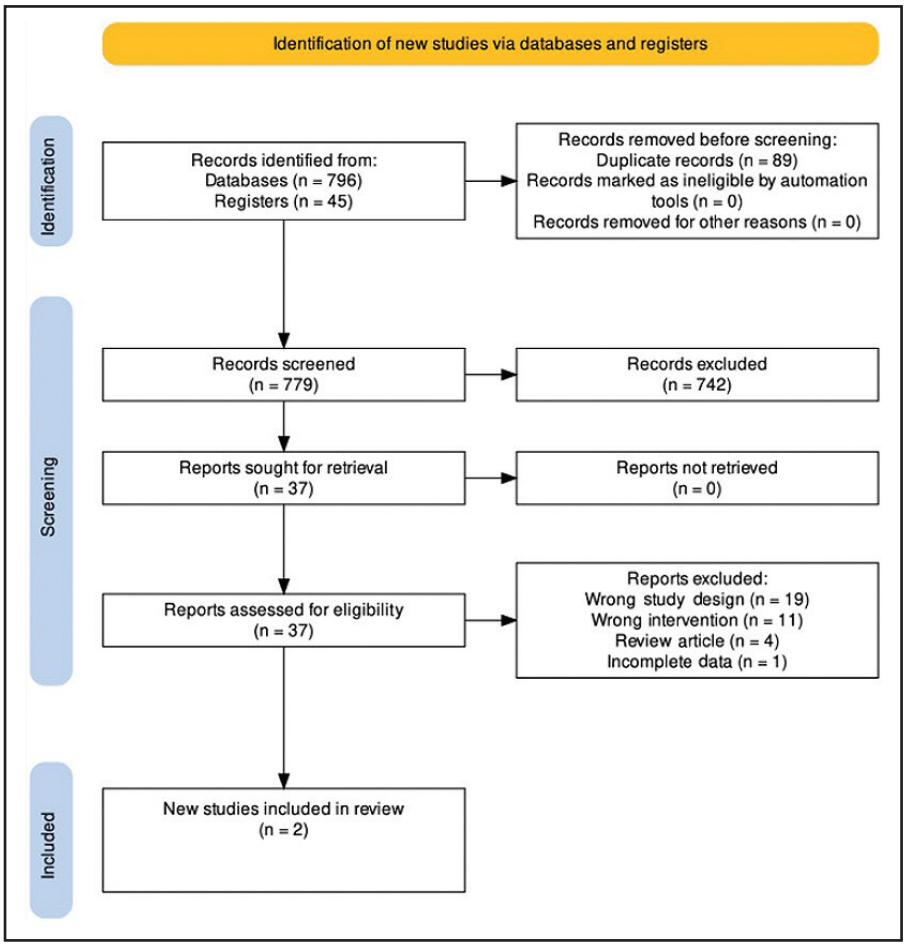

Figure 1. Study flow diagram.

Study characteristics

Table I includes the baseline characteristics and demographics of participants. Overall, the baseline characteristics between groups were similar. There were 190 patients overall, with 99 undergoing RAPN and 91 undergoing LPN.

Risk of bias assessment

The results of the quality assessment of each study in each of the assessed domains are provided in Figures 2 and 3. Each domain has been assessed separately.

Allocation

Random sequence generation

Zhou needed to outline the randomisation process clearly and was, therefore, scored as having an unclear risk of bias. Würnschimmel et al. used a computer randomisation program deemed low risk of bias.

Allocation concealment

Neither study commented on allocation concealment and how this was performed within the study, leading to an unclear risk of bias.

Blinding

Blinding of participants and personnel

Blinding was not performed in either study. Due to the nature of the intervention, both studies were deemed at high risk of blinding bias.

Blinding of outcome assessment

In both studies, objective outcomes were assessed as having a low risk of bias, and subjective outcomes were assessed as having a high risk of bias, giving an overall risk of bias of high.

Table I
Baseline characteristics

Study Name	Würnschimmel et al.		Zhou et al.	
	RAPN	LPN	RAPN	LPN
Number of patients	61	54	38	37
Age (Median in years)	62.7	63.9	62.0 +/- 10.3	63.2 +/- 10.3
Left Sided %	47%	54%	66%	57%
Gender (Male %)	66%	72%	55%	59%
BMI (Kg/m^2) +/- SD	27.5 +/- 5.3	28.5 +/- 5.4	NR	NR
Sample Size	115		75	
Intervention (Number)	Robotic assisted partial nephrectomy (n=61)		Robotic assisted partial nephrectomy (n=38)	
Control (Number)	Laparoscopic partial nephrectomy (n=54)		Laparoscopic partial nephrectomy (n=37)	
Follow Up	6 months minimum		2 years	
Study design	Prospective RCT		Prospective RCT	
Protocol	No		No	
Country/Context	Switzerland/Single centre		China/Single centre	
Language	English		English	
Dates of study	2015-2019		January 2015-July 2016	
Inclusion criteria of participants	>18 years of age cT1-cT2 renal tumours		Unilateral tumour No evidence of lymph node metastasis Early stage RCC (T1a, T1b or exophytic T2a)	
Exclusion criteria of participants	Charlson Comorbidity Index >10 CKD stage 4/5 Previous renal surgery Concomitant oncology disease Immune disease cT3+ renal tumour		Bilateral renal tumour or solitary kidney Localised invasion of tumour including renal vein thrombosis Significant anatomical variation Severe comorbidities Previous radiation or chemotherapy Not suitable for either surgery Unable to follow up	
Primary Outcome	Renal Function at 6 months		N/A	
Secondary Outcome	Operation time Warm ischemic time Haemoglobin changes Positive surgical margin Length of hospital stay Complications 6-month eGFR level		Operation time Warm ischemic time Haemoglobin changes Recurrence of disease Complications Postoperative creatinine levels	
Funding	Disclosed		No information	
Declaration of conflict of interests	No information		No information	

RAPN: Robotic assisted partial nephrectomy, LPN: Laparoscopic partial nephrectomy

Incomplete outcome data

Neither study reported incomplete data. Therefore, both studies were judged to be at low risk of bias.

Selective reporting

Neither study included a published protocol. All outcomes appeared to be reported appropriately and logically as RCTs. Given that there was no protocol to compare to, both studies were judged as having an unclear risk of bias.

Other potential bias

Zhou et al. declared no conflict of interest, and Würnschimmel et al. declared receipt of funding from a not-for-profit with a mission to advance urological research. Therefore, both studies were judged at low risk of other biases.

Publication bias

A funnel plot was created in RevMan to check for publication bias. Since only two studies were included, several key issues arise in interpreting this funnel plot. These include a lack of statistical power, an inability to assess symmetry, higher susceptibility to chance, and limited contextual information. Hence, the Cochrane Handbook recommends caution when interpreting any funnel plot involving less than 10 studies (Fig. 4).[17]

Results of synthesis

Safety outcomes

Zhou reported no conversions from partial to radical nephrectomy. Würnschimmel reported conversion from partial to radical nephrectomy in two laparoscopic cases and no robotic cases, with no statistical significance between groups (RR 0.18, 95% CI 0.01–3.62, p=0.26). Neither study reported any cases being converted to an open nephrectomy.

Two studies included data for complication rates (total 190, 99 RAPN, 91 LPN). There was no difference in overall complication rates (RR 0.71, 95% CI 0.39–1.28, p=0.25). Patients undergoing robotic surgery had a reduced risk of Clavien-Dindo grade 1–2 complications (RR 0.39, 95% CI 0.17–0.89, p=0.03). There was no difference in Clavien-Dindo grade 3–5 complications between groups (RR 2.03, 95% CI 0.65–6.34, p=0.22) (Fig. 5).

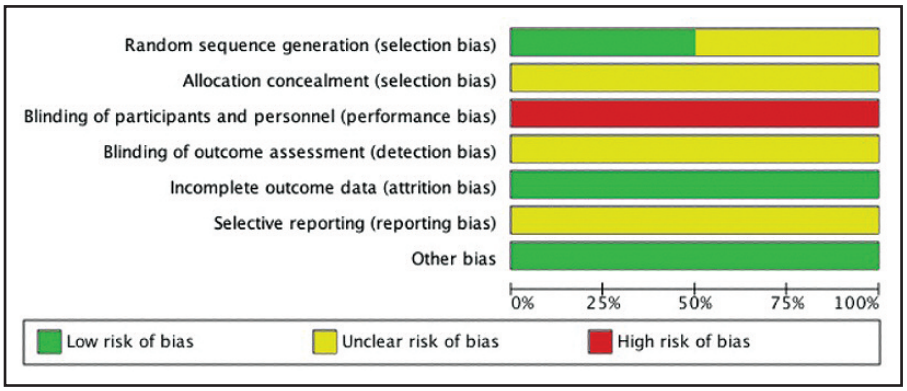

Figure 2. Risk of bias graph. Review authors' judgements about each risk of bias item presented as percentages across all included studies.

Effectiveness outcomes

Operative time: Both studies included data for operative time (total 190, 99 RAPN, 91 LPN). Laparoscopic surgery had a slightly shorter operative time than robotic partial nephrectomy (MD 14.27 minutes, 95% CI 1.10–27.43, p=0.03). There is significant statistical heterogeneity (I^2=91%) (Fig. 6).

Warm ischemia time:Both studies included data for warm ischemia time (total 190, 99 RAPN, 91 LPN). Robotic surgery has a slightly shorter warm ischemia time than laparoscopic partial nephrectomy (MD 2.38 minutes, 95% CI 4.20–0.56, p=0.01). There is no significant statistical heterogeneity (I^2=0%) (Fig. 7).

Change in renal function: Zhou reported a change in renal function using the difference in serum creatinine, showing a decrease of 1.92+/-2.05µmol/L in the robotic group, compared to the reduction of 6.57+/-4.38µmol/L (p<0.005) in the laparoscopic group at six months postoperatively. Würnschimmel reported a change in renal function by measuring the estimated glomerular filtration rate (eGFR). At six months, the robotic group had a 16% (4.5–20.0% interquartile range [IQR]) decrease in eGFR, compared to a 14% decrease (7.0–23.5% IQR) in the laparoscopic group (p=0.3).

Length of stay: Zhou did not include data on the length of stay. Würnschimmel reports a slightly decreased length of stay in the robotic group (MD 0.20 days, 95% CI -1.45–1.05, p=0.75). This was not a statistically significant difference.

Positive surgical margin: Both studies

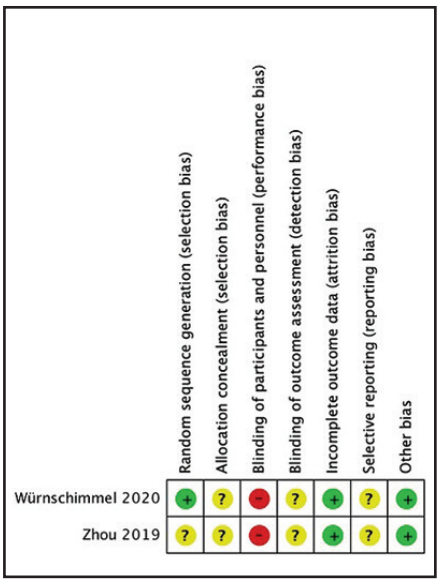

Figure 3. Risk of bias summary. Review authors' judgements about each risk of bias item for each included study.

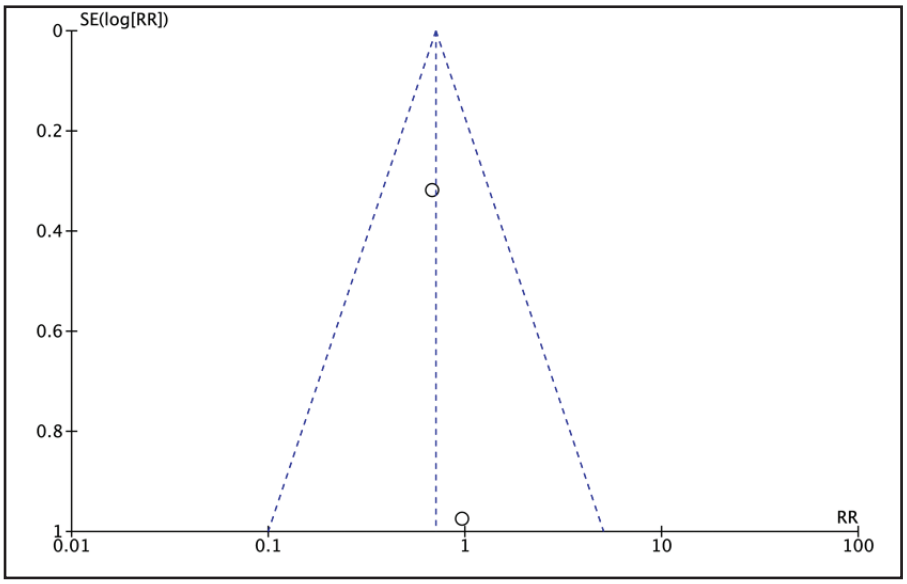

Figure 4. Funnel plot of comparison: RAPN versus LPN in complications.

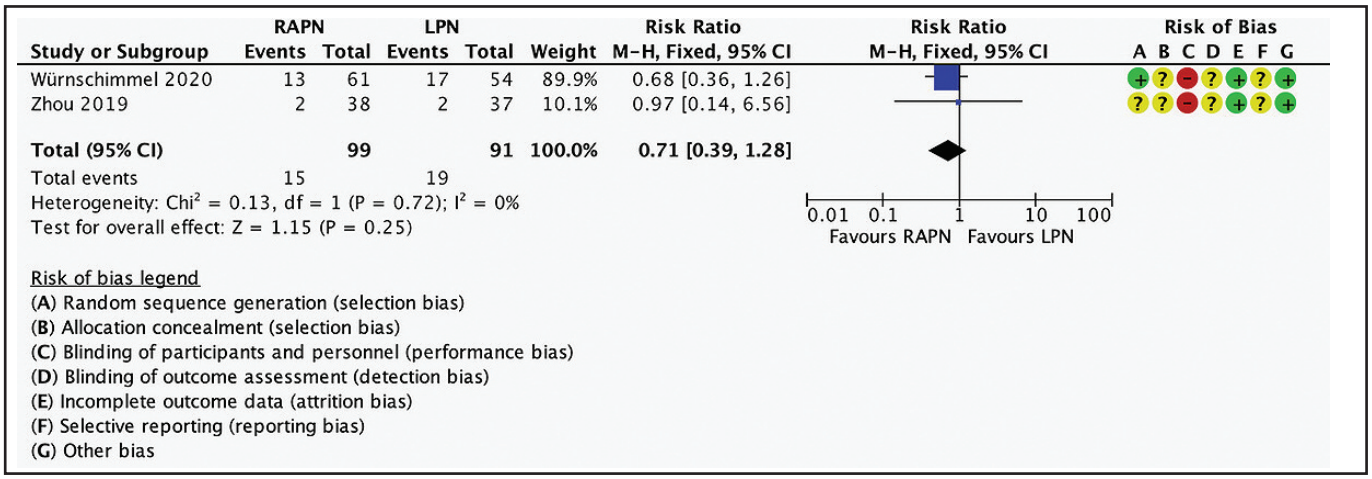

Figure 5. Forest plot for complications in RARP versus LPN.

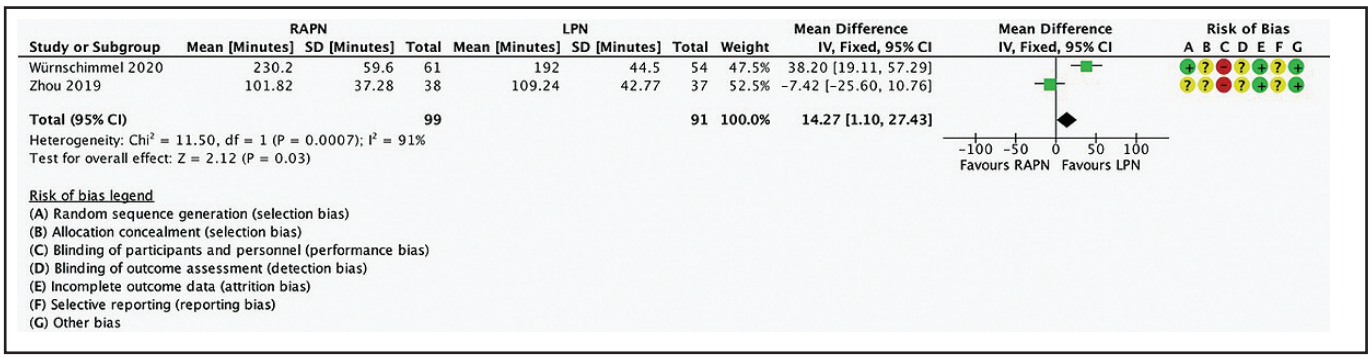

Figure 6. Forest plot for operative time in RARP versus LPN.

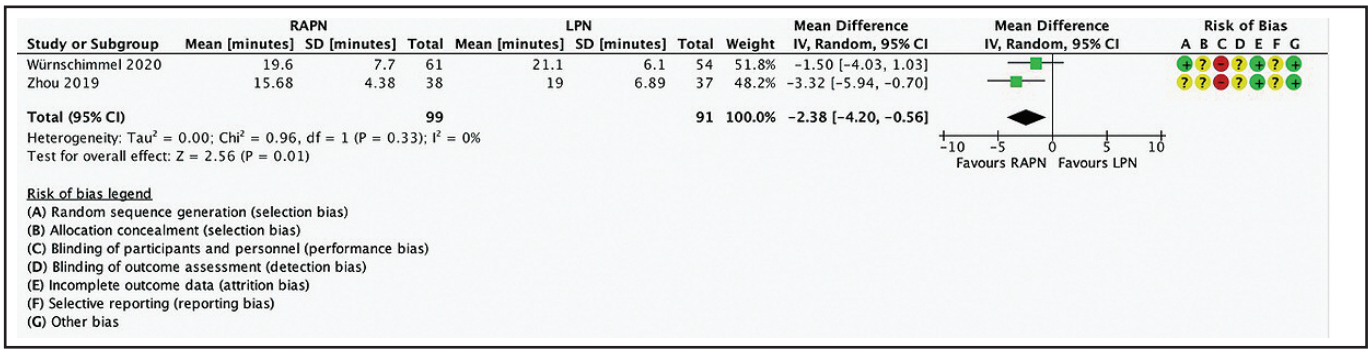

Figure 7. Forest plot for warm ischemia time in RARP versus LPN.

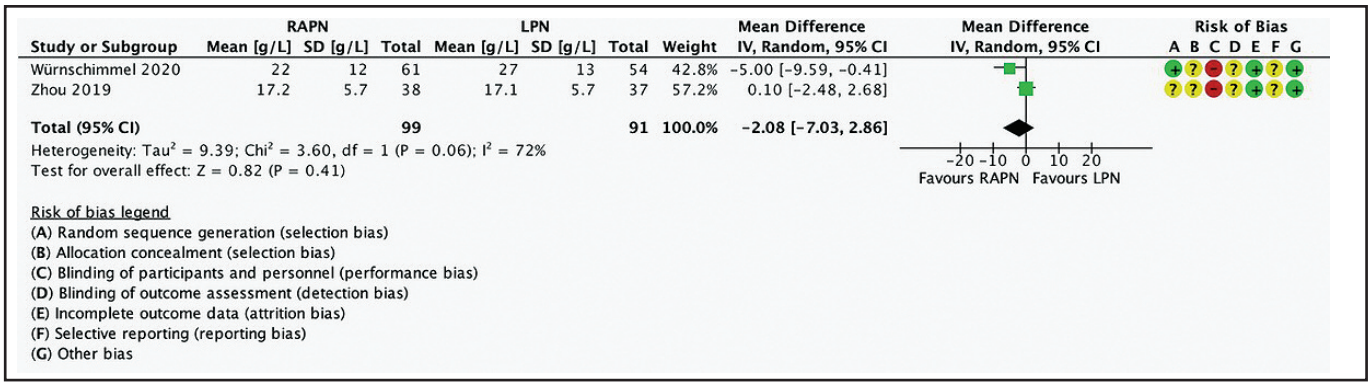

Figure 8. Forest plot for change in hemoglobin in RARP versus LPN.

included data on positive surgical margin rates (total 190, 99 RAPN, 91 LPN). In Zhou's study, there were no events of a positive surgical margin. In the other study, LPN had a lower positive surgical margin rate (RR 6.21, 95% CI 0.33–117.56, p=0.22). However, this was not statistically significant.

Change in haemoglobin: Both studies included data on the difference between pre- and postoperative haemoglobin levels (total 190, 99 RAPN, 91 LPN). Robotic surgery was associated with a lower reduction in haemoglobin levels than laparoscopic surgery (MD 2.08g/L, 95% CI 7.03, -2.86, p=0.41). There was no significant heterogeneity (I^2=72%) (Fig. 8), and neither study reported any measure of pain.

Subgroup and sensitivity analysis

No subgroup analysis or sensitivity analysis was performed.

DISCUSSION

Key findings

This systematic review and meta-analysis suggest that the clinical outcomes and safety of robot-assisted partial nephrectomy are similar to those of laparoscopic partial nephrectomy in the surgical management of small renal masses. However, the primary endpoint of conversion to open partial nephrectomy was not seen in either study.

It was difficult to assess the conversion from partial to radical nephrectomy as there were limited events. Out of the 190 operations performed, only two cases of conversion were reported, indicating a low conversion rate of 1% in comparison to the 4% reported in the literature.[18] This lower conversion rate may be due to smaller tumours in this study, as both included only tumours up to T2a. The generalizability of these results can also, therefore, only be applied to tumours of T2a or lower. This is particularly relevant as much of the benefit of using the robotic approach is potentially realised when performing more difficult partial nephrectomy cases. Therefore, the differences in approaches may be minimised.

The included studies did not show a significant difference in overall complication rates between RAPN and LPN, consistent with the existing literature suggesting that both procedures are generally safe with a low incidence of adverse events.[19] However, the reduced risk of Clavien-Dindo grade 1–2 complications in patients undergoing RAPN indicates a potential advantage regarding minor postoperative events. This finding could be related to the enhanced dexterity and precision robotics offers. Robotic surgery offers benefits such as improved visualisation, greater precision, and enhanced manoeuvrability due to features like a 3D vision system, high-definition magnification, and ergonomic comfort.[4] These technical advantages contribute to a shorter learning curve and potentially reduce the occurrence of postoperative complications. Robotic systems' increased dexterity and manoeuvrability have been linked to fewer complications than laparoscopic procedures.[20]

Our review found that although RAPN had slightly longer operative times, the difference was minor. A 14-minute difference in operative time is unlikely to be clinically significant. It also needed to be clarified how operative time was calculated in both studies. Neither study clarified whether operative time included robot set-up or robotic console time.

In contrast, the difference in warm ischemic time may be significant. This meta-analysis showed that RAPN has over two minutes less warm ischemic time than LPN. Traditionally, shorter warm ischemia times have been associated with better outcomes, especially the return of renal function.[21] However, recent studies have questioned this long-held belief.[22] A retrospective series of over three thousand patients suggests that warm ischemic time does not impact postoperative renal function.[23] This is again demonstrated by our study, given that the reduced warm ischemic time in the RAPN group did not lead to any statistically significant changes in renal function at six months postoperatively. The discrepancy in operative times may also reflect the learning curve associated with RAPN, which could decrease with growing experience and technological advancements.[24]

Interestingly, our review found no significant differences in the length of hospital stay. Only one study reported on this outcome, meaning there is no comparison between studies and, hence, no meta-analysis of this outcome. The results must, therefore, be interpreted as such. Würnschimmel et al. showed the mean difference in length of stay between groups was 0.2 days. This result was both statistically and clinically insignificant. This is in keeping with the literature, which suggests that LPNs and RAPNs have comparable lengths of stay, although this is shorter than OPN.[25]

The absence of reported measures of pain in the included studies highlights a gap in the literature that future research should aim to address. Postoperative pain is a critical aspect of patient recovery and satisfaction. Understanding how RAPN and LPN differ in this regard would be valuable for comprehensive patient counselling. Given the similar size of incisions, pain between approaches would theoretically be similar, although this is yet to be proven in prospective randomised controlled trials. Jin et al. showed no significant pain difference in a retrospective analysis.[26]

Comparison with existing knowledge

Previous systematic reviews have compared RAPN to LPN but have only focused on retrospective studies. There have yet to be any last systematic reviews including only RCTs. Many of these reviews include more significant numbers of patients. These studies have shown that RAPN has more favourable outcomes than LPN for conversion to open or radical surgery, warm ischemia time, change in renal function, and decreased length of stay.[19] Our review would agree that there is shorter warm ischemia time, but the other outcomes are similar.

Other systematic reviews have compared RAPN via the transperitoneal and retroperitoneal approaches,[27] open compared to laparoscopic approaches,[28] open compared to robotic approaches,[29] and the use of RAPN in complex cases.[30] These studies all compared different approaches to this current systematic review.

Strengths and limitations

In this review, we utilised an extensive search strategy that included various data sources to locate randomised controlled trials, regardless of publication status or language. This study only included RCTs, considered the gold intervention standard.

It is essential to acknowledge the limitations within our analysis. The inherent heterogeneity of the study designs and patient populations, as well as the small number of included studies, poses a

challenge in drawing definitive conclusions. Moreover, the lack of long-term follow-up data limits our understanding of the durability of oncological control and renal function preservation.

The quality of evidence for all studies included in this review was consistently low. Both studies had limitations inherent to their design. Because the intervention involved surgery, these studies have a high risk of selection bias due to poor allocation concealment and lack of blinding. Both studies included in this review are at high risk of bias, and their results should be interpreted cautiously. Suggestions for improving the quality of evidence in future RCTs have been outlined in the 'Implications for Research' section.

One of the main areas for improvement in evaluating new or developing surgical techniques is considering the user's experience and the learning curve of performing surgeries. The success of surgical procedures depends highly on the surgeon's level of expertise, the number of surgeries they have performed, and the experience of the medical institution where the surgery is being performed. It is important to note that this review cannot account for any factors that may potentially impact surgical procedure outcomes.

The studies included in this systematic review are older, commencing in 2015. Since then, robotic surgery has progressed rapidly. In 2014, da Vinci released the Xi platform (Intuitive Surgical, Sunnyvale, California), one of today's most common models.[31] These studies do not indicate which platform was used, but familiarity with robotic surgery has changed since then.

The results should be interpreted cautiously, given the high risk of bias and the low number of studies and participants included.

Implication for practice

This systematic review emphasises that while RAPN provides potential minor benefits, they are unlikely to outweigh a surgeon's preference for an approach based on their training, experience, and resources.

Implication for research

Overall, the evidence supporting RAPN's minor advantages over LPN is of low quality. Given the explosive growth in surgical robotics and the delay between practice and published RCTs, we anticipate significantly more contemporary evidence coming to hand. These RCTs should focus on:

- Conducting larger-scale RCTs with long-term follow up to assess the safety and efficacy of RAPN versus LPN and their impact on oncological outcomes and renal function preservation over time.
- Incorporating patient-reported outcomes into study designs to evaluate postoperative pain, quality of life, and satisfaction with the surgical procedure, providing a more holistic understanding of the benefits and drawbacks of each technique.
- Exploring the role of surgeon experience and the learning curve associated with RAPN and LPN, as these factors could significantly influence the outcomes of the surgeries. Understanding these dynamics could help tailor surgical education and practice to optimise patient outcomes.
- Investigating the cost-effectiveness of RAPN compared to LPN, considering not only the direct costs associated with the surgical procedures but also indirect costs related to recovery time, complication management, and long-term health outcomes.

The RCTs examined in this systematic review were prone to bias. Any further RCTs examining RAPN against LPN should focus on reducing bias to improve the quality and validity of these studies. Several strategies are essential to minimise bias in surgical RCTs, including employing sham interventions, meticulous study design to address blinding challenges, and minimising selection bias.[32] Ensuring rigorous adherence to methodology and comprehensive reporting also plays a crucial role in enhancing RCT quality and validity.[33] Techniques to limit detection, performance, and attrition biases, alongside transparent reporting of randomisation methods and blinding procedures, are critical for improving RCT outcomes.[34] Overall, a comprehensive approach focusing on these elements is crucial for mitigating bias and improving the reliability of surgical RCT findings.

CONCLUSION

In conclusion, our systematic review supports using RAPN as a safe and effective alternative to LPN, with potential advantages in reducing minor complications and warm ischemia time. However, given the comparable outcomes in most other measured variables, the choice between RAPN and LPN may ultimately come down to surgeon preference, patient-specific factors, and resource availability. Future studies with larger sample sizes and more extended follow-up periods are necessary to confirm these findings and to investigate other outcomes, such as quality of life, oncological outcomes, and long-term renal function.

The findings of this comprehensive review suggest that while overall complication rates do not significantly differ between the two techniques, RAPN may offer advantages in terms of reduced minor complication rates and shorter warm ischemia times. These potential benefits highlight RAPN's role as a viable, if not preferable, alternative to LPN, particularly considering the continuous advancements in robotic surgery.

Despite this review's thoroughness, several gaps in the existing knowledge base become apparent. Firstly, the limited number of high-quality RCTs available for inclusion underscores the need for more rigorous research in this field. The existing studies provide a valuable starting point. Still, they are insufficient to draw definitive conclusions regarding the long-term outcomes, particularly oncological control, renal function preservation, and patient-reported outcomes such as quality of life and postoperative pain.

Furthermore, the studies included in this review primarily focus on short- to medium-term outcomes, leaving a significant knowledge gap regarding the long-term efficacy and safety of RAPN versus LPN. Additionally, the review points out the lack of data on patient-reported outcomes, which are crucial for understanding the impact of these surgical techniques on patients' postoperative recovery and overall quality of life.

Future directions for research in this area should include conducting larger-scale RCTs with long-term follow up, incorporating patient-reported outcomes into study designs, exploring the role of surgeon experience and the learning curve associated with RAPN and LPN, and investigating the cost-effectiveness of RAPN compared to LPN, considering not only the direct costs associated with the surgical procedures but also indirect costs related to recovery time, complication management, and long-term health outcomes.

By addressing these gaps through

focused research efforts, the medical community can better understand the comparative benefits of RAPN and LPN, ultimately guiding clinical practice towards the most effective, safe, and patient-centred approaches for managing renal tumours. STI

AUTHORS' DISCLOSURES

The authors have no conflicts of interest to disclose.

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