Length of hospital stay and procedure time after partial nephrectomy or percutaneous thermal ablation

A systematic review and meta-analysis

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ABSTRACT

INTRODUCTION: This systematic review addressed the length of hospital stay (LOS) and procedure time in patients with small renal masses (SRM) undergoing open, conventional laparoscopic (OPN), and robot-assisted partial nephrectomy (RAPN), as well as percutaneous thermal ablation (PTA) in different geographic areas.

METHODS: We conducted a comprehensive search in databases (MEDLINE, EMBASE, CINAHL) until July 2023, and we applied random-effect meta-analysis, with evidence certainty assessed by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework.

RESULTS: We screened 3456 titles and abstracts, ultimately identifying 60 eligible studies. For the length of LOS (days) following OPN, our pooled estimates revealed means of 5.7 in North America, 7.1 in Europe, and 13.4 in Asia; laparoscopic partial nephrectomy means were 3.1, 5.4, and 5.8, respectively; for RAPN, means were 2.7, 3.8, and 7.1, respectively; and for PTA, means were 1.2, 1.6, and 1.6, respectively. Regarding procedure time (minutes) after OPN, means were 187 in North America, 132 in Europe, and 184 in Asia; after laparoscopic partial nephrectomy, means were 198, 127, and 200, respectively; after RAPN, means were 189, 150, and 192, respectively; and for PTA, mean was 144 in North America and no studies addressed procedure time in Europe and Asia.

CONCLUSIONS: Our study provides the most trustworthy available estimates of LOS and procedure time for patients undergoing invasive procedures for the management of SRM. These findings emphasize the need for context-specific considerations when informing patients and making treatment decisions.

INTRODUCTION

The increasing use of abdominal imaging techniques, such as computed tomography, ultrasound, and magnetic resonance imaging, has led to a rising estimate of the incidence of renal cell carcinoma over the past few decades.[1-3] Renal cell carcinoma is now the 14th most common cancer globally, with over 431 000 new cases diagnosed in 2020 and nearly 180 000 resulting deaths.[4] Its incidence varies geographically and among population subgroups, with higher rates observed in high-income countries, males, and older individuals.[5]

Many of the incidentally detected renal lesions are small renal masses (SRMs), typically defined as solid masses with a maximal diameter of ≤4 cm.[6] A significant proportion (20–30%) of SRMs are benign renal lesions, such as oncocytomas. Even if malignant, most SRMs have low metastatic potential.[7,8]

The most common approaches for managing SRMs are nephron-sparing surgery and percutaneous thermal ablation (PTA), each with their own risks and burdens.[9,10] For nephron-sparing surgery, specifically partial nephrectomy (PN), three surgical approaches are available: open (OPN), conventional laparoscopic (LPN), and robot-assisted (RAPN). Each approach has distinct consequences, with LPN, for instance, resulting in shorter hospital length of stay (LOS) and less postoperative pain compared to OPN surgery.[11] To minimize treatment costs and serve patients optimally, reduction of LOS

KEY MESSAGES

- The LOS after partial nephrectomy varies by geographic region: shortest stays in North America and longest in Asia.
- Robot-assisted partial nephrectomy and conventional laparoscopic partial nephrectomy are associated with shorter hospital stays compared to open partial nephrectomy.
- Percutaneous thermal ablation generally results in the shortest hospital stays across all regions.
- Procedure times for partial nephrectomy and percutaneous thermal ablation also show regional variations, with significant differences observed between North America, Europe, and Asia.
- Findings emphasize the importance of considering regional healthcare practices and the specific needs of patients when making treatment decisions for small renal masses.

has become a priority in many developed countries; however, variations in healthcare policies across regions and the influence of traditions and beliefs can impact LOS.[12]

Patients with a SRM who have opted for PN require estimates of the burdens associated with each approach, in particular LOS. Surgeons who engage with patients in making the decisions regarding management may also consider the procedural time as bearing on the decision. Currently, there is no comprehensive review summarizing the evidence on LOS and procedural time in patients with SRM. Because such a review would help inform relevant shared decision-making regarding choice of procedure, we have summarized the evidence available regarding the LOS and procedural time for OPN, LPN, RAPN, and PTA in patients with SRM.

METHODS

We registered the protocol of this review in the PROSPERO (International Prospective Register of Systematic Review); registration ID is CRD42022308375. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards guided our reporting.

Data sources and searches

We systematically searched MEDLINE (Medical Literature Analysis and Retrieval System Online), EMBASE (Excerpta Medica database), and CINAHL (Cumulative Index of Nursing and Allied Health Literature) from database inception to the end of July 2023. Additional sources included hand searching the reference lists of the included articles and recommendations from our team's two urologist members (PR and PV) (Search strategy shown in Appendix A; available at *cuaj.ca*).

Eligibility criteria

We included studies meeting these criteria: 1) randomized controlled trials, cohort studies (retrospective or prospective), and case series with over 10 patients; 2) studies reporting at least one of the following outcomes in SRM patients: LOS and procedure length; 3) studies providing health outcomes as mean and standard deviation (SD) or convertible estimates (median, range, interquartile range [IQR]); and 4) studies written in English. There were no restrictions on publication status, country, or period. Studies were included if 80% of masses had a maximum diameter ≤4 cm, despite varying size thresholds for SRMs.

We excluded studies: 1) on patients with specific health conditions (e.g., diabetes); and 2) without clear treatment specifications.

Procedures included were nephrectomy and TA. For nephrectomy, we focused on PN (open, laparoscopic, robotic) via transperitoneal or retroperitoneal approaches. For TA, we included only percutaneous approaches, excluding laparoscopic TA, and restricted to cryoablation and radiofrequency ablation.

Study selection and data extraction

Reviewers received detailed instructions for each step of title and abstract screening, full-text reading, risk of bias assessment, and data abstraction. Pairs of reviewers independently screened titles and abstracts and then reviewed the full text of studies judged potentially eligible. For studies judged eligible, pairs of reviewers abstracted the data and assessed the risk of bias, resolving discrepancies at each step through discussion. When necessary, a third, more experience reviewer resolved remaining discrepancies.

We recorded the country in which the study was conducted, participants' age, gender and tumor size distribution, type of tumor, and sample size, as well as type of intervention.

Risk of bias and certainty of evidence

Our study addresses prognostic outcomes related to LOS and procedure duration for the considered procedures. We chose the QUIPS bias risk assessment tool[13] for prognostic studies, modified for our study designs and outcomes. We assessed bias risk using four QUIPS domains: "study participation," "outcome measurement," "study attrition," and "statistical analysis and reporting." We excluded "prognostic factor measurement" and "study confounding," as they were inapplicable. Studies were categorized as high or low risk of bias, with any high-risk domain marking the study as high risk.

To rate the certainty of the LOS and procedure time, we used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach for prognostic questions.[14] For publication bias, we planned to use Begg's test and funnel plots if sufficient studies were available.

Data analysis

To calculate pooled estimates of LOS and procedure time, we extracted mean and SDs, or converted medians, IQRs, or ranges to means and SDs using Wan et al's equations.[15]

We hypothesized that LOS might vary by geographic region, expecting longer LOS in Asia compared to other regions.[12] We also anticipated differences in LOS and procedure time between studies with small vs. large sample sizes and low vs. high risk of bias. LOS comparisons across regions (North America, Europe, Asia, and others) were done using Kruskal-Wallis tests. Differences based on sample size and risk of bias were analyzed using independent t-tests and Welch t-tests. Studies were considered small if the sample size was under 100 and were categorized by risk of bias using the QUIPS tool.

A p-value of 0.05 was set for significance in hypothesis tests. Pooled means were calculated using the DerSimonian-Laird random effects method. The credibility of subgroup effect claims was evaluated using a tailored version of the ICEMAN tool,[16] assessing the region's influence on prognostic factors.

RESULTS

Literature search and study characteristics

We screened 3456 titles and abstracts and retrieved 294 possibly eligible full texts. Of these, 60 original studies including 10 416 patients proved eligible (Figure 1). Many

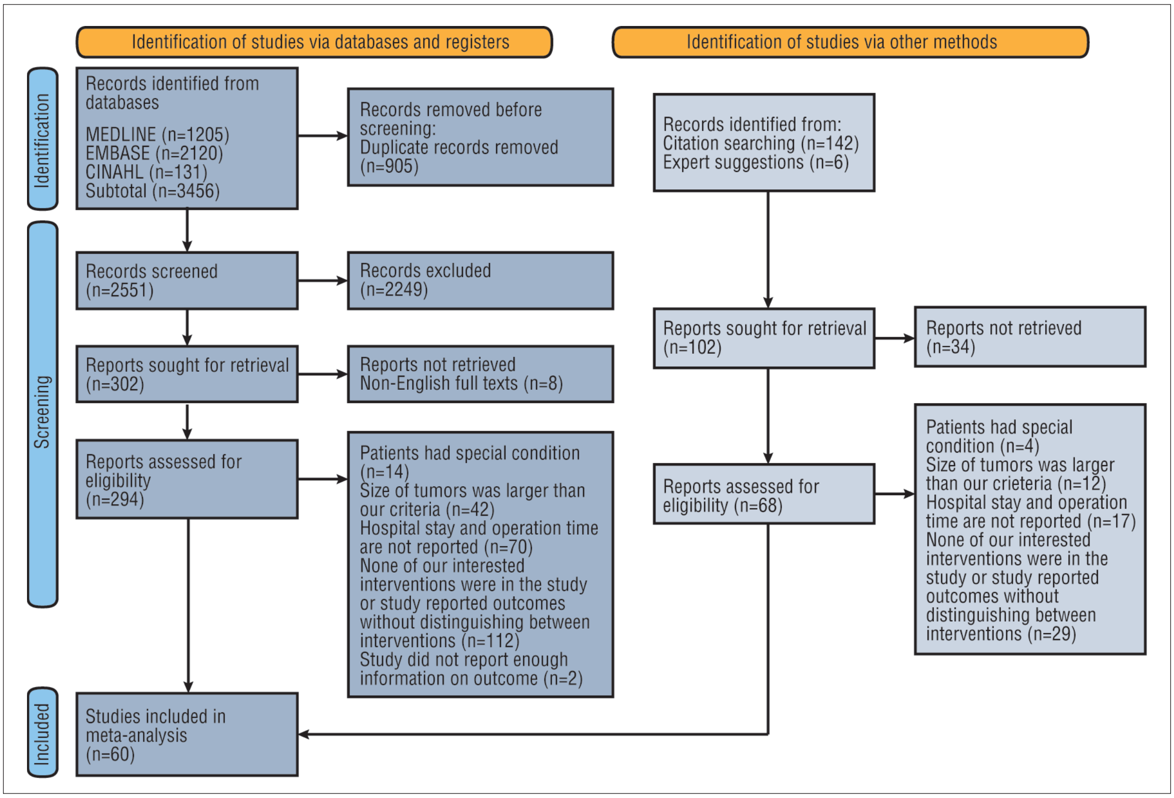

Figure 1. PRISMA flow diagram.

participants were males, aged 50–65 years old, and the mean tumor size in most studies was 2–3 cm (Appendix B, Supplementary Table 1; available at *cuaj.ca*).

Risk of bias

Of the 60 eligible studies, 31 proved at high risk of bias. Supplementary Table 2 (available at *cuaj.ca*) presents the details of bias risk assessments.

Prognostic factor analysis

We did not see significant results in test for prognostic effect of sample size of included studies and risk of bias; however, we found that chance could not easily explain differences based on region of studies for LOS after OPN, LPN, and RAPN but could for PTA. Table 1 shows the results of test of prognostic factors.

Applying the ICEMAN instrument, we concluded high credibility of prognostic factor modification based on region of studies for LOS after RAPN and a moderate credibility OPN and LPN, and a low credibility for PTA. We concluded high credibility for procedure time of OPN and a moderate credibility for LPN, RAPN, and PTA. For the rest of potential effect modifiers, ICEMAN did not suggest a prognostic factor analysis (Appendix C at *cuaj.ca* shows the results of completed ICEMAN tool). Therefore, we analyzed LOS and procedure time in subgroups of area. Supplementary Table 3 (Appendix B at *cuaj.ca*) summarizes the results and the GRADE quality of evidence assessments

Although many of the subgroups did not contain 10 studies, we assessed publication bias in those subgroups that had 10 or more studies. We did not see any publication bias based on the results of Begg's test and funnel plots in those subgroups (Table 1).

Length of hospital stay

Open partial nephrectomy

The pooled mean LOS in the North America subgroup (n=6 studies) was 5.7 days (95% confidence interval [CI] 4.6–6.5); in the Europe subgroup (n=4 studies) 7.1 days (95% CI 5.7–8.4); and in the Asian subgroup (n=4 studies) 13.4 days (95% CI 7.6–19.3).

Conventional laparoscopic partial nephrectomy

The pooled mean LOS in North America (n=11 studies) was 3.1 days (95% CI 2.5–3.6); in the Europe subgroup (n=4 studies) 5.4 days (95% CI 3.4–7.4); and in the Asian subgroup (n=7 studies[17-20]) 5.8 days (95% CI 4.8–6.8).

Robot-assisted partial nephrectomy

The pooled mean LOS in the North America subgroup (n=6 studies) was 2.7 days (95% CI 1.9–3.5); in the Europe subgroup (n=7 studies) 3.8 days (95% CI 2.6–4.9); and in the Asian subgroup (n=8 studies) 7.1 days (95% CI 5.3–8.9).

Percutaneous thermal ablation

The pooled mean LOS in the North America subgroup (n=6 studies) was 1.2 days (95% CI 0.7–1.6); in the Europe subgroup 1.6 days (95% CI 1.0–2.1); and in one study conducted in Brazil (n=60 patients) was 1.6 days (95% CI

Table 1. Test of prognostic factors, Kruskal Wallis test, independent t-test, and Welch t-test

Prognostic factor	Outcome	Intervention	Chi square/t	df	p
Region of studies	Hospital stays	OPN	8.25	2	0.012
		LPN	12.18	2	0.002
		RAPN	13.19	2	0.001
		PTA	1.65	2	0.439
	Procedure time	OPN	9.05	2	0.011
		LPN	9.15	3	0.010
		RAPN	7.22	2	0.027
		PTA	3.86	2	0.145
Sample size of study	Hospital stays	OPN	0.94	11	0.365
		LPN	1.32	20	0.201
		RAPN	0.14	20	0.891
		PTA	0.53	8	0.610
	Procedure time	OPN	0.55	14	0.592
		LPN	0.61	25	0.546
		RAPN	0.26	27	0.794
		PTA	-0.03	5	0.975
Risk of bias	Hospital stays	OPN	0.50	11	0.629
		LPN	-0.18	20	0.855
		RAPN	0.25	20	0.808
		PTA	2.50	8	0.037
	Procedure time	OPN	1.61	14	0.131
		LPN	0.56	25	0.580
		RAPN	0.42	27	0.680
		PTA	-1.21	5	0.282

LPN: laparoscopic partial nephrectomy; OPN: open partial nephrectomy; PTA: percutaneous thermal ablation; RAPN: robot-assisted partial nephrectomy.

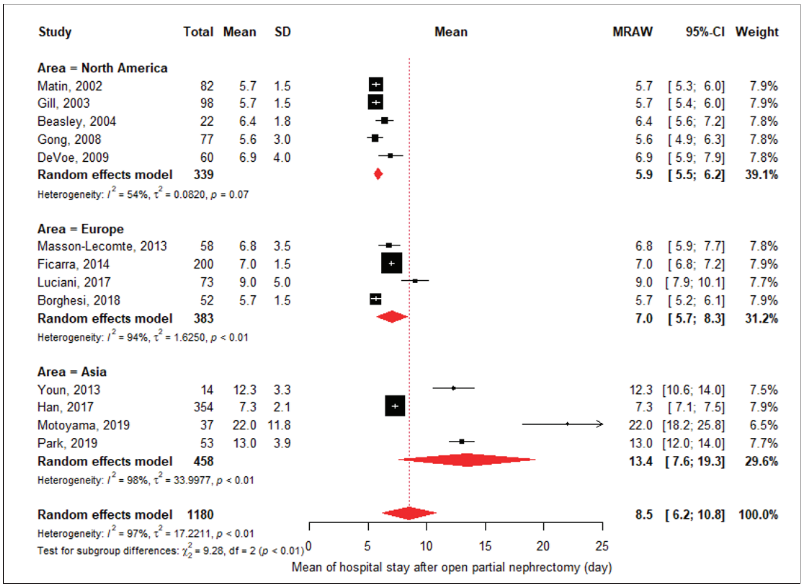

Figure 2. Forest plot of length of hospital stay in patients with small renal masses after open partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

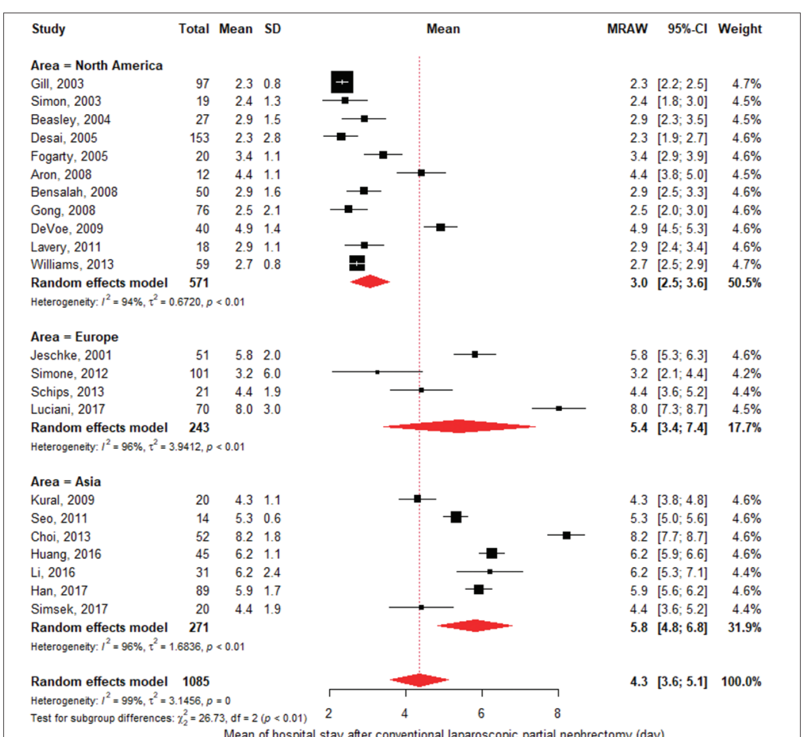

Figure 3. Forest plot of length of hospital stay in patients with small renal masses after conventional laparoscopic partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

1.3–1.9). Supplementary Tables 2 and 3 (Appendix B at *cuaj.ca*), along with Figures 2–5, provide detailed information on LOS after OPN, LPN, RAPN, and TA.

Procedure time

Open partial nephrectomy

The pooled estimated mean of duration of procedure in the North America subgroup (n=6 studies) was 187 minutes (95% CI 158–215); 132 minutes (95% CI 123-141) in the Europe subgroup (n=5 studies); and 184 minutes (95% CI 160–208) in the Asian subgroup (n=5 studies).

Conventional laparoscopic partial nephrectomy

The pooled estimated mean of duration of procedure in the North America subgroup (n=12 studies) was 198 minutes (95% CI 163–221); 127 minutes (95% CI 83–171) in the Europe subgroup (n= 4 studies); and 200 minutes (95% CI 168–231) in Asian subgroup (n=10 studies). One study was conducted in Australia (n=50 patients). The authors reported a mean procedure time of 224 minutes (95% CI 213–234).

Robot-assisted partial nephrectomy

The pooled estimated mean duration of procedure in the North American subgroup (n=10 studies) was 189 minutes (95% CI 172–206); 150 minutes (95% CI 121–178) in the Europe subgroup (n=7 studies); and 192 minutes (95% CI 169–214) in the Asian subgroup (n=11 studies).

Percutaneous thermal ablation

The pooled estimated mean duration of procedure in the North American subgroup (n=5 studies) was 144 minutes (95% CI 115–174) and 98 minutes (95% CI 91–105) in one study (n=60 patients) conducted in Brazil. No studies reported the procedural time in the Europe and Asia subgroups. Supplementary Tables 2 and 3 (available in Appendix B at *cuaj.ca*), along with Figures 6–9 provide detailed information on duration of OPN, LPN, RAPN, and TA procedures.[30-79]

DISCUSSION

The findings of our systematic review and meta-analysis shed light on the LOS in patients with SRMs undergoing different surgical approaches. Specifically, we observed similar durations of hospital stay for both LPN and RAPN procedures, while OPN was associated with longer LOS. Across all approaches, the LOS proved shortest in North America. In contrast, Europe exhibited longer hospital stays, with even longer stays in Asia. The observed regional disparities underscore the potential influence of healthcare practices, healthcare infrastructure, and patient management in shaping hospitalization durations.

Our evaluation revealed that many available studies on PTA were conducted in North America. These patients exhibited shorter hospital stays in comparison to those undergoing PN procedures. This observation may reflect the regional differences in procedural preferences and hospital protocols, potentially indicating variations in postoperative care or recovery trajectories.

Regarding the quality of evidence, our findings indicate a low-to-high certainty of evidence for studies conducted in North America and Europe and as moderate-to-high for studies conducted in Asia. This assessment underscores robustness of the findings, particularly observed in Asian studies.

Strengths and limitations

The strengths of this systematic review include a comprehensive literature search, without any restrictions on the time of publication. The inclusion of at least two trained reviewers in the assessment of all 60 included studies, along with the tailored risk of bias, GRADE assessments, and ICEMAN assessments of subgroup effects, enhance the reliability and validity of the findings. Additionally, the criteria for study inclusion and exclusion resulted in a group of homogeneous studies, contributing to the high directness in GRADE evaluation, particularly for LPN, RAPN, and PTA. The application of the modified ICEMAN tool helped evaluate the credibility of prognostic factor analysis, addressing the lack of a reliable tool for systematic reviews of factors modifying the results of prognostic studies.

One primary methodologic limitation of this review was the restriction to English-language studies, which may introduce potential language bias. Limitations are inherent in the number and design of the available studies. For instance, only a small number of studies reported procedural time and LOS after PTA, limiting the feasibility of conducting subgroup analysis for this procedure. Furthermore, the inclusion of some studies with patients having tumors >4 cm poses potential limitations; however, we restricted studies to those in which over 80% of participants had undergone intervention for tumors ≤4 cm.

Due to the absence of individual participant data, the impact of outliers on mean LOS and procedural time could not be assessed. Despite the inclusion of 60 studies in this systematic review, many subgroups did not contain enough studies, preventing a robust statistical assessment of publication bias.

The other limitation of our study is the inability to account for all factors that may influence the outcomes of interest. Specifically, patient comorbidities, renal tumor complexity, and the presence of multiple tumors were not uniformly collected across the included studies. These variables can significantly impact both hospital stay duration and procedure time. Future studies should aim to incorporate these factors to provide a more comprehensive analysis.

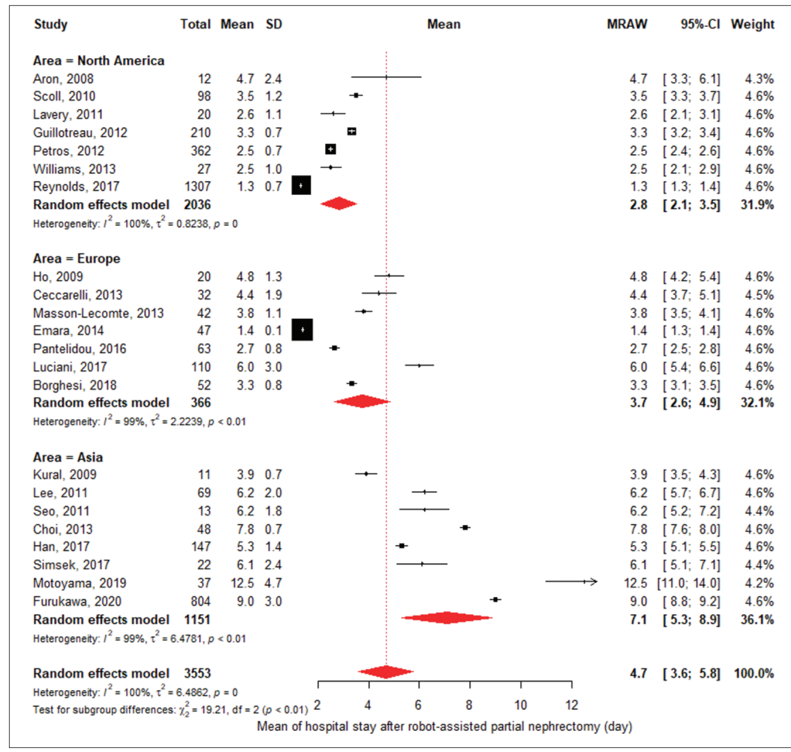

Figure 4. Forest plot of length of hospital stay in patients with small renal masses after robotic-assisted partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

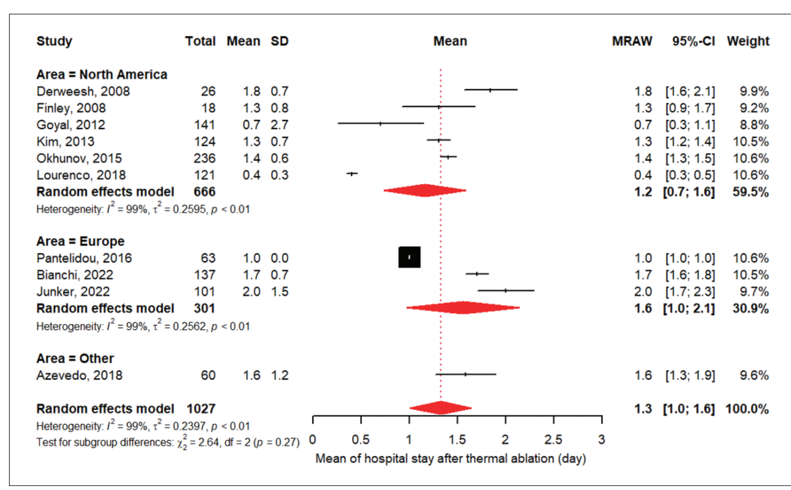

Figure 5. Forest plot of length of hospital stay in patients with small renal masses after percutaneous thermal ablation. CI: confidence interval; SD: standard deviation.[30-79]

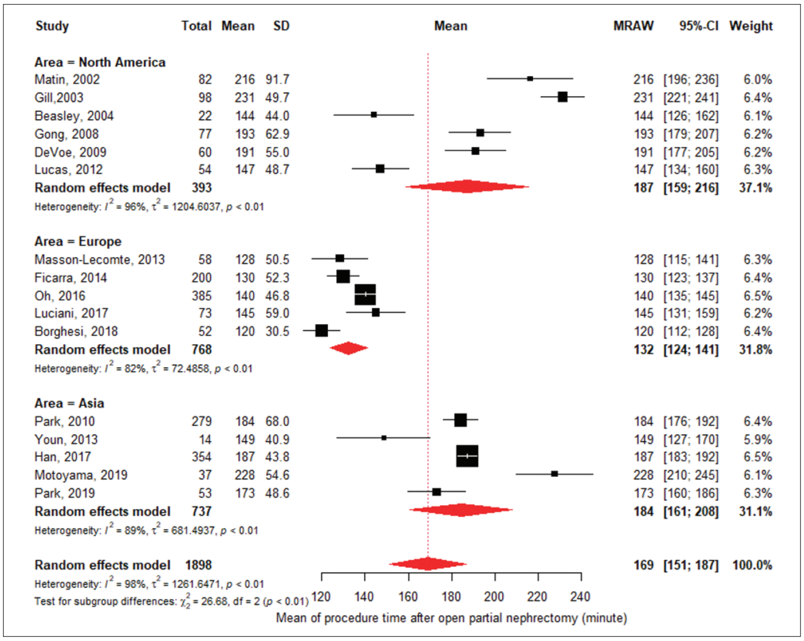

Figure 6. Forest plot of procedure time in patients with small renal masses after open partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

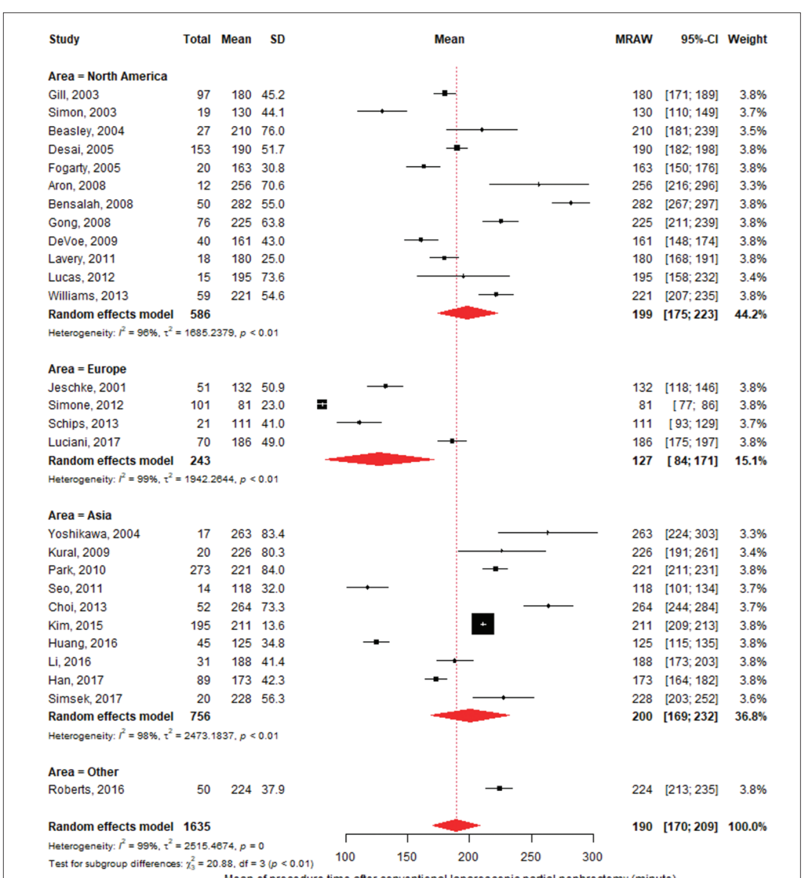

Figure 7. Forest plot of procedure time in patients with small renal masses after conventional laparoscopic partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

Relation to prior work

A prior systematic review and meta-analysis reported LOS and procedure time for RAPN and LPN in SRM patients.[21] This review included six studies, with five overlapping our review.[18,19,22-24] One study on bilateral synchronous kidney tumors was excluded, as it did not meet our criteria.[25] The previous review, focusing on studies from North America and Asia, found a LOS of 3.6 days for LPN in North America and 4.8 days in Asia. For RAPN, LOS was 3.5 days in North America and 5.0 days in Asia. This finding is consistent with our results, as the LOS for LPN and RAPN in North America was shorter than in Asia (3.1 vs. 5.8 days for LPN and 2.8 vs. 7.1 for RAPN [North America vs. Asia, respectively]).

The difference in the pooled estimates may be explained by the fact that our study included a larger number of studies, as well as those published more recently for both LPN and RAPN. It is plausible that surgeons have reduced the LOS for LPN either given the positive experience observed following robotic-assisted surgery in North America or due to the pressure to reduce costs associated with hospitalization.

As a result of comprehensive nature of our study and since ours included six additional studies, our results showed a longer LOS after RAPN in Asia (7.1 days) than in the previously reported meta-analysis. Two of these six studies were carried out in Japan, where prolonged hospitalization is influenced by healthcare policies, with mean hospital stays of 12.5[26] and nine[27] days. These studies significantly contributed to an elevated pooled estimation of LOS within the Asian subgroup.

In terms of procedure duration, the previous systematic review reported an average procedure time of 215 minutes for LPN in North America and 150 minutes in Asia. For RAPN, the average procedure time was 215 minutes in North America and 187 minutes in Asia. Our findings indicate slightly shorter procedure times for both LPN and RAPN in North America, with averages of 199 minutes and 189 minutes, respectively. Conversely, we observed longer procedure times for both LPN and RAPN in studies conducted in Asia, with averages of 200 minutes and 199 minutes, respectively. Again, differences can be explained by our inclusion of more recently published studies, which likely reflect greater perioperative and/or intraoperative efficacy due the physicians' experience and the better overall patient care gained over time. On the other hand, our study encompasses three studies conducted in Japan[11,26,28] and one study conducted in Korea[17] that reported prolonged procedure times. As a result, the procedure time within the Asian subgroup of our study is longer compared to that reported in the previous systematic review.

Of importance, the prior review used the Newcastle-Ottawa Scale to evaluate risk of bias,[29,30] while we used the QUIPS instrument developed specifically for prognostic studies. The prior review did not address the certainty of the evidence, nor the credibility of the apparent differences across geographic areas. We applied the GRADE approach to assess the quality of evidence in our meta-analysis and the ICEMAN instrument to address the credibility of the apparent differences across geographic regions. This enhanced methodology allows for a more comprehensive and robust assessment, providing a clearer and more reliable insight into the prognostic outcomes in different geographic regions, making our study an advancement over prior approaches.

Implications of findings for practice and research

This systematic review and meta-analysis offer crucial insights for patients and surgeons in selecting procedures for SRM management, aiding in shared decision-making. The findings may guide the creation of point-of-care decision aids, helping patients make informed choices. By detailing LOS variations across regions and surgical approaches, our review enhances the existing evidence base, assisting clinicians and researchers in decision-making and future studies.

Clinicians in Europe and Asia should investigate the factors contributing to longer LOS compared to North America. Adjusting management strategies could reduce LOS, lower costs, and improve patient experiences.

Further research should explore the causes of geographic variations and identify strategies to optimize patient care and outcomes. This review underscores the need for studies with larger, diverse populations to address limitations and bolster evidence on the prognostic outcomes of these interventions.

CONCLUSIONS

Our systematic review and meta-analysis present the most accurate estimates of LOS and procedural time for patients undergoing invasive procedures for the management of SRMs. The findings also highlight significant geographic variations in the LOS, emphasizing the need for further research and understanding of the underlying factors contributing to these differences.

COMPETING INTERESTS: Dr. Richard has participated in advisory boards for Astellas, Bayer, and Novartis; has received speaker honoraria from AbbVie, Astellas, Bayer, Janssen, Knight, Novartis, and Tolmar; has participated in clinical trials supported by Merck; and is on the board of Kidney Cancer Research Network of Canada. The remaining authors do not report any competing personal or financial interests related to this work.

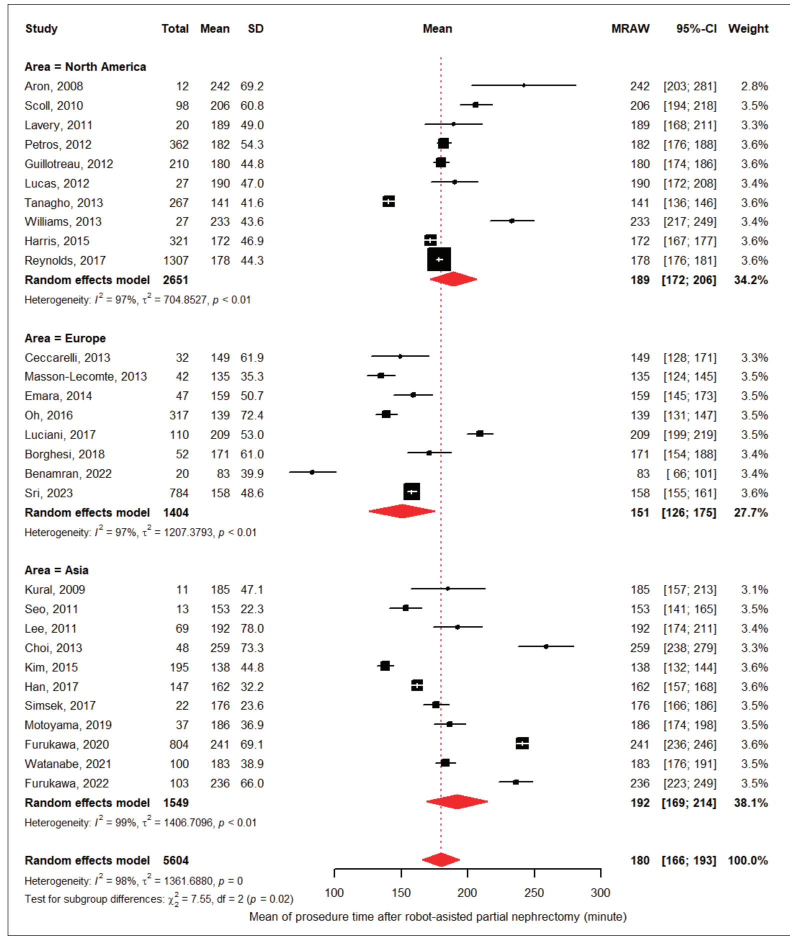

Figure 8. Forest plot of procedure time in patients with small renal masses after robotic-assisted partial nephrectomy. CI: confidence interval; SD: standard deviation.[30-79]

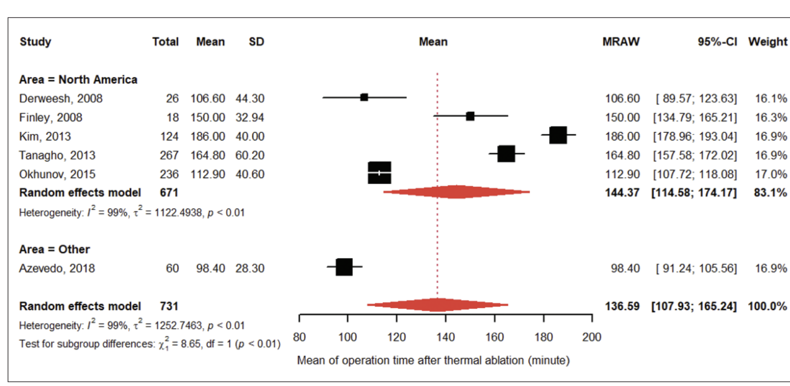

Figure 9. Forest plot of procedure time in patients with small renal masses after percutaneous thermal ablation. CI: confidence interval; SD: standard deviation.[30-79]

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This paper has been peer reviewed.

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