Review Article | Surgery: Urological Surgery

Robotic assisted partial nephrectomy in the treatment of small renal masses: a literature review

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Background and Objective: The diagnosis of patients with small renal masses (SRMs) has increased, as has the use of robotic surgery in their treatment. Our objective is to review the role of robotic partial nephrectomy (PN) in the management of SRM.

Methods: Articles were selected from 2005–2022 on PubMed and MEDLINE databases using the keywords: "robotic-assisted partial nephrectomy", "laparoscopic partial nephrectomy" and "small renal masses".

Key Content and Findings: Existing researches revealed that relative to open partial nephrectomy (OPN), robotic-assisted partial nephrectomy (RAPN) has less significant (Clavien-Dindo ≥2) complications: 8% *vs.* 25% (P<0.001). Also, lower estimated blood loss (100 *vs.* 400 mL; P<0.001), shorter length of stay (median 5 *vs.* 6 days; P<0.001), and lower risk of active kidney injury were found in the RAPN group. In regards to positive surgical margins, no significant difference was found between RAPN and OPN. When comparing RAPN and laparoscopic partial nephrectomy (LPN), RAPN had a shorter warm ischemia time (P=0.005), a shorter length of stay (P=0.004) and a lower reduction in estimated glomerular filtration rate (P=0.03). In Preoperative Aspects and Dimensions Used for an Anatomical (PADUA) <10 tumors, a research pointed out a lower risk of positive margins in RAPN *vs.* LPN (odds ratio 0.59; 95% confidence interval: 0.35–0.99; P=0.04). Safety outcomes were even more promising in very SRM (<2 cm) with robotic-assisted approach.

Conclusions: RAPN provides higher rates of trifecta outcomes when compared to OPN and LPN in the treatment of SRM. Whilst active surveillance and FT remain valid options for unfit patients, RAPN, whenever an active treatment is indicated, stands as a safe approach with excellent outcomes.

Keywords: Partial nephrectomy (PN); robotic surgery; small renal masses (SRM); renal tumor; laparoscopy

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Introduction

The increased incidence of renal cancer in the United States of America, from 51,190 new cases in 2007 to 79,000 in 2022, reflects the impact of cross-sectional imaging techniques for diagnostic evaluation (1-3). It has been reported as well a steady decrease in tumor size at presentation, with mean tumor size reducing from 4.1 cm [1993] to 3.6 cm [2003] on stage 1 tumors (4). More recent study showed that the proportion of patients presenting with stage I renal cell carcinoma (RCC) has stabilized (70%), suggesting that stage migration may have ended (5). These early diagnoses, mainly due to incidental tumors spotted on abdominal routine imaging, highlighted a variety of small renal masses (SRMs) that can be treated with optimal oncologic outcomes through minimally invasive surgery. Nephron-sparing surgery (NSS) gained space in the treatment of SRM and proved to be safe with acceptable complications when compared to radical nephrectomy (RN) (6). Open partial nephrectomy (OPN) showed the possibility of decreasing the incidence of chronic kidney diseases, cardiovascular morbidity and overall mortality (7). On the other hand, robotic-assisted partial nephrectomy (RAPN) significantly increased in the last 15 years: from 2008 to 2018, there was a 45% relative annual increase in RAPN in the USA (8). In current guidelines for the management of cT1a renal tumors, partial nephrectomy (PN) is considered the standard of care, given the renal function protection compared with RN (9,10), but we don't have a large number of studies exploring the advantages of RAPN on these initial masses. Hence we present a non-systematic review exploring the role of RAPN in SRM. We present this article in accordance with the Narrative Review reporting checklist (available at https://amj.amegroups.com/article/view/10.21037/amj-23-232/rc).

Methods

Articles were selected from 2005–2022 on PubMed and MEDLINE databases using the keywords: "robotic-assisted partial nephrectomy", "small renal masses", and "laparoscopic partial nephrectomy". We identified 83 articles during the search and selected the articles with the highest level of evidence and the highest number of patients (Table S1).

Results

Larcher *et al.* [2018], in a prospective cohort of 472 patients comparing RAPN and OPN for cT1-2c renal tumors, found that patients who underwent RAPN had significantly less overall complications [21% *vs.* 36%; odds ratio (OR) 0.46, 95% confidence interval (CI): 0.28–0.75; P=0.002], less Clavien-Dindo (CD) ≥2 complications (8% *vs.* 25%; OR 0.27, 95% CI: 0.14–0.52; P<0.001), and CD ≥3 complications (3% *vs.* 9%; OR 0.31, 95% CI: 0.11–0.88; P<0.03). Moreover, compared to OPN, patients who underwent RAPN had less estimated blood loss (median 100 *vs.* 400 mL; P<0.001) and a shorter length of stay (5 *vs.* 6 days; P<0.001). Also, RAPN did not increase positive surgical margins (OR 1, 95% CI: 0.42–2.37; P>0.99) or 5-year rates of local recurrence-free survival (RFS) during 41 months follow-up [hazard ratio (HR) 1.76, 95% CI: 0.56–5.49; P=0.3] (11). Using the Preoperative Aspects and Dimensions Used for an Anatomical (PADUA) score (based on anatomical features and tumor size) to investigate complex tumors (PADUA score 10–14) with a median size of 45±18.12 mm and creatine of 0.73±0.56 mg/dL, Buffi *et al.* [2019] in a prospective multicenter series from 2010 to 2017 with 255 patients reported a mean estimated blood loss of 213±222 mL, median warm ischemia time (WIT) of 18 [15–23] min, mean creatinine level 1d after of 1.17 mg/dL and CD >2 on PADUA 10, 11 and 12–13 of 3 (3.3%), 4 (6.2%) and 5 (11.9%) respectively (P<0.57) (12,13). Five (1.9%) were intraoperatively converted to RN, of which two were because of bleeding and one because of uncertainty about the tumor margins. Another potential risk factor for worse outcomes was the male gender (2-fold higher in contrast to female counterparts), which could be partly explained by the higher rate of adherent perinephric fat (14,15). The study confirmed that RAPN can be safe and feasible even in complex renal masses, although optimal surgical outcomes may be more challenging in male patients with PADUA scores up to 12–13.

Another study from 2019 assessed complication rate, surgical margins, WIT, and acute kidney injury (AKI) of 2,331 patients diagnosed with cT1N0M0 treated with OPN, laparoscopic partial nephrectomy (LPN), or RAPN from 2013 to 2016 (16). Their evaluation included a modified trifecta outcome criteria: a combination of negative surgical margins, WIT <25 min, and absence of postoperative CD ≥2 complications. AKI was defined according to RIFLE (>25% reduction in preoperative estimate glomerular function or a 1.5-fold or higher increase in creatinine at discharge compared to baseline creatinine) (17). Bravi *et al.* (16) found that patients who underwent RAPN and laparoscopic procedures had less CD ≥2 complications (OR

0.27; 95% CI: 0.15–0.47; OR 0.52; 95% CI: 0.34–0.78; both P≤0.002) when compared to OPN. RAPN also had less CD ≥2 than LPN (OR 0.54; 95% CI: 0.33–0.91; P=0.02). Both RAPN and laparoscopic nephrectomy had less postoperative AKI compared to open surgery (P<0.001), with no significant difference between each other (OR 0.99; 95% CI: 0.72–1.35; P=0.9).

Analyzing the modified trifecta outcome, the authors noticed the possibility of different outcomes due to the discrepancy of PADUA score in each group (there was a lean to open approach in higher PADUA masses). In this regard, it was tested the hypothesis of a different relationship between the surgical approach and the modified trifecta, according to the baseline nephrometric score. The probability of achieving a modified trifecta in PADUA <10 tumors was higher through RAPN than OPN (OR 1.66; 95% CI: 1.09–2.53; P=0.02). RAPN also demonstrated a lower risk of positive margins in PADUA <10 tumors when compared with LPN (OR 0.59; 95% CI: 0.35–0.99; P=0.04) (16).

When we consider very SRM, the role of RAPN seems even more promising, as Carbonara *et al.* [2020] concluded in a cohort comparing 352 patients with a renal mass of <2 cm (34.5%) and 667 with a renal mass of 2–4 cm (65.5%) both managed with RAPN. The trifecta criteria considered negative margins, no CD ≥3 complications, and a decrease of less than ≤30% on the estimated glomerular filtration rate (eGFR) postoperative compared to the baseline. In study group showed shorter WIT (median 14 *vs.* 18 min, P<0.001), fewer complications (9.6% *vs.* 14.7%, P<0.001), without any CD ≥3 complications (0 *vs.* 5.7%, P<0.001) and higher eGFR at discharge and at last follow-up 36 months after (P=0.001 and P=0.007, respectively). Local recurrence in the RAPN and control group was 3 (0.8%) and 10 (1.4%), respectively (P>0.99). Lastly, both estimated blood loss and the rate of malignant or benign masses were similar between groups. Limitations of the study were the absence of a control group of active surveillance (AS) and ablation cases, as well as the retrospective study design (18) (*Table 1*).

Discussion

Current guidelines consider nephron-sparing surgeries with minimally invasive treatments the standard care for SRM, and active surveillance (AS) may be elected in selected scenarios (20). Compared to immediate intervention, AS with timely delayed intervention offers a safe and cost-effective approach to managing patients with SRM. For patients harboring tumors of very low metastatic potential, AS may lead to better patient outcomes than immediate intervention (21). Baio *et al.* conducted a study to investigate if there are a subgroup of patients with renal masses that are more likely to have benign tumors. They identified a subgroup of patients, namely young women (<50 years) affected by tumors ≤3 cm, with a significantly reduced probability of harboring malignant tumors, so the choice of renal biopsy and AS may therefore be more strongly recommended for the patients with these characteristics (22).

Another option for these initial tumors is focal therapy (FT), which comprises radiofrequency ablation (RFA), cryoablation, microwave ablation and irreversible electroporation. Yoon *et al.* [2018] in a systematic review comparing FT and RAPN in SRM demonstrated better cancer control through RAPN [FT had a relative risk (RR) of 9.9 and 6.4 for local recurrence and distant metastasis compared to RAPN]. However, FT was associated with significantly better postoperative eGFR preservation and less bleeding (23). Thus, FT should be considered in unfit older patients with significant morbidities and/or compromised renal function.

Nevertheless, for normally fit patients RAPN is the safest option for SRM. RAPN when compared to OPN demonstrated an equal risk of positive margins, renal function 1d after, with less blood loss and CD ≥2 complications (10,12,15). Relative to LPN, an extensive literature has reported a higher probability of achieving the trifecta outcome (WIT <25 min, negative surgical margins, and no perioperative complications) through RAPN (24-26), especially when treating PADUA <10 masses (16). Luciani *et al.* [2016] reported fewer CD III–IV complications in RAPN (7.2%) compared to either open or laparoscopic surgery (12.3% and 17.1%, respectively), as well as CD II (11% *vs.* 20.5% *vs.* 16%). The author also found that RAPN, compared to OPN or LPN, had a lower estimated blood loss and transfusion rate (10% *vs.* 21.4% *vs.* 21.9%), with higher rates of conversion to OPN in LPN when compared to RAPN (8.6% *vs.* 5.5%). Moreover, the length of stay was shorter in the RAPN group (27).

In a systematic review with meta-analysis of 23 studies (n=2,240), comparing RPN and LPN, Choi *et al.* [2014] pointed out a significantly lower rate of conversion to OPN (RR 0.45, P=0.02) or to RN (P<0.001; RR 0.18), shorter ischemia time [P=0.005; weighted mean difference (WMD) −2.97], a smaller decrease in eGFR (P=0.03; standardized mean difference −0.18) and shorter length of stay (P=0.004;

Table 1 Operative outcomes and PADUA score

Study	n	Surgical access	WIT	Clavien-Dindo ≥2	Estimated blood loss	Positive surgical margins	PADUA score
Larcher *et al.*, 2018 (11)	472	RAPN/OPN	No difference: both 15 min (estimate 1, 95% CI: 1–3, P=0.2)	8%/25% [OR 0.27 (95% CI: 0.14–0.52), P<0.001]	100/400 mL [estimate –381 (95% CI: –469 to –293), P<0.001]	No difference: both 6% (41-month follow-up)	Median: both 8 (IQR: both 7–9)
Buffi *et al.*, 2020 (13)	255	RAPN	Mean 18.6±7.6 min (33.7% had WIT >20 min)	14.5%	Estimated median [IOR]: 150 [100–250] mL	1.9% (28-month follow-up)	10, 43.5%; 11, 33.3%; 12, 17.6%; 13, 5.5%
Bravi *et al.*, 2021 (16)	2,331	RAPN/ OPN/LPN	Median [IQR]: 15 [11–20]/ 16 [13–20]/ 16 [13–20] min	RAPN *vs*. OPN [OR 0.27 (95% CI: 0.15–0.47), P≤0.002]; RAPN *vs*. LPN [OR 0.54 (95% CI: 0.33–0.91), P=0.02]	Median [IQR]: 100 [50–200]/ 200 [100–300]/ 150 [80–265] mL	No difference between RAPN and LPN *vs*. OPN nor RAPN *vs*. LPN	RAPN: 6, 22%; 7–9, 65%; 10+, 13%. LPN: 6, 20%; 7–9, 69%; 10+, 10%. OPN: 6, 18%; 7–9, 61%; 10+, 21%
Carbonara *et al.*, 2021 (18)	1,019	RAPN in very SRM/ SRM	Median 14/18 min (P<0.001)	9.2%/22.7%	No significant difference	Local recurrence 3 (0.8%)/10 (1.4%) (P=0.1)	Not reported (T1a <2 cm and 2–4 cm)
Choi *et al.*, 2014 (19)	2,240	RAPN/LPN	WMD: –2.97 (95% CI: –5.05 to –0.89), P=0.005	No difference: CD 3–5 (P=0.78; RR 0.94); RAPN had lower rate of conversion to OPN (P=0.02)	No significant difference: WMD 5.72 (95% CI: –31.43 to 42.87), P=0.76	No significant difference: RR 1.09 (95% CI: 0.64–1.84), P=0.75	Not reported (T1a–b)

PADUA, Preoperative Aspects and Dimensions Used for an Anatomical; RAPN, robot-assisted partial nephrectomy; SRM, small renal mass; OPN, open partial nephrectomy; LPN, laparoscopic partial nephrectomy; WIT, warm ischemia time; CD, Clavien-Dindo; IQR, interquartile range; WMD, weighted mean difference; RR, relative risk; OR, odds ratio; CI, confidence interval.

WMD –0.21) for RAPN. There were no significant differences between the groups for change of blood loss (P=0.76; WMD 5.72; 95% CI: –31.43 to 42.87), positive surgical margins (P=0.75; RR 1.09; 95% CI: 0.64–1.84) and CD complications both 1–2 (P=0.62; RR 1.06; 95% CI: 0.85–1.31) and 3–5 (P=0.78; RR 0.94; 95% CI: 0.61–1.46) (19).

Additionally, surgical techniques in RAPN, such as sutureless renorrhaphy could achieve even more promising Trifecta and renal function outcomes, as well as shorter operative time and length of stay (28). Therefore, robot-assisted surgery represents a safer therapeutic option with better perioperative outcomes for SRM.

This data may reflect many benefits of robot-assisted surgery, such as minimally invasive access, enhanced 3-D visualization, improved surgical ergonomics, increased instrument accuracy, possibility of intraoperative ultrasonography use and availability of tracers for analyzing parenchymal ischemia that might facilitate PN both in the resection and the reconstructive phases of the surgery. These advantages could decrease renal vessel injury and also could increase the resection rate of inaccessible tumors, reducing the rate of conversion to either RN or open surgery. Furthermore, LPN is associated with a steep learning curve, being regarded as a difficult surgery to master.

Finally, we must always keep in mind that patient selection is fundamental and the decision on the ideal treatment option must be individualized based on the specific characteristics of the patient and the tumor. For patients with good performance status to undergo surgery and tumors of relatively small size and low complexity, PN is preferred, and RAPN offers a minimally invasive option with a short hospital stay and low perioperative morbidities. However, for patients with more advanced tumors and/or highly complex tumors, PN is a challenge even in the most experienced hands and minimally invasive RN is preferred due to its safety and good oncological results. Following this line, for patients who do not have good surgical conditions, approaches such as AS and FT should be remembered and chosen in cases of tumors with less complexity and aggressiveness.

Conclusions

RAPN provides higher rates of trifecta outcomes when compared to OPN and LPN in the treatment of SRM. Whilst AS and FT remain valid options for unfit patients,

RAPN, whenever an active treatment is indicated, stands as a safe approach with excellent outcomes. Notwithstanding the significant data present to this day, clinical trials with longer follow-ups are needed to define RAPN as the standard treatment option for SRM.

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Footnote

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://amj.amegroups.com/article/view/10.21037/amj-23-232/rc

Peer Review File: Available at https://amj.amegroups.com/article/view/10.21037/amj-23-232/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://amj.amegroups.com/article/view/10.21037/amj-23-232/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Supplementary

Table S1 The search strategy summary

Items	Specification
Date of search	31 Dec 2022
Databases and other sources searched	PubMed and Medline
Search terms used	"robotic-assisted partial nephrectomy", "small renal masses", and "laparoscopic partial nephrectomy"
Timeframe	2005–2022
Inclusion criteria	Highest level of evidence and number of patients; English articles
Selection process	A.d.O.P. conducted independently

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