World Journal of Urology (2024) 42:213
https://doi.org/10.1007/s00345-024-04890-w

TOPIC PAPER

Open versus robotic partial nephrectomy in obese patients: a multi-institutional propensity score-matched analysis (UroCCR 43—Robese study)

Jean Baptiste Beauval[1] · Zine-Eddine Khene[2] · Mathieu Roumiguié[3] · Razvan Rahota[1] · Arnaud Mejean[4] · Nicolas Doumerc[3] · Morgan Roupret[5] · Philippe Paparel[6] · Arnauld Villers[7] · Franck Bruyere[8] · Cédric Lebacle[19,9] · François Xavier Nouhaud[10] · Cécile Champy[11] · Alexandre de la Taille[11] · Hervé Lang[12] · Jérome Rizk[13] · Mathieu Durand[14] · Charles Dariane[4] · Thomas Charles[15] · Romain Boissier[16] · Jean Alexandre Long[17] · Pierre Bigot[18] · Karim Bensalah[2] · Jean Christophe Bernhard[19]

Received: 29 September 2021 / Accepted: 6 March 2023

Abstract

Introduction There is limited evidence on the outcomes of robotic partial nephrectomy (RPN) and open partial nephrectomy (OPN) in obese patients (BMI ≥ 30 kg/m^2). In this study, we aimed to compare perioperative and oncological outcomes of RPN and OPN.

Methods We relied on data from patients who underwent PN from 2009 to 2017 at 16 departments of urology participating in the UroCCR network, which were collected prospectively. In an effort to adjust for potential confounders, a propensity-score matching was performed. Perioperative outcomes were compared between OPN and RPN patients. Disease-free survival (DFS) and overall survival (OS) were estimated using the Kaplan–Meier method and compared using the log-rank test.

Results Overall, 1277 obese patients (932 robotic and 345 open were included. After propensity score matching, 166 OPN and 166 RPN individuals were considered for the study purposes; no statistically significant difference among baseline demographic or tumor-specific characteristics was present. A higher overall complication rate and major complications rate were recorded in the OPN group (37 vs. 25%, $p = 0.01$ and 21 vs. 10%, $p = 0.007$; respectively). The length of stay was also significantly longer in the OPN group, before and after propensity-score matching ($p < 0.001$). There were no significant differences in Warm ischemia time ($p = 0.66$), absolute change in eGFR ($p = 0.45$) and positive surgical margins ($p = 0.12$). At a median postoperative follow-up period of 24 (8–40) months, DFS and OS were similar in the two groups (all $p > 0.05$).

Conclusions In this study, RPN was associated with better perioperative outcomes (improvement of major complications rate and LOS) than OPN. The oncological outcomes were found to be similar between the two approaches.

Keywords Partial nephrectomy · Obesity · Robot-assisted · Mini-invasive surgery · Morbidity · Outcomes

Introduction

Partial nephrectomy (PN) represents the standard of care for the treatment of small renal masses [1, 2]. It provides equivalent oncological control and better preservation of renal function relative to radical nephrectomy [3]. Over the last decade, the surgical approach has shifted from open partial nephrectomy (OPN) to laparoscopy with robotic assistance in the majority of the cases [4, 5]. The benefits of robotic partial nephrectomy (RPN) have been widely reported: it decreases surgical morbidity, analgesic requirements, length of hospital stay and convalescence [6, 7].

At the same time, the prevalence of obesity has increased dramatically in the last decades, and it is a growing health concern worldwide [8]. Obesity is correlated to higher perioperative complication rates when compared to normal-weight populations. This adds difficulty to the complexity of minimally invasive surgery per se, mostly due to the increased adipose tissue that can limit the motion of instruments and increased perinephric fat thickness, which requires a more extensive dissection and it has been found to be associated with increased blood loss and operative time [9, 10].

Extended author information available on the last page of the article

In this specific population, the benefits of RPN over OPN have generally been reported using single institution and small sample sizes [11–13]. Despite the inherent limitations of observational studies, the data suggests that RPN seems to be associated with decreased blood loss, peri-operative complications, and length of stay. Obesity is correlated to higher perioperative complication rates when compared to normal-weight populations. Furthermore, there are studies published across the surgical field advocating that especially obese patients gain from minimal invasive procedures.

Our objective was to compare perioperative and oncologic outcomes of RPN and OPN in a large and contemporary multi-institutional cohort of obese patients.

Patients and methods

Study population

All patients in this study were prospectively enrolled in the UroCCR (French Research Network for Kidney Cancer) multicentric database (ClinicalTrials.gov: NCT03293563/CNIL agreement DR-2013-206). We conducted a retrospective analysis of all obese patients (BMI $\geq$ 30 kg/m^2) who underwent PN for a localized kidney tumor at 16 academic departments of urology between 2009 and 2017. Only OPN and RPN were included (i.e., purely laparoscopic cases were excluded). Patients who had multiples renal masses on the same kidney and those with a solitary kidney were excluded from the analysis to minimize the confounding effect on perioperative outcomes. All RPNs were performed using the da Vinci surgical system through a transperitoneal approach.

Co-variates

Demographic data and preoperative clinical variables included gender, age at surgery, body mass index (BMI), smoking status (active/former smoker vs. non-smoker), diabetes, hypertension, Anticoagulant/antiplatelet treatments, ECOG PS score, American Society of Anesthesiology (ASA) score, preoperative estimated glomerular filtration rate (eGFR) tumor size and R.E.N.A.L. nephrometry score [13]. Tumor complexity was graded as low (RENAL score 4–6), moderate (score 6–9), or high (score 10–12). The glomerular filtration rate (GFR) was estimated using the Modification of Diet in Renal Disease (MDRD) equation [14]. Pathologic data consisted of stage, grade, surgical margins, and histologic subtype. Tumor histology was evaluated according to the 2004 World Health Organization criteria. pTNM was defined in accordance with the European Association of Urology.

Outcomes

The following variables were collected: operative time (OT, "skin to skin"), warm ischemia time (WIT), estimated blood loss (EBL), conversion to radical nephrectomy, intra operative complication, overall complication rate, major complication rate, transfusion rate, absolute change in estimated glomerular filtration rate and length of stay (LOS). Intraoperative complications were defined as an undesired event due to the surgical intervention occurring between skin incision and skin closure.

Postoperative complications were graded using the Clavien–Dindo classification [15, 16]. Major complications were defined as a Clavien score of 3 or higher. All outcomes were recorded within 30 d of the procedure.

The patients were followed up according to local protocols, which involved clinical examination, serum creatinine measurement, and contrast-enhanced computed tomography of the chest, abdomen, and pelvis at 6, 12, 18, 24 months and then yearly for a minimum of 5 years. The oncological outcomes were disease-free survival (DFS) and overall survival (OS). DFS was defined as the time from surgery to disease recurrence (including local and distant recurrences), or death from any cause. OS was defined as the time from surgery to death from any cause. For DFS and OS endpoints, patients who are alive were censored at the date of the last contact.

Statistical analysis

Medians and interquartile ranges (IQR) were generated for continuously coded variables, and frequencies and proportions were generated for categorical variables. To partly account for potential selection biases arising from non-random allocation of patients undergoing OPN and RPN, we performed a propensity-score-matched analysis. For the present study, propensity scores were computed by modeling a logistic regression considering the following variables: RENAL nephrometry score, tumor size, baseline eGFR and ECOG PS. Based on the resulting propensity score, patients who underwent OPN were matched 1:1 without replacement to patients who underwent RPN using nearest-neighbor matching within a propensity-score-based caliper. A standard caliper size of $0.2 \times \log$ [SD of the propensity score] was used.

Mann–Whitney U test and Chi-squared tests were used to evaluate the differences in peri-operative characteristics between the groups. Kaplan–Meier analysis with log-rank tests were performed to evaluate the difference in oncological outcomes between the groups. Missing data were imputed five times, with predictive mean matching for numeric variables and logistic regression for binary variables. Statistical analyses were performed using Stata 16.1 statistical software (Stata, College Station, TX, USA). All tests were two-sided with a significance level at $p < 0.05$.

Results

Table 1 shows the characteristics of the initial study cohort of 1277 patients before and after they were matched according to the aforementioned criteria. Of these patients, 932 (73%) underwent RPN and 345 (27%) underwent OPN. Before propensity-score matching, patients in the OPN group had a larger tumor ($p = 0.04$), a higher anatomical complexity score ($p = 0.03$) and a lower baseline eGFR ($p = 0.006$) than the RPN group. In addition, more patients in the OPN group had an ECOG score ≥ 1 (32% vs. 25%; $p = 0.01$). Using propensity score, 166 patients in the OPN group were matched 1:1 to patients in the RPN group. Patient's baseline characteristics were similar in the two groups (all $p > 0.05$).

Perioperative outcome for the pre- and post-propensity score matched cohorts are presented in Table 2. Operative time and warm ischemia time were similar between the two groups (all $p > 0.05$). In the matched cohort, operative time was shorter in the OPN group ($p < 0.001$). EBL and transfusion rates were higher in the OPN group (360 vs. 200 ml, $p < 0.001$, and 6 vs. 2%, $p < 0.001$, respectively). However, after propensity-score matching no difference was observed regarding the transfusion rate between the two groups ($p = 0.32$).

Regarding perioperative complications, the intra-operative complication rate was higher in the OPN groups ($p < 0.001$). However, after propensity score matching this difference was found not to be significant. The incidence of overall and major post-operative complications was higher in the OPN group (39 vs. 16%, $p < 0.001$ and 18 vs. 5%, $p < 0.001$; respectively) (Supplementary Table S1).

Table 1 Demographics and preoperative variables of obese patients undergoing partial nephrectomy, all patients and patients analyzed with propensity score matching

Variables	Full data set			Standardized difference, %	PS-matched patients			Standardized difference, %
	OPN (n = 345)	RPN (n = 932)	*p* value		OPN (n = 166)	RPN (n = 166)	*p* value	
Age, y (IQR)	60 (54–67)	60 (52–67)	0.69	− 0.01	63 (54–68)	62 (56–69)	0.79	0.03
Sex, no. (%)								
Female	106 (30.7)	357 (38.3)	0.01	− 0.15	54 (32.5)	68 (41)	0.11	0.09
Male	239 (69.2)	575 (61.7)			112 (67.4)	98 (59)		
BMI, kg/m^2 (IQR)	32.9 (31.1–35.8)	33.2 (31.2–36.4)	0.08	0.08	32.8 (31–35.6)	33.5 (31.4–37)	0.09	0.07
ECOG PS, no. (%)								
0	182 (67.4)	606 (74.7)	0.01	0.16	112 (67.5)	120 (72.2)	0.09	0.09
≥ 1	88 (32.7)	205 (25.2)			54 (32.5)	46 (27.7)		
ASA score, no. (%)								
1–2	238 (75)	708 (76)	0.74	0.03	107 (64.4)	102 (61.4)	0.41	0.03
3–4	76 (25)	224 (24)			59 (35.6)	64 (38.5)		
Smoking status, n (%)	87 (25.2)	190 (20.3)	0.06	0.11	46 (27.7)	48 (28.9)	0.90	0.02
Hypertension, n (%)	206 (59.7)	577 (61.9)	0.47	0.04	104 (62.6)	112 (67.4)	0.12	0.02
Diabetes, n (%)	97 (28.1)	258 (27.6)	0.87	0.01	49 (29.5)	48 (28.9)	0.90	0.01
Anticoagulant/antiplatelet treatments, no. (%)	52 (15)	128 (13.7)	0.54	0.03	33 (19.8)	42 (25.3)	0.29	0.08
Tumor size, cm (IQR)	4.2 (2.9–5)	3.9 (2.7–4.5)	0.04	− 0.13	4 (3–5.5)	4.3 (3–7)	0.08	0.02
RENAL score, (IQR)	7 (6–9)	8 (6–10)	0.03	− 0.29	7 (6–9)	7 (6–9)	0.28	0.01
R.E.N.A.L. complexity, no. (%)								
Low (4–6)	80 (32)	309 (41.7)	0.02	0.21	50 (30.1)	52 (31.3)	0.12	0.02
Moderate (7–9)	120 (48)	314 (42.4)			85 (51.2)	68 (40.9)		
High (10–12)	50 (20)	117 (15.8)			31 (18.6)	46 (27.7)		
Preoperative eGFR, ml/min (IQR)	78.3 (59.7–91.3)	83.7 (64.4–99.2)	0.006	0.23	77.3 (64.8–92.5)	73 (53.6–90.9)	0.07	− 0.10

BMI, body mass index; ASA, American Society of Anesthesiologists; ECOG, Eastern Cooperative Oncology Group; NSS, Nephron Sparing Surgery; eGFR, Estimated glomerular filtration rate

Table 2 Perioperative outcomes of obese patients undergoing partial nephrectomy, all patients and patients analyzed with propensity score matching

Variables	Full data set			PS-matched patients		
	OPN (n = 345)	RPN (n = 932)	*p* value	OPN (n = 166)	RPN (n = 166)	*p* value
OT, min, median (IQR)	170 (126–190)	168 (121–208)	0.59	159 (120–175)	180 (132–238)	< 0.001
EBL, ml, median (IQR)	360 (200–600)	200 (100–400)	< 0.001	350 (150–500)	300 (100–400)	0.03
Hilar clamping no. (%)	278 (81.7)	771 (83.1)	0.55	147 (89.6)	122 (73.4)	< 0.001
WIT, min, median (IQR)	17 (13–23)	16 (12–23)	0.83	18 (14–25)	17 (12–24)	0.66
Conversions to radical nephrectomy (%)	6 (1.7)	13 (1.3)	0.65	3 (1.8)	0	0.08
Intra operative complication no. (%)	55 (16.4)	43 (4.6)	< 0.001	13 (7.9)	13 (4.2)	0.17
Overall complication no. (%)	136 (39.4)	152 (16.3)	< 0.001	62 (37.3)	42 (25.3)	0.01
Major complications no. (%)	63 (18.3)	51 (5.4)	< 0.001	35 (21.1)	17 (10.3)	0.007
Transfusion no. (%)	22 (6.4)	22 (2.3)	< 0.001	11 (6.6)	7 (4.2)	0.32
Median days length of stay (IQR)	7 (5–9)	3 (2–5)	< 0.001	8 (5–10)	4 (2–6)	< 0.001
% Change in eGFR at discharge, (IQR)	− 9 (− 12 to 8.3)	− 4 (− 8 to 7.9)	0.15	− 5 (− 8 to 6.5)	− 6 (− 8 to 7.5)	0.45

OT, Operative time; EBL, Estimated Blood Loss; WIT, Warm Ischemia Time

These differences remained significant in the matched cohort ($p < 0.001$). LOS was also significantly longer in OPN group, before and after propensity-score matching ($p < 0.001$). Finally, no differences in post-operative renal function between the two groups was observed in both cohorts ($p > 0.5$).

Concerning pathological outcomes (Table 3), no significant difference was found in the percentages of malignant lesions, histologic subtypes, pathological staging, and grading (all $p > 0.05$). Lastly, no differences were found in the rate of positive surgical margins between the two groups in both cohort ($p > 0.05$).

After a median (IQR) of 24 (8–40) months postoperatively, 71 patients had disease progression: 25 in the OPN group and 46 in the RPN group. 23 patients died during follow-up. There were no significant differences in overall survival and disease-free survival between the two groups before and after the propensity score matching (all $p > 0.05$) (Figs. 1A-B, 2B-B).

Table 3 Pathological results of obese patients undergoing partial nephrectomy, all patients and patients analyzed with propensity score matching

Variable	Full data set			PS-matched patients		
	OPN (n = 345)	RPN (n = 932)	*p* value	OPN (n = 166)	RPN (n = 166)	*p* value
Tumor pathology (%)			0.08			0.47
Malignant	290 (92.1)	768 (88.5)		141 (92.1)	141 (89.8)	
Benign	25 (7.9)	100 (11.5)		12 (7.8)	16 (10.1)	
Histologic subtypes (%)*						
Clear cell	205 (75.6)	562 (76.8)	0.51	99 (77.3)	101 (76.5)	0.89
Papillary	50 (18.4)	116 (15.8)		21 (16.4)	24 (18.1)	
Chromophobe	16 (5.9)	53 (7.2)		21 (6.2)	7 (5.3)	
Nuclear grade (%)*						
1–2	154 (60.3)	441 (64.6)	0.22	73 (57)	82 (64)	0.25
3–4	101 (39.6)	241 (35.3)		55 (42.9)	46 (36)	
Stage (%)*						
1	232 (82.8)	640 (85.5)	0.07	106 (80.3)	97 (69.2)	0.11
2	19 (6.7)	26 (3.4)		9 (6.8)	13 (9.2)	
3	29 (10.3)	82 (10.9)		17 (12.8)	30 (21.4)	
No. positive surgical margins (%)*	36 (12.4)	136 (13.1)	0.58	20 (14.1)	16 (11.4)	0.12

*Only renal cell carcinomas were included for analyses

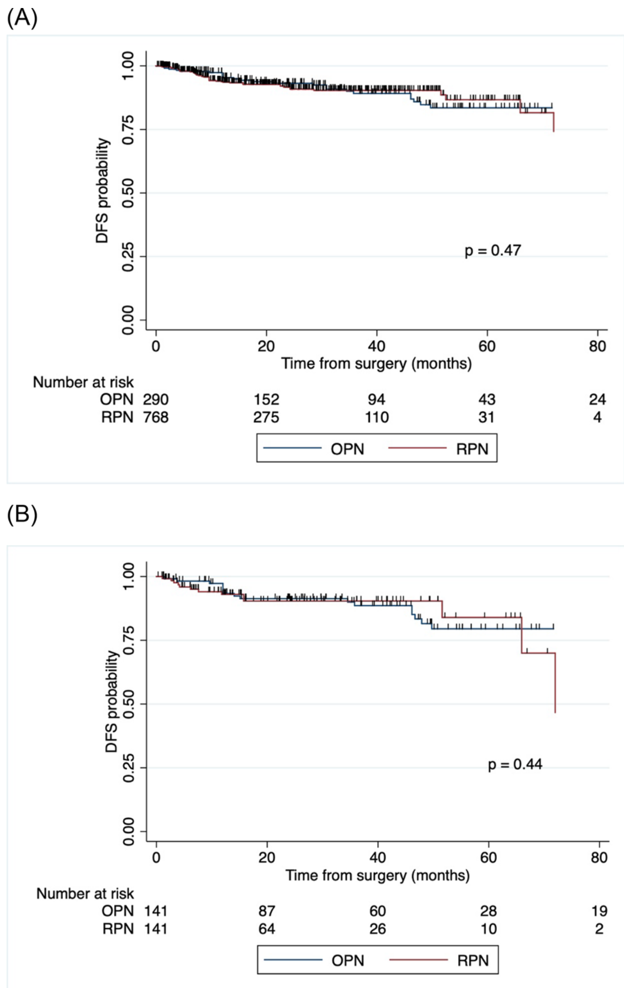

Fig. 1 Kaplan–Meier curves comparing open partial nephrectomy (OPN) and robotic partial nephrectomy (RPN) for disease-free survival, all patients (**A**) and patients analyzed with propensity score matching (**B**). *Only renal cell carcinoma was included for analyses

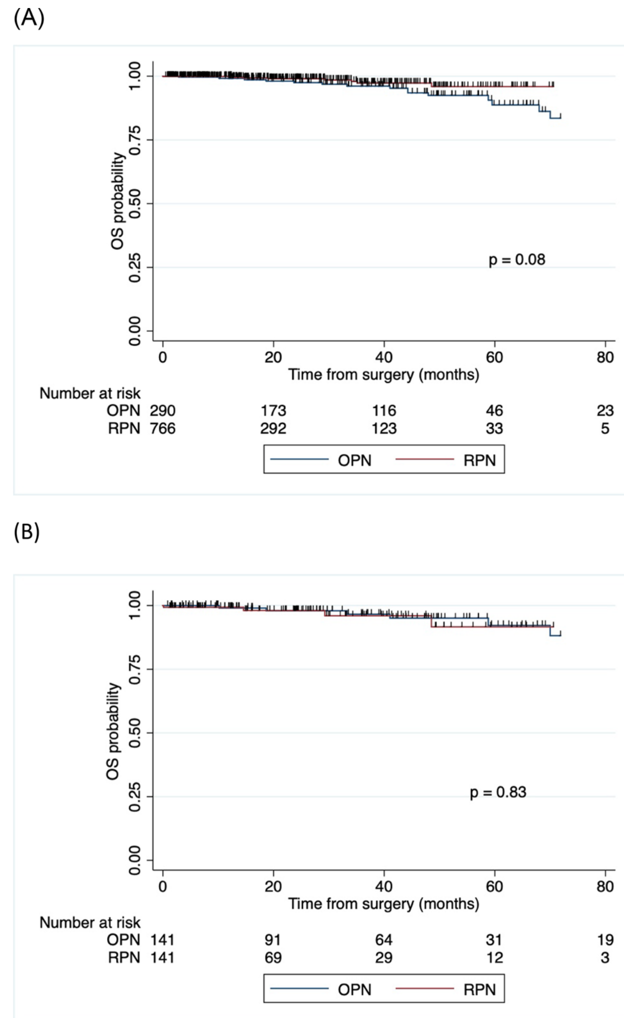

Fig. 2 Kaplan–Meier curves comparing open partial nephrectomy (OPN) and robotic partial nephrectomy (RPN) for overall survival, all patients (**A**) and patients analyzed with propensity score matching (**B**). *Only renal cell carcinoma were included for analyses

Discussion

PN is the standard of care for treatment of small renal tumors. The surgical approach (open vs. minimally invasive surgery) is mainly related to patient's health status [17], surgeon's experience [18], tumor complexity [19], and robotic platform availability [20]. Over the last decade, the robotic approach has gained popularity with the ambition to decrease perioperative morbidity while maintaining optimal functional and oncological outcomes [6, 21]. At the same time, the overweight/obese population has been steadily increasing worldwide and operative interventions and perioperative care of these patients can be challenging [22]. We performed a study that reflects real life conditions in an effort to assess perioperative, oncological and functional outcomes by comparing OPN and RPN in the specific population of obese patients. To control more comprehensively for biases associated with the selection of a particular approach over the other, we stringently matched OPN and RPN patients using a propensity score–matching method. Our study revealed important findings and several relevant observations deserve further discussion.

First, RPN was associated with a relevant benefit in terms of perioperative morbidity relative to OPN. The RPN approach is associated with decreased bleeding, fewer transfusions, and a much shorter hospital stay. Remarkably, this benefit was consistent when major complications were taken into consideration, with a 10% decrease with the robotic approach. One explanation to this phenomenon could be that the robotic systems offer enhanced vision and several degrees of freedom that make renal parenchyma repair after tumor excision easier to perform. It would seem plausible that a more efficient and faster repair would be associated with fewer complications postoperatively. In addition, by avoiding large open wounds or incisions, we decrease the rate of postoperative complications, especially those related to the wound such as dehiscence, infection, cellulitis, and incisional hernia.

Our findings are in keeping with the results of previous studies suggesting the major advantages of the robotic approach. In a small cohort of 66 obese patients undergoing OPN (n = 21), laparoscopic partial nephrectomy (n = 31), and RPN (n = 14), Webb et al. investigated the impact of approaches on blood loss and length of stay. They demonstrated that among obese patients, both laparoscopic and robotic partial nephrectomy are associated with less blood loss than open partial nephrectomy (300 ml vs. 150 ml) and shorter LOS (4 days vs. 3 days, $p < 0.05$) [11, 25]. Using data from 2008-2016 of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), Khalil et al. compared 6041 obese MIPN patients and 3064 obese OPN patients. They found that compared to OPN, the likelihood of 30-day postoperative morbidity was significantly lower in MIPN patients [13]. More recently, Malkoc and colleagues analyzed the impact of surgical approaches on outcomes in otherwise healthy obese patients undergoing partial nephrectomy for small renal masses (< 4 cm) in a cohort of 237 cases from the Cleveland Clinic. They found that robotic approach offers less blood transfusion, decreased operative time, faster recovery, and fewer perioperative complications compared to the open approach [12].

As the patient population is growing older and fatter, striking the right balance between life-prolonging surgical procedures while maintaining quality of life through minimizing treatment related complications becomes key for achieving the best possible outcomes for our patients. In addition to mini invasive surgery, we had to propose for patients, and specially in obese patients, various aspects of enhanced recovery after onco-urologic surgery (importance of pre-habilitation and re-habilitation, ERAS…).

However, these studies were limited by the risk of unmeasured baseline differences between RPN and OPN candidates. For example, critical determinants of perioperative morbidity such as tumor complexity and patient's health status were incompletely accounted for, when the effect of the approach was estimated, resulting in a non-negligible risk of biased observations. In addition, using single institution series represent a major weakness that limits the generalizability of the results.

Second, our study analyzed pathological and oncological outcomes after RPN and OPN in obese patient. Our findings suggest that there is no significant difference between the two groups in terms of disease recurrence (full and matched data) and overall survival (full and matched data). Despite the need for a longer follow-up evaluation, we believe this is an important finding because the results presented herein would suggest that the technical conduct of the operation may be improved by using the robotic approach with decreased EBL, post-operative complications and LOS without compromising oncological outcomes.

One of the strengths of our study is the large sample size. The analysis was performed using a matched analysis to reduce selection bias and provide a fairer comparison between the two approaches. Nonetheless, there are some limitations that must be acknowledged. The major shortcomings were those inherent to the retrospective design and subsequent potential for biases. There were subtle differences in surgical technique and perioperative management that could contribute to flaw our results. However, this multi-institutional approach may also allow findings to be more applicable at other centers. We only used the RENAL score whereas other scores, such as the Preoperative Aspects and Dimensions Used for an Anatomical and the centrality index have been reported. We chose the RENAL score because it is simple, easy to calculate and has shown good inter-observer reproducibility [23]. Moreover, it seems to provide more reliable information when compared with other scores [24]. Another limitation to our study is the relatively short follow-up. Finally, surgeries were performed by surgeons with various levels of expertise, which could have impacted perioperative outcomes but was not adjusted for (data was not available).

Conclusions

In the present study, RPN was associated with better perioperative outcomes (improvement of major complications rate and LOS) than OPN. Although the follow-up was relatively short, the oncological outcomes were found to be similar between the two approaches. Longer follow-up and additional prospective studies are needed to confirm our results.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00345-024-04890-w.

Author contributions JBB and JCB: Project development. All authors: Data collection. JBB, ZEK, MR: Data analysis. JBB, ZEK, MR: Manuscript editing.

Data availability No applicable.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

Ethical approval Local ethics committee approval.

Informed consent Informed consent was obtained for every patient included into the French kidney cancer network database UroCCR (CNIL-DR 2013-206; NCT No. 03293563).

References

1. Ljungberg B, Albiges L, Abu-Ghanem Y et al (2019) European association of urology guidelines on renal cell carcinoma: the 2019 update. Eur Urol 75:799–810. https://doi.org/10.1016/j.eururo.2019.02.011
2. Campbell SC, Clark PE, Chang SS et al (2021) Renal mass and localized renal cancer: evaluation, management, and follow-up: AUA guideline: part I. J Urol 206:199–208. https://doi.org/10.1097/JU.0000000000001911
3. Kunath F, Schmidt S, Krabbe L-M et al (2017) Partial nephrectomy versus radical nephrectomy for clinical localised renal masses. In: The Cochrane Collaboration (ed) Cochrane database of systematic reviews. Wiley, Chichester
4. Schiavina R, Mari A, Antonelli A et al (2015) A snapshot of nephron-sparing surgery in Italy: a prospective, multicenter report on clinical and perioperative outcomes (the RECORd 1 project). Eur J Surg Oncol EJSO 41:346–352. https://doi.org/10.1016/j.ejso.2014.12.001
5. Alameddine M, Koru-Sengul T, Moore KJ et al (2019) Trends in utilization of robotic and open partial nephrectomy for management of cT1 renal masses. Eur Urol Focus 5:482–487. https://doi.org/10.1016/j.euf.2017.12.006
6. Peyronnet B, Seisen T, Oger E et al (2016) Comparison of 1800 robotic and open partial nephrectomies for renal tumors. Ann Surg Oncol 23:4277–4283. https://doi.org/10.1245/s10434-016-5411-0
7. Ficarra V, Minervini A, Antonelli A et al (2014) A multicentre matched-pair analysis comparing robot-assisted versus open partial nephrectomy: perioperative results of RAPN vs. OPN. BJU Int 113:936–941. https://doi.org/10.1111/bju.12570
8. NCD Risk Factor Collaboration (NCD-RisC) (2016) (2016) Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. Lancet Lond Engl 387:1377–1396. https://doi.org/10.1016/S0140-6736(16)30054-X
9. Sood A, Abdollah F, Sammon JD et al (2015) The effect of body mass index on perioperative outcomes after major surgery: results from the national surgical quality improvement program (ACS-NSQIP) 2005–2011. World J Surg 39:2376–2385. https://doi.org/10.1007/s00268-015-3112-7
10. Davidiuk AJ, Parker AS, Thomas CS et al (2014) Mayo adhesive probability score: an accurate image-based scoring system to predict adherent perinephric fat in partial nephrectomy. Eur Urol 66(6):1165–1171. https://doi.org/10.1016/j.eururo.2014.08.054
11. Webb CM, Kamel M, Eltahawy E et al (2015) A comparative study of open, laparoscopic and robotic partial nephrectomy in obese patients. Urol Ann 7:231–234. https://doi.org/10.4103/0974-7796.152023
12. Malkoc E, Maurice MJ, Kara O et al (2017) Robot-assisted approach improves surgical outcomes in obese patients undergoing partial nephrectomy. BJU Int 119:283–288. https://doi.org/10.1111/bju.13675
13. Khalil MI, Ubeda J, Soehner T et al (2019) Contemporary perioperative morbidity and mortality rates of minimally invasive vs. open partial nephrectomy in obese patients with kidney cancer. J Endourol 33:920–927. https://doi.org/10.1089/end.2019.0310
14. Levey AS, Bosch JP, Lewis JB et al (1999) A more accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. Modification of Diet in Renal Disease Study Group. Ann Intern Med 130:461–470
15. Dindo D, Demartines N, Clavien P-A (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240:205–213
16. Mitropoulos D, Artibani W, Biyani CS et al (2017) Validation of the Clavien–Dindo grading system in urology by the European association of urology guidelines ad hoc panel. Eur Urol Focus. https://doi.org/10.1016/j.euf.2017.02.014
17. Khene Z-E, Peyronnet B, Kocher NJ et al (2018) Predicting morbidity after robotic partial nephrectomy: the effect of tumor, environment, and patient-related factors. Urol Oncol 36:338.e19-338.e26. https://doi.org/10.1016/j.urolonc.2018.04.005
18. Larcher A, Muttin F, Peyronnet B et al (2019) The learning curve for robot-assisted partial nephrectomy: impact of surgical experience on perioperative outcomes. Eur Urol 75:253–256. https://doi.org/10.1016/j.eururo.2018.08.042
19. Khene Z-E, Mazouin C, Larcher A et al (2021) Predicting complications after robotic partial nephrectomy: back to simplicity. Eur Urol Focus. https://doi.org/10.1016/j.euf.2021.04.017
20. Alimi Q, Peyronnet B, Sebe P et al (2018) Comparison of short-term functional, oncological, and perioperative outcomes between laparoscopic and robotic partial nephrectomy beyond the learning curve. J Laparoendosc Adv Surg Tech A 28:1047–1052. https://doi.org/10.1089/lap.2017.0724
21. Grivas N, Kalampokis N, Larcher A et al (2019) Robot-assisted versus open partial nephrectomy: comparison of outcomes. A systematic review. Minerva Urol E Nefrol Ital J Urol Nephrol 71:113–120
22. Ri M, Aikou S, Seto Y (2017) Obesity as a surgical risk factor. Ann Gastroenterol Surg 2:13–21. https://doi.org/10.1002/ags3.12049
23. Okhunov Z, Rais-Bahrami S, George AK et al (2011) The comparison of three renal tumor scoring systems: C-Index, P.A.D.U.A., and R.E.N.A.L. Nephrometry Scores J Endourol 25:1921–1924. https://doi.org/10.1089/end.2011.0301
24. Borgmann H, Reiss A-K, Kurosch M et al (2016) R.E.N.A.L. score outperforms PADUA score, C-Index and DAP score for outcome prediction of nephron sparing surgery in a selected cohort. J Urol 196:664–671. https://doi.org/10.1016/j.juro.2016.03.176
25. Naeem N, Petros F, Sukumar S, Patel M, Bhandari A, Kaul S, Menon M, Rogers C (2011) Robot-assisted partial nephrectomy in obese patients. J Endourol 25(1):101–105. https://doi.org/10.1089/end.2010.0272

Authors and Affiliations

Jean Baptiste Beauval[1] · Zine-Eddine Khene[2] · Mathieu Roumiguié[3] · Razvan Rahota[1] · Arnaud Mejean[4] · Nicolas Doumerc[3] · Morgan Roupret[5] · Philippe Paparel[6] · Arnauld Villers[7] · Franck Bruyere[8] · Cédric Lebacle[19,9] · François Xavier Nouhaud[10] · Cécile Champy[11] · Alexandre de la Taille[11] · Hervé Lang[12] · Jérome Rizk[13] · Mathieu Durand[14] · Charles Dariane[4] · Thomas Charles[15] · Romain Boissier[16] · Jean Alexandre Long[17] · Pierre Bigot[18] · Karim Bensalah[2] · Jean Christophe Bernhard[19]

✉ Jean Baptiste Beauval
jbbeauval@gmail.com

1 Department of Urology, Clinique La Croix du Sud, Quint Fonsegrives, Toulouse, France

2 Department of Urology, University Hospital, Rennes, France

3 Department of Urology, University Hospital of Rangueil, Toulouse, France

4 Department of Urology, HEGP, Paris, France

5 Department of Urology, La Pitié Salpétrière, Paris, France

6 Department of Urology, University Hospital, Lyon, France

7 Department of Urology, University Hospital, Lille, France

8 Department of Urology, University Hospital, Tours, France

9 Department of Urology, Kremlin Bicetre University Hospital, Paris, France

10 Department of Urology, University Hospital, Rouen, France

11 Department of Urology, Mondor University Hospital, Créteil, France

12 Department of Urology, University Hospital, Strasbourg, France

13 Department of Urology, St Joseph Hospital, Paris, France

14 Department of Urology, University Hospital, Nice, France

15 Department of Urology, University Hospital, Poitiers, France

16 Department of Urology, University Hospital, Marseille, France

17 Department of Urology, University Hospital, Grenoble, France

18 Department of Urology, University Hospital, Angers, France

19 Department of Urology, University Hospital, Bordeaux, France