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Gopal Sharma

Milap Shah

Puneet Ahluwalia

Prokar Dasgupta

Benjamin J. Challacombe

See next page for additional authors

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Authors

Gopal Sharma, Milap Shah, Puneet Ahluwalia, Prokar Dasgupta, Benjamin J. Challacombe, Mahendra Bhandari, Rajesh Ahlawat, Sudhir Rawal, Nicolo M. Buffi, Ananthakrishanan Sivaraman, James R. Porter, Craig G. Rogers, Alexandre Mottrie, Ronney Abaza, Khoon Ho Rha, Daniel Moon, Thyavihally B. Yuvaraja, Dipen J. Parekh, Umberto Capitanio, Kris K. Maes, Francesco Porpiglia, Levent Turkeri, and Gagan Gautam

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ORIGINAL ARTICLE

Perioperative outcomes following robot-assisted partial nephrectomy in elderly patients

Gopal Sharma[1] · Milap Shah[1] · Puneet Ahluwalia[1] · Prokar Dasgupta[2] · Benjamin J. Challacombe[3] · Mahendra Bhandari[4] · Rajesh Ahlawat[5] · Sudhir Rawal[6] · Nicolo M. Buffi[7] · Ananthakrishanan Sivaraman[8] · James R. Porter[9] · Craig Rogers[10] · Alexandre Mottrie[11] · Ronney Abaza[12] · Khoon Ho Rha[13] · Daniel Moon[14] · Thyavihally B. Yuvaraja[15] · Dipen J. Parekh[16] · Umberto Capitanio[17] · Kris K. Maes[18] · Francesco Porpiglia[19] · Levent Turkeri[20] · Gagan Gautam[1]

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Abstract

Objective To compare perioperative outcomes following robot-assisted partial nephrectomy (RAPN) in patients with age ≥ 70 years to age < 70 years.

Methods Using Vattikuti Collective quality initiative (VCQI) database for RAPN we compared perioperative outcomes following RAPN between the two age groups. Primary outcome of the study was to compare trifecta outcomes between the two groups. Propensity matching using nearest neighbourhood method was performed with trifecta as primary outcome for sex, body mass index (BMI), solitary kidney, tumor size and Renal nephrometery score (RNS).

Results Group A (age ≥ 70 years) included 461 patients whereas group B included 1932 patients. Before matching the two groups were statistically different for RNS and solitary kidney rates. After propensity matching, the two groups were comparable for baselines characteristics such as BMI, tumor size, clinical symptoms, tumor side, face of tumor, solitary kidney and tumor complexity. Among the perioperative outcome parameters there was no difference between two groups for operative time, blood loss, intraoperative transfusion, intraoperative complications, need for radical nephrectomy, positive margins and trifecta rates. Warm ischemia time was significantly longer in the younger age group (18.1 min vs. 16.3 min, $p = 0.003$). Perioperative complications were significantly higher in the older age group (11.8% vs. 7.7%, $p = 0.041$). However, there was no difference between the two groups for major complications.

Conclusion RAPN in well-selected elderly patients is associated with comparable trifecta outcomes with acceptable perioperative morbidity.

Keywords Robotic · Partial nephrectomy · Elderly · Propensity-matching

Introduction

Partial nephrectomy (PN) as a treatment option for small localized renal masses has become the standard of care [1]. Utilization rates of partial nephrectomy for renal masses have increased across all age groups [2, 3]. Superior functional and comparable oncological outcomes for PN compared to radical nephrectomy (RN) have translated into increased adoption of PN [4, 5]. In recent years, there has been a trend toward increased utilization of partial nephrectomy as a treatment option for managing localized small renal masses [6, 7]. However, its utilization in the elderly population remains poor [2, 3]. Reasons for this underutilization could be manifold. There is little doubt about the efficacy of partial nephrectomy in renal function preservation compared to RN [8–10]. However, elderly patients are at a significantly higher risk of death due to competing causes of mortality. Therefore, they may not extract long-term cardiovascular benefits from renal function preservation. Thus, the lack of proven benefits in terms of overall and cancer-specific survival may be one of the deterrents for undergoing PN in the elderly population [9–12].

Some studies have even reported superior overall survival due to a decrease in other causes of mortality such as cardiovascular events due to better renal function preservation with

✉ Gagan Gautam
gagangg@gmail.com

Extended author information available on the last page of the article

Table 1 Comparison of baseline characteristics between the two age groups (Age ≥ 70 years and < 70 years)

Variable	Age ≥ 70 years (Group A) (n = 461)	Age < 70 years (Group B) (n = 1932)	p-value
Age (mean ± SD)	75.01 ± 4.12	53.4 ± 10.68	**< 0.0001**
Sex			
Male	307 (66.6%)	1267 (65.6%)	0.680
Female	154 (33.4%)	665 (35.4%)	
BMI (Kg/m^2)	28.1 ± 5.25	28.6 ± 6.16	0.076
Tumor size (mean ± SD) mm	35.2 ± 15.8	34.8 ± 17.04	0.711
Charlson comorbidity index	1.7 ± 1.6	1.1 ± 1.3	**< 0.0001**
Clinical symptoms			
Asymptomatic	394 (85.4%)	1610 (83.3%)	
Local	63 (13.6%)	296(15.3%)	0.458
Systemic	4 (0.8%)	26 (1.3%)	
Single kidney	22 (4.7%)	38 (1.96%)	**0.001**
Tumor side			
Right	238 (51.6%)	976 (50.5%)	0.669
Left	223 (48.4%)	956 (49.5%)	
Face of tumor			
Anterior	257 (55.7%)	1034 (53.5%)	0.388
Posterior	204 (44.3%)	898 (46.5%)	
Polar Location of Tumor			
Upper	146 (31.6%)	615 (31.8%)	
Mid	154 (33.4%)	749 (38.7%)	0.07
Lower	161 (34.9%)	568 (29.3%)	
Preoperative hemoglobin	12.98 ± 1.61	13.4 ± 1.71	**< 0.0001**
Preoperative creatinine	1.08 ± .40	0.94 ± 0.31	**< 0.0001**
Preoperative eGFR	68.4 ± 23.5	83.5 ± 23.2	**< 0.0001**
Renal Nephrometry Score (Mean ± SD)	6.88 ± 1.75	7.07 ± 1.83	**0.034**
RENAL complexity grouping			
Low	203 (44%)	754 (39%)	**0.011**
Intermediate	229 (49.6%)	977 (50.5%)	
High	29 (6.3%)	201 (10.4%)	
Clinical stage			
T1a	328 (71.1%)	1345 (69.6%)	0.450
T1b	122 (26.4%)	519 (26.6)	
T2a	11 (2.3%)	68 (3.5%)	
Number of lesions operated			
1	430 (93.2%)	1843 (95.3%)	
2	23 (4.9%)	74 (3.8%)	0.098
3	6 1.3%)	13 (0.6%)	
4	2 (0.4%)	1 (0.05%)	
6	0	1 (0.05%)	
Surgical access			
Retroperitoneal	69 (14.9%)	252 (13%)	0.276
Transperitoneal	392 (85.1%)	1680(87%)	
Operative time (Mean ± SD)	188.7 ± 63.4	190.6 ± 66.7	0.688
Warm ischemia time (Mean ± SD)	16.2 ± 8.7	18.37 ± 9.26	**< 0.0001**
Blood loss ml (Median with range)	50 (20–3500)	100 (20–2730)	0.153
Intraoperative transfusion	9 (1.9%)	64 (3.3%)	0.127
Intraoperative complications	22 (4.7%)	91 (4.7%)	0.955
Need for conversion to radical nephrectomy	11 (2.4%)	18 (0.9%)	**0.010**
Perioperative complications	58(12.5%)	151(7.8%)	**0.001**

Table 1 (continued)

Variable	Age ≥ 70 years (Group A) (n = 461)	Age < 70 years (Group B) (n = 1932)	p-value
Grade I	27 (5.8%)	78 (4%)	
Grade II	19 (4.1%)	33 (1.7%)	**0.006**
Grade III	10(2.1%)	31 (1.6%)	
Grade IV	2 (0.4%)	9 (0.5%)	
Trifecta	330 (71.5%)	1375 (71.1%)	0.860
Positive margin	14 (3%)	52 (2.7%)	0.684

SD standard deviation, *BMI* body mass index, *eGFR* estimated glomerular filtration rate, *PCS* Pelvicalyceal system

Bold values are statistically significant i.e. p-value < 0.05

PN [13, 14]. However, this comes at the expense of increased perioperative complications associated with PN [15–17]. The apprehension of increased complications without any proven oncological benefit has led to a lower acceptance of PN for the elderly patient population. Population-based studies have shown lower rates of increased adoption of PN for elderly patients compared to their younger counterparts [2, 3]. Literature on perioperative outcomes following PN for the elderly population is limited. Furthermore, non-invasive treatment options as focal therapy has provided an alternative to PN in frail elderly patients with comorbidities [1].

Few studies have reported outcomes following robot-assisted partial nephrectomy (RAPN) in the elderly population [18–20]. These studies have reported acceptable outcomes following RAPN in well-selected elderly patients. However, none of these studies have compared results with younger patients. Hence, with this Vattikuti collective quality initiative (VCQI) database study, we aimed to compare perioperative outcomes between patients aged ≥ 70 years and < 70 years following RAPN.

Materials and methods

Vattikuti collective quality initiative (VCQI) database

VCQI is a prospective web-based multi-institutional collaborative database for various robotic surgical procedures [21–24]. Details of centers contributing to the database is provided in the supplementary file. Ethics clearance was obtained from each participating institution prior to data sharing. Due to the multi-institutional nature of the database, patients without adequate data had to be excluded from the study. For every patient, demographic, perioperative and postoperative data were collected as detailed in Table 1. Perioperative complications were graded as per Clavien–Dindo classification [25]. The primary objective of this study was the comparison of trifecta outcomes between patients over the age of 70 years and those aged less than 70 years. Subgroup analysis of patients over the age of 80 years and those aged less than 80 years was also performed. Trifecta outcome was achieved without any complications, negative surgical margins, and warm ischemia time ≤ 25 min or zero ischemia [24, 26].

Statistical analysis

We checked the normality of continuous data using Kolmogorov–Smirnov and Shapiro tests of normality. An independent sample Student's t test was used if data were normally distributed. Kruskal–Wallis test was used for non-normally distributed variables. For categorical variables, chi-square tests or Fisher's exact tests were used. Propensity matching using the nearest neighborhood method was performed with trifecta as the primary outcome for sex, BMI, solitary kidney, tumor size and RNS. All the statistical tests were two-sided and performed with a significance level of $p < 0.05$. The statistical tests were double-sided and conducted using SPSS version 23 (IBM corporation, New York, USA) and Stata (version 16; StataCorp, College Station, TX, USA). A p-value performed < 0.05 was used to define significance.

Results

From October 2014 to 2020, the participating centers contributed data of 3,801 patients who underwent RAPN. Of the 3,801 patients, 2,393 patients with complete data were included for the final analysis.

Prematching

Group A (age ≥ 70 years) included 461 patients, whereas group B included 1932 patients. A comparison of two groups for baseline factors revealed that the two groups were comparable for sex, BMI and clinical tumor size. Mean age in A group was 75.1 years and 52.8 years ($p = 0.000$) in group B.

Table 2 Comparison of perioperative outcomes between the two age groups post matching (Age ≥ 70 years and < 70 years)

Variable	Age ≥ 70 years (Group A) (n = 440)	Age < 70 years (Group B) (n = 440)	p-value
Age (mean ± SD)	75.0 ± 4.1	53.3 ± 10.8	**< 0.0001**
Sex			
Male	306 (69.5%)	290 (65.9%)	0.249
Female	134 (30.5%)	150 (34.1%)	
BMI (Kg/m^2)	28.6 ± 5.2	28.6 ± 6.2	0.155
Tumor size (mean ± SD) mm	34.9 ± 14.3	34.1 ± 14.8	0.417
Charlson comorbidity index	1.7 ± 1.6	1.1 ± 1.3	**< 0.0001**
Clinical symptoms			
Asymptomatic	376 (85.4%)	361 (82%)	
Local	60 (13.6%)	73 (16.5%)	0.372
Systemic	4 (0.9%)	6 (1.5%)	
Single kidney	13 (2.95%)	9 (2.04%)	0.388
Tumor side			
Right	226 (51.3%)	222 (50.4%)	0.590
Left	214 (48.6%)	218 (49.6%)	
Face of tumor			
Anterior	246 (56%)	237 (53.8%)	0.542
Posterior	194 (44%)	203 (46.2%)	
Polar Location of Tumor			
Upper	151 (34.3%)	119 (27%)	
Mid	147 (33.4%)	147 (33.4%)	**0.026**
Lower	142 (32.2%)	142 (32.2%)	
Preoperative hemoglobin	12.9 ± 1.6	13.5 ± 1.7	**0.0001**
Preoperative creatinine	1.07 ± 0.4	0.95 ± 0.3	**< 0.0001**
Preoperative eGFR	68.9 ± 23.5	83.2 ± 22.1	**< 0.0001**
Renal Nephrometry Score (Mean ± SD)	6.9 ± 1.7	7.0 ± 1.7	0.176
RENAL complexity grouping			
Low			
Intermediate	190 (43.1%)	173 (39.3%)	0.408
High	222 (50.5%)	232 (52.7%)	
Surgical access	28 (6.4%)	35 (7.9%)	
Retroperitoneal	64 (14.5%)	54 (12.2%)	0.323
Transperitoneal	376 (85.5%)	386 (87.8%)	
Warm ischemia time (Mean ± SD)	189.4 ± 63.6	186.7 ± 68.8	0.652
Blood loss ml (Median with range)	16.3 ± 8.5	18.1 ± 9.4	**0.003**
Warm ischemia time (Mean ± SD)	50 (20–3500)	100 (20–2730)	0.153
Intraoperative transfusion	9 (2%)	18 (4%)	0.079
Intraoperative complications	19 (4.3%)	24 (5.4%)	0.434
Need for conversion to radical nephrectomy	9 (2%)	5 (1.1%)	0.281
Perioperative complications	52(11.8%)	34(7.7%)	**0.041**
Grade I	24 (5.4%)	18 (4.1%)	
Grade II	17 (3.8%)	9 (2%)	0.324
Grade III	9 (2%)	6 (1.3%)	
Grade IV	2 (0.4%)	1 (0.2%)	
Trifecta	317 (72%)	309 (70.2%)	0.552
Positive margin	14 (3.2%)	20 (4.5%)	0.294

Bold values are statistically significant i.e. p-value < 0.05

Table 3 Multivariate analysis for the predictors of the trifecta outcomes

Variable	Odds ratio	95% confidence interval	p value
Age			
<70	Ref		0.369
≥70	1.11	(0.88, 1.41)	
Sex			
Male	Ref		**0.032**
Female	1.24	(1.02, 1.52)	
Body mass Index	1.01	(0.99, 1.02)	0.097
Tumor size	0.98	(0.97, 0.99)	**<0.0001**
Preoperative creatinine	0.89	(0.67, 1.17)	0.405
Renal nephrometry score	0.88	(0.83, 0.93)	**<0.0001**

Bold values are statistically significant i.e. p-value < 0.05

There was no significant difference between the two groups for clinical symptoms, side of tumor, face of tumor, polar location of tumor and number of lesions operated. However, group A included a significantly higher number of patients with solitary kidneys (4.7% vs. 1.96%, $p=0.000$). The mean RNS score was higher in group B patients (7.07 vs 6.88, $p=0.03$). Group B also had a significantly higher number of patients in the 'high complexity' stratification of RNS (10.4% vs. 6.3%). Preoperative hemoglobin (12.98 vs. 13.4, $p=0.000$), and eGFR (68.4 vs. 83.5, $p=0.000$) were significantly lower in group A, whereas creatinine was significantly higher in group A (1.08 vs. 0.94, $p=0.000$) (Table 1).

In comparison of operative variables, two groups were comparable for surgical access (transperitoneal or retroperitoneal), duration of surgery, blood loss, positive margin intraoperative transfusion and intraoperative complications. Conversion to radical was significantly higher in the older age group (2.4% vs. 0.9%, $p=0.010$) (Table 1). The postoperative complication rate was significantly higher in group older age group (12.5% vs. 7.8%, $p=0.001$). However, the rate of major (grade III/IV) complications was similar in the two groups (2.6% vs. 2%, $p=0.841$). Overall, major complications were noted in 52 of the patients. Among the patients with major complications, organ failure/ need for intensive care was required in 11 patients. Angioembolization was needed in 21 patients, 11 patients required Double J stenting for urine leak and rexploration was needed in 9 patients.The two groups showed no statistically significant difference for trifecta (71.5% vs. 71.1%, $p=0.860$).

Postmatching

Propensity matching was possible for 440 patients in either group. After propensity matching, the two groups were comparable for baseline characteristics such as BMI, tumor size, clinical symptoms, tumor side, face of tumor, solitary kidney and tumor complexity (Table 2). Among the perioperative outcome parameters there was no difference between the two groups for operative time, blood loss, intraoperative transfusion, intraoperative complications, need for radical nephrectomy, positive margins and trifecta rates. Warm ischemia time was significantly longer in the younger age group (18.1 min vs. 16.3 min, $p=0.003$). Perioperative complications were significantly higher in the older age group (11.8% vs. 7.7%, $p=0.041$). However, there was no difference between the two groups for major complications. On multivariate analysis, gender, tumor size and renal nephrometery score were identified as independent predictors of trifecta (Table 3).Standardized mean differenced and variance ratios for the continuous covariates postmatching have been provided in the supplementary table.

Subgroup analysis

Comparison of patients aged more than 80 years ($n=69$) and less than 80 years ($n=2324$) showed that the two groups were comparable for certain baseline characteristics such as tumor size, sex, clinical symptoms, tumor side, face of tumor, tumor location, solitary kidney and tumor complexity (Table 4). There was no difference between the two groups for operative time, blood loss, intraoperative transfusion, intraoperative complications, need for radical nephrectomy, positive margins and trifecta rates. Warm ischemia time was significantly longer in the younger age group (18 min vs. 14.2 min, $p=0.001$). Perioperative complications were significantly higher in the older age group (16% vs. 8.5%, $p=0.031$). However, there was no difference between the two groups for major complications (2.9% vs. 2.1%, $p=0.675$).

Discussion

In the present study, before matching the two age groups were comparable in sex, BMI and clinical tumor size. However, the two groups differed significantly for Charlson comorbidity index, solitary kidney rates and renal nephrometery scores. There was no difference in the two groups for operative time, intraoperative complications, need for blood transfusion and blood loss. Mean WIT was significantly longer in the younger age group (18.3 ± 9.26 vs. 16.2 ± 8.7, $p=0.000$). Mean WIT remained longer in the younger age group even after matching. Furthermore, the conversion to radical nephrectomy was significantly higher in the elderly age group. However, there was no difference between the two groups for conversion to radical nephrectomy after matching (2% vs. 1.1%, $p=0.281$). We noted significantly higher complications in group A (age ≥ 70 years) in the present study (before and after matching). However, this increased predilection was limited to the

Table 4 Comparison of baseline characteristics between the two age groups (Age ≥ 80 years and < 80 years)

Variable	Age ≥ 80 years (Group A) ($n = 69$)	Age < 80 years (Group B) ($n = 2324$)	p-value
Age (mean ± SD)	82.6 ± 2.1	56.8 ± 12.3	**< 0.0001**
Sex			
Male	45 (65.2%)	1529 (65.8%)	0.921
Female	24 (34.8%)	795 (34.2%)	
BMI (Kg/m^2)	27.0 ± 4.3	28.6 ± 6.0	**0.030**
Tumor size (mean ± SD) mm	37.7 ± 13.7	34.8 ± 16.8	0.158
Charlson comorbidity index	1.6 ± 1.5	1.2 ± 1.4	**0.023**
Clinical symptoms			
Asymptomatic	57 (82.6%)	1947 (83.8%)	
Local	11 (16%)	348(15%)	0.963
Systemic	1 (1.4%)	29 (1.2%)	
Single kidney	1 (1.4%)	59 (2.5%)	0.568
Tumor side			
Right	34 (49.2%)	1180 (50.7%)	0.806
Left	35 (50.7%)	1144 (49.3%)	
Face of tumor			
Anterior	40 (57.9%)	1251 (53.8%)	0.496
Posterior	29 (42%)	1073 (46.2%)	
Polar Location of Tumor			
Upper	15 (21.7%)	746 (32%)	
Mid	27 (39.1%)	876 (37.7%)	0.132
Lower	27 (39.1%)	702 (30.2%)	
Preoperative hemoglobin	12.6 ± 1.4	13.3 ± 1.7	**0.001**
Preoperative creatinine	1.1 ± 0.3	0.97 ± 0.3	**0.002**
Preoperative eGFR	64.7 ± 19.9	81 ± 24	**< 0.0001**
Renal Nephrometry Score (Mean ± SD)	6.88 ± 1.6	7.0 ± 1.8	0.483
RENAL complexity grouping			
Low	30 (43.4%)	927 (39.8%)	0.831
Intermediate	33 (47.8%)	1173 (50.4%)	
High	6 (8.7%)	224 (9.6%)	
Operative time (Mean ± SD)	174.7 ± 46	190.6 ± 66.5	0.180
Warm ischemia time (Mean ± SD)	14.2 ± 9.9	18.0 ± 9.1	**0.001**
Blood loss ml (Median with range)	100 (50–9650)	150 (50–1500)	0.163
Intraoperative transfusion	1 (1.4%)	72 (3%)	0.433
Intraoperative complications	5 (7.2%)	108 (4.6%)	0.316
Need for conversion to radical nephrectomy	2 (2.9%)	27 (1.1%)	0.194
Perioperative complications	11(16%)	198(8.5%)	**0.031**
Grade I	6 (8.7%)	99 (4.2%)	
Grade II	3 (4.3%)	49 (2.1%)	0.165
Grade III	1(1.4%)	40 (1.7%)	
Grade IV	1 (1.4%)	10 (0.4%)	
Major	2 (2.9%)	50 (2.1%)	0.675
Trifecta	49 (71%)	1656 (71.2%)	0.965
Positive margin	1 (1.4%)	65 (2.8%)	1.00

SD standard deviation, *BMI* body mass index, *eGFR* estimated glomerular filtration rate, *PCS* pelvicalyceal system

Bold values are statistically significant i.e. p-value < 0.05

minor complications (grade 1 and 2), with rates of major complications being the same between the two groups. Similar results were noted when we compared for subgroup analysis for patients with age greater and lesser than 80 years. Literature is divided on the complication rates following PN compared to RN. Some studies have reported similar [27–29] and others have reported increased [15, 17] complications in patients undergoing PN compared to RN irrespective of the age group. A similar predicament related to complication rates for PN compared to RN is noted in studies reporting outcomes specifically in the elderly population. Two studies have reported (Lowrance et al. [30] and Veccia et al. [12]) significantly higher complication rates for elderly patients who underwent PN compared to RN. However, An et al. [10] and Antonelli et al. [8] reported similar complications between RN and PN in their patient cohort.

Only a handful of studies have previously reported outcomes of PN in the elderly patient population [12, 18–20]. In their cohort of patients with a median age of 78 years, Ingels et al. reported rates of blood transfusion, trifecta, intraoperative complications and major complications of 14.7%, 45%, 9% and 6.2%, respectively [18]. In contrast, patients above ≥ 70 years in the present study had much higher trifecta rates (71.5%) with lower perioperative morbidity. However, it is to be pointed out that in the study by Ingels et al. different surgical modalities (open, laparoscopic and robotic) were employed and a robotic approach was predictive of lower complication rates [18]. In their cohort of elderly patients who underwent RAPN, Vartolomei et al. reported perioperative outcomes similar to the present study [20]. Authors reported median operative time, blood loss, warm ischemia time and length of stay of 180 min, 100 ml, 14.5 min, and 5 days respectively. Positive surgical margins, overall complications and trifecta outcomes were reported in 1.9%, 15.4% and 71.2% respectively [20]. Similar results were reported by Bindayi et al. in their study for PN in their cohort of elderly patients [19]. Veccia et al. compared RAPN to robotic RN in patients older than 65 years of age [12]. Authors reported positive surgical margin, overall complications, major complications and blood transfusion rates as 6%, 24%, 19% and 6%, respectively, in the RAPN group [12]. Superior rates of these perioperative outcomes were noted in the present study. Results of RAPN stated in the present study for the elderly group compare well for perioperative outcomes of the contemporary RAPN series [31–34].

Our study is not without limitations. First, due to the study's retrospective nature, the probability of a selection bias in patient inclusion is high. This is highlighted by the fact that elderly patients had lower complexity tumors in general, as compared to the matched cohort of younger patients. Propensity-matching between the two groups was performed to make two groups comparable for baseline factors. Furthermore, of the 3,801 patients, we included only 2393 patients with complete data in this study. This could be one of the major limitations of this study. Second, the VCQI database also lacks surgeon experience or center caseload data. Lastly, third, there is heterogeneity in surgical techniques, learning curves, and perioperative management of patients due to the broader reach of the VCQI database However, for precisely the same reasons, we believe that our study is closer to the 'real world scenario' of the outcomes of RAPN in elderly patients and may provide unique insights regarding the same.

Conclusion

Robot-assisted partial nephrectomy in well-selected elderly patients may be associated with comparable trifecta outcomes. However, the rates of overall perioperative complications were significantly higher in the elderly patient population.

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Author contributions All the authors were involved in data acquisition and manuscript editing. GS, MS, PA & GG were involved in conception, design, analysis, manuscript writing and editing. G.G was involved in supervision of the project.

Data availability statement Corresponding author had full access to data and same can be provided on request to genuine authors.

Declarations

Conflict of interest Ronney Abaza is a speaker for Intuitive surgical, Conmed Inc and VTI. Benjamin J Challacombe, Kris K Maes, Rajesh Ahlawat and Gagan Gautam are proctors for Intuitive surgical. Other authors report no conflict of interests.

Research involving human participants and/or animals This study is retrospective analysis of VCQI database and ethics approval was obtained from all the participating centers prior to data collection.

Informed consent Need for consent waived off by ethics committee.

References

1. Ljungberg B, Albiges L, Bedke J, Bex A, Capitanio U, Giles RH, et al (2021) members of EAU guidelines on Renal Cell Carcinoma 2021. https://uroweb.org/guideline/renal-cell-carcinoma/. Accessed 27 Feb 2022
2. Leppert JT, Mittakanti HR, Thomas IC, Lamberts RW, Sonn GA, Chung BI et al (2017) Contemporary use of partial nephrectomy: are older patients with impaired kidney function being left behind? Urology 100:65–71 (**Epub 2016/09/17**)

3. Tan HJ, Daskivich TJ, Shirk JD, Filson CP, Litwin MS, Hu JC (2017) Health status and use of partial nephrectomy in older adults with early-stage kidney cancer. Urol Oncol 35(153):e7–e14 (**Epub 2016/12/14**)
4. Mir MC, Derweesh I, Porpiglia F, Zargar H, Mottrie A, Autorino R (2017) Partial nephrectomy versus radical nephrectomy for clinical T1b and T2 renal tumors: a systematic review and meta-analysis of comparative studies. Eur Urol 71:606–617 (**Epub 2016/09/12**)
5. Ljungberg B, Albiges L, Abu-Ghanem Y, Bensalah K, Dabestani S, Fernandez-Pello S et al (2019) European Association of Urology Guidelines on Renal Cell Carcinoma: the 2019 Update. Eur Urol 75:799–810 (**Epub 2019/02/26**)
6. Woldrich JM, Palazzi K, Stroup SP, Sur RL, Parsons JK, Chang D et al (2013) Trends in the surgical management of localized renal masses: thermal ablation, partial and radical nephrectomy in the USA, 1998–2008. BJU Int 111:1261–1268 (**Epub 2013/03/09**)
7. Kim SP, Gross CP, Meropol N, Kutikov A, Smaldone MC, Shah ND et al (2017) National treatment trends among older patients with T1-localized renal cell carcinoma. Urol Oncol 35(113):e15–e21 (**Epub 2016/11/15**)
8. Antonelli A, Veccia A, Pavan N, Mir C, Breda A, Takagi T et al (2019) Outcomes of partial and radical nephrectomy in octogenarians—a multicenter international study (Resurge). Urology 129:139–145 (**Epub 2019/03/28**)
9. Chung JS, Son NH, Lee SE, Hong SK, Lee SC, Kwak C et al (2015) Overall survival and renal function after partial and radical nephrectomy among older patients with localised renal cell carcinoma: a propensity-matched multicentre study. Eur J Cancer 51:489–497 (**Epub 2015/01/13**)
10. An JY, Ball MW, Gorin MA, Hong JJ, Johnson MH, Pavlovich CP et al (2017) Partial vs radical nephrectomy for T1–T2 renal masses in the elderly: comparison of complications, renal function, and oncologic outcomes. Urology 100:151–157 (**Epub 2016/11/28**)
11. Ristau BT, Handorf EA, Cahn DB, Kutikov A, Uzzo RG, Smaldone MC (2018) Partial nephrectomy is not associated with an overall survival advantage over radical nephrectomy in elderly patients with stage Ib-II renal masses: an analysis of the national cancer data base. Cancer 124:3839–3848 (**Epub 2018/09/13**)
12. Veccia A, Dell'oglio P, Antonelli A, Minervini A, Simone G, Challacombe B et al (2020) Robotic partial nephrectomy versus radical nephrectomy in elderly patients with large renal masses. Minerva Urol Nefrol 72:99–108 (**Epub 2019/09/19**)
13. Sun M, Trinh QD, Bianchi M, Hansen J, Hanna N, Abdollah F et al (2012) A non-cancer-related survival benefit is associated with partial nephrectomy. Eur Urol 61:725–731 (**Epub 2011/12/17**)
14. Ficarra V, Bhayani S, Porter J, Buffi N, Lee R, Cestari A et al (2012) Predictors of warm ischemia time and perioperative complications in a multicenter, international series of robot-assisted partial nephrectomy. Eur Urol 61:395–402 (**Epub 2011/11/15**)
15. Van Poppel H, Da Pozzo L, Albrecht W, Matveev V, Bono A, Borkowski A et al (2011) A prospective, randomised EORTC intergroup phase 3 study comparing the oncologic outcome of elective nephron-sparing surgery and radical nephrectomy for low-stage renal cell carcinoma. Eur Urol 59:543–552 (**Epub 2010/12/28**)
16. Van Poppel H, Da Pozzo L, Albrecht W, Matveev V, Bono A, Borkowski A et al (2007) A prospective randomized EORTC intergroup phase 3 study comparing the complications of elective nephron-sparing surgery and radical nephrectomy for low-stage renal cell carcinoma. Eur Urol 51:1606–1615 (**Epub 2006/12/05**)
17. Lesage K, Joniau S, Fransis K, Van Poppel H (2007) Comparison between open partial and radical nephrectomy for renal tumours: perioperative outcome and health-related quality of life. Eur Urol 51:614–620 (**Epub 2006/11/14**)
18. Ingels A, Duc S, Bensalah K, Bigot P, Paparel P, Beauval JB et al (2021) Postoperative outcomes of elderly patients undergoing partial nephrectomy. Sci Rep 11:17201 (**Epub 2021/08/27**)
19. Bindayi A, Autorino R, Capitanio U, Pavan N, Mir MC, Antonelli A et al (2020) Trifecta outcomes of partial nephrectomy in patients over 75 years old: analysis of the REnal SURGery in elderly (RESURGE) Group. Eur Urol Focus 6:982–990 (**Epub 2019/02/26**)
20. Vartolomei MD, Matei DV, Renne G, Tringali VM, Crisan N, Musi G et al (2019) Long-term oncologic and functional outcomes after robot-assisted partial nephrectomy in elderly patients. Minerva Urol Nefrol 71:31–37 (**Epub 2018/09/20**)
21. Arora S, Abaza R, Adshead JM, Ahlawat RK, Challacombe BJ, Dasgupta P et al (2018) "Trifecta" outcomes of robot-assisted partial nephrectomy in solitary kidney: a Vattikuti Collective Quality Initiative (VCQI) database analysis. BJU Int 121:119–123 (**Epub 2017/07/28**)
22. Arora S, Bronkema C, Porter JR, Mottrie A, Dasgupta P, Challacombe B et al (2020) Omission of cortical renorrhaphy during robotic partial nephrectomy: a vattikuti collective quality initiative database analysis. Urology 146:125–132 (**Epub 2020/09/18**)
23. Arora S, Heulitt G, Menon M, Jeong W, Ahlawat RK, Capitanio U et al (2018) Retroperitoneal vs transperitoneal robot-assisted partial nephrectomy: comparison in a multi-institutional setting. Urology 120:131–137 (**Epub 2018/07/28**)
24. Sharma G, Shah M, Ahluwalia P, Dasgupta P, Challacombe BJ, Bhandari M et al (2022) Comparison of perioperative outcomes following transperitoneal versus retroperitoneal robot-assisted partial nephrectomy: a propensity-matched analysis of VCQI database. World J Urol 40(9):2283–2291
25. Dindo D, Demartines N, Clavien PA (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 (**Epub 2004/07/27**)
26. Khalifeh A, Autorino R, Hillyer SP, Laydner H, Eyraud R, Panumatrassamee K et al (2013) Comparative outcomes and assessment of trifecta in 500 robotic and laparoscopic partial nephrectomy cases: a single surgeon experience. J Urol 189:1236–1242 (**Epub 2012/10/20**)
27. Lau WK, Blute ML, Weaver AL, Torres VE, Zincke H (2000) Matched comparison of radical nephrectomy vs nephron-sparing surgery in patients with unilateral renal cell carcinoma and a normal contralateral kidney. Mayo Clin Proc 75:1236–1242 (**Epub 2000/12/29**)
28. Corman JM, Penson DF, Hur K, Khuri SF, Daley J, Henderson W et al (2000) Comparison of complications after radical and partial nephrectomy: results from the National Veterans Administration Surgical Quality Improvement Program. BJU Int 86:782–789 (**Epub 2000/11/09**)
29. Stephenson AJ, Hakimi AA, Snyder ME, Russo P (2004) Complications of radical and partial nephrectomy in a large contemporary cohort. J Urol 171:130–134 (**Epub 2003/12/11**)
30. Lowrance WT, Yee DS, Savage C, Cronin AM, O'Brien MF, Donat SM et al (2010) Complications after radical and partial nephrectomy as a function of age. J Urol 183:1725–1730 (**Epub 2010/03/20**)
31. Simhan J, Smaldone MC, Tsai KJ, Li T, Reyes JM, Canter D et al (2012) Perioperative outcomes of robotic and open partial nephrectomy for moderately and highly complex renal lesions. J Urol 187:2000–2004 (**Epub 2012/04/14**)
32. Dulabon LM, Kaouk JH, Haber GP, Berkman DS, Rogers CG, Petros F et al (2011) Multi-institutional analysis of robotic partial

nephrectomy for hilar versus nonhilar lesions in 446 consecutive cases. Eur Urol 59:325–330 (**Epub 2010/12/15**)

33. Scoll BJ, Uzzo RG, Chen DY, Boorjian SA, Kutikov A, Manley BJ et al (2010) Robot-assisted partial nephrectomy: a large single-institutional experience. Urology 75:1328–1334 (**Epub 2010/01/19**)
34. Patel MN, Krane LS, Bhandari A, Laungani RG, Shrivastava A, Siddiqui SA et al (2010) Robotic partial nephrectomy for renal tumors larger than 4 cm. Eur Urol 57:310–316 (**Epub 2009/12/01**)

Authors and Affiliations

Gopal Sharma[1] · Milap Shah[1] · Puneet Ahluwalia[1] · Prokar Dasgupta[2] · Benjamin J. Challacombe[3] · Mahendra Bhandari[4] · Rajesh Ahlawat[5] · Sudhir Rawal[6] · Nicolo M. Buffi[7] · Ananthakrishanan Sivaraman[8] · James R. Porter[9] · Craig Rogers[10] · Alexandre Mottrie[11] · Ronney Abaza[12] · Khoon Ho Rha[13] · Daniel Moon[14] · Thyavihally B. Yuvaraja[15] · Dipen J. Parekh[16] · Umberto Capitanio[17] · Kris K. Maes[18] · Francesco Porpiglia[19] · Levent Turkeri[20] · Gagan Gautam[1]

Gopal Sharma
gopal.26669192@gmail.com

Milap Shah
drmilapshah@gmail.com

Puneet Ahluwalia
puneet1923@gmail.com

Prokar Dasgupta
prokarurol@gmail.com

Benjamin J. Challacombe
ben.challacombe@gstt.nhs.uk

Mahendra Bhandari
Mahendra@vattikutifoundation.com

Rajesh Ahlawat
rajesh.ahlawat@gmail.com

Sudhir Rawal
sudirrawal85@gmail.com

Nicolo M. Buffi
buffi.nicolomaria@gmail.com

Ananthakrishanan Sivaraman
ananthsiv@gmail.com

James R. Porter
porter@swedishurology.com

Craig Rogers
crogers2@hfhs.org

Alexandre Mottrie
a.mottrie@telenet.be

Ronney Abaza
ronneyabaza@hotmail.com

Khoon Ho Rha
khrha@yuhs.ac.kr

Daniel Moon
drdanielmoon25@gmail.com

Thyavihally B. Yuvaraja
yuvaraja.tb@relianceada.com

Dipen J. Parekh
parekhd@med.miami.edu

Umberto Capitanio
capitanio.umberto@hsr.it

Kris K. Maes
kris.k.maes@gmail.com

Francesco Porpiglia
porpiglia@libero.it

Levent Turkeri
turkeri@marmara.edu.tr

[1] Department of Urologic Oncology, Max Institute of Cancer Care, Saket, New Delhi, India

[2] King's Health Partners, King's College, London, UK

[3] Guys and St Thomas' Hospital, London, UK

[4] Vattikuti Foundation, Detroit, MI, USA

[5] The Medicity Hospital, New Delhi, India

[6] Rajiv Gandhi Cancer Institute and Research Centre, New Delhi, India

[7] Humanitas Research Hospital, Rozzano, MI, Italy

[8] Chennai Urology and Robotics Institute, Chennai, India

[9] Swedish Medical Center, Seattle, WA, USA

[10] Henry Ford Hospital, Detroit, MI, USA

[11] ORSI Academy, Melle, Belgium

[12] Central Ohio Urology Group and Mount Carmel Health System Prostate Cancer Program, Columbus, OH, USA

[13] Yonsei University Health System, Seoul, South Korea

[14] Peter MacCallum Cancer Centre, Royal Melbourne Clinical School, University of Melbourne, Melbourne, Australia

[15] Kokilaben Dhirubhai Ambani Hospital, Mumbai, India

[16] University of Miami Health System, Miami, FL, USA

[17] Urological Research Institute (URI), IRCCS Ospedale San Raffaele, Milan, Italy

[18] Center for Robotic and Minimally Invasive Surgery, Hospital Da Luz, Luz Sáude, Portugal

[19] San Luigi Gonzaga Hospital of Orbassano, Turin, Italy

[20] Department of Urology, Altunizade Hospital, Acıbadem M.A., Aydınlar University, Istanbul, Turkey