

Operative outcomes of robotic partial nephrectomy

A report of the first 101 cases from a single center in Saudi Arabia

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ABSTRACT

الأهداف: اكتسب استئصال الكلية الجزئي بالروبوت شعبية في المراكز الكبرى في البلدان المتقدمة، مع نتائج ممتازة للمرضى. ومع ذلك، لا يوجد تقرير عن نتائج تلك الجراحة من الشرق الأوسط حتى الآن وهنا نقدم أول تقرير عن النتائج من مستشفى واحد في المملكة العربية السعودية.

الطريقة: راجعنا بأثر رجعي الحالات المتتالية للمرضى الذين يخضعون لاستئصال الكلية الجزئي بالروبوت في مؤسستنا في الفترة ما بين يناير 2008م ويناير 2018م. تشير الدراسة إلى معلومات عن المرضى، وخصائص الأورام، وتفصيل العملية الجراحية، والنتائج المحيطة بالجراحة باستخدام إحصائيات وصفية.

النتائج: خضع 101 مريض للجراحة خلال فترة الدراسة. كان حجم الورم الوسطي 3 (1.3-6.4) سم. كانت فقدان الدم 200 (5-1500) مللي لتر، ومدته نقص التروية الحار 17 (8-40) دقيقة، وقت العملية 166 (66-381) دقيقة، والتحويل إلى استئصال الكلية جزئي بالفتح الجراحي 9 (8.9%) من المرضى، والمضاعفات الكبرى في 3 (3%) من المرضى، هوامش جراحية إيجابية في 5 (5%) من المرضى، والإقامة في المستشفى 4 (2-14) يوم. تحقق فيما مجموعه 73 (73%) من المرضى الخلو من أي مضاعفات، وهوامش الجراحية السلبية، ومدته نقص التروية ≥ 25 دقيقة. تتضمن قيود الدراسة التصميم بأثر رجعي وحجم المجموعة الصغيرة.

الخاتمة: في هذه السلسلة، تشابهت التجربة الأولية لاستئصال الكلية الجزئي بالروبوت مع نتائج جراحية مماثلة لتلك التي ذكرتها مراكز عالميه كبرى.

Objectives: To report robotic partial nephrectomy (RPN) outcomes from a single tertiary hospital in Saudi Arabia.

Methods: We retrospectively reviewed consecutive cases of patients undergoing RPN at King Faisal Specialist Hospital and Research Center, Riyadh,

Kingdom of Saudi Arabia, between January 2008 and January 2018. The study reports patient's demographics, tumor characteristics, operative details, and perioperative outcomes, using descriptive statistics of median and range values.

Results: One hundred and one patients underwent RPN during the study period. Average tumor size was 3 (1.3-6.4) cm and average radius exophytic nearness anterior/posterior location (RENAL) score was 6 (4-10). Perioperative parameters were blood loss 200 (5-1500) ml and warm ischemia time 17 (8-40) minutes, excluding off-clamp surgery in 12 (11.9%); operative time was 166 (66-381) minutes. Conversion to open partial nephrectomy occurred in 9 (8.9%) patients, major complications in 3 (3%) patients, positive surgical margins in 5 (5%) patients, and the hospital stay was 4 (2-14) days. A total of 73 (73%) patients achieved a trifecta of freedom from any complication, negative surgical margins, and ischemia time ≤ 25 minutes. Study limitations included the retrospective design and small cohort size.

Conclusions: The initial experience of robotic partial nephrectomy was associated with a surgical outcome comparable to that reported by higher-volume centers.

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Robotic-assisted partial nephrectomy (RPN) has exhibited superiority to laparoscopic partial nephrectomy (LPN) for small renal tumors; thus, the recent trend in minimally invasive partial nephrectomy has shifted toward RPN.¹⁻³ Robotic-assisted partial nephrectomy embrace a brief learning curve and has advantages in all the parameters of warm ischemia time (WIT), conversion to open surgery, surgical margins, perioperative complications, change of renal function, and length of hospital stay (LOS).¹⁻⁴ We report the perioperative outcomes of RPN surgery in a single center in Saudi Arabia.

Methods. This is a retrospective study of the electronic records of patients who underwent RPN at King Faisal Specialist Hospital and Research Center, Riyadh, Kingdom of Saudi Arabia, between January 2008 and January 2018. The Institution Review Board approved the project. The study was conducted according to principles of Helsinki Declaration.

Inclusion criteria involved all patients who underwent RPN of any age, gender or indication. No exclusion criteria were applied.

Surgical technique. The Si robotic system (da Vinci® Surgical System, da Vinci® Si, USA) was used for all RPNs. A 3-arm or 4-arm robotic approach was used according to the surgeon's preference. The kidney was mobilized entirely outside Gerota's fascia, and the tumor with intact peri-renal fat was localized and scored using electrocautery and the adjacent kidney de-fatted. Intraoperative laparoscopic ultrasound was used in some of the recent cases. Sharp resection of the tumor was performed using robotic scissors. Sutured renorrhaphy was carried out in 2 stages: the bed of the resection was sutured in a running fashion, using monofilament absorbable sutures or self-locking barbed suture (V-Loc 90; Covidien, Mansfield, Massachusetts) according to the surgeon's preference, and then the partial nephrectomy defect was closed by interrupted monofilament suture. All cases were video-recorded for quality assurance and review if necessary. The reported parameters included patients' demographics; tumor characteristics, including size, location, radius exophytic nearness anterior/posterior location (RENAL) nephrometry score, stage, histopathology type, grade, and surgical margin; operative details,

including operative time, WIT, estimated blood loss (EBL); and postoperative outcomes, including day one serum creatinine, estimated glomerular filtration rate (eGFR) change, LOS, and complications. We used the Modification of Diet in Renal Disease Study Group equation (MDRD) to calculate eGFR.⁵ To assess the progress of learning of the surgeons, we divided the patients into 2 nearly equal chronological groups and compared their characteristics and perioperative outcomes. To review the literature, we conducted a PubMed search for citations up to December 2017 using the term "robotic partial nephrectomy" and restricted the output to "English Language and Human". We compared perioperative outcomes of publications that included a number of patients similar to our series.

We used the program SPSS version 20 (IBM Corporation, USA) for the statistical analysis. We utilized descriptive statistics reporting the median, standard deviation (SD), minimum and maximum values for continuous variables and numbers and percentages for categorical values. In subgroup analysis, we compared continuous variables with analysis of variance reporting mean and SD values and for categorical values, we utilized Fisher exact test. Significant results were reported if $p < 0.05$.

Results. A total of 101 consecutive patients underwent RPN (Table 1), between January 2008 and January 2018. Four urologists without prior experience in RPN performed 85 procedures (Figure 1). Patients were diagnosed with a small renal mass either incidentally ($n=72$; 71.3%) or due to symptoms (pain or hematuria; $n=29$; 28.7%). Clinical staging showed that 84 (84%) patients had a stage T1aN0M0 tumor, whereas 16 patients had a stage of T1bN0M0. Eighty tumors (79.2%) were solid and 20 (19.8%) were complex renal cysts. One patient had RPN for a non-functioning upper renal moiety.

Surgical outcomes of RPN are shown in Table 1. Four patients (4%) needed an intraoperative transfusion of a single unit of blood. Nine patients (8.9%) were converted to open partial nephrectomy because of bleeding or lack of progress in dissection. During RPN, 12 patients (11.9%) underwent no renal vascular clamping, whereas warm ischemia occurred in 89 patients (88.1%) by selective arterial clamping. Preoperatively, 96 (95%) patients had an eGFR value greater than 60 ml/min/1.77m²; postoperatively, none of these patients experienced a decrease in eGFR below 60 ml/min/1.77m². Of all patients; however, 16 (15.8%) experienced a decrease in eGFR of $\leq 15\%$.

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Table 1 - Patient's characteristics and global surgical outcome (N=101).

Characteristics	Number of patients (%)			
Gender				
Female	42 (41.6)			
Male	59 (58.4)			
Renal score^a				
Renal score 4–6	68 (67.3)			
Renal score ≥7	32 (31.7)			
Weight				
Normal or overweight	52 (51.5)			
Obese (BMI >30)	49 (48.5)			
Histopathology				
CRCC	57 (56.4)			
AML	8 (7.9)			
Oncocytoma	7 (6.9)			
Papillary carcinoma	14 (13.9)			
Chromophobe	10 (9.9)			
Other benign	5 (5.0)			
Positive surgical margin	5 (5.0)			
	Median	Min	Max	SD
Weight in (KG)	81.6	37.5	143.8	19
BMI	30	16.2	45.3	6
Age at diagnosis (years)	47.2	21	77.3	13.7
Size of lesion (Maximum diameter in cm)	3	1.3	6.4	1
Renal score ^a	6	4	10	1.7
Procedure time (minutes)	166	66	381	57.4
EBL (ml)	200	5	1500	213.4
WIT (minutes) [†]	17	8	40	6.1
Postoperative duration (days)	4.00	2	14	1.423
Preoperative creatinine (µmol/l)	76	38	148	22.2
1st postoperative creatinine (µmol/l)	81	42	178	24.5
Preoperative eGFR ml/m ²	93.5	45.0	180.5	24.3
Postoperative eGFR (ml/m ²)	88.7	34.8	166.4	23.7
Decrease in eGFR (ml/m ²)	4.3	-38.6	47.1	15.4
Decrease in eGFR %	5.9	-44.7	42.6	14.8

AML - angiomyolipoma, BMI - body mass index, CCRCC - clear cell renal cell carcinoma, EBL - estimated blood loss, eGFR - estimated glomerular filtration rate, WIT - warm ischemia time, *one patient had RPN for non-functioning upper moiety and is not included.
[†]12 of 89 patients had no vascular clamping.

Table 2 shows a comparison between patients without and with a decrease in eGFR of ≤15%. In patients who demonstrated the decrease, the only significant risk factors were a longer procedure time and the presence of a complication. This decrease occurred though there was a significantly better preoperative eGFR in those patients. Pathological examination of the tumors revealed 68 pT1a (68%), 8 pT1b (8%), 6 pT3a (6%), and 19 benign lesions (18.8%), including 8 angiomyolipomas (7.9%), 7 oncocytomas (6.9%), and 4 other lesions (4%). A positive surgical margin was documented in 5 cases (5%). One patient had a tumor rupture/spillage; this patient remained free of disease after 30 months.

Table 2 - Comparison between cases based on a postoperative decrease of eGFR ≥15%.

Variables	Decrease of eGFR ≥15%		P-value		
	No n (%)	Yes n (%)			
Gender					
Female	35 (35)	7 (7)	0.778		
Male	51 (50)	8 (8)			
Conversion to open					
No	80 (79)	12 (12)	0.129		
Yes	6 (6)	3 (3)			
Transfusion					
No	84 (83)	13 (13)	0.104		
Yes	2 (2)	2 (2)			
Off clamp technique					
No	77 (76)	12 (12)	0.380		
Yes	9 (9)	3 (3)			
Surgical margins					
Negative	81 (81)	14 (14)	1.000		
Positive	5 (5)	0 (0)			
Minor complication					
No	76 (75)	9 (9)	0.013		
Yes	10 (10)	6 (6)			
Major complication					
No	83 (82)	15 (15)	1.000		
Yes	3 (3)	0 (0)			
Any complication					
No	74 (73)	9 (9)	0.025		
Yes	12 (12)	6 (6)			
Trifecta achieved*					
No	65 (65)	8 (8)	0.194		
Yes	21 (21)	6 (6)			
Histopathology					
Benign	19 (19)	2 (2)	0.731		
Malignant	67 (66)	13 (13)			
	n	Mean±SD	n	Mean±SD	
BMI	86	30.5±5.9	15	28.3±6.1	0.192
Age at diagnosis (years)	86	49.1±13.7	15	46.5±13.8	0.507
Size of lesion (max diameter in cm)	86	3.0±1.1	15	3.3±1.0	0.303
Renal score [†]	86	5.7±1.7	14	6.5±1.6	0.102
Procedure time (minutes)	86	161.2±42.6	15	219.7±90.8	0.000
EBL (ml)	86	253.8±215.5	15	271.7±207.2	0.767
WIT (minutes) [‡]	77	17.4±5.6	12	18.7±8.8	0.512
Preoperative eGFR ml/m ²	86	93.9±22.3	15	109.1±31.1	0.025
Postoperative eGFR (ml/m ²)	86	92.7±23.3	15	80.9±24.2	0.075
Decrease in eGFR (ml/m ²)	86	1.2±11.9	15	28.1±13.0	0.000
Decrease in eGFR %	86	0.8±12.4	15	25.4±8.9	0.000

BMI - body mass index, EBL - estimated blood loss, eGFR - estimated glomerular filtration rate, WIT - warm ischemia time, *Trifecta - freedom of any complication, negative surgical margin and ischemia time ≤25 min.
[†]one patient had robotic partial nephrectomy (RPN) for non-functioning upper moiety and is not included. [‡]12 of 89 patients had no vascular clamping

Table 3 shows a comparison between patients without and with a PSM. The only significant difference was a higher mean age in the PSM group. Postoperatively, minor complications (Clavien-Dindo grade I-II) were encountered in 16 (15.8%) patients. Only 3

Table 3 - A comparison between cases with positive and negative surgical margins.

Variables	Surgical margins		P-value		
	Negative n (%)	Positive n (%)			
Gender			0.646		
Female	40 (40)	1 (1)			
Male	55 (55)	4 (4)	1.000		
Conversion to open					
No	86 (86)	5 (5)	1.000		
Yes	9 (9)	0 (0)			
Transfusion			0.449		
No	91 (91)	5 (5)			
Yes	4 (4)	0 (0)			
Off clamp technique					
No	85 (85)	4 (4)			
Yes	10 (10)	1 (1)			
Minor complication					
No	80 (80)	4 (4)	1.000		
Yes	15 (15)	1 (1)			
Major complication					
No	92 (92)	5 (5)	1.000		
Yes	3 (3)	0 (0)			
Any complication					
No	78 (78)	4 (4)	1.000		
Yes	17 (17)	1 (1)			
Histopathology					
Benign	20 (20)	0 (0)	0.580		
Malignant	75 (75)	5 (5)			
Variables	n	Mean±SD	n	Mean±SD	
BMI	95	30.3±5.9	5	30.7±5.1	0.900
Age at diagnosis (years)	95	48.2±13.5	5	61.2±10.4	0.038
Size of lesion (max diameter in cm)	95	3.0±1.1	5	3.6±0.5	0.250
Renal score [†]	95	5.8±1.7	5	5.4±1.3	0.568
Procedure time (minutes)	95	169.2±54.7	5	151.0±30.4	0.464
EBL (ml)	95	257.9±215.1	5	250.0±217.9	0.936
WIT (minutes) [†]	85	17.6±6.2	4	17.0±4.2	0.846
Preoperative eGFR (ml/m ²)	95	96.6±23.9	5	76.2±9.4	0.061
Postoperative eGFR (ml/m ²)	95	91.8±24.0	5	72.2±5.4	0.071
Decrease in eGFR (ml/m ²)	95	4.8±15.3	5	4.0±6.0	0.909
Decrease in eGFR %	95	4.2±14.9	5	4.6±8.0	0.951

BMI - body mass index, EBL - estimated blood loss, eGFR - estimated glomerular filtration rate, WIT - warm ischemia time, *one patient had RPN for nonfunctioning upper moiety and is not included.
[†]12/89 patients had no vascular clamping

Table 4 - Comparison between first 50 cases and subsequent 51 cases.

Variables	Cases 1-50 n (%)	Cases 51-101 n (%)	P-value		
Gender					
Female	20 (19.8)	22 (21.8)	0.841		
Male	30 (29.7)	29 (28.7)			
Conversion to open					
No	46 (45.5)	46 (45.5)	1.000		
Yes	4 (4.0)	5 (5.0)			
Transfusion					
No	50 (49.5)	47 (46.5)	0.118		
Yes	0 (0.0)	4 (4.0)			
Off clamp technique					
No	44 (43.6)	45 (44.6)	1.000		
Yes	6 (5.9)	6 (5.9)			
Surgical margins					
Negative	47 (47.0)	48 (48.0)	1.000		
Positive	3 (3.0)	2 (2.0)			
Minor complication					
No	42 (41.6)	43 (42.6)	1.000		
Yes	8 (7.9)	8 (7.9)			
Major complication					
No	48 (47.5)	50 (49.5)	0.617		
Yes	2 (2.0)	1 (1.0)			
Any complication					
No	41 (40.6)	42 (41.6)	1.000		
Yes	9 (8.9)	9 (8.9)			
Trifecta achieved*					
No	37 (37.0)	36 (36.0)	1.000		
Yes	13 (13.0)	14 (14.0)			
Histopathology					
Benign	8 (7.9)	13 (12.9)	0.327		
Malignant	42 (41.6)	38 (37.6)			
	n	Mean±SD	n	Mean±SD	
BMI	50	30.1±5.9	51	30.3±6.1	0.820
Age at diagnosis (years)	50	48.0±13.5	51	49.3±14.0	0.627
Size of lesion (max diameter in cm)	50	2.9±1.0	51	3.2±1.1	0.116
Renal score [†]	50	5.9±1.7	50	5.8±1.6	0.723
Procedure time (minutes)	50	151.2±48.7	51	188.3±57.0	0.001
EBL (ml)	50	225.1±148.1	51	287.3±260.0	0.144
WIT (minutes) [‡]	44	17.1±5.1	45	18.1±7.0	0.433
Preoperative eGFR (ml/m ²)	50	94.7±24.2	51	97.6±24.4	0.544
Postoperative eGFR (ml/m ²)	50	94.8±24.2	51	87.2±22.7	0.104
Decrease in eGFR (ml/m ²)	50	-0.2±14.7	51	10.4±14.3	0.000
Decrease in eGFR %	50	-1.3±14.9	51	10.1±12.5	0.000

BMI - body mass index, EBL - estimated blood loss, eGFR - estimated glomerular filtration rate, WIT - warm ischemia time, *Trifecta - freedom of any complication, negative surgical margin and ischemia time ≤25 min.
[†]One patient had RPN for nonfunctioning upper moiety and is not included. [‡]n = 89, 12 patients had no vascular clamping.

Table 5 - Tumor characteristics: Comparison of current series with others reporting ≥100 patients.

Study	Centers (n)	Years	Patient number	Tumor category	Tumor size (cm)		Renal score	
					Mean ± SD	Median (range)	Mean ± SD	Median (range)
Benway et al ⁶	Multicenter (3)	2004 - 2008	129		2.9			
Scoll et al ⁷	Single institution	2007 - 2009	100			2.8 (1-8)	6.8 ± 1.7*	7 (4-10) [†]
Kaouk et al ⁸	Single institution	2006 - 2011	400		3.17 ± 1.64		7.2 ± 2	
Tanagho et al ⁹	Multicenter (5)	2007 - 2011	886		3 ± 1.6		6.9 ± 2	
Ficarra et al ¹⁰	Multicenter (4)	2008 - 2010	200			2.8 (1.9-3.5)		
Minervini et al ¹¹	Multicenter (6)	2010 - 2011	105		2.8 ± 1.5			7 (6-7) [†]
Oh et al ¹²	Single surgeon	2003 - 2013	100		2.52 ± 1.26	(0.90-6.00)		7 (6-9)
Kim et al ¹³	Multicenter (5)	2003 - 2011	195		2.35 ± 1.16			
Lista et al ¹⁴	Multicenter (3)	2006 - 2012	339			2.7(1-7)		8 (6-13) [†]
Maddox et al ¹⁵	Single institution	2008 - 2013	241	T1b-T3		5 (4.1-5.2)	7.1 ± 2.2	
Zargar et al ¹	Multiple (5)	2004 - 2013	1185			2.3 (1.3)		7 (3)
Abdel Raheem et al ¹⁶	Single surgeon	2006 - 2015	295					
			72	PADUA ≤7		2 (1.5-2.7)		
			102	PADUA 8-9		2.9 (1.8-3.9)		
			121	PADUA ≥10		4.1 (2.9-5.3)		
Janda et al ¹⁷	Single institution	2008 - 2014	232					
			168	T1a		2.6 (2.0-3.1) [‡]	6.9 ± 2.01	
			64	T1b		4.8 (4.5-5.6) [‡]	8.2 ± 1.62	
Peyronnet et al ¹⁸	Multicenter (6)	2006 - 2014	937		3.3 ± 0.6		6.8 ± 0.1	
Potretzke et al ¹⁹	Single institution	2007 - 2014	286		2.8 ± 1.4		7.4 ± 1.9	
Xie et al ²⁰	Single surgeon	2013 - 2014	144		3.1 ± 2.0		6.7 ± 2.0	
Han et al ²¹	Single institution	2011 - 2014	147		2.58 ± 1.13		6.58 ± 1.80	
Luciani et al ²²	Single surgeon	2012 - 2016	110			3.5 (2.5-4.8)		
Maurice et al ²³	Single center	2011 - 2015	301	T1a		2.7 (2.0-3.3)		7 (5-8)
			114	T1b		5.0 (4.4-5.7)		9 (7-10)
Moskowitz et al ²⁴	Multicenter (4)	2008 - 2015	1139			3.0 (2.1-4.0)		7.0 (6.0-9.0)
Paulucci et al ²⁵	Multicenter (4)	2008 - 2016	960 [§]			3 (2.1-4)		7 (6-9)
Veeratterapillay et al ²⁶	Multicenter (4)	2012 - 2015	250		3.1 ± 1		6.1 ± 2	
Current study	Single center	2008 - 2018	101	T1a-T1b	3.1 ± 1	3(1.3-6.4)	5.8 ± 1.7	6 (4-10)

*PADUA score, †Calculated from data, ‡Pathologic tumor size, §Beyond learning curve. For each surgeon the initial 50 cases were excluded, and inclusion was capped at 300 consecutive patients.

(3%) patients had a complication grade ≥III, Clavien-Dindo classification. One had an arteriovenous fistula requiring embolization 3 weeks postoperatively, one had a diaphragmatic injury requiring intraoperative repair, and one patient developed atrial fibrillation requiring intensive care admission. A total of 73 (73%) patients achieved a trifecta of freedom from any complication, negative surgical margins, and ischemia time ≤25 min. The outcomes of WIT, EBL, conversion to open and trifecta achievement were not different between the first and subsequent 50 patients (Table 4). Significantly longer operative time and more decrease in eGFR were found in the latter group.

Discussion. This initial experience of RPN in one Middle Eastern country demonstrates outcomes comparable to Western series reporting on at least

100 RPN (Tables 5-7).^{1,6-26} Our initial 101 cases had a slightly lower median renal score of 6 and a mean score of 5.8 compared to 22 studies reporting a median renal score between 7 and 9 and a mean score ranging between 6 and 8.2. This tendency to select less complex renal masses for RPN reflects the initial experience of our surgeons embarking on the procedure. Tumor size, however, in the current series was comparable to other studies. The median tumor size in the current series was 3 cm and the mean was 3.1 cm compared to a range of median size of 2 to 5 cm and mean of 2.4 to 3.3 cm reported in other studies. The smallest tumor in the current series was 1.3 cm in diameter, whereas in other studies the smallest reported tumor was 0.9 cm. Remarkably, operative and postoperative parameters gauging the surgeons' skills in performing RPN was on par with those reporting larger series

Table 6 - Comparison of current series with others reporting ≥100 patients.

Study	OR time (min)		WIT (min)		Unclamped n (%)	EBL (mL)	
	Mean ± SD	Median (range)	Mean ± SD	Median (range)		Mean (SD)	Median (range)
Benway et al ⁶	189		19.7			155	
Scoll et al ⁷	206	203 (85-369)	25.5	25.5 (0-53)	12 (12.0)	127	50 (50-800)
Kaouk et al ⁸	190.3 ± 57		19.2 ± 10.7		36 (9.0)	260	
Tanagho et al ⁹	183.6 ± 60.4		18.8 ± 9		66 (7.5)	181 (208.9)	100 (100-250)*
Ficarra et al ¹⁰		120 (90-157)		18 (14-23)	20 (10.0)		100 (50-150)
Minervini et al ¹¹	168 ± 56		18.2 ± 7		40 (38.0)	125 (128)	
Oh et al ¹²	182.89 ± 83.98		21.86 ± 9.3			212.04 (160.8)	
Kim et al ¹³		135 (110-170)	23.82 ± 12.0		Excluded		200 (100-300)
Lista et al ¹⁴	141.7 ± 130	130 (60-350)	17.8	17 (7-51)	0	136.6	100 (30-1600)
Maddox et al ¹⁵		183 (156-220)		20.5 (17-25)			200 (100-300)
Zargar et al ¹	168 ± 68			18 (9)			100 (125)
Abdel Raheem et al ¹⁶		149 (107-180)		23 (18-27)	26 (36.1)		200 (100-332)
		163 (128-196)		24 (18-30)	20 (19.6)		275 (130-563)
		164 (119-219)		26 (22-32)	5 (4.2)		360 (200-550)
Janda et al ¹⁷		179 (153-210)		21 (16-26)	9 (5.0)		100 (75-250)
		210 (182-237)		23 (19-31)	0 (0)		200 (100-325)
Peyronnet et al ¹⁸	153.2 ± 2		15.7 ± 0.3		61 (6.6)	275.1 (13)	
Potretzke et al ¹⁹	154.8 ± 49.4		19.8 ± 8.7		(25.3)	179.7 (229.1)	
Xie et al ²⁰	118.7 ± 34.4		17.9 ± 6.4			86.5 (87.5)	
Han et al ²¹	162.3 ± 32.2		24.7 ± 7.3				
Luciani et al ²²		200 (120-385)		22 (0-45)			150 (0-900)
Maurice et al ²³				17 (13-23)			
				26 (20-30)			
Moskowitz et al ²⁴		183.0 (151.0-224.0)		15.0 (11.0-20.0)			100.0 (50.0-150.0)
Paulucci et al ²⁵		179 (150-220)		16 (12.5-21)	94 (10.4)		100 (50-150)
Veeratterapillay et al ²⁶	141 ± 38†		16.7 ± 8			205 (145)	
Current study	170.4 ± 57.4	166 (66-381)	17.6 ± 6.1	17 (8-40)	12 (11.9)	256.5 (213.4)	200 (5-1500)

EBL - estimated blood loss, WIT - warm ischemia time, *Interquartile range, † Console time

beyond the learning curve. The median WIT in the current series was 17 minutes and the mean was 17.6 in comparison to other studies with a median range of WIT of 15-26 minutes and a mean range of 15.7-25.5 minutes. The off-clamp RPN constituted 11.9% of the current series compared to a range of 0-38% reported by others. The operative time, EBL, and LOS were comparable to other reported series. The current series had 5% positive surgical margin (PSM) compared to a range of 0-9.9% reported by others. Except for older age, we found no significant risk factor associated with PSM. Any complication was reported only in 3% of cases. This favorable outcome is among the lowest reported by other series, ranging between 0.4% and 39%. The development of a complication or the longer procedure time were risk factors for a decrease of eGFR ≤15% even in face of a higher preoperative eGFR. We did not factor in the analysis risk factors for decreased eGFR such as diabetes, hypertension, dyslipidemia or nephrotoxic medications. As these risk factors likely contributed to the preoperative eGFR, we think that

for the purpose of a short-term perioperative analysis of eGFR change as a surrogate for quality of surgery, our conclusions are accurate. To evaluate the impact of RPN on renal function in the long term, these risk factors among other confounders of the renal functional reserve are worthwhile to study. The current series reported the highest trifecta, 73%, in comparison to the 5 studies reporting a trifecta outcome ranging between 37.5% and 72.2%. On a different note, the conversion rate to open surgery was the second most common in all studies reviewed. Conversion to open partial nephrectomy in the current series was 8.9%, and no case was converted to nephrectomy. In comparison, other series reported conversion to open nephrectomy, either to partial or total, in 0-11.7%.

Although the number of patients who underwent RPN was relatively small per surgeon and spanning a long period compared to higher-volume centers, the results indicate that the number of surgeries needed to gain the cumulative learning experience is small. Comparison of the first 50 cases with the subsequent

Table 7 - Postoperative outcome: Comparison of current series with others reporting ≥100 patients.

Study	LOS (days)		PSM n (%)	Conv. OPN n (%)	Comp. n (%)	Trifecta* n (%)
	Mean (SD)	Median (range)				
Benway et al ⁶	2.4		5 (3.9)	2 (3.3)	11 (18.3)	
Scoll et al ⁷	3.2	3 (1-7)	5 (5.7)	2 (2.0)	11 (11.0)	
Kaouk et al ⁸	3.6		9 (2.3)	6 (1.5)	61 (15.3)	
Tanagho et al ⁹				7 (11.7)	139 (13.0)	
Ficarra et al ¹⁰	6 (5-6)		9/158 (5.7)		28/200 (14.0)	
Minervini et al ¹¹		5 (4-6)	6 (5.7)	1 (1.0)	1 (1.0)†	
Oh et al ¹²	5.4 (1.8)		0 (0.0)		10 (10.0)	
Kim et al ¹³			3 (1.5)	Excluded		
Lista et al ¹⁴			22 (6.5)	3 (0.9)	49 (14.5)	
Maddox et al ¹⁵			3 (6.8)		1 (0.4)	
Zargar et al ¹			38 (3.2)	2 (0.2)‡	192 (16.2)	829 (70.0)
Abdel Raheem et al ¹⁶		5 (4-5)	3 (4.1)	0‡	7 (9.7)	47 (65.3)
		5 (5-7)	6 (5.8)	1 (1.0)‡	26 (25.5)	58 (56.9)
		5 (5-8)	12 (9.9)	7 (5.9)‡	26 (21.5)	45 (37.5)
Janda et al ¹⁷		1.7 (0.86)	10 (6.0)	5 (3.0)	61 (36.0)	
		2.2 (2.51)	4 (6.0)	0 (0)	25 (39.0)	
Peyronnet et al ¹⁸	4.7 (0.2)		48 (5.2)		168 (17.9)	
Potretzke et al ¹⁹	2.2 (1.1)		(6.0)		(9.9)	
Xie et al ²⁰	6.3 (2.1)		2 (1.4)		14 (9.7)	90 (62.5)§
Han et al ²¹	5.3 (1.4)				5 (3.4)	
Luciani et al ²²		6 (4-22)	7 (6.3)		8 (7.3)†	
Maurice et al ²³			12 (4.1)		19 (6.3)†	199 (66.1)
			7 (6.2)		4 (3.5)†	46 (40.4)
Moskowitz et al ²⁴		1.0 (1.0-2.0)	50 (5.2)		130 (11.3)	
Paulucci et al ²⁵		1 (1-2)	30 (4)		115 (12.0)	484 (72.2)
Veeratterapillay et al ²⁶			(7.3)	5 (2.0)	(16.4)	
Current study	3.8 (1.4)	4 (2-14)	5 (5)**	9 (8.9)	3 (3.0)†	73 (73.0)

Comp. - complications, Conv. - conversions, LOS - length of stay, PSM - positive surgical margin, *Trifecta was defined as (i) freedom from any complication, (ii) negative surgical margins, and (iii) ischemia time ≤25 min (including cold or warm ischemia), †Major complication: grade ≥3 Clavien-Dindo complications, ‡Conversion to radical nephrectomy, §MIC score (1) the surgical margins are negative, (2) warm ischemia time (WIT) is < 20 min, and (3) no major complications occur (grades 3-4 according to the Clavien-Dindo classification), **One patient with RPN for nonfunctioning upper renal moiety was excluded from the calculation.

surgeries showed no significant difference in the WIT, EBL, complication rate, conversion to open surgery, PSM or achievement of a trifecta benchmark all of which indicate no appreciable change in the quality of surgery over the protracted period. Admittedly the duration of surgery increased, and this may have contributed more significant decrease in post-operative eGFR. The longer duration of surgery might be due to a more difficult surgery beyond the actual time and skill spent to excise the tumor from the kidney. Different factors contributed to the favorable outcome of the current series. The first factor was that all surgeons had prior experience with laparoscopic partial nephrectomy and robotic nephrectomy. These findings on the transition from laparoscopic to robotic partial nephrectomy are similar to other reports from single surgeon series at

high-volume centers.²⁷ Second, 2 experienced surgeons teamed up in a single case. We believe it is important for outcomes of RPN to be reported from various parts of the world, thus attesting to the generalizability of the robotic technique as well as bringing the benefits of robotic technology to Middle Eastern patients. Study limitations include the retrospective design and small cohort size. Future studies from our region may include long-term functional and oncological outcomes of RPN.

In conclusions, our initial experience of robotic partial nephrectomy is associated with a surgical outcome comparable to that reported by higher volume centers. The favorable outcome reflects that the number of surgeries needed to gain the cumulative learning experience is small, even with a protracted course of time.

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