Is surgeon intuition equivalent to models of operative complexity in determining the surgical approach for nephron sparing surgery?

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ABSTRACT

Introduction: The choice of approach for partial nephrectomy often depends on surgical complexity. We aimed to determine if surgeon intuition was equivalent to markers of operative complexity, such as RENAL nephrometry and Mayo adhesive probability (MAP) score, in determining the surgical approach for partial nephrectomy (PN).

Materials and Methods: We retrospectively identified 119 masses removed for suspected renal cell carcinoma from January 2012 to September 2014 by a single surgeon who intuitively chose treatment with one of three surgical approaches: Open PN (OPN), robotic-assisted transperitoneal PN (RATPN), or robotic-assisted retroperitoneal PN (RARPN). Clinicodemographic characteristics, pathological features, and postoperative outcomes were compared for each approach. Logistic regression was performed to identify independent predictors of open surgical resection, our primary endpoint.

Results: Fifty-four tumors (45%) were resected via OPN, 40 (34%) via RATPN, and 25 (21%) via RARPN. OPN was performed in patients with more comorbidities ($P = 0.02$), lower baseline renal function ($P < 0.01$), more solitary kidneys ($P < 0.01$), and more multifocal disease ($P < 0.01$). Patients undergoing OPN had higher median nephrometry scores compared to RATPN and RARPN patients (8 vs. 7 vs. 7, respectively; $P = 0.03$), but MAP scores were no different among all three groups ($P = 0.36$). On multivariate analysis, higher nephrometry scores (odds ratio: 1.41, 95% confidence interval: 1.10–1.81; $P = 0.007$) were independently associated with open surgical resection. Nephrometry score was predictive of OPN (area under curve = 0.64, $P = 0.01$) with a score of 6.5 having the highest sensitivity and specificity (76% and 42%, respectively).

Conclusions: RENAL nephrometry score was associated with surgical approach intuitively chosen by an experienced surgeon, but the presence of adherent perinephric fat did not correlate with decision-making.

Key words: Intuition, Mayo adhesive probability score, nephrometry score, partial nephrectomy, robotic surgery, surgical approach

INTRODUCTION

Nephron-sparing surgery has become the preferred treatment approach for clinical T1 and certain T2 renal masses suspicious for malignancy.[1] This is especially true in imperative scenarios such as with solitary kidneys, bilateral renal masses, or in the presence of chronic kidney disease.[2]

The use of minimally-invasive surgery, with either a robotic-assisted or laparoscopic approach, has been established as an appropriate treatment alternative to open surgery for partial nephrectomy (PN).[3] Robotic-assisted retroperitoneal PN (RARPN) has also evolved as an option for posterior renal masses or in patients with prior abdominal

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surgery.[4] open PN (OPN), however, still may play a role in the resection of larger, more complex, endophytic lesions, especially in centrally located, hilar tumors which pose a greater risk of vascular complications.[5,6]

The RENAL nephrometry score is a standardized prognostic nomogram that quantifies renal tumor size, location, and depth as a measure of tumor complexity in patients undergoing PN.[7] It can predict postoperative complications and affect surgical decision-making as well as the desired treatment approach.[8,9] The presence of thick, adherent, "sticky" fat can also affect the ease of perinephric fat dissection, which can guide preoperative surgical planning and potentially the surgical approach offered to patients.[10] The Mayo adhesive probability (MAP) score was developed as an accurate image-based scoring system to predict adherent perinephric fat (APF) in patients undergoing PN.[11]

In this study, we determined whether indices of operative complexity, such as the RENAL nephrometry and MAP score, were equivalent to a surgeon's intuition in determining treatment approach for PN by measuring their predictive ability to correlate with open surgical resection as the desired approach for an experienced surgeon.

MATERIALS AND METHODS

Patients and data source

Our study population consisted of 119 renal masses removed for presumed renal cell carcinoma (RCC) from January 2012 to September 2014 by a single surgeon. PN was performed with one of three surgical approaches: (1) OPN, (2) robotic-assisted transperitoneal PN (RATPN), or (3) RARPN, which was chosen based on the surgeon's intuition without any predetermined scoring parameters. Our surgeon had completed over 200 OPNs, 55 laparoscopic PNs, and 75 robotic-assisted PNs prior to the study period, which is well beyond the reported learning curve of about 25 cases.[12,13] RATPN was adopted for posterior tumors beginning in 2012, so this time point was chosen as the study start date. There were no conversions to radical nephrectomy during the study period or conversions from one surgical approach to another.

Patients were identified in an Institutional Review Board-approved departmental database, which includes all demographic information, clinical data, and postoperative follow-up on patients that undergo PN at our institution. Follow-up was maintained through electronic health records and our center's tumor registry, which tracks patients' follow-up at other medical facilities.

RENAL nephrometry and Mayo adhesive probability scoring

The RENAL nephrometry score and MAP score were calculated retrospectively for each renal lesion using techniques described by Kutikov and Uzzo and Davidiuk *et al*., respectively.[7,11] A multifocal renal mass was defined as more than one suspicious lesion on the ipsilateral kidney that was resected during the same operative procedure. For multifocal renal masses, the tumor with the largest size was assigned and analyzed. Since bilateral renal masses were resected in a staged, stepwise fashion at our institution, each lesion was evaluated individually as a separate event with their own nephrometry and MAP score. A small subset of patients also had salvage PN after failed cryoablation, but these tumors were scored similarly to primary lesions.

Study variables and measures

Study variables included patient demographics (age, sex, and race), body mass index (BMI in kg/m^2), American Society of Anesthesiologists (ASA) score, and age-adjusted Charlson comorbidity index (CCI). BMI was based on the patient's height and weight at the time of surgery, ASA score was determined by the anesthesiologist's assessment of the patient before surgery, and CCI was based on the patient's past medical history. Preoperative creatinine levels were also obtained from solitary measurements drawn 1–2 weeks prior to surgery, which were used to estimate the glomerular filtration rate (eGFR in mL/min/1.73 m^2) based on the modification of diet in renal disease study equation.[14]

Disease-specific characteristics included tumor size on final pathology, tumor histology, Fuhrman nuclear grade, pathologic tumor classification, and final margin status for both benign (angiomyolipoma or oncocytoma) and malignant histology. Frozen section for margin assessment was not utilized for any RATPN and RARPN cases and only a small proportion of OPN cases. All slides and hematoxylin and eosin stains from every PN performed during the study period were reviewed by our institution's pathologists with expertise in genitourinary malignancies. Preoperative image-guided biopsies were not routinely recommended in patients considered to be candidates for PN. Staging was assigned according to the 2010 American Joint Committee on Cancer system.

Intraoperative factors abstracted included the surgical approach, operative time (in minutes [min]), warm or cold ischemia time (in min), estimated blood loss (in cc), and use of an intraoperative blood transfusion. Operative time included port placement, console time, and skin closure for robotic-assisted procedures. Cold ischemia was rarely utilized for OPN and was not utilized for either RATPN or RARPN.

Short-term postoperative outcomes included the length of stay (LOS in days), presence of complications within 60 days of surgery, change in eGFR during the 6–8 weeks postoperative period, and presence of a recurrence during available follow-up. LOS was defined from the date of surgery until date of initial discharge, and complications were captured via review of the patient's postoperative course (i.e., discharge summary) and subsequent clinic visits up to 60 days following PN. The Clavien–Dindo scoring system was used to categorize 60-day complications. Patients with multiple complications during the postoperative period were assigned the one with the highest grade, and high-grade complications were defined as Clavien > IIIa.

Follow-up after PN was performed with a postoperative physical examination (PE) every 6 months for 2 years, a baseline computed tomography or magnetic resonance imaging scan within 3–12 months of surgery, and annual PEs and surveillance imaging performed thereafter for 3–5 years if the initial postoperative workup was negative. This was similar for patients with a positive surgical margin on either frozen or permanent section. Disease recurrence was defined as clinical evidence of renewed malignancy on PE or cross-sectional imaging after a cancer-free period of at least 3 months, and the site of disease recurrence was categorized as local (kidney, retroperitoneal lymph nodes), or distant (adrenal gland, lungs, bones, liver, etc.).

Statistical analysis

Continuous variables were reported as medians and interquartile ranges (IQRs), and categorical variables were reported as frequency counts and percentages. Clinicodemographic, pathologic, and postoperative characteristics were compared for renal masses treated with OPN versus RATPN versus RARPN. The Kruskal–Wallis test was used to determine any difference in medians, and the Chi-square test was used for proportions.

Variables found to be different among all three groups ($P < 0.1$) in addition to RENAL nephrometry and MAP score were placed in a multivariate model. Logistic regression was used to identify independent predictors of open surgical resection as the desired treatment approach intuitively chosen by our surgeon, which was the primary endpoint. Solitary kidney, multifocal renal mass, and prior cryoablation were not included as variables even though they were statistically different among all three groups because no events occurred in the robotic cohort.

Receiver operating characteristic curves of RENAL nephrometry and MAP score with the occurrence of OPN were also plotted. Optimal cut-off points were determined visually by minimizing the Euclidean distance between the curve and upper left corner of the graph (point [0, 1]) and by the Youden index, which maximizes the vertical distance from the curve to the line of equality thereby maximizing the sum of sensitivity and specificity.

Statistical analyses were performed with the Statistical Package for the Social Sciences software package version 21.0 (IBM Corporation, Armonk, NY, USA). All tests were two-sided with a $P < 0.05$ considered as statistically significant.

RESULTS

The clinicodemographic characteristics of our study population are listed in Table 1. Patients who underwent OPN had more medical comorbidities (median CCI: 6.5 vs. 6.0 vs. 5.0; $P = 0.02$) and lower baseline renal function (median eGFR: 68 vs. 90 vs. 84; $P < 0.01$) than RATPN or RARPN patients. OPN was also performed in more solitary kidneys (20 vs. 0 vs. 0%; $P < 0.01$) and for more multifocal renal masses (18 vs. 0 vs. 0%; $P < 0.01$). In addition, RARPN was performed for more posteriorly-located renal lesions than OPN or RATPN (100 vs. 54 vs. 8%; $P < 0.01$).

The intraoperative, postoperative, and pathological features of our study population are listed in Table 2. OPN was associated with a shorter operative time (160 vs. 248 vs. 224 min; $P < 0.01$), more intraoperative blood loss (250 vs. 150 vs. 100 cc; $P < 0.01$), and a longer postoperative LOS (5 vs. 3 vs. 3 days; $P < 0.01$) than RATPN or RARPN. Median warm ischemia time was shorter during OPN (20 vs. 30 vs. 27 min; $P < 0.01$) with four renal masses resected off-clamp compared to one in the robotic group. Although a larger percentage of OPN patients experienced a postoperative complication within 60 days (52 vs. 43 vs. 16%), this difference did not reach statistical significance ($P = 0.06$). In addition, the type of postoperative 60-day complications was similar across all groups [Table 3].

Median follow-up in the study population was 12 months (IQR: 3–20) with three recurrences, all occurring in patients who had an OPN. Median time to recurrence was 15 months (IQR: 6–17) with one recurrence developing locally in the kidney (at nonresection site in patient with a negative margin), and two occurring distantly in lungs and bone of the left iliac crest, respectively. There were no perioperative deaths or deaths due to disease.

The operative complexity of our study population is listed in Table 1. Renal masses removed via OPN had a higher median nephrometry score than those removed via RATPN or RARPN (8 vs. 7 vs. 7; $P = 0.03$). This was secondary to larger median tumor size (3.5 vs. 3.0 vs. 2.3 cm; $P < 0.01$) and more tumors with >50% endophytic components (54 vs. 27 vs. 36%; $P = 0.03$). The median nephrometry score of renal masses, however, was similar in the setting of one versus two kidneys (7 vs. 7, $P = 0.65$), unilateral versus bilateral disease (7 vs. 7, $P = 0.82$), unifocal versus multifocal disease (7 vs. 8.5, $P = 0.27$), and in the presence or absence of prior cryoablation (7 vs. 7, $P = 0.23$). In addition, nephrometry score did not differ in the presence or absence of RCC (8 vs. 7, $P = 0.10$) and was not gender-specific (male vs. female: 7 vs. 7, $P = 0.89$).

The median MAP score of renal masses, on the other hand, was similar regardless of surgical approach (2 vs.

Table 1: Clinicodemographic characteristics

Variable	Open (*n*=54)	Robotic-assisted		*P*
		Transperitoneal (*n*=40)	Retroperitoneal (*n*=25)	
Median age, years (IQR)	64 (57-72)	64 (58-71)	56 (50-70)	0.06
Sex, *n* (%)				
Male	32 (59)	27 (67)	16 (64)	0.71
Female	22 (41)	13 (33)	9 (36)	
Race, *n* (%)				
White	44 (82)	36 (90)	24 (96)	0.16
Nonwhite	10 (18)	4 (10)	1 (4)	
Median BMI, kg/m^2 (IQR)	31 (26-37)	29 (26-32)	31 (27-34)	0.32
ASA score, *n* (%)				
2	24 (44)	28 (70)	14 (56)	0.05
3 or 4	30 (56)	12 (30)	11 (44)	
CCI, *n* (%)				
2-5	21 (39)	18 (45)	18 (72)	0.02
>6	33 (61)	22 (55)	7 (28)	
Median preoperative eGFR, mL/min/1.73 m^2 (IQR)	68 (54-88)	90 (77-99)	84 (77-102)	<0.01
Solitary kidney, *n* (%)	11 (20)	0 (0)	0 (0)	<0.01
Bilateral renal mass, *n* (%)	12 (22)	2 (5)	3 (12)	0.06
Multifocal renal mass, *n* (%)	10 (18)	0 (0)	0 (0)	<0.01
Prior cryoablation, *n* (%)	4 (7)	0 (0)	0 (0)	0.08
Side, *n* (%)				
Right	29 (54)	21 (53)	13 (52)	>0.99
Left	25 (46)	19 (47)	12 (48)	
Location, *n* (%)				
Anterior	19 (35)	22 (55)	0 (0)	<0.01
Posterior	29 (54)	3 (8)	25 (100)	
Lateral	6 (11)	15 (37)	0 (0)	
Mass >50% endophytic, *n* (%)	29 (54)	11 (27)	9 (36)	0.03
Hilar location, *n* (%)	7 (13)	7 (17)	6 (24)	0.47
Median nephrometry score (IQR)	8 (7-9)	7 (6-8)	7 (5-8)	0.03
Median MAP score (IQR)	2 (1-4)	2 (0-3)	1 (0-3)	0.36

IQR=Interquartile range, MAP=Mayo adhesive probability, eGFR=Estimate the glomerular filtration rate, CCI=Charlson comorbidity index, MAP=Mayo adhesive probability, ASA=American Society of Anesthesiologists, BMI=Body mass index

2 vs. 1; $P = 0.36$) [Table 1]. The median MAP score of tumors was also similar in the setting of one versus two kidneys (2 vs. 2, $P = 0.65$) and with unilateral versus bilateral disease (2 vs. 3, $P = 0.08$) but differed in tumors with unifocal versus multifocal disease (2 vs. 3.5, $P = 0.026$) and in the presence or absence of prior cryoablation (4.5 vs. 2, $P = 0.004$). In addition, MAP score was no different in the presence or absence of RCC (2 vs. 1, $P = 0.31$) but was gender-specific (male vs. female: 3 vs. 0, $P < 0.01$).

On multivariate analysis, a higher nephrometry score (odds ratio [OR]: 1.41, 95% confidence interval [CI]: 1.10–1.81; $P = 0.007$) and a lower baseline renal function (OR: 0.98, 95% CI: 0.96–0.996; $P = 0.022$) were both independently associated with OPN as the surgical approach intuitively chosen by our experienced surgeon [Table 4]. Nephrometry score was a stronger predictor of OPN than MAP score (area under curve [AUC] = 0.64 vs. 0.57) with 6.5 having the highest sensitivity and specificity (76% and 42%, respectively) [Figure 1].

DISCUSSION

Although the RENAL nephrometry and MAP score are useful tools in quantifying renal tumor complexity in patients undergoing PN, their clinical utility in an experienced surgeon's practice may be limited. Review of a patient's preoperative imaging in the eyes of an experienced surgeon may inherently measure these factors, which can play a role in determining the desired surgical approach to PN.

Table 2: Intraoperative and postoperative features

Variable	Open (*n*=54)	Robotic-assisted		*P*
		Transperitoneal (*n*=40)	Retroperitoneal (*n*=25)	
Median operative time, min (IQR)	160 (135-183)	248 (224-282)	224 (205-255)	<0.01
Median ischemia time, min (IQR)				
Warm (*n*=116)	20 (13-22)	30 (26-35)	27 (23-34)	<0.01
Cold (*n*=3)	50 (43-53)	-	-	
Median EBL, cc (IQR)	250 (175-500)	150 (125-300)	100 (50-250)	<0.01
Intraoperative blood transfusion, *n* (%)	5 (9)	5 (12)	0 (0)	0.20
Median tumor size, cm (IQR)	3.5 (2.1-4.5)	3.0 (2.0-3.7)	2.3 (1.7-2.5)	<0.01
Pathology, *n* (%)				
Benign (AML or oncocytoma)	6 (11)	6 (15)	7 (28)	0.45
Clear cell RCC	32 (59)	22 (55)	12 (48)	
Nonclear cell RCC	16 (30)	12 (30)	6 (24)	
Fuhrman grade, *n* (%)				
None	7 (13)	6 (15)	7 (28)	0.24
1 or 2	31 (57)	17 (42)	9 (36)	
3 or 4	16 (30)	17 (43)	9 (36)	
Positive margins, *n* (%)	1 (2)	1 (2)	1 (4)	0.85
Tumor stage, *n* (%)				
None	7 (13)	6 (15)	7 (28)	0.04
T1a	29 (54)	26 (65)	17 (68)	
T1b–T2b	18 (33)	8 (20)	1 (4)	
Median LOS, days (IQR)	5 (4-5)	3 (3-4)	3 (2-3)	<0.01
Complications (60-day), *n* (%)				
None	26 (48)	23 (57)	21 (84)	0.06
I or II	21 (39)	12 (30)	3 (12)	
IIIa-IV	7 (13)	5 (13)	1 (4)	
Median eGFR change, mL/min/1.73 m^2 (IQR)	6 (0-16)	10 (0-20)	10 (0-16)	0.66
Recurrence, *n* (%)	3 (6)	0 (0)	0 (0)	
Local	1 (2)	-	-	0.16
Distant	2 (4)	-	-	

eGFR=Estimate the glomerular filtration rate, IQR=Interquartile range, LOS=Length of stay, RCC=Renal cell carcinoma, AML=Angiomyolipoma, EBL=Estimated blood loss

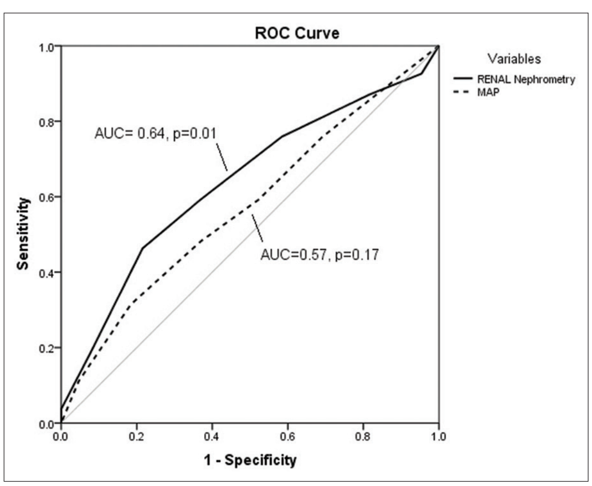

Figure 1: RENAL nephrometry and Mayo adhesive probability score as a predictor of open partial nephrectomy

Whether these scores correlate with the approach for PN intuitively chosen by a surgeon and more importantly, whether they need to be calculated by an experienced surgeon prior to definitive surgical resection is debatable. We hypothesized that open surgical resection was utilized for tumors deemed to be more complex according to the RENAL nephrometry score and with a higher risk of APF calculated by the MAP score.

Increasing tumor complexity (measured with the nephrometry score) was associated with an open surgical approach for PN intuitively chosen by our experienced surgeon for patients in this study, but the likelihood of APF during dissection (measured with MAP score) did not appear to correlate with decision-making. The question as to whether these prognostic models need to be calculated

Table 3: Postoperative 60-day complications

Complication type	Open (*n*=42*)	Robotic-assisted		Total (*n*=65*)
		Transperitoneal (*n*=18*)	Retroperitoneal (*n*=5*)	
Cardiovascular, *n* (%)				
Acute myocardial infarction	0	1	1	2
Anemia	4	4	0	8
Atrial/ventricular arrythmia	0	0	1	1
Congestive heart failure	2	0	0	2
Deep vein thrombosis	1	0	0	1
Total	7 (17)	5 (28)	2 (40)	14 (22)
Gastrointestinal, *n* (%)				
Gastroesophageal reflux	1	0	0	1
Ileus	2	1	0	3
Total	3 (7)	1 (6)	0 (0)	4 (6)
Genitourinary, *n* (%)				
Hematuria	3	0	0	3
Renal artery pseudoanuerysm	5	1	0	6
Urinary retention	1	3	1	5
Urinoma	2	1	1	4
Total	11 (26)	5 (28)	2 (40)	18 (28)
Infectious, *n* (%)				
Urinary tract infection	4	3	1	8
Wound infection	5	0	0	5
Intraabdominal abscess	1	0	0	1
Clostridium difficile	1	0	0	1
Pneumonia	2	1	0	3
Fungal skin rash	2	1	0	3
Total	15 (36)	5 (28)	1 (20)	21 (32)
Pulmonary, *n* (%)				
COPD exacerbation	1	2	0	3
Respiratory failure	1	0	0	1
Total	2 (5)	2 (11)	0 (0)	4 (6)
Renal, *n* (%)				
ARF/dehydration	3	0	0	3
ESRD-dialysis	1	0	0	1
Total	4 (10)	0 (0)	0 (0)	4 (6)

*Total complications > patient number secondary to multiple complications in some patients. COPD=Chronic obstructive pulmonary disease, ESRD=End-stage renal disease, ARF=Acute renal failure

before surgery or if an experienced surgeon intuitively makes this differentiation with routine clinical judgment is one that should be raised since RENAL nephrometry and MAP scores were not calculated prospectively in this study. No differences in high-grade complications were noted between patient groups based on surgical approach, supporting the possibility that operative risk was intuitively determined and decision-making adjusted based on risk assessment according to the primary tumor characteristics (more so than the perinephric characteristics).

A physician's intuition has been analyzed in the past with respect to patient outcomes. Using a visual analog scale, the accuracy of a surgeon's prediction of perioperative complications was measured.[15] Clinical assessment of operative risk by the surgeon independently improved the prediction of postoperative complications, obviating the need for sophisticated preoperative prognostic models. Similarly in this study, since there was no difference in perioperative outcomes (i.e., 60-day complications, change in renal function) or oncological control (positive margins, recurrence rate) across all surgery types, it suggests that

Table 4: Predictors of open partial nephrectomy

Variable	Multivariable			
	OR	95% CI		*P*
		Lower	Upper	
Age, years	0.99	0.95	1.04	0.77
ASA=3 or 4 (reference: ASA=2)	1.74	0.66	4.59	0.26
Age-adjusted CCI □6 (reference: CCI □5)	1.30	0.36	4.65	0.69
Preoperative eGFR, mL/min/1.73 m^2	0.98	0.96	0.996	0.022
Bilateral renal mass (reference: None)	3.18	0.90	11.32	0.074
Nephrometry score	1.41	1.10	1.81	0.007
MAP score	1.04	0.81	1.34	0.75

OR=Odds ratio, CI=Confidence interval, eGFR=Estimate the glomerular filtration rate, CCI=Charlson comorbidity index, MAP=Mayo adhesive probability, ASA=American Society of Anesthesiologists

experienced clinicians intuitively measure operative risk during routine assessment of tumor characteristics on imaging, obviating the need for complex scoring systems.

There are limitations to this study. Since RENAL nephrometry and MAP score are image-based modalities, there may be subjectivity and interobserver variability in their measurements. We have previously reported, however, good interobserver reliability with the RENAL nephrometry scoring system with a concordance rate of 94%, 76%, 66%, 80%, and 54% for the R, E, N, A, and L components, respectively, when evaluated independently by three separate surgeons.[16] Such a study using the MAP scoring system has yet to be done. In addition, we have applied these indices to patients retrospectively, but prospective comparisons are necessary in the future to evaluate surgical safety and complications.

This study also represents a single-institutional, single-surgeon experience with limited, short-term follow-up due to the study population's contemporary nature. We did not include patients evaluated as a second opinion or those who chose observation, percutaneous ablation, or radical nephrectomy. Comparisons between types of complications among surgical approaches were also limited due to small numbers and an underpowered sample size. Finally, change in eGFR at 6–8 weeks postoperatively may not be representative of a true decline in renal function, and we did not perform split function assessment routinely with nuclear imaging pre- and post-procedure for more accurate representation.

Although there was a significant bias toward RARPN in the treatment of posteriorly-located renal masses ($P < 0.01$), we believed the adoption of a retroperitoneal technique in 2012 for posterior tumors would reduce location as a selection bias toward choosing an open surgical approach. Some surgeons, however, feel that all renal tumors (regardless of location) can be approached transperitoneal with mobilization and "flipping" of the kidney when necessary.[17] In addition, there was a selection bias toward OPN for multifocal renal masses, tumors in solitary kidneys, and for patients undergoing salvage PN followed failed cryoablation. Even when excluding these patients ($n = 25$), the median nephrometry score still differed between OPN versus RATPN versus RARPN patients (8 vs. 7 vs. 7, $P = 0.02$), whereas median MAP score did not (2 vs. 2 vs. 2, $P = 0.93$). A higher nephrometry score was also still independently associated with an open surgical approach in our multivariate model (OR: 1.59, 95% CI: 1.16–2.17; $P = 0.004$), and the AUC of nephrometry score as a predictor of OPN improved to 0.69 ($P = 0.004$) with a score of 6.5 having a sensitivity of 84% and specificity of 42%. Despite our selection bias, robotic-assisted PN has been shown to be a feasible treatment option with low surgical morbidity, reliable preservation of renal function, and early oncologic safety for suspicious renal masses in patients with a solitary kidney and for ipsilateral multifocal disease.[18,19]

The RENAL nephrometry and MAP score may still serve as useful standardized tools in research-based settings when presenting and analyzing patient outcomes in comparison to other known reports. Interestingly, median nephrometry and MAP score did not differ in this study in the presence or absence of RCC. This is in contrast to prior reports showing more benign histology associated with a lower RENAL nephrometry score and more pathologic upstaging of T1 lesions associated with a higher RENAL nephrometry score although our study is limited by a smaller sample size.[20,21] Median MAP score was also significantly different between males and females in our study population consistent with prior literature by Bylund *et al.* who showed that 94% of patients with perinephric "sticky" fat were men compared to only 54% of controls without "sticky" fat ($P < 0.05$).[22] There also may be some utility in calculating the risk of APF preoperatively since it has been shown to be associated with longer robotic operative times in a recent prospective study.[23]

CONCLUSIONS

The RENAL nephrometry and MAP score are research-based tools that measure and report on operative complexity in patients undergoing PN. We demonstrated that nephrometry score is associated with an open surgical approach for PN intuitively chosen by an experienced surgeon in clinical practice. The usefulness of these prognostic models, therefore, may be somewhat diminished since this differentiation can often be made based on a surgeon's judgment.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Motzer RJ, Agarwal N, Beard C, Bolger GB, Boston B, Carducci MA, *et al.* NCCN clinical practice guidelines in oncology: Kidney cancer. J Natl Compr Canc Netw 2009;7:618-30.
2. Campbell SC, Novick AC, Belldegrun A, Blute ML, Chow GK, Derweesh IH, *et al.* Guideline for management of the clinical T1 renal mass. J Urol 2009;182:1271-9.
3. Choi JE, You JH, Kim DK, Rha KH, Lee SH. Comparison of perioperative outcomes between robotic and laparoscopic partial nephrectomy: A systematic review and meta-analysis. Eur Urol 2015;67:891-901.
4. Hu JC, Treat E, Filson CP, McLaren I, Xiong S, Stepanian S, *et al.* Technique and outcomes of robot-assisted retroperitoneoscopic partial nephrectomy: A multicenter study. Eur Urol 2014;66:542-9.
5. Chan DY, Marshall FF. Partial nephrectomy for centrally located tumors. Urology 1999;54:1088-91.
6. Frank I, Colombo JR Jr., Rubinstein M, Desai M, Kaouk J, Gill IS. Laparoscopic partial nephrectomy for centrally located renal tumors. J Urol 2006;175(3 Pt 1):849-52.
7. Kutikov A, Uzzo RG. The R.E.N.A.L. nephrometry score: A comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 2009;182:844-53.
8. Hayn MH, Schwaab T, Underwood W, Kim HL. RENAL nephrometry score predicts surgical outcomes of laparoscopic partial nephrectomy. BJU Int 2011;108:876-81.
9. Waldert M, Klatte T. Nephrometry scoring systems for surgical decision-making in nephron-sparing surgery. Curr Opin Urol 2014;24:437-40.
10. Zheng Y, Espiritu P, Hakky T, Jutras K, Spiess PE. Predicting ease of perinephric fat dissection at time of open partial nephrectomy using preoperative fat density characteristics. BJU Int 2014;114:872-80.
11. Davidiuk AJ, Parker AS, Thomas CS, Leibovich BC, Castle EP, Heckman MG, *et al.* Mayo adhesive probability score: An accurate image-based scoring system to predict adherent perinephric fat in partial nephrectomy. Eur Urol 2014;66:1165-71.
12. Haseebuddin M, Benway BM, Cabello JM, Bhayani SB. Robot-assisted partial nephrectomy: Evaluation of learning curve for an experienced renal surgeon. J Endourol 2010;24:57-61.
13. Pierorazio PM, Patel HD, Feng T, Yohannan J, Hyams ES, Allaf ME. Robotic-assisted versus traditional laparoscopic partial nephrectomy: Comparison of outcomes and evaluation of learning curve. Urology 2011;78:813-9.
14. Hougardy JM, Delanaye P, Le Moine A, Nortier J. Estimation of the glomerular filtration rate in 2014 by tests and equations: Strengths and weaknesses. Rev Med Brux 2014;35:250-7.
15. Woodfield JC, Pettigrew RA, Plank LD, Landmann M, van Rij AM. Accuracy of the surgeons' clinical prediction of perioperative complications using a visual analog scale. World J Surg 2007;31:1912-20.
16. Kolla SB, Spiess PE, Sexton WJ. Interobserver reliability of the RENAL nephrometry scoring system. Urology 2011;78:592-4.
17. Wang L, Lee BR. Robotic partial nephrectomy: Current technique and outcomes. Int J Urol 2013;20:848-59.
18. Boris R, Proano M, Linehan WM, Pinto PA, Bratslavsky G. Initial experience with robot assisted partial nephrectomy for multiple renal masses. J Urol 2009;182:1280-6.
19. Hillyer SP, Bhayani SB, Allaf ME, Rogers CG, Stifelman MD, Tanagho Y, *et al.* Robotic partial nephrectomy for solitary kidney: A multi-institutional analysis. Urology 2013;81:93-7.
20. Satasivam P, Sengupta S, Rajarubendra N, Chia PH, Munshey A, Bolton D. Renal lesions with low R.E.N.A.L nephrometry score are associated with more indolent renal cell carcinomas (RCCs) or benign histology: Findings in an Australian cohort. BJU Int 2012;109 Suppl 3:44-7.
21. Tay MH, Thamboo TP, Wu FM, Zhaojin C, Choo TB, Ramaan L, *et al.* High R.E.N.A.L. Nephrometry scores are associated with pathologic upstaging of clinical T1 renal-cell carcinomas in radical nephrectomy specimens: Implications for nephron-sparing surgery. J Endourol 2014;28:1138-42.
22. Bylund JR, Qiong H, Crispen PL, Venkatesh R, Strup SE. Association of clinical and radiographic features with perinephric "sticky" fat. J Endourol 2013;27:370-3.
23. Davidiuk AJ, Parker AS, Thomas CS, Heckman MG, Custer K, Thiel DD. Prospective evaluation of the association of adherent perinephric fat with perioperative outcomes of robotic-assisted partial nephrectomy. Urology 2015;85:836-42.