Original Article

RENAL nephrometry score: Predicting perioperative outcomes following open partial nephrectomy

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Abstract

Background: Partial nephrectomy has emerged as a standard treatment for small renal masses offering oncologic control equivalent to radical nephrectomy, with preservation of renal function and evidence for equivalent survival. In this study, we evaluated RENAL nephrometry score (RNS) in predicting perioperative outcomes in patients with partial nephrectomy.

Materials and Methods: This was a prospective observational study conducted from February 2016 to August 2017 which included patients who underwent partial nephrectomy. The patients were divided into three groups depending on the complexity scores (low, moderate, and high). Tumors were assigned RNS and tumor-node-metastasis staging of the clinically malignant tumors was done. Blood loss, warm ischemia time (WIT), and surgical complications were assessed.

Results: A total of 20 patients underwent open partial nephrectomy during the study. There were 4 (20%) low, 11 (55%) moderate, and 5 (25%) high-complexity lesions. Blood loss was significantly different in three groups. All the cases in high-complexity group were performed with clamping the renal vessels with a mean WIT of 29 min. The overall complication rates were significantly different between the groups ($P = 0.007$); however, majority of the complications were low grade (Grades I and II) and were managed conservatively.

Conclusion: In the present study, RNS was correlated with predicting surgical access route, need for clamping during partial nephrectomy, blood loss, decrease in glomerular filtration rate of operated kidneys, postoperative complications, and tumor grade.

Keywords: Partial nephrectomy, perioperative outcomes, RENAL nephrometry score

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INTRODUCTION

Renal cell carcinoma (RCC) is most fatal of all urologic cancers and surgery is still the only curative therapeutic approach. Total nephrectomy was the traditional surgical approach because it removes the kidney in totality with whole tumor mass and most patients have another good kidney. However, in the late 1970s, nephron-sparing surgery (NSS) was introduced which to preserve healthy kidney tissue. Partial nephrectomy preserves healthy kidney tissue but had the possibility of relapse. Successive research demonstrated that partial nephrectomy has almost similar survival rate in patients with initial tumor stage to that of radical nephrectomy.[1,2] In 2002, the upper limit for resectable tumors was set at 4 cm in diameter (Stage T1a).[3] However, recent studies have shown that the acceptable limit is 7 cm (Stage T1) and in some cases

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even 10 cm (Stage T2).[4] During the last decade, partial nephrectomy has emerged as a standard treatment for small renal masses offering oncologic control equivalent to radical nephrectomy with preservation of renal function and evidence for equivalent survival. The size of resectable tumors has increased over the years, showing that the boundaries of NSS are constantly being pushed forward.

Due to the myriad treatment options available to the patient and treating urologist in case of renal mass, clinical decision-making is overly subjective and is based on numerous often subjective factors including competing health risks (real or perceived), the interpreted tumor anatomy, physician experience/comfort, and patient preference/perceptions of the ease/efficacy of various treatment modalities. Various anatomy-based nephrometry scores have been assigned from preoperative imaging and delineate renal mass characteristics and the relationship to adjacent structures. Use of standardized objective and reproducible measures minimizes interobserver variability.

RENAL nephrometry score (RNS) was developed by Kutikov and Uzzo[5] to standardize the assessment of anatomical features of renal tumor. The scoring system is based on the five most reproducible features that characterize the anatomy of a solid renal mass:

- R: Radius-scores tumor size as maximal diameter
- E: Exophytic/endophytic properties of the tumor
- N: Nearness of the deepest portion of the tumor to the collecting system or renal sinus
- A: Anterior (a)/posterior (p) descriptor
- L: Location relative to the polar line.

Polar lines are defined as the plane of the kidney above or below which the medial lip of parenchyma is interrupted by the renal sinus fat, vessels, or the collecting system on axial imaging. All components except for the (A) descriptor are scored on a 1-, 2-, or 3-point scale. The (A) describes the principal mass location to the coronal plane of the kidney. The suffix "x" is assigned to the tumor if an anterior or posterior designation is not possible. An additional suffix "h" is used to designate a hilar location of the tumor (abutting the main renal artery or vein).

Nephrometry scores help urologists with the possible technical difficulty during partial nephrectomy for a given mass and have been correlated with ischemia time, operation time, blood loss, complications, and the likelihood of conversion from partial nephrectomy to radical nephrectomy. Therefore, nephrometry scores serve as a mean to objectify the salient anatomic features, compare outcomes, and develop metrics for treatment decision-making.

MATERIALS AND METHODS

This was a prospective nonrandomized observational study conducted at tertiary care center in India from February 2016 to August 2017 (18-months period). The study included patients who underwent partial nephrectomy for clinically malignant tumor (up to stage T2N0M0), benign renal masses necessitating removal due to symptoms such as persistent pain or complications such as hematuria and recurrent infection, and complex cystic lesions (Bosniak Grades III and IV). Patients with clinical stage more than T2, metastatic renal tumors and those not willing for NSS for the fear of residual renal tumors were excluded from the study.

Detailed patient history and demographic variables (including patient age, gender, body mass index [BMI], risk factors affecting progressive renal functions [diabetes, hypertension, and cardiovascular disease (CVD)], and preexisting renal disease) and biochemical and radiological investigations were recorded. Tumors were assigned RNS, and tumor-node-metastasis staging of the clinically malignant tumors was done. Preoperative and postoperative (at 3 months) diethylenetriamine pentacetic acid scans were done to compare the change in glomerular filtration rate (GFR) of individual kidneys and total GFR.

Patients were divided into three groups depending on the complexity scores (low complexity [score 4–6], moderate complexity [score 7–9], and high complexity [10 or more]) and taken up for partial nephrectomy. Assessment of operative variables such as blood loss, warm ischemia time (WIT), and surgical complications was performed. Oncological data included tumor histology and grade, pathological T stage, surgical resection margins, and local/distant recurrence.

Surgical technique

The techniques employed to perform partial nephrectomy included polar nephrectomy, heminephrectomy, mid-segmental partial nephrectomy, and wedge resection. Pelvicalyceal system (PCS) was intubated with a ureteric catheter to look for intraoperative opening of the PCS. Tumor was approached either through retroperitoneal flank approach or transperitoneal approach. After dissection of the renal hilum, the renal vessels were looped and when required the vessels were clamped. Not all cases were done with vessel clamping. The extent of the tumor was assessed intraoperatively with palpation and corroborated with the preoperative imaging. Electrocautery was used

to score the resection margin. Electrocautery was used to deepen the scored resection line, and the tumor was excised with adequate margin of normal renal parenchyma with sharp and blunt dissection using a tenotomy scissors and Penfield neurological spatula. Smaller intrarenal vessels were controlled with electrocautery, whereas larger intrarenal vessels were controlled with pediatric hemostats and ligated with a 4–0 polyglactin suture. Tumors were not subjected to the frozen section. Methylene blue was injected through ureteric catheter to evaluate the integrity of the collecting system. If the PCS got opened, it was closed with polyglactin 4.0 suture. A bolster of Surgicel® (Ethicon Inc., Somerville, NJ, USA) was anchored to the cut surface with the help of two or three hemostatic sutures. The abdominal drain was kept and the ureteric catheter, if given, was removed in the evening of operation [Figure 1].

Statistical analysis

The statistical analysis was performed using SPSS IBM software, version 21.0 (IBM, Chicago, IL, USA). Descriptive analysis was presented using mean, standard deviation, and range. Comparison between two groups was done with independent sample *t*-test; ANOVA test was utilized in more than two groups. The Chi-square test was used for categorical variables. Statistical significance was kept at 0.05 levels, and confidence interval was set at 95%.

RESULTS

A total of 20 patients (males, n = 12; females, n = 8) underwent open partial nephrectomy during the study. There were 4 (20%) low, 11 (55%) moderate, and 5 (25%) high-complexity lesions, with a mean size of tumors in the low, moderate, and high-complexity group being 3.03, 6.18, and 9.16 cm, respectively ($P < 0.0001$) [Table 1]. One of the female patients was 22 weeks' pregnant with a right-sided renal mass, whose biopsy came as a histopathological surprise as Wilms' tumor of favorable histology. There was no statistically significant difference between patient's mean age according to gender (males, 50.75 years; females, 41.74 years; $P = 0.096$) or according to different complexity groups ($P = 0.503$). The majority of patients in our study had

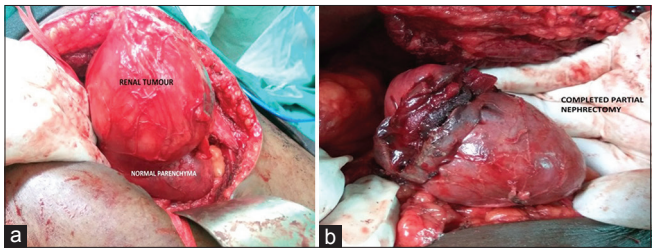

Figure 1: (a) Pre- and (b) postoperative image of partial nephrectomy of left-sided renal tumor

normal BMI (55%) with rest being either preobese (15%) or obese (30%). As the majority of patients in our study were from middle or lower socioeconomic class, they did not seek medical attention till symptoms occurred and resultant tumors of larger size and complexity. Abdominal pain was the most common symptom either alone or in combination with fever and hematuria. All except one of the tumors in our study were unilateral and majority of the tumors (14/19 [73.68%]) were right sided. The majority of patients in the moderate-complexity group (7/11 [63.64%]) had risk factors for progressive renal disease such as hypertension, diabetes mellitus, and CVD.

All cases of low-complexity group and majority of cases in moderate complexity, the hilum was approached through a retroperitoneal flank approach. In right-sided upper polar and all high-complexity tumors, the hilum was approached through a transperitoneal approach because it provided more working space for the right-sided upper polar tumors and better vessel control for the high-complexity tumors. All the cases in high-complexity group were done with clamping the renal vessels with a mean WIT of 29 min. Only the pregnant female in moderate-complexity group was operated with clamping. Rest of the moderate-complexity and low-complexity tumors were operated without clamping. The mean operative times were similar for all groups.

As high-complexity cases were done with renal vessel clamping, blood loss was statistically different between moderate- and high-complexity groups but not statistically different between low- and high-complexity groups [Table 2]. The change in GFR of the operated kidney at 3 months was statistically different between low or moderate and low- or high-complexity group but not between the moderate- and high-complexity groups. This might be due to clamping in the high-complexity group and more prevalence of risk factors associated with progressive renal disease in the moderate-complexity group (63.64%). However, the change in total GFR of the different groups was not statistically different owing to the compensation of the nonoperated kidney. The proportion of decrease in GFR of the operated kidneys at 3 months was significantly higher in clamping group than nonclamping group (P = 0.033). The multiple regression analysis revealed that % change in GFR of the operated kidney was also related to the tumor size (i.e., amount of normal renal parenchyma left) (P = 0.032) and presence of risk factors for progressive renal disease (P = 0.013) but not on BMI (P = 0.71) [Table 3].

Complications were recorded according to the Clavien-Dindo classification. The overall complication rates

Table 1: Perioperative outcomes after open partial nephrectomy in different RENAL nephrometry score groups

Characteristic	Low complexity (*n*=4)	Moderate complexity (*n*=11)	High complexity (*n*=5)	*P*
Age years	45.50	50.09	42.00	0.503
Tumor size (cm)	3.03	6.18	9.16	0.0001
WIT (min)	-	-	29	
EBL (ml)	315.00	641.82	280.00	0.001
Complications	-	4 (36.36)	5 (100)	0.007
Urine leak	-	1 (9.09)	2 (40)	0.338
Positive surgical margin	-	1 (9.09)	1 (20)	-
Histology				
Oncocytoma	1 (25)	1 (9.09)	-	-
Angiomyolipoma	-	1 (9.09)	-	
Wilms tumor	-	1 (9.09)*	-	
Clear cell RCC	3 (75)	8 (72.73)	5 (100)	
Fuhrman nuclear grade				
I	-	-	-	
II	2 (66.67)	5 (62.50)	-	
III	1 (33.33)	2 (25)	2 (40)	
IV	-	1 (12.50)	3 (60)	
Postoperative hospital stay (Days)	3.00	5.55	9.80	0.002

*Pregnant patient. EBL: Estimated blood loss, WIT: Warm ischemia time, RCC: Renal cell carcinoma, Data presented as mean or *n* (%)

Table 2: Comparison of the mean drop in glomerular filtration rate of operated kidney and total glomerular filtration rate at 6 weeks between different complexity groups

Complexity	*n*	Mean	*P*
Low	4	−9.3500	0.047
Medium	10	−19.2500	
High	4	−20.9750	
	Complexity		*P*
Change in GFR of operated kidney	Low	Medium	0.046
	Low	High	0.032
	Medium	High	0.912
Change in total GFR	Low	Medium	0.985
	Low	High	0.880
	Medium	High	0.737

GFR: Glomerular filtration rate

Table 3: Multiple regression analysis for percent reduction in glomerular filtration rate of operated kidney

Variable	Parameter estimate	SE	*t*	*P*
Tumor size	−4.12221	1.59487	−2.58	0.0324
Preoperative GFR	0.01649	0.16023	0.10	0.9206
Risk factors for progressive renal disease (present/absent)	−8.66153	2.76078	−3.14	0.0139
BMI	1.07530	2.84774	0.38	0.7155

BMI: Body mass index, SE: Standard error, GFR: Glomerular filtration rate

were significantly different between the groups ($P = 0.007$); however, majority of the complications were low grade (Grades I and II) and were managed conservatively. Three patients developed postoperative urinary leak, two of them were managed by Double-J stenting and one was managed conservatively without any intervention. BMI was not significantly associated with overall complication rates ($P = 0.232$); however, obesity (BMI >30) was significantly associated with urine leak in the postoperative periods ($P = 0.023$).

Increasing complexity group was associated with increasing Fuhrman nuclear grade of clear cell RCC, with all tumors in high-complexity group being Grade III or IV. There was a perfect correlation between radiological and pathological "T" stage in the low- and the moderate-complexity groups; however, there were significant upstaging (80% of cases) between radiological and pathological "T" stage in high-complexity group. One patient each in moderate-complexity (Fuhrman nuclear Grade of II – underwent observation, no recurrence after 11 months of follow-up) and high-complexity (Fuhrman nuclear Grade IV – underwent salvage nephrectomy) groups had positive surgical margin. Of the 16 patients that underwent partial nephrectomy for malignant pathology, only one (6.25%) had recurrence at 3 months and underwent salvage nephrectomy. Rest 15 (93.75%) had no recurrence after a mean follow-up period of 12.6 months (longest follow-up of 22 months and shortest 7 months).

DISCUSSION

The majority of papers that have studied nephrometry score systems are retrospective, whereas the present study was a prospective study. The widespread use of imaging modalities has increased the detection rate of renal tumors, which are mostly identified from smaller and incidental renal masses. Thus, at present, more than 60% of such patients are diagnosed with T1 tumors.[6] In this study, 70% of the patients had tumors diagnosed at T1 stage. Partial nephrectomy is recommended in patients with T1a tumors and is also favored in patients with T1b tumors when technically feasible;[3] however, we were able to perform partial nephrectomy in 6 (30%) of our patients with T2 tumors with good oncological outcomes. Long *et al*., in their

study, with 49 renal tumors >7 cm in size who underwent partial nephrectomy had a 5- and 10-year overall survival rates of 94.5% and 70.9%, respectively.[4]

Treatment decisions for renal malignancies depend largely on qualitative data, including a description of tumor anatomy and the experience of the treating surgeon. Surgical decision-making and dataset comparisons have been significantly enhanced by several nephrometry scoring systems that quantify the pertinent characteristics of localized renal lesions and have been validated in different studies.

The target of ideal partial nephrectomy should be good oncological outcome with a negative surgical margin, maximum renal function preservation, and minimizing complications. Over a period of time, partial nephrectomy has given us results equivalent to radical nephrectomy in properly selected cases. Partial nephrectomy has demonstrated local recurrence rates of 1%–3.2% and overall cancer-free survival well over 90%.[7,8] Consistently, in the present study, the recurrence rate was 6.25% (only one patient) for malignant renal mass may be due to a small cohort. None of the patients died of RCC after a mean follow-up of 12.6 months.

Status regarding positive surgical margin is quite unclear. Shah *et al*. found that a positive surgical margin was significantly associated with a higher risk of recurrence in cases with adverse pathological features (pT2–3a or Fuhrman Grades III–IV).[9] Ani *et al*., in their population-based study, showed that although positive surgical margins are fairly prevalent, they appear to have little to no impact on 5-year disease-specific and overall survival rates.[10] Therefore, in the present study, the patient with positive surgical margin associated with adverse pathological features (pT3a, Fuhrman Grade IV) underwent salvage nephrectomy, whereas patients without adverse features (pT1a, Fuhrman Grade II) were followed up without any intervention and were recurrence free after 8 months.

Preservation of renal function after partial nephrectomy depends on some modifiable (percentage volume preservation and ischemia time) and nonmodifiable (preoperative renal function, risk factors for progressive renal disease such as hypertension, diabetes mellitus, age, and tumor size) factors. Several studies have shown that nonclamping partial nephrectomy is associated with better postoperative renal function but higher blood loss.[11-13] Although controversial in literature, several clinical studies suggest that the maximum period of WIT time for the preservation of renal function should not exceed 20 min.[13,14] In the present study, the mean WIT was 29 min and clamping was associated with decreased blood loss (mean, 280 ml) and a greater decrease in GFR ($P = 0.033$). Lane *et al*. found that preoperative GFR and amount of preserved renal parenchyma were the strongest features associated with long-term renal function after partial nephrectomy when short warm ischemic intervals were applied.[15] In the present study, decrease in GFR was significantly associated with tumor size ($P = 0.032$), risk factors for progressive renal disease ($P = 0.013$) but not with preoperative GFR ($P = 0.92$) and BMI ($P = 0.71$).

There are conflicting studies regarding the association of RNS and complications, with Zhou *et al*. showing an association between the two,[16] whereas Stroup *et al*. showing none.[17] In this study, the rate of complication was associated significantly with the RNS ($P = 0.007$). The urinary leak rates of 6.6% in the present study were consistent with the 2%–10.5% rates reported in the literature.[18] Preoperative insertion of a ureteral catheter has not shown to decrease the rate of postoperative urine leaks.[19] Studies with minimally invasive partial nephrectomy have shown no association between BMI and complication rate including urine leak.[20] However, in this study, with only open approach to partial nephrectomy, BMI was significantly associated with incidence of urine leak ($P = 0.029$) but not with overall complication rates ($P = 0.231$). The RNS was recently evaluated to determine its ability to preoperatively predict the histology and grade renal masses.[21] In their work, the authors found a high correlation between nephrometry score and tumor grade and histology.

Although nephrometry scores are widely adopted in the clinical scenario, their ability to assess surgical difficulty preoperatively might be limited by their complexity, the risk of interobserver variability and the inclusion of factors not associated with surgical outcomes. Despite their elaborate designs, current nephrometry scores do not always capture the entire clinical picture and two tumors with similar nephrometry scores do not necessarily pose the same technical challenges. As an example, a 2-cm, left-sided, lower-pole exophytic renal neoplasm (RENAL score 4a) is potentially far simpler to resect than a similar sized, right-sided, upper-pole posterior renal neoplasm (RENAL score 4p). To clarify this further, suppose the former patient is a 35-year-old female with a BMI of 20 kg/m^2 and the latter is a 50-year-old male with a large fatty liver and BMI of 50 kg/m^2. Despite relatively similar tumor complexity scores, the two procedures could not be more dissimilar regarding challenges faced

by the surgeon. A tumor's nephrometry score does not capture certain relevant characteristics, for example, the presence of a tumor thrombus, which would affect surgical treatment and approach. Therefore, other novel methods of renal nephrometry (contact surface area, number of renal columns invaded by tumor, and arterial-based complexity score) have been devised which take these limitations into consideration, but need validation.[22-24]

CONCLUSION

The present study has limitations and the major one is the small sample size and a short follow-up period. Based on our results and the results of the available published studies, the RNS system provides a useful, flexible, and reproducible tool to objectify salient renal anatomy. It can aid surgeons in preoperative decision-making concerning management therapy. In this study, RNS was correlated with predicting surgical access route, need for clamping during partial nephrectomy, blood loss, decrease in GFR of operated kidneys, postoperative complications, and tumor grade.

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Conflicts of interest
There are no conflicts of interest.

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