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The Nephrometry Score: Is It Effective for Predicting Perioperative Outcome During Robot-Assisted Partial Nephrectomy?

Jae Seung Yeon, Seung Jun Son, Young Ju Lee, Woo Heon Cha[1], Won Suk Choi[2], Jin Woo Chung[1], Byung Ki Lee[1], Sangchul Lee[1], Chang Wook Jeong[1], Sung Kyu Hong[1], Seok-Soo Byun[1], Sang Eun Lee[1]

Department of Urology, Seoul National University Hospital, Seoul, [1]Department of Urology, Seoul National University Bundang Hospital, Seongnam, [2]Choi Urology Clinic, Yongin, Korea

Purpose: Robot-assisted partial nephrectomy (RPN) has emerged as an alternative treatment for the management of small renal masses. This study was designed to investigate parameters that predict perioperative outcomes during RPN.

Materials and Methods: We retrospectively reviewed the medical records of 113 patients who underwent RPN between September 2008 and May 2012 at the Seoul National University Bundang Hospital. Clinical parameters, including warm ischemia time (WIT), estimated blood loss (EBL), and R.E.N.A.L and PADUA scores, were evaluated to predict perioperative outcomes.

Results: Of the 113 patients, 81 were men and 32 were women. The patients' mean age was 53.5 years, and their mean body mass index was 22.3 kg/m^2. Age, gender, and mass laterality had no effect on perioperative complications, WIT, or EBL. Univariate analysis revealed that a distance between the tumor and the collecting system of $\leq$4 mm or a renal mass size of $>$4 cm were associated with adverse profiles of complications, WIT, and EBL. However, multivariate analysis showed no association between the predictive parameters and tumor complexity as assessed by nephrometry scores. Tumor size of $>$4 cm increased the risk of blood loss $>$300 mL (odds ratio [OR], 3.5; 95% confidence interval [CI], 1.3–9.7; p=0.016). A distance between the tumor and the collecting system of $\leq$4 mm was associated with increased risk of WIT exceeding 20 minutes (OR, 2.8; 95% CI, 1.3–6.3; p=0.012).

Conclusions: Tumor size and proximity of the mass to the collecting system showed significant associations with EBL and WIT, respectively, during RPN. The R.E.N.A.L and PADUA nephrometry scoring systems did not predict perioperative outcomes.

Keywords: *Nephrectomy; Renal cell carcinoma; Robotics; Surgical blood loss; Warm ischemia*

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Corresponding Author:
Seok-Soo Byun
Department of Urology, Seoul National University Bundang Hospital, 173-82 Gumi-ro, Bundang-gu, Seongnam 463-707, Korea
TEL: +82-31-787-7342
FAX: +82-31-787-4057
E-mail: ssbyun@snubh.org

INTRODUCTION

The worldwide incidence of renal cell carcinoma (RCC) is increasing. Early stage RCC cases have become more common because of the widespread screening with imaging modalities. Nephron-sparing surgery (NSS) is the current treatment of choice for early small renal tumors. Partial nephrectomy can be used for achieving oncological outcomes equivalent to those with radical nephrectomy and is associated with reduced overall mortality [1-3]. However, partial nephrectomy is a difficult and relatively challenging procedure compared with radical nephrectomy [4], and evaluating predictive factors before the surgery is therefore important.

The R.E.N.A.L nephrometry score is an anatomical scoring system for assessing the complexity of renal tumors [5]. The acronym refers to radius, endophytic/exophytic aspect, nearness of sinus, anterior/posterior aspect, and loca-

tion relative to the polar lines [5]. Similarly, the PADUA nephrometry system uses some dimensional and anatomical parameters in scoring. It considers tumor location in various aspects, relationships with the sinus and collecting system, as well as tumor size and endophytic/exophytic features [6]. The nephrometry score is a recognized predictor of perioperative complications during open partial nephrectomy [7]. This scoring system is useful for deciding whether renal tumor cases should be treated with surgery or conservative management. Numerous issues such as age, comorbidities, life expectancy, and classification of renal mass complexity are significant determinants of treatment for renal masses. The probability of perioperative complications is also an important factor when surgery is being considered.

Robot-assisted NSS is performed in an increasing number of cases. The procedure has the advantages of low morbidity rates and few perioperative complications [8-10]. The noncompromised oncological efficacy obtained by using this procedure is comparable to that obtained with conventional open partial nephrectomy [11]. Blood loss during surgery, ischemia time during the nephron-sparing procedure, and other perioperative complications are important factors for patient morbidity and decision making for treatment modality. Nephrometry scoring systems evaluating the anatomical complexity of renal tumors are used to validate the perioperative outcomes of partial nephrectomy. However, few studies have applied the scoring systems to robot-assisted partial nephrectomy (RPN).

The purpose of the present study was to validate the predictive value of various parameters, including the R.E.N.A.L and PADUA nephrometry scoring systems, for perioperative outcomes during RPN.

MATERIALS AND METHODS

1. Patients' characteristics

We collected and analyzed data from 113 patients with renal tumors who underwent RPN between September 2008 and May 2012 at the Seoul National University Bundang Hospital. Cases in which RPN was changed to radical nephrectomy were excluded. The institutional review board of Seoul National University Bundang Hospital approved this retrospective study (IRB no. B-1304/198-108).

2. Clinical parameters

Each patient underwent preoperative computed tomography evaluation, and all R.E.N.A.L nephrometry scores were obtained from these images. The "R" or radius of the renal tumor represented the lesion size. "E" described the appearance of the mass from the renal surface. "N" was determined as nearness of the tumor margin to the renal sinus or collecting system. "A" described the location of the mass (anterior vs. posterior). "L" represented the location with respect to polarity [9]. Similarly, PADUA nephrometry scoring was also measured from those data resources. Each score was calculated by two senior urologists, and concordance between the observers was met without conflict throughout all cases.

Perioperative clinical parameters, including warm ischemia time (WIT), estimated blood loss (EBL), and perioperative and postoperative complications were analyzed. We determined the complication divergence point as 20 minutes for WIT and 300 mL for EBL. It is known that WIT longer than 20 minutes leads to a decrease in renal function [12]. Minimally invasive partial nephrectomy tends to have less bleeding, approximately less than 300 mL [9,13-16]. Therefore, we used this as a criterion of considerable bleeding.

3. Statistical analysis

Data were expressed as mean±standard deviation. Categorical variables were analyzed by using the chi-square test. Univariate and multivariate logistic regression models were also used for statistical analyses. A p-value of <0.05 was considered statistically significant. SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis.

RESULTS

Patient demographics are shown in Table 1. The study population consisted of 81 men and 32 women with a mean age of 53.5±11.0 years. Mean body mass index was calculated as 25.3±10.7 kg/m^2. Preoperative mean serum creatinine levels were 0.94±0.19 mg/dL, and estimated glomerular filtration rate (Modification of Diet in Renal Disease 7) was 81.5±18.0 mL/min/1.7 m^2. Mean renal mass size was 3.1±2.4 cm, and 62 lesions (55.4%) were found in the left kidney. The calculated R.E.N.A.L nephrometry score was 7.0±1.6. As indicators of perioperative complications, the mean values of WIT and EBL were 22.1±8.0 minutes and 179.3±144.3 mL, respectively. Table 1 also displays the pathologic outcomes. A total of 96 cases (85%) were proven to be RCC. No cases had a positive surgical margin.

Univariate and multivariate logistic regression analyses of perioperative complications, WIT, and EBL were performed to evaluate their predictive value. The univariate analysis (Table 2) showed no difference in perioperative complications between patients younger than and older than 60 years. The gender of patients and laterality of renal tumors also had no significant effect on complications or on WIT and EBL. Patients were divided into 2 groups by R.E.N.A.L and PADUA nephrometry scores (<7 vs. ≥ 7 and <9 vs. ≥ 9, respectively). A total of 70 patients had a R.E.N.A.L nephrometry score of 7 or greater (62%). WIT greater than 20 minutes was associated with a nephrometry score of ≥ 7, but perioperative complications and EBL >300 mL had no statistically significant relationship with nephrometry score. A total of 48 patients were graded as 9 or greater on the PADUA nephrometry score (42%), and no association was revealed in the statistical analysis with this score.

We isolated each element of the R.E.N.A.L nephrometry

TABLE 1. Patient demographics and perioperative clinical parameters (n=113)

Variable	Value
Patient demographic	
Age (y)	53.5±11.0
Body mass index (kg/m^2)	25.3±3.3
Gender	
Male	81
Female	32
Preoperative creatinine (mg/dL)	0.9±0.2
Preoperative estimated GFR (kg/cm^2)	81.5±21.9
Size of renal mass (cm)	3.1±2.4
Site	
Left	62 (55.4)
Right	50 (44.6)
R.E.N.A.L score	7.0±1.6
PADUA score	8.5±1.6
Operation time (min)	172.6±100.3
Warm ischemia time (min)	22.1±8.0
Estimated blood loss (mL)	179.3±144.3
Pathologic data	
Renal cell carcinoma	96 (85.0)
Clear cell	84
Papillary	7
Chromophobe	5
Collecting duct	0
Unclassified	0
Angiomyolipoma	6 (5.3)
Oncocytoma	6 (5.3)
Others	5 (4.4)
Pathological tumor stage	
T1a	80
T1b	16
Fuhrman nuclear grade (I/II/III/IV)	0/50/43/3
Positive surgical margin	0
Intraoperative complication	
Organ injury cases	6
Open conversion cases	2
Postoperative complication (Clavien grade)	
Minor complication	
Wound problem (I)	1
Ileus (I)	1
Minor problem needed monitoring (I)	1
Gross hematuria with transfusion (II)	3
Major complication	
Wound problem with repairing procedure (IIIa)	2
Abdominal fluid collection with drain insertion (IIIa)	1

Values are presented as mean±standard deviation or number (%).
Estimated GFR, glomerular filtration rate calculated by using the Modification of Diet in Renal Disease study equation.
The complication cases include some redundancy in patients.

score for intensified analysis. There was an increased tendency of WIT > 20 minutes (p=0.016) and EBL > 300 mL (p=0.018) when the renal mass was larger than 4 cm. The exophytic property of the mass (comparison between entirely endophytic masses and others) had no significant effect on any of the complication parameters. The nearness of the tumor to the collecting system or sinus was associated with adverse profiles for WIT and EBL. The frequency of WIT > 20 minutes and EBL > 300 mL was greater when the distance between the tumor and the collecting duct was < 4 mm. Other elements of the R.E.N.A.L nephrometry score, such as the face of the tumor and polar location, had no correlation with complications.

The results of the multivariate analyses are shown in Table 3. The size of the renal tumor and the nearness of the mass to the collecting system or sinus were significant predictors of RPN complications. The risk of bleeding resulting in a blood loss of > 300 mL increased 3.5 times (95% confidence interval [CI], 1.3–9.7) when the tumor was larger than 4 cm. The frequency of long WIT was greater (odds ratio [OR], 2.8; 95% CI, 1.3–6.3) when the distance between the tumor margin and the collecting system or sinus was less than 4 mm.

Perioperative complications occurred in 16 patients, including 6 perirenal organ injuries, 2 open conversions, 3 wound complications, and 3 gross hematuria cases (Table 1). Organ injury cases consisted of two renal vein lacerations, two spleen injuries, and one liver and colon injury. Two open conversions were determined owing to difficulty in approaching the isolated renal tumor and a too small peritoneal cavity for robot control, respectively. Postoperatively, there were three hematuria and transfusion cases, one wound problem, one ileus, and one minor problem ranked as Clavien grade I or II. The major postoperative complications classified as Clavien grade III were two other wound problems that needed repairing and one case of abdominal fluid collection that required percutaneous drainage. Univariate and multivariate analyses revealed that no parameter had a significant correlation with perioperative complications.

DISCUSSION

Currently, NSS for early stage renal tumors is a standard therapeutic modality. Laparoscopic partial nephrectomy is considered to be comparable to conventional open surgery with respect to cancer control and perioperative complications [13,14,17,18]. RPN is emerging as an alternative to purely laparoscopic surgery with comparable oncological outcomes and extent of invasiveness [8-11]. However, RPN is a challenging procedure for which many factors, such as WIT, EBL, and perioperative complications, should be considered [9]. WIT correlates with residual renal function after the operation [19]; therefore, the expected duration of NSS should be estimated preoperatively, because the benefits of nephron sparing may not outweigh the increased risk of bleeding [4]. Excessive blood loss and perioperative complications should be avoided depending on the types of comorbidities in the patients. For this, the identification of significant predictive factors that

TABLE 2. Univariate logistic regression analysis to predict perioperative complications, WIT > 20 minutes, and EBL > 300 mL

Variable	Perioperative complications		WIT > 20 min		EBL > 300 mL	
	Cases	p-value	Cases	p-value	Cases	p-value
Age (y)		0.912		0.820		0.792
< 60	12/86 (13.9)		53/86 (61.6)		20/86 (23.3)	
≥ 60	4/27 (14.8)		18/27 (66.7)		5/27 (18.5)	
Gender		0.116		0.130		0.329
Male	9/81 (11.1)		47/81 (58.0)		16/81 (19.8)	
Female	7/32 (21.9)		24/32 (75.0)		9/32 (28.1)	
Site		0.248		0.435		0.070
Left	11/62 (17.7)		41/62 (66.1)		18/62 (29.0)	
Right	5/50 (10.0)		29/50 (58.0)		7/50 (14.0)	
Renal mass size (cm)		0.163		0.016		0.018
≤ 4	11/92 (11.9)		53/92 (57.6)		16/92 (17.4)	
> 4	5/21 (23.8)		18/21 (85.7)		9/21 (42.9)	
Exophytic property		0.761		0.452		1.000
Exophytic	14/96 (14.6)		60/96 (62.5)		21/96 (21.9)	
Entirely endophytic	2/17 (11.8)		11/17 (64.7)		4/17 (23.5)	
Nearness of the tumor to the collecting system or sinus (mm)		0.846		0.013		0.031
> 4	9/61 (14.8)		32/61 (52.5)		11/61 (18.0)	
≤ 4	7/52 (13.5)		39/52 (75.0)		14/52 (26.9)	
Polar location		0.591		0.693		0.249
Upper & lower pole	8/51 (15.7)		31/51 (60.8)		10/51 (19.6)	
Cross polar line	4/27 (14.8)		16/27 (59.3)		4/27 (14.8)	
Entirely between polar line	4/35 (11.4)		24/35 (68.6)		11/35 (31.4)	
Face		0.791		0.907		0.260
Anterior	8/60 (13.3)		38/60 (63.3)		16/60 (26.7)	
Posterior	8/53 (15.1)		33/53 (62.3)		9/53 (17.0)	
R.E.N.A.L score		0.292		0.016		0.110
< 7	8/43 (18.6)		21/43 (48.8)		6/43 (14.0)	
≥ 7	8/70 (11.4)		50/70 (71.4)		19/70 (27.1)	
PADUA score		0.515		0.133		0.123
< 9	8/65 (12.3)		37/65 (56.9)		11/65 (16.9)	
≥ 9	8/48 (16.7)		34/48 (70.8)		14/48 (29.1)	

Values are presented as number (%).
WIT, warm ischemia time; EBL, estimated blood loss.

TABLE 3. Multivariate logistic regression analysis to predict parameters of perioperative complications, WIT > 20 minutes, and EBL > 300 mL

Variable	Perioperative complications	WIT > 20 min	EBL > 300 mL
Age (y)	0.928	0.143	0.879
Gender	0.098	0.077	0.289
Laterality	0.244	0.482	0.056
Renal mass size (≤ 4 cm vs. > 4 cm)	0.166	0.056	OR, 3.516 95% CI, 1.269–9.739 p=0.016
Exophytic property	0.747	0.839	0.475
Nearness of the tumor to the collecting system or sinus (> 4 mm vs. ≤ 4 mm)	0.817	OR, 2.806 95% CI, 1.253–6.286 p=0.012	0.604
Polar location	0.876	0.457	0.099
Face (anterior vs. posterior)	0.817	0.570	0.115
R.E.N.A.L score (< 7 vs. ≥ 7)	0.302	0.485	0.239
PADUA score (< 9 vs. ≥ 9)	0.533	0.943	0.382

Values are presented as p-value unless otherwise indicated.
WIT, warm ischemia time; EBL, estimated blood loss; OR, odds ratio; CI, confidence interval.

affect WIT, EBL, and perioperative complications is very important. The results of the present study showed that the size of the renal mass had a significant association with WIT, EBL, and perioperative complications. Proximity or nearness of the tumor to the collecting duct may also be a significant predictor of longer WIT and high volume of E BL. However, multivariate analysis demonstrated that tumor size is associated with high EBL, whereas nearness predicts only long WIT. Nephrometry score was not found to be a definitive indicator of EBL, WIT, or perioperative complications. Previous studies reported an association of nephrometry scores with longer ischemia time and higher volumes of blood loss in cases of open and laparoscopic partial nephrectomy [20,21].

Several factors may account for those results. The resected surface area of larger tumors would be correspondingly larger. Because the sliced surface area contains many bleeding points, such as venules or arterioles and occasionally larger vessels, the amount of blood loss would be anticipated to increase with the size of the resected tumor.

The probability of damaging the collecting system or sinuses during resection increases when the tumor is located deeper. More repair procedures are needed for a mass located near the collecting duct than for one located at a greater distance. The repair procedure of the tumor bed and parenchymal renorrhaphy plays an important role in determining WIT. Ischemia time is predicted to increase as the distance between the collecting system and the mass decreases. Nonetheless, tumors located at the hilum cannot be treated with precision by using RPN [15,16]. Furthermore, the overall outcomes of the procedure for renal masses with a nephrometry score of ≥ 7 were acceptable [22].

A previous study showed a correlation between the nephrometry score and WIT and EBL during RPN [16]. Interestingly, we did not find such a relationship in the present study. Instead, there were other relations of the components of the R.E.N.A.L score with WIT or EBL. The differences in results might be based on the disparity of data composition. The profile of the nephrometry score in the previous study was distributed relatively unequally. For 67 patients, they were categorized as 62 versus 5, and 12 versus 55, in the "R" and "N" components, respectively. Those weighted distributions of the "R" and "N" components may have overwhelmed the whole nephrometry score, consequently affecting the result.

This study had inherent limitations. The number of cases included was relatively small, and the study was retrospective in nature and was based on a review of medical records. There may also have been a selection bias, because more complex tumors would be recommended for open partial nephrectomy or radical nephrectomy. Further investigation should be done with a larger volume of cases, including other important parameters such as postoperative renal functional change and long-term oncological data.

CONCLUSIONS

The present study investigated the effectiveness of nephrometry systems and other parameters to predict perioperative complications, WIT, and EBL in RPN. Overall tumor complexity as assessed by R.E.N.A.L and PADUA nephrometry scoring was not a definitive risk factor for perioperative outcomes. Tumor size and nearness of the mass to the collecting system or sinus were significant indicators of EBL and WIT, respectively. Further large-scale research would be necessary to clarify the results of this study.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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