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Factors Influencing the Operative Approach to Renal Tumors: Analyses According to RENAL Nephrometry Scores

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Purpose: To evaluate the relationship between RENAL nephrometry score (RNS) and operative approach for renal masses.
Materials and Methods: This study included 206 consecutive patients who underwent renal tumor surgery between January 2008 and October 2012. We divided the patients into four groups by surgical approach: open radical nephrectomy (ORN, 53 patients), laparoscopic radical nephrectomy (LRN, 83 patients), open partial nephrectomy (OPN, 31 patients), and laparoscopic partial nephrectomy (LPN, 39 patients). We retrospectively assessed the RNS for each surgery group and evaluated the relationship between this score and operative approach.
Results: The mean RNSs of the ORN, LRN, OPN, and LPN groups were 9.75, 8.35, 6.72, and 5.76, respectively. When the RNS was analyzed according to nephron-sparing, the mean RNSs of the RN groups (ORN and LRN) and the PN groups (OPN and LPN) were significantly different (8.89 and 6.09, respectively; $p<0.001$). All the individual components of the RNS were significantly different between RN and PN. In the RN groups, the criteria for open versus laparoscopic surgery were based on tumor size ('R' score=2.43 for open, 1.54 for laparoscopic, $p<0.001$) and tumor location relative to the polar line ('L' score=2.55 for open, 2.09 for laparoscopic, p=0.006). In the PN groups, the criteria for open or laparoscopic surgery were based only on exophytic/endophytic property ('E' score=1.87 for open, 1.41 for laparoscopic, p=0.046).
Conclusions: The RNS was significantly different in all surgery groups. The decision to take a laparoscopic approach was primarily influenced by the R and L scores for RN and by the E score for PN.

Keywords: *Kidney; Laparoscopy; Nephrectomy*

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INTRODUCTION

In recent decades, enhanced accuracy in imaging has increased the number of patients who are incidentally diagnosed with small renal masses (SRMs). Nephron-sparing surgery (NSS) is frequently preferred to remove SRMs because it offers the best residual renal function [1,2]. The oncological outcome of partial nephrectomy (PN) is comparable to that of radical nephrectomy (RN), and some reports suggest that the overall survival of PN is better than that of RN [3,4].

Additionally, minimally invasive surgery (MIS), which includes laparoscopic radical nephrectomy (LRN), laparoscopic partial nephrectomy (LPN), and robot-assisted partial nephrectomy (RAPN), has become popular owing to the benefits of less postoperative pain and better cosmetic outcomes compared with open RN (ORN) or open PN (OPN). Despite the advantages of NSS and MIS, the surgical technique is difficult to perform and has a steep learning curve. Some reports of experienced urologists show comparable complication rates between OPN and LPN [5,6]; however, the technique is considered quite challenging and may result in more frequent complications than conventional OPN, typically for beginners [7]. Therefore, the decision to undertake NSS and MIS should be made carefully to minimize the possibility of complications.

To predict the potential surgical difficulty and risk for complications associated with a surgical plan, the renal mass complexity reporting system—or RENAL nephrometry score (RNS)—was developed by Kutikov and Uzzo [8]. We evaluated the relationship between the RNS and the operative approach for renal tumors and studied which individual RNS components have the largest effect on the operative approach chosen. We also investigated the complications of each surgery group.

MATERIALS AND METHODS

1. Study cohort and data

We reviewed the medical records of patients who underwent renal tumor surgery at Kosin University College of Medicine between January 2008 and October 2012. We excluded 62 patients who had urothelial tumors, multiple renal tumors, or an anatomical or functional solitary kidney. By these criteria, the study included 206 consecutive patients. After approval from the Institutional Review Board, all authors reviewed patient computed tomography (CT) scans and determined the RNS. All reviewers subsequently discussed the patients' RNSs to determine the interobserver concordance. In cases lacking concordance, the authors reviewed the axial, coronal, and sagittal view of the CT scans again and discussed the RNS together. We divided the patients into four groups based on surgical approach: ORN, LRN, OPN, and LPN. We retrospectively assessed the RNS of each surgery group and analyzed each individual RNS component. The RNS components consisted of the following: the maximum tumor size (R), the exophytic/endophytic property of the tumor (E), the tumor's proximity to the collecting system (N), tumor location relative to the polar line (L), and anterior/posterior location of the tumor on the surface of the kidney as a suffix (A) [8]. Each component was scored on a scale of 1 to 3 with the exception of (A), which is only a descriptor of tumor location. Renal masses that were located anterior or posterior from the coronal section line were labeled 'a' or 'p,' respectively. If the renal mass location was vague, it was labeled 'x.' We compared the sum of the RNS and each RNS component between each surgery group.

2. Complications

We reviewed the patients' medical records to assess surgical complications. The severity of complications was evaluated by using the Clavien-Dindo classification [9]. Surgical complications over grade III were regarded as severe complications, and complications of grade I/II were regarded as minor complications; hence, we divided the complications into grade I/II and grade III/IV.

3. Statistical analysis

We compared the RNSs of the RN (ORN and LRN) groups with those of the PN groups (OPN and LPN) on the basis of whether the operative approach was nephron-sparing or not. Additionally, we compared RNSs depending on the degree of surgical invasiveness (laparoscopy versus open approach). Statistical analyses were performed by one-way analysis of variance (ANOVA) with post hoc Tukey test and Student t-test by using PASW ver. 18.0 (IBM Co., Armonk, NY, USA). The significance level was set at $p<0.05$.

RESULTS

1. RENAL nephrometry score

Tumor characteristics and RNS data for all groups are described in Table 1. ORN was performed in 53 patients, LRN in 83, OPN in 31, and LPN in 39, respectively. The mean age of the ORN, LRN, OPN, and LPN surgery groups was 60.98, 61.68, 57.77, and 57.74 years, respectively. The mean age of the RN group was significantly higher than that of the PN group (61.37 years vs. 57.75 years, p=0.041). The mean RNS of the ORN, LRN, OPN, and LPN groups was 9.75, 8.35, 6.72, and 5.76, respectively, and all were significantly different from each other (one-way ANOVA, $p<0.001$). The percentage of low RNSs (scores of 4–6) for the ORN, LRN, OPN, and LPN groups was 5.7%, 14.5%, 48.4%, and 71.8%, respectively [10,11]. When the RNS was analyzed according to association with NSS, the mean RNSs for RN (ORN and LRN groups) and PN (OPN and LPN groups) were significantly different (8.89 and 6.09, respectively, $p<0.001$). All the individual components of the RNS (except 'A') were significantly different between the RN and PN groups. In the RN groups, the decision to perform open versus laparoscopic surgery was affected by tumor size and location relative to the polar line (R=2.43 for open, R=1.54 for laparoscopic, $p<0.001$; L=2.55 for open, L=2.09 for laparoscopic, p=0.006). In the PN groups, the decision to perform open versus laparoscopic surgery was affected only by exophytic/endophytic property (E=1.87 for open, E=1.41 or laparoscopic, p=0.046).

2. Complications

There were two open conversions in the LRN group. There were no open conversions in the LPN group but one case was converted to RN during the operation. Two patients in the OPN group and one patient in the LPN group had postoperative urine leakage. Most grade I/II complications were blood transfusion and paralytic ileus (85.7%). For the grade III/IV complications, there were several interventional procedures and reoperations. Two cases of postoperative urine leakage in the OPN group were resolved spontaneously with drainage owing to the small amount; however, one case of postoperative urine leakage in the LPN group needed ureteral stenting owing to continuous urine drainage. There was one reoperation in each of the OPN and LPN groups because of delayed postoperative bleeding. In the reoperations, the OPN patient underwent bleeding control only, whereas the LPN patient underwent nephrectomy. An additional LPN patient had continuous bloody drainage that required a renal angioembolization.

TABLE 1. Tumor characteristics and renal nephrometry score data

Variable	ORN (n=53)	LRN (n=83)	OPN (n=31)	LPN (n=39)	p-value (RN vs. PN)	p-value (ORN vs. LRN)	p-value (OPN vs. LPN)
Age (y)	60.8±12.41	61.68±11.05	57.77±10.29	57.74±10.06	0.041	0.508	0.998
Tumor size (cm)	7.74±3.17	4.25±1.83	2.93±1.00	2.96±1.28	0.000	0.000	0.851
RNS total score	9.75±1.79	8.35±1.67	6.72±2.10	5.76±1.64	0.000	0.000	0.041
R[a] score	2.43±0.73	1.54±0.59	1.26±0.45	1.16±0.44	0.000	0.000	0.899
E[b] score	2.06±0.76	1.98±0.67	1.87±0.83	1.41±0.68	0.002	0.915	0.046
N[c] score	2.71±0.67	2.72±0.66	2.06±1.00	1.8±0.931	0.000	0.999	0.560
L[d] score	2.55±0.70	2.09±0.82	1.51±0.90	1.25±0.72	0.000	0.006	0.532
Suffix a[e]	20 (37.8)	32 (38.6)	11 (35.5)	14 (35.9)	0.845	0.555	0.924
RNS complexity group					0.000	0.001	0.041
High (10–12)	33 (62.3)	26 (31.3)	3 (9.7)	1 (2.6)			
Moderate (7–9)	17 (32.1)	45 (54.2)	13 (41.9)	10 (25.6)			
Low (4–6)	3 (5.6)	12 (14.5)	15 (48.4)	28 (71.8)			
Pathology					0.000	0.143	0.462
Malignancy	50 (94.3)	80 (96.4)	26 (83.9)	34 (87.2)			
Clear cell RCC	45	71	25	30			
Papillary RCC	4	5	1	4			
Chromophobe RCC	1	3	0	0			
Sarcomatoid RCC	0	1	0	0			
Benign	3 (5.7)	3 (3.6)	5 (16.1)	5 (12.8)			
Oncocytoma	2	3	1	0			
Angiomyolipoma	0	0	4	5			
Leiomyoma	1	0	0	0			
Clavien-Dindo complications					0.006	0.008	0.993
Grade I/II	21 (39.6) 14 Transfusion, 4 paralytic ileus, 3 wound dehiscence	14 (16.9) 8 Transfusion, 4 paralytic ileus, 2 fever	2 (6.5) 2 Transfusion	3 (7.7) 2 Transfusion			
Grade III/IV	2 (3.8) 1 Reoperation, 1 acute renal failure	2 (2.4) 1 Reoperation, 1 hepatic failure	1 (3.2) 1 Angioembolization	1 (2.6) 1 Ureteral stenting			

Values are presented as mean±standard deviation or number (%).
ORN, open radical nephrectomy; LRN, laparoscopic radical nephrectomy; OPN, open partial nephrectomy; LPN, laparoscopic partial nephrectomy; RNS, renal nephrometry score; RCC, renal cell carcinoma.
[a]:R: the maximum tumor size. [b]:E: the exophytic/endophytic property of the tumor. [c]:N: the tumor's proximity to the collecting system. [d]:L: tumor location relative to the polar line. [e]:a: anterior/posterior location of the tumor on surface of the kidney as a suffix.

Surgical complications using the Clavien-Dindo classification are listed in Table 1. There was no statistical difference between the groups in the number of patients who experienced grade III or IV complications.

DISCUSSION

The RNS is a renal mass complexity reporting system that was developed by Kutikov and Uzzo [8] to predict the surgical difficulty of PN and the possibility of surgery-related complications. Other reporting systems besides the RNS have been developed, such as the preoperative aspects and dimensions used for an anatomical (PADUA) score and the centrality index (C-index) [12,13]. The PADUA classification system consists of factors similar to those of the RNS, such as tumor size, exophytic/endophytic property, polar location, renal sinus involvement, and collecting system involvement. The C-index is a calculating method that uses the renal mass diameter and the distance between the center of the kidney and the center of the renal mass. These three renal tumor scoring systems have all demonstrated interobserver reliability and an ability to predict perioperative outcomes [14-16]; however, we selected the RNS for our study because of the simplicity of its scoring. Canter et al. [17] reported that patients who underwent RN had a significantly larger total RNS, as well as larger individual R, N, and L component scores. They also found that the RNS accurately stratified the operative approach to solid renal masses. Rosevear et al reported that patients who underwent RN had a larger RNS than did patients who underwent PN, which suggests that the RNS accurately predicted the operative preference of surgeons [18]. Our study's findings are consistent with these results, especially for the total and individual component scores of the RN group compared with the PN group. In a study that was limited to just analyses of patients who underwent PN, Stroup et al. [19] reported that the mean RNS of the OPN group was higher than that of MIS (LPN or RAPN) and that all the individual RNS components were also significantly higher than those for MIS. In our study, the total RNS of the OPN group was significantly higher than that of the LPN group (6.72 vs. 5.76, p=0.022). However, even though all individual RNS components for the OPN group were slightly higher than those of the LPN group, there were no statistically significant differences in the individual components between the OPN group and the LPN group, with the exception of the E component (1.87 vs. 1.41, p=0.041). The reason for this may have been a lack of experience with challenging cases and a trend to perform PN in easier cases (e.g., exophytic, small size, and peripheral renal tumors) in our department. The mean RNSs of the OPN and LPN groups were 8.0 and 6.3 in Stroup et al. [19]'s study. However, the mean RNSs of the OPN and LPN groups in our study were 6.72 and 5.76. The mean size of the renal tumors in the OPN group was smaller in our study than in Stroup's study (2.93 cm vs. 4.2 cm). In contrast, the LPN group in our study had a larger mean tumor size than did Stroup's LPN group (2.96 cm vs. 2.4 cm), even though our LPN group had smaller RNSs. It may be that renal mass size is not the best explanation for why the RNS was lower in the LPN group in our study than in Stroup et al. [19]'s study. A better explanation may be the preference for exophytic renal masses. If that is correct, we can presume that the decision to perform LPN versus OPN is influenced by the exophytic/endophytic property rather than by tumor size in our department. In support of this conclusion, renal tumor size was not significantly different between the OPN (2.96 cm) and LPN (2.96 cm) groups. In cases that required RN, the mass size (R) and the relative polar location (L) were the only important factors influencing laparoscopy. To the best of our knowledge, there have been no studies examining ORN versus LPN decision making by RNS analysis. Originally, because the RNS was introduced as a renal mass complexity reporting system for PN, the score was not thought to be meaningful for consideration of RN. However, when applied to RN, renal mass size (R) is the most influential factor in deciding whether to perform open or laparoscopic surgery, with the next most important being polar location (L). The finding of polar location (L) as an important factor for the laparoscopic approach in the RN group is unexpected, and we suggest that it is important for large renal masses that involve the polar line and the axial renal midline.

Some reports have been published regarding perioperative outcomes and their association with RNS. Endophytic renal mass (E) and polar renal mass (L) were associated with urine leakage as based on RNS analysis [20], and the RNS is an independent factor for longer warm ischemia time and collecting system entry [21]. When analyzed by individual components, warm ischemia time is associated with the R, E, and N components of the RNS [21-23]. We did not evaluate the association between RNS and urine leakage in the present study because we had too few cases of urine leakage: two cases in the OPN group and one case in the LPN group. Additionally, we did not analyze the association between warm ischemia time and RNS because an off-clamp technique that does not clamp the renal hilum was used in about half of the LPN group [24]. For NSS, the application of the RNS can be expanded to predicting histologic aggressiveness and tumor recurrence after thermal ablation therapy [25-27]. A limitation of this study is that we could not analyze the relationship between the RNSs of each surgical group and the surgeon's preference, surgeon's experience, or medical comorbidity of the patients. After gaining some experience in laparoscopy, a surgeon may attempt to perform LPN in challenging cases such as endophytic and central renal tumors, whereas a beginner might be hesitant to perform the surgery laparoscopically owing to technical difficulties. Thus, it may be meaningful to compare data between one's early and late LPN experiences to better understand the learning curve [5]. Another limitation of this study is the evaluation of complications owing to a lack of NSS data and the retrospective nature of the study design. Actually, for severe complications (Clavien-Dindo classification grade III/IV), we had only two cases of reoperations, one case of angioembolization and one case of postoperative ureteral stenting, among all patients. These are too few to evaluate the relationship between each operative approach and surgical complications.

CONCLUSIONS

The RNS can be used to predict the operative approach for renal tumors. Each individual component was an important factor for deciding whether to perform NSS. The R and L components of the RNS reporting system are significant for decision making regarding LRN, and the E component has significance for LPN. In the future, further evaluation is needed with randomization and the inclusion of other factors that could have an influence, such as age, medical comorbidity, and surgeon's experience.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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