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Original Article

Efficacy of combined renal imaging and C-index scoring systems in evaluation of renal mass

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Abstract: Objective: The goal of this study was to evaluate the impact of the renal imaging scoring system (R.E.N.A.L and C-index) on the choice of surgical approaches for T1 stage renal masses. Methods: This study reports retrospective analysis of clinical data from 213 patients, who underwent surgery for renal masses from January 2012 to December 2016, and assessment of imaging data from the R.E.N.A.L and C-index scoring system. Tumors were classified into three groups by R.E.N.A.L first: low, middle and high, then combined with C-index, these three groups are further divided into six group: LL: low (low), LH: low (high), ML: middle (low), MH: middle (high), HL: high (low), HH: high (high). Statistical methods were used to analyze the correlation between RENAL, C-index, and surgical approaches. Results: According to the R.E.N.A.L and C-index scoring system, the complexity of renal tumors is associated with partial nephrectomy ($P < 0.01$), and intraoperative warm ischemia time ($P < 0.01$). Among the high-level R.E.N.A.L. complexity tumors, the proportion of partial nephrectomy was low, but the warm ischemia time was increased. As for the C-index scoring system, tumor complexity also connected with the proportion intraoperative blood loss ($P < 0.01$). The percent of partial nephrectomy surgery in the patients with high complexity tumors was low, and suffered longer warm ischemia time and more blood loss. Comparing LL with LH, the proportion of partial nephrectomy ($P < 0.05$), intraoperative warm ischemia time ($P < 0.05$), and intraoperative bleeding volume ($P < 0.05$) was statically different. In addition, the proportion of partial nephrectomy ($P < 0.05$), intraoperative warm ischemia time ($P < 0.05$), and intraoperative bleeding volume ($P < 0.05$) show significant differences when comparing ML with MH. However, there is no difference between HL and HH group. Conclusion: The combination of the two scoring systems (R.E.N.A.L. and C-index) might provide more reasonable and accurate choices for surgical approaches and reduction in the occurrence of adverse events.

Keywords: Renal mass, renal scoring system, partial nephrectomy, radical nephrectomy

Introduction

Since the first scoring system for renal mass appeared in 2009, other quantitative systems based on CT have emerged to evaluate the anatomical characteristics of tumor [1-3]. The R.E.N.A.L. and C-index (CI) scoring systems are more common in clinical practice [4]. Some studies have held that the R.E.N.A.L. system can predict perioperative complications, while the C-index has been associated with surgical difficulties [5, 6]. As reported, the two systems could assist surgeons to select appropriate surgical approaches [7, 8]. However, both of them had inevitable limitations. Tumor size, location, convexity, distance from the urinary collection system are vital essentials for the success of operation and account for unequal proportions [9, 10]. Hence, the R.E.N.A.L. system alone can hardly reveal actual influence of separate factors to the operation. Similarly, C-index has only two characteristic parameters, it could not provide comprehensive assessment of the tumor either [11, 12]. Therefore, this study explored the effect of combining R.E.N.A.L. and C-index systems in the classification of tumor complexity and surgical management.

Objectives and methods

Clinical data

Perioperative data from 213 patients with stage T1N0M0 renal tumors who underwent

Table 1. R.E.N.A.L scoring system

Abbreviation	Scores		
	1	2	3
(R) size/cm	≤ 4	4~7	≥ 7
(E) convexity	≥ 50%	< 50%	Complete endogenetic tumor
(N) distance from the urinary collection system/mm	≥ 7	4~7	≤ 4
(A\P) location in dorsal or ventral side	A (abdominal side), P (dorsal side), X (unidentified location)		
(L) relationships with renal poles	The tumor was completely located in the upper or lower pole of the kidney	Most of the tumors were located in the upper or lower pole of the kidney	More than 50% of the tumor passes through the upper or lower pole of the kidney

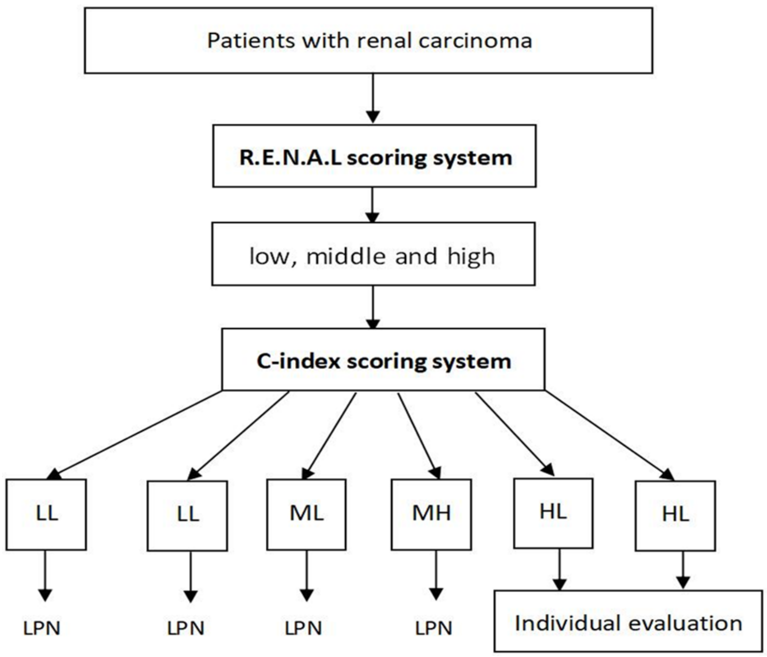

Figure 1. Flowchart of the options for surgical methods in men with renal carcinoma. Flowchart of the options for surgical methods based on combinations of the two systems.

laparoscopic partial nephrectomy (LPN) or laparoscopic radical nephrectomy (LRN) respectively from January 2013 to December 2016 was analyzed in our center.

Patients involved were required to meet the inclusion criteria as follows: (1) laparoscopic surgery for solitary tumors; (2) diameter of localized tumors is less than 7 cm confirmed by preoperative imaging. The major exclusion criterion contained: (1) patients with severe systematic diseases; (2) unilateral renal agenesis; (3) bilateral renal tumors; (4) tumors larger than 7 cm, or progressive localized renal carcinoma; (5) patients unable to undergo laparoscopic surgery due to individual reasons.

A total of 213 patients (140 men, 73 women) were included and the mean age was 58±12 years (range, 25 to 80 years). The mean diameter of tumors was 3.7±1.8 cm (range, 2 to 6.9 cm). LPN was performed in 191 cases and LRN was conducted in 22 cases. This study involved 150 cases of T1aN0M0 tumors and 63 cases of T1bN0M0 tumors. There were 4 cases of LPN for patients eventually diverted to LRN, in which uncontrollable renal bleeding occurred in 3 cases after tumor resection for failing to separate and block the accessory renal artery. Renal hemorrhage with parenchymal laceration was found in one case when suturing the incision. Injuries to the renal collecting system were observed in 16 patients (hematuria, 10 cases; urinary fistula, 6 cases). The mean warm ischemia time in LPN was 18.1±5.2 minutes and blood loss ranged 10-500 ml. The average decrease of postoperative renal function was 39±16%. Postoperative pathological diagnosis was as follows: 175 cases of suprarenal epithelioma (SRE), 6 cases of renal chromophobe cell carcinoma (RCCC), 4 cases of papillary renal cell carcinomas (PRCC) and 28 cases of renal angiomyolipoma (RAML).

Methods

All patients received a CT scan and enhanced scan using Lightspeed VCT before operation and the scanning parameters were as follows: 120 KV, 150-180 mAs, and 5 mm intervals. Three-dimensional reconstruction was conducted after scanning the objective fields with 1.5 mm intervals.

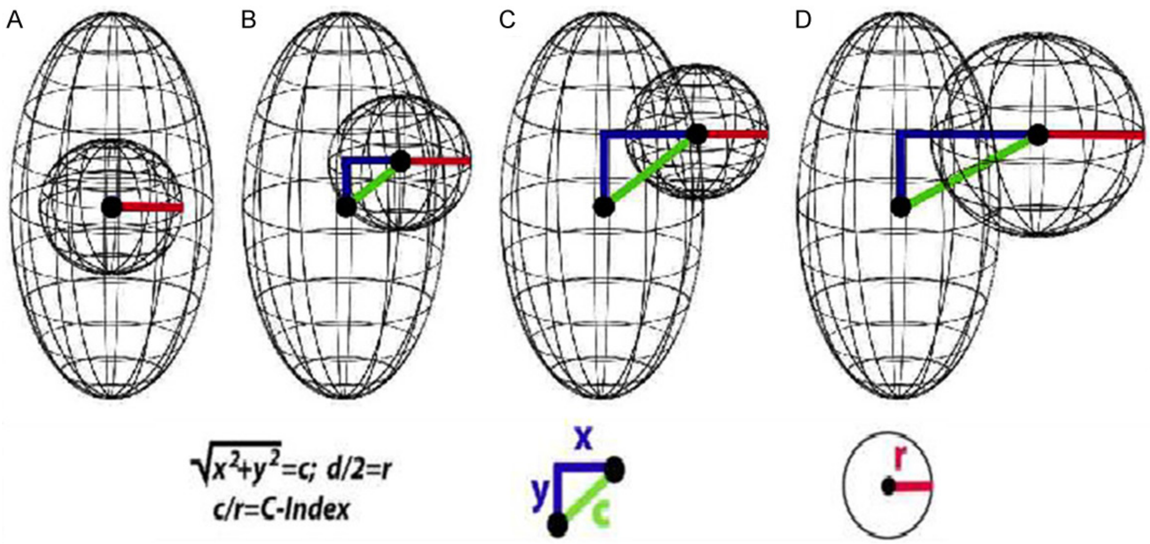

Figure 2. Illustrations for the C-index scoring system. A: x=0, y=0, c=0, r=1.8; c/r=0. B: x=1.6, y=1.2, c=2, r=2; c/r=1. C: x=3.5, y=2, c=4, r=2; c/r=2. D: x=4.6, y=2, c=5, r=3; c/r=1.7.

Table 2. Proportions of LPN under the R.E.N.A.L scoring system

Methods	Low (4-6)	Medium (7-9)	High (10-12)	Total
Cases	83	116	14	213
LPN	80	106	5	191
LRN	3	10	9	22
Proportions of LPN	96.39%	91.38%	35.71%	89.67%
χ^2	-	-	48.41	-
P	-	-	< 0.01	-

The R.E.N.A.L. and C-index scores were calculated respectively according to the preoperative characteristics of CT scan. The scores of tumor CT imaging in each patient were conducted independently by two experienced radiologists.

Intraoperative blood loss was the number of hemostatic gauze plus amount of blood in the aspirator. Postoperative urinary leakage was defined as urine out flowed from the retroperitoneal drainage tube 2 days after operation. Hematuria was divided into three levels, in which first-degree hematuria needed no intervention, second-degree hematuria was defined as the need of blood transfusion, and the third-degree hematuria referred to that surgery treatment has to be adopted. Renal function of all patients was detected before the operation and evaluation of postoperative renal function was conducted in outpatient department. Relevant data was collected to calculate the GFR by intravenous injection of 99mTc-DTPA.

The R.E.N.A.L. scoring system contained four quantitative parameters (R: tumor size, E: convexity of tumor, N: distance from urinary collection system, A: relationships with renal poles) and one unquantifiable point (L: location in dorsal or ventral side). Each item was calculated and summed to the total score, in which 4-6 was mild complexity, 7-9 was moderate complexity, and 10-12 was considered highly complexity (**Table 1**). The C-index scoring system mainly reflected the size and centrality of tumors. CI was calculated with the radius of tumor and the distance from tumor's center to renal center. The flowchart bellow illustrated the procedure for surgical methods based on combinations of the two systems (**Figure 1**). We regarded that CI ≥ 2.5 was low complexity, and CI < 2.5 was high complexity (**Figure 2**).

According to the R.E.N.A.L scoring system, the anatomical complexity of tumors was divided into three levels: low-degree, medium-degree, and high-degree. Based on the previous classification, CI was scored in each complexity of tumors respectively, leading to six subgroups: LL: low (low), LH: low (high), ML: medium (low), MH: medium (high), HL: high (low) and HH: high (high). The correlation between our classification method and the choice of operation were evaluated.

Table 3. Postoperative characteristics of LPN under the R.E.N.A.L scoring system

Groups	Warm ischemia time	Blood loss	Urinary leakage first-degree	Hematuria	Second-degree	Third-degree	Decrease in renal function
High (10-12)	29.3±3.6	54.0±23.0	5	2	1	2	0.45±0.13
Medium (7-9)	23.8±4.3	40.0±24.1	1	3	1	1	0.36±0.14
Low (4-6)	20.8±4.2	35.1±15.8	0	0	0	0	0.32±0.16
P value	< 0.01	> 0.05	-	-	-	-	> 0.05

Table 4. Proportions of surgical methods under the C-index scoring system

Groups	High-level (< 2.5)	Low-level (≥ 2.5)	Total
Cases	99	114	213
LPN	78	113	191
LRN	21	1	22
Proportions of LPN	78.79%	99.12%	89.67%
P	-	< 0.01	

Chi-square test, Student's t-test, and Fisher's exact test were used to analyze the correlation. We utilized Stata software (version 12.0; StataCorp LP, College Station, TX) to perform all statistical analyses. *P* values were considered statistically significant when less than 0.05.

Results

In the R.E.N.A.L. scoring system, there was statistical significance in the proportions of LPN and warm ischemic time in different groups (P < 0.01) (**Table 2**). Intraoperative blood loss and the postoperative affected renal function had no statistical significance (**Table 3**). For the C-index scoring system, the proportions of LPN (P < 0.01), warm ischemic time (P < 0.01) and postoperative affected renal function (P < 0.05) achieved statistical significance (**Table 4**; **Figure 3**).

After the combining of two systems, proportions of LPN in different subgroups are as shown in **Table 5**. Proportions of LPN (P < 0.05), warm ischemia time (P < 0.05) and intraoperative blood loss (P < 0.05) showed significant difference between LL and LH (**Figure 4**). Furthermore, the subgroups of ML and MH had the similar statistical result (**Figure 5**).

In addition, associations between the choice of operation methods and each scoring points in R.E.N.A.L. system were analyzed. OR values of each items were listed as follows: convexity of tumor (OR=9.52), distance from the urinary collection system (OR=6.44), relationships with renal poles (OR=5.08), the tumor size (OR=2.88) (**Table 6**).

Discussion

In accordance with the concept of precishe medicine, the European Association of Urology (EAU) has already recommended the laparoscopic partial nephrectomy (LPN) as the standard surgical treatment for T1a renal tumor, even for stage T1b (diameters, 4-7 cm) if conditions permitted [13, 14]. With development of imaging, CT can provide a quantitative data for the estimation of clinical characteristics. However, the choice of surgical management is still mainly based on the surgeon's experience which is of poor stability. Some scholars have proposed that the R.E.N.A.L. and C-index scoring systems have relationships with perioperative complications in renal cancer patients [15]. Furthermore, Ljungberg B et al. also have held that the two systems are valuable for the optimization of surgical methods in patients [16].

However, the two scoring systems both have disadvantages respectively in clinical practice. Consistent with Simmon's opinions, tumor sizes and the distance from the urinary collection system found to be essential factors for the operation [17]. Nevertheless, the five scoring elements in R.E.N.A.L. weighted equally, which is not in accordance with real clinical circumstances. Hence, under the classifications of the R.E.N.A.L., subgroups were divided by combining the C-index scoring system to emphasize the elements of tumor size and the distance from the urinary collection system, which may reveal the anatomical parameters distinctly and assist in the evaluation of surgical difficulties.

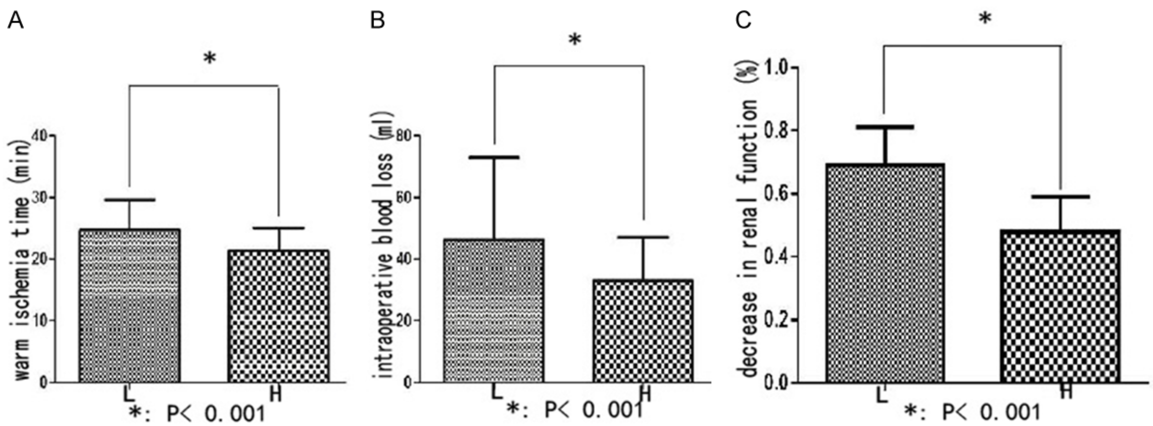

Figure 3. Histogram revealing the statistical results for operative characteristics between L group and H group under the C-index scoring system.

Table 5. Combination of the R.E.N.A.L and C-index scoring systems

Surgical methods	Subgroups						Total
	LL	LH	ML	MH	HL	HH	
LPN	59 (100)	21 (87.50)	53 (98.15)	53 (85.48)	1 (100)	4 (30.77)	191
LRN	0 (0)	3 (12.50)	1 (1.85)	9 (14.52)	0 (0)	9 (69.23)	22
P	-	0.02	-	0.02	-	0.36	

Notes: LL: low (low), LH: low (high), ML: middle (low), MH: middle (high), HL: high (low), HH: high (high).

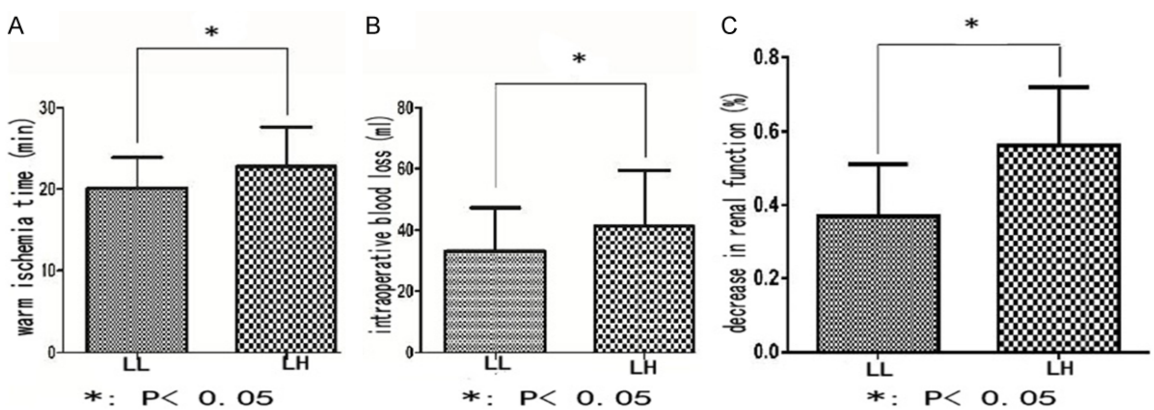

Figure 4. Histogram revealing the statistical results for operative characteristics between LL group and LH group under the two systems.

In our center, we conducted comprehensive investigations to evaluate the relationships between the scoring parameters and surgical approaches for renal cancer patients. OR value of tumor convexity and distance from kidney center were the two primary factors related to the choice of surgical methods among all scoring elements. Hence, based on the R.A.N.A.L. scoring system, the C-index was utilized to perform the further classification to evaluate the surgical risks, which provided scientific basis for the choice of precise operative methods.

Warm ischemia time, intraoperative blood loss, injuries to renal collecting system, and the decrease in postoperative renal function are important indicators to evaluate the complexity of operation [18]. In our combination of the two systems, the complexity of tumors has been divided specifically. For groups of LL and LH, significant differences were found in warm

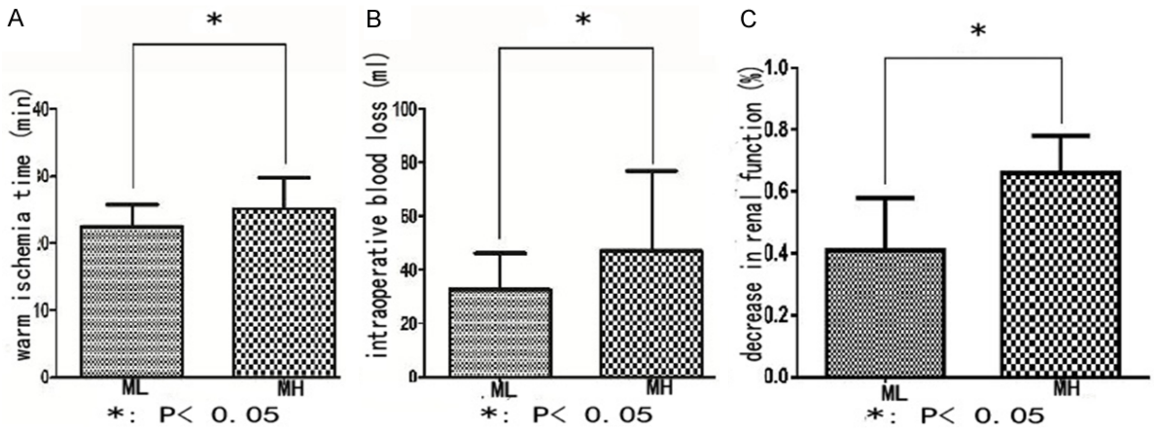

Figure 5. Histogram revealing the statistical results for operative characteristics between ML group and MH group under the two systems.

Table 6. Relationships between anatomical characteristics and option of surgical methods based on the R.E.N.A.L scoring system

R.E.N.A.L scoring system	Methods		X^2	*P*	OR	95% CI
	LPN	LRN				
(R) size			21.12	< 0.01	2.88	1.55-5.36
1	113	8				
2	66	6				
3	12	8				
(E) convexity			87.46	< 0.01	9.52	3.37-26.88
1	83	3				
2	104	6				
3	4	13				
(N) distance from the urinary collection system			38.87	< 0.01	6.64	2.69-16.35
1	75	3				
2	110	11				
3	6	8				
(L) relationships with renal poles			32.89	< 0.01	5.08	2.20-11.72
1	77	4				
2	107	10				
3	7	8				

ischemia time, intraoperative blood loss, injuries to renal collecting system, and the decrease in postoperative renal function. The difference existed likely in groups of ML and MH. This suggested that the difficulties of operation were various in subgroups after further classifications of tumor complexities. The same difference was observed in groups of MH and ML. In the study, there was no significant difference in intraoperative blood loss and postoperative renal function based on the R.E.N.A.L scoring system alone. Nonetheless, postoperative parameters of variously complex tumors had significant differences when combined with the C-index scoring system, which suggested that combination of the two systems might further differentiate the complexity and risks of surgeries.

The proportion of LPN in LL group was higher than that in LH group, which is the same result in subgroups of ML and MH. Preoperative decision for surgical methods depended on the tumor anatomical characteristics and surgeon's experiences. Under the R.E.N.A.L. scoring system, the same complexity of renal tumors in the R.E.N.A.L. scoring system could further be divided into more precise subgroups by C-index, in which LPN was more preferable in group with lower scores. However, the above result was not observed in groups of HL and HH, which may be caused by the number of samples. In addition, the majority (21/22) of patients treated with LRN was high-scored complex tumors under the C-index scoring system. This result suggested that the LRN might be carefully evaluated again if the cases were low-scored complex renal tumors in C-index scoring system. These cases might be potentially suitable for LPN.

Therefore, based on the imaging examination system, the combination of the two systems could further differentiate the same complexity of renal tumors into specific subgroups. This approach may describe the tumor anatomical characteristics clearer, and be a valuable option for surgery.

Disclosure of conflict of interest

None.

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