Surgical complexity and prognostic outcome of small volume renal cell carcinoma with high-level venous tumor thrombus and large volume renal cell carcinoma with low-level thrombus

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Abstract

Background: Radical nephrectomy with thrombectomy is one of the most difficult and complicated urological operations. But the roles of renal tumor volume and thrombus level in surgical complexity and prognostic outcome are not clear. This study aimed to evaluate the surgical complexity and prognostic outcome between the volume of renal cell carcinoma (RCC) and the level of venous tumor thrombus.

Methods: The clinical data of 67 RCC cases with renal vein or inferior vena cava (IVC) tumor thrombus from January 2015 to May 2018 were retrospectively analyzed. Among these 67 cases, 21 (31.3%) were small tumors with high-level thrombus (tumor $\leq$7 cm in diameter and thrombus Neves Level II–IV), while 46 (68.7%) were large tumors with low-level thrombus group (tumor >7 cm in diameter and thrombus Level 0–I). Clinical features, operation details, and pathology data were collected. Univariable and multivariable logistic regression analyses were applied to evaluate the risk factors for small tumor with high-level thrombus.

Results: Patients with small tumors and high-level thrombus were more likely to have longer operative time (421.9 ± 135.1 min *vs.* 282.2 ± 101.9 min, $t = 4.685$, $P < 0.001$), more surgical bleeding volume (1200 [325, 2900] mL *vs.* 500 [180, 1000] mL, $U = 270.000$, $P = 0.004$), more surgical blood transfusion volume (800 [0, 1400] mL *vs.* 0 [0, 800] mL, $U = 287.500$, $P = 0.004$), more plasma transfusion volume (0 [0, 800] mL *vs.* 0 [0, 0] mL, $U = 319.000$, $P = 0.004$), higher percentage of open operative approach (76.2% *vs.* 32.6%, $\chi^2 = 11.015$, $P = 0.001$), higher percentage of IVC resection (33.3% *vs.* 0%, $\chi^2 = 17.122$, $P < 0.001$), and higher percentage of post-operative complications (52.4% *vs.* 19.6%, $\chi^2 = 7.415$, $P = 0.010$) than patients with large tumors and low-level thrombus. In multivariate analysis, decreased hemoglobin (Hb) (odds ratio [OR]: 0.956, 95% confidence interval [CI]: 0.926–0.986, $P = 0.005$) and non-sarcomatoid differentiation (OR: 0.050, 95% CI: 0.004–0.664, $P = 0.023$) were more likely to form small tumors with high-level tumor thrombus rather than large tumor with small tumor thrombus. The estimated mean cancer-specific survival times of small tumor with high-level thrombus and large tumor with low-level thrombus were 31.6 ± 3.8 months and 32.5 ± 2.9 months, without statistical significance ($P = 0.955$). After univariate and multivariate Cox proportional hazard survival regression analyses, only distant metastasis (hazard ratio [HR]: 3.839, $P = 0.002$), sarcomatoid differentiation (HR: 7.923, $P < 0.001$), alkaline phosphatase (HR: 2.661, $P = 0.025$), and severe post-operative complications (HR: 10.326, $P = 0.001$) were independent predictors of prognosis.

Conclusions: The level of the tumor thrombus was more important than the diameter of the primary kidney tumor in affecting the complexity of surgery. In the same T3 stage, neither the renal tumor diameter nor the tumor thrombus level was an independent risk factor for prognosis.

Keywords: Inferior vena cava; Tumor thrombus; Renal cell carcinoma; Cancer-specific survival; Prognosis; Neves classification

Introduction

Renal cell carcinoma (RCC) is a common urinary system malignant tumor that accounts for 2% to 3% adult malignant tumors.[1] In locally advanced RCC, 4% to 10% patients have inferior vena cava (IVC) tumor thrombus.[2] Patients with untreated RCC associated with IVC tumor thrombus have poor prognosis with a median survival time about 5 months and 1-year tumor-specific survival rate about 29%.[3] Radical nephrectomy and IVC thrombectomy can effectively improve the prognosis with significantly increased 5-year tumor-specific survival rate of 40% to 65%.[4] However, radical nephrectomy with IVC thrombectomy is one of the most difficult and complicated urology operations because of its large range of surgical

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trauma, high risk of anesthesia and intra-operative bleeding. It is known that the volume of renal tumor is an important index to reflect the complexity of surgery. Normally, larger tumors are more difficult to be dissociated and result in more blood loss during the operation. The level of tumor thrombus is also an indicator of surgery complexity. It is a common clinical problem that small volume RCC can be associated with high-level tumor thrombus and large volume tumor with low-level thrombus. The question is then what are the roles of renal tumor volume and thrombus level in surgical complexity and which of these two factors affects the complexity of surgery more? At present, few literatures have studied the relationship between them.

In 2010 International Union against cancer TNM staging system, the diameter of renal tumor and the level of tumor thrombus are important prognostic indicators. For RCC without venous tumor thrombus, the current classification system is as follows: stage T1 is within or equal to 7 cm; stage T2 is greater than 7 cm in diameter; if the tumor invades the renal vein (Neves classification level 0), it is classified as stage T3a; if the tumor invades the IVC below the diaphragm (Neves classification level I–III), as T3b; if the tumor invades the IVC above the diaphragm (Neves classification level IV), as T3c. However, for RCC with venous thrombus, T staging is performed according to the thrombus level instead of focusing on the diameter of the primary tumor. Therefore, according to the TNM staging system, in patients with RCC without lymph node metastasis or distant metastasis, small tumor and high tumor thrombus level should have a worse prognosis than those with large tumor and low thrombus level, because the former has a higher T stage. The study on the effectiveness of such classification is rare. The objective of this study was to report our experience in the surgical management of RCC with tumor thrombus, to assess surgical complexity and prognostic outcome of small volume RCC tumor with high-level tumor thrombus and large volume tumor with low-level thrombus.

Methods

Ethical approval

The study was conducted in accordance with the *Declaration of Helsinki* and was approved by the Ethics Committees of Peking University Third Hospital. Informed consent was obtained from all individual participants prior to their enrollment in this study.

Patient selection

The clinical data of 153 renal mass patients with renal vein or IVC tumor thrombus admitted to the Urology Department of Peking University Third Hospital from January 2015 to May 2018 were retrospectively analyzed. Patients without surgical treatment, with recurrence of tumor thrombectomy, nephroblastoma, urothelial carcinoma, or other pathological types were excluded. Finally, after excluding 18 small tumors with low-level thrombus and 38 large tumors with high-level thrombus, 67 eligible patients were eventually included in the study [Figure 1].

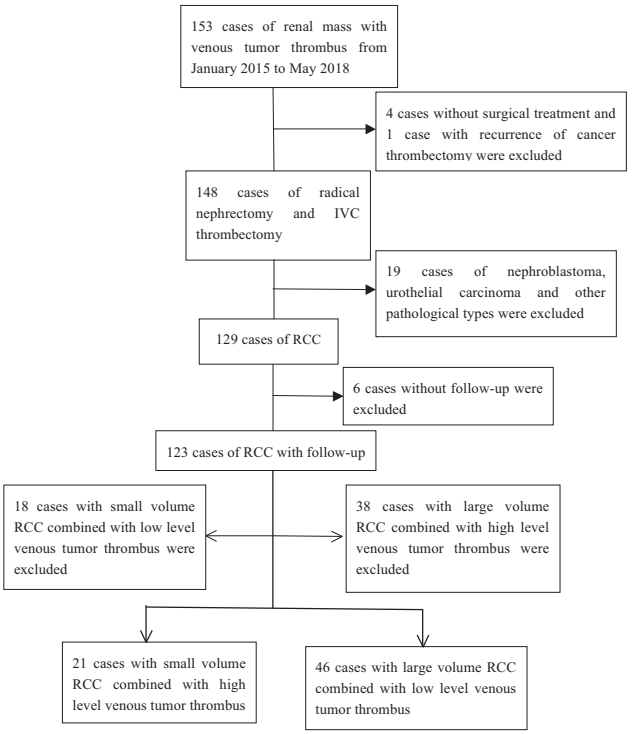

Figure 1: Flowchart of the study. IVC: Inferior vena cava; RCC: Renal cell carcinoma.

Clinical and pathology information

Clinical features, including age, gender, laterality, body mass index, serum Hb, albumin (Alb), corrected serum calcium (CCa), and alkaline phosphatase, serum creatinine (SCr), glomerular filtration rate, American Society of Anesthesiologists grading system score, nodal and metastasis status, and pathologic features were collected. SCr was re-tested 1 week after surgery. CCa is calculated using the Orrell formula ($CCa = Ca - 0.707 \times [Alb - 3.4]$).[5]

Pre-operative magnetic resonance imaging or computed tomography (CT) data were reviewed by two radiologists blinded to patients' surgery information. We measured the length of tumor thrombus and assessed whether the tumor thrombus invaded vessel wall. To define the level of venous tumor thrombus extension, we followed the Neves classification system.[2] Level 0 tumor thrombus included those restricted to renal vein; level I referred to those extending into IVC but $\leq$2 cm; level II referred to those extending into IVC by >2 cm but below the hepatic veins; level III referred to above the hepatic veins but below the diaphragm; level IV referred to tumor thrombus extending above the diaphragm or into the right atrium. Given the diversity of surgical strategies, we classified patients into low-level and high-level venous tumor thrombus, using extending into IVC by $\leq$2 or >2 cm as the cut off line. Post-operative immunotherapy or targeted molecular therapies were suggested if distant metastasis existed before surgery.

Surgery and complications

The surgical approach of IVC tumor thrombectomy in our institution was described previously.[6,7] In laparoscopic

radical nephrectomy and thrombectomy, all patients underwent laparoscopic retroperitoneal approach except that the patients, who had left RCC with level I–II tumor thrombus, if necessary, underwent the retroperitoneal approach to free the kidney combined with the transperitoneal approach to free the IVC. In the procedure of open radical nephrectomy and thrombectomy, RCC was treated with a chevron incision through the transperitoneal approach.

Modified Clavien grading system was used to evaluate the post-operative complications.[8] Complications of grade ≥III were defined as severe complications.[9]

Monitoring and follow-up

The first follow-up was carried out at 1 month after operation, then every 3 months in the first 2 years, and every 6 months thereafter. Follow-up examinations included routine laboratory tests and imaging assessment (including abdominal ultrasonography and/or enhanced abdominal CT, chest CT) to exclude local recurrence or metastasis. Appropriate treatments (adjuvant targeted agents) were provided in cases of local recurrence or distant metastasis. The decision to receive sunitinib, axitinib, or sorafenib therapy was made mainly by the surgeon and patients. The treatment regimen was at least 3 months of sorafenib orally 400 mg twice per day during a 4-week cycle, or sunitinib orally 50 mg per day for a 6-week cycle (4 weeks on treatment, 2 weeks off), or axitinib orally 5 mg twice per day during a 4-week cycle. Therapy continued until unacceptable toxicities, or patient withdrawal. Follow-up information was obtained via phone interviews and outpatient records. The last follow-up was completed in December 2018. During the follow-up period, the cause of patient's death was confirmed by the death certificate offered by the hospital.

Statistical analysis

Continuous variables with normally distribution were shown as the mean ± standard deviation and analyzed using Student's *t* test for data, and continuous variables with non-normally distribution were shown as the median (Q1, Q3) and analyzed using Mann-Whitney *U* test. Categorical variables were summarized with percentage and compared using the Pearson Chi-square test. The survival time was calculated from the date of operation to the date of death or last follow-up (when the patient was confirmed to be alive). The Kaplan-Meier method was used to analyze the survival curve, and differences between groups were compared using the log-rank test. Analysis of cancer-specific survival (CSS) was performed using both univariate and multivariate Cox proportional hazard survival regression analyses to find the factors that influence the prognosis. Univariate analysis was used to analyze risk factors for small tumor with high-level thrombus, and then significant factors were included in subsequent multivariate logistic regression analysis. The results were summarized with odds ratios (ORs) and 95% confidence intervals (CIs). The statistical analyses were performed with SPSS version 24.0 (IBM Inc., Chicago, IL, USA). All tests were two-sided, and P values < 0.05 were considered to be statistically significant.

Results

Clinical and radiographic features of our cohort are shown in Table 1. In 67 patients, 21 (31.3%) had small tumors with high-level thrombus (tumor ≤7 cm in diameter and thrombus Level II–IV) [Figure 2], 46 (68.7%) had large tumors with low-level thrombus group (tumor >7 cm in diameter and thrombus Level 0–I) [Figure 3]. These patients with small tumors and high-level thrombus were more likely to have decreased Hb ($P = 0.011$), longer operative time ($P < 0.001$), more surgical bleeding volume ($P = 0.004$), more surgical blood transfusion volume ($P = 0.004$), more plasma transfusion volume ($P = 0.004$), higher percentage of open operative approach ($P = 0.001$), higher percentage of IVC resection ($P < 0.001$), lower percentage of sarcomatoid differentiation in post-operative pathology ($P = 0.049$), and higher percentage of post-operative complications ($P = 0.010$) than the patients with large tumors and low-level thrombus.

Univariate and multivariate analyses of pre-operative clinical and radiographic features predicting small tumors and high-level thrombus were done and the results showed that decreased Hb (OR: 0.956; 95% CI: 0.926–0.986, $P = 0.005$) and non-sarcomatoid differentiation (OR: 0.050; 95% CI: 0.004–0.664, $P = 0.023$) were more likely to form small tumors with high-level tumor thrombus, rather than large tumor with small tumor thrombus in the final multivariate analysis.

A total of 5 (7.5%) patients developed venous thromboembolism. We did not routinely use anti-coagulation. Patients who had lower extremity edema would be tested with B-ultrasound. Anti-coagulation with low-molecular-weight heparin anti-coagulation was only used when patients had been confirmed to have lower extremity venous thrombosis, as there were literatures reporting that heparin anti-coagulation has a hemorrhagic risk.

The median follow-up time was 14.0 months (0–44.0 months). The survival information of all patients was available. At the last follow-up, 17 patients were deceased, and all of them were cancer-related deaths. The estimated mean CSS time was 32.3 ± 2.3 months for all patients. The 3-year CSS was 58.6%. The estimated mean CSS times of small tumor with high-level thrombus group and large tumor with low-level thrombus group were 31.6 ± 3.8 months and 32.5 ± 2.9 months, without significant difference ($P = 0.955$) [Figure 4]. When considering the N0M0 sub-group, the estimated mean CSS times of small tumor with high-level thrombus group and large tumor with low-level thrombus group were 33.6 ± 5.6 months and 27.9 ± 2.1 months. There was no significant difference in CSS time between the two groups ($P = 0.463$) [Figure 5].

To identify factors that influence the prognosis of patients with RCC and tumor thrombosis, we analyzed all 123 patients including 18 small tumors with low-level thrombus and 38 large tumors with high-level thrombus rather than 67 patients. Analysis of CSS was performed using both univariate and multivariate Cox proportional hazard survival regression analyses. Only distant metastasis (hazard ratio [HR]: 3.839, $P = 0.002$), sarcomatoid

Table 1: Comparison of clinical and pathologic features between small tumor with high-level thrombus group (tumor ≤ 7 cm in diameter and thrombus Level II–IV) and large tumor with low-level thrombus group (tumor >7 cm in diameter and thrombus Level 0–I).

Features	Small tumor with high-level thrombus ($n = 21$)	Large tumor with low-level thrombus ($n = 46$)	Statistical values	*P*
Age (years)	60.0 ± 10.0	57.2 ± 12.8	0.914*	0.364
Sex			0.651†	0.553
Male	14 (66.7)	35 (76.1)		
Female	7 (33.3)	11 (23.9)		
BMI (kg/m^2)	23.6 ± 3.3	23.3 ± 4.1	0.266*	0.791
Tumor diameter (cm)	5.3 ± 1.7	10.3 ± 2.6	8.160*	<0.001
Hemoglobin (g/L)	109.5 ± 21.1	124.7 ± 22.5	2.613*	0.011
Serum calcium (mg/L)	86 ± 5	89 ± 8	1.884*	0.064
Albumin (g/L)	36.9 ± 5.6	38.2 ± 5.9	0.863*	0.392
Pre-operative serum creatinine (μmol/L)	97.5 ± 23.2	91.3 ± 20.6 ($n = 45$)	1.100*	0.276
Serum creatinine 1 week after operation (μmol/L)	93.1 ± 23.5 ($n = 20$)	93.8 ± 23.9 ($n = 45$)	0.103*	0.919
Alkaline phosphatase (U/L)	105.5 ± 69.4	95.7 ± 49.0	0.664*	0.509
Operative time (min)	421.9 ± 135.1	282.2 ± 101.9	4.685*	<0.001
Surgical bleeding volume (mL)	1200 (325, 2900)	500 (180, 1000)	270.000‡	0.004
Surgical blood transfusion volume (mL)	800 (0, 1400)	0 (0, 800)	287.500‡	0.004
Plasma transfusion volume (mL)	0 (0, 800)	0 (0, 0)	319.000‡	0.004
Tumor side			2.903†	0.212
Left	6 (28.6)	22 (47.8)		
Right	15 (71.4)	24 (52.2)		
ASA score			5.622†	0.052
1	1 (4.8)	5 (10.9)		
2	14 (66.7)	38 (82.6)		
3	6 (28.6)	3 (6.5)		
Clinical symptoms			0.720†	0.888
No	4 (19.0)	11 (23.9)		
Local symptoms	10 (47.6)	17 (37.0)		
Systemic symptoms	3 (14.3)	7 (15.2)		
Both local and systemic symptoms	4 (19.0)	11 (23.9)		
cN stage			0.552†	0.598
cN0	8 (38.1)	22 (47.8)		
cN1	13 (61.9)	24 (52.2)		
cM stage			0.196†	0.760
cM0	17 (81.0)	35 (76.1)		
cM1	4 (19.0)	11 (23.9)		
Neves classification			67.000†	<0.001
0	0	19 (41.3)		
I	0	27 (58.7)		
II	11 (52.4)	0		
III	6 (28.6)	0		
IV	4 (19.0)	0		
Operative approach			11.015†	0.001
Laparoscope	5 (23.8)	31 (67.4)		
Open operation	16 (76.2)	15 (32.6)		
IVC resection			17.122†	<0.001
No	14 (66.7)	46 (100.0)		
Yes	7 (33.3)	0		
Pathology type			2.832†	0.126
Clear cell carcinoma	16 (76.2)	42 (91.3)		
Non-clear cell carcinoma	5 (23.8)	4 (8.7)		
Furmans classification			1.920†	0.185
1–2	5 (23.8)	19 (41.3)		
3–4	16 (76.2)	27 (58.7)		
Sarcomatoid differentiation			4.193†	0.049
No	20 (95.2)	34 (73.9)		
Yes	1 (4.8)	12 (26.1)		
Post-operative complications			7.415†	0.010
No	10 (47.6)	37 (80.4)		
Yes	11 (52.4)	9 (19.6)		
Post-operative adjuvant targeted therapy			0.234†	0.791
No	10 (47.6)	19 (41.3)		
Yes	11 (52.4)	27 (58.7)		

The data are shown as mean ± standard deviation, median (Q1, Q3) or *n* (%). * *t* values; †Chi-square values; ‡*U* values. BMI: Body mass index; ASA: American Society of Anesthesiologists; IVC: Inferior vena cava.

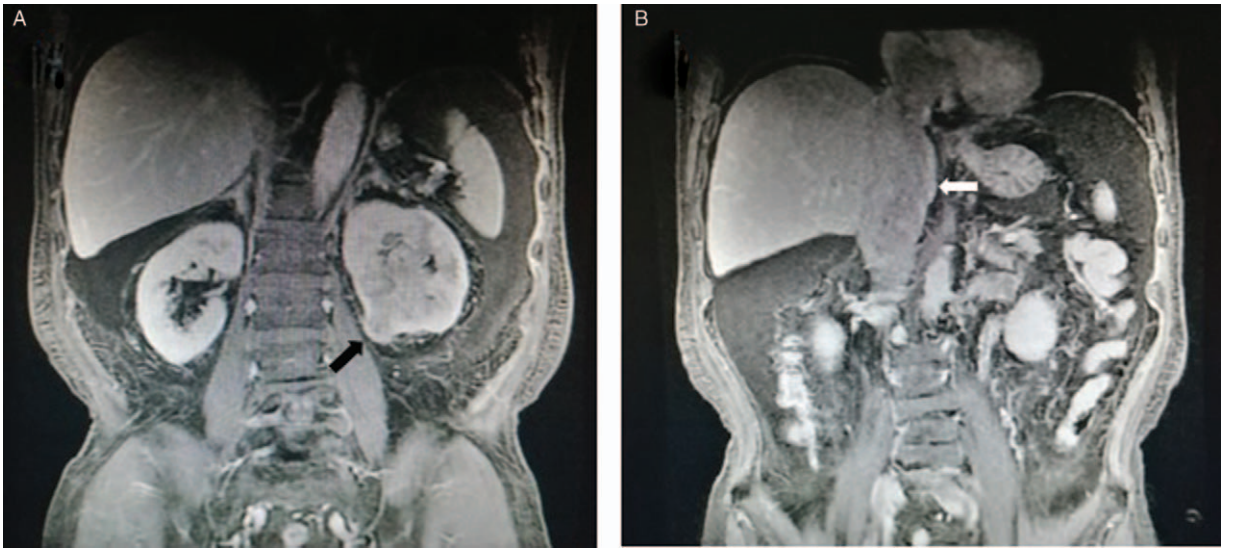

Figure 2: The MRI images showed that a 67 years old man had small tumor (A; 2.6 cm × 3.3 cm × 3.1 cm, black arrow) with high-level thrombus (B; level IV, the length of thrombus was 8.0 cm, white arrow). The pathology type was renal clear cell carcinoma. MRI: Magnetic resonance imaging.

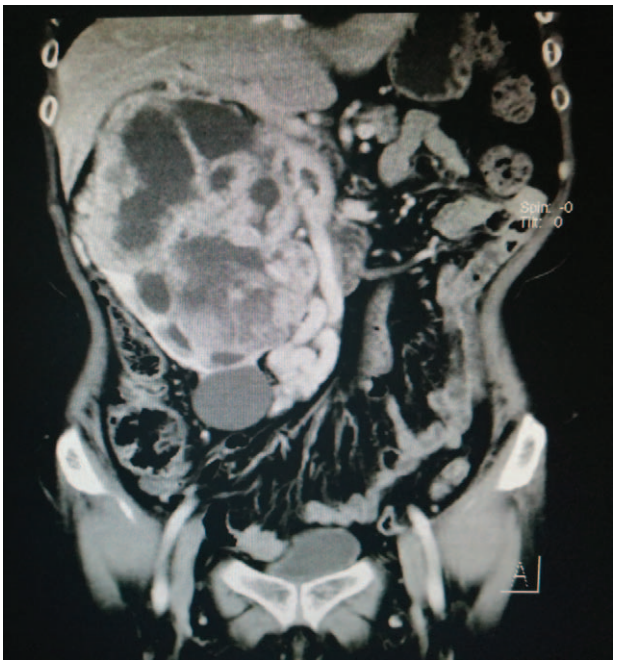

Figure 3: The CT image showed that a 66 years old woman had a large tumor (17.5 cm × 11.5 cm × 9.0 cm) with low-level thrombus (Level I, the length of thrombus was 2.5 cm). The pathology type was renal clear cell carcinoma. CT = Computed tomography.

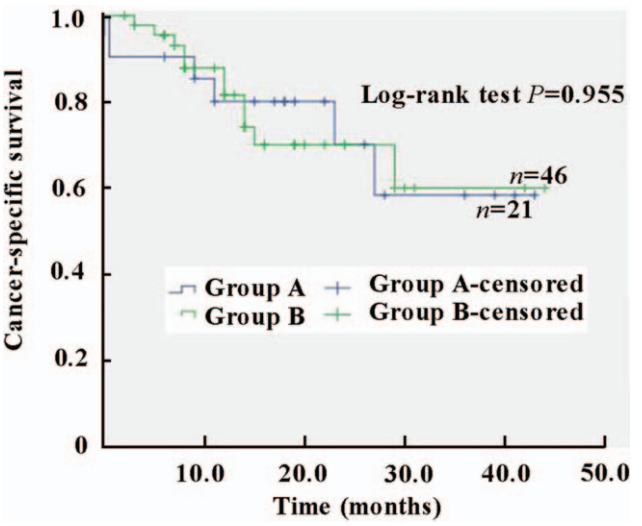

Figure 4: Cancer-specific survival of small tumor with high-level thrombus group (Group A) and large tumor with low-level thrombus group (Group B).

differentiation (HR: 7.923, $P < 0.001$), alkaline phosphatase (HR: 2.661, $P = 0.025$), severe post-operative complications (HR: 10.326, $P = 0.001$) were independent predictors of prognosis [Table 2].

Discussion

Radical nephrectomy and IVC thrombectomy is a traditional and effective treatment for RCC with IVC tumor thrombus and played an important role in improving prognosis. However, it is also one of the most difficult complicated operations in urology. The procedure of operation could be divided into two parts: nephrectomy and IVC thrombectomy. Some scholars believed that the IVC should be given priority in the sequence of surgical procedures.[10] The advantage of this approach was that it reduced the compression of IVC during freeing renal tumors, thereby reducing the risk of tumor thrombus falling off and pulmonary embolism. However, according to the operation experience in our center, priority treatment of renal tumors in surgical procedures could still achieve the same effect without increasing the occurrence of tumor thrombus shedding events. In addition, after freeing kidney adequately, we could get more operation space to deal with IVC tumor thrombus. On the whole, nephrectomy and removal of IVC tumor

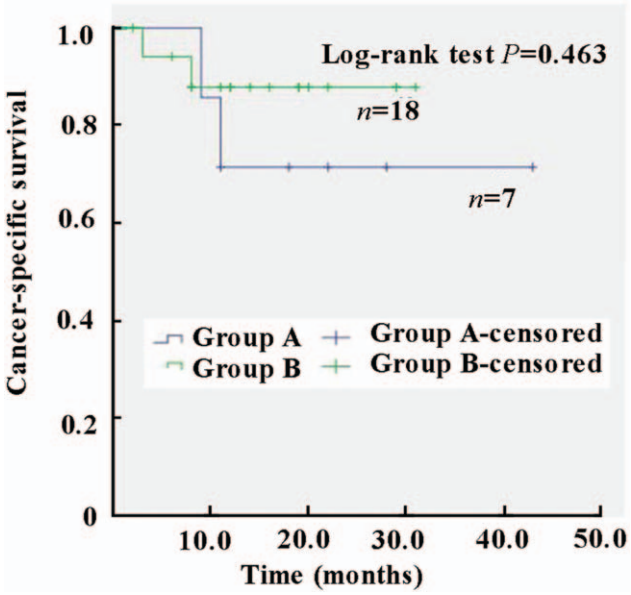

Figure 5: In the N0M0 sub-group, the cancer-specific survival of small tumor with high-level thrombus group (Group A) and large tumor with low-level thrombus group (Group B).

thrombus were important parts of complete operation which affected the operation complexity.

The size of renal tumor was an important index to reflect the complexity of surgery.[11,12] Generally, tumors with larger diameter tended to adhere to normal surrounding tissues. In the process of freeing kidney, more sharp dissociation was needed instead of blunt dissociation, which increased the operation time. In addition, larger tumors also mean that more tissue needed to be freed for creating enough space for operation. Especially for laparoscopic surgery, larger tumors occupied more space, which reduced the space created by pneumoperitoneum and became more difficult to expose the visual field. For tumor thrombus existed in renal vein or IVC, renal blood reflux was blocked partially or completely. This leads to collateral circulation and increase of circuitous veins around the tumor during the operation. In the process of dissociation, the amount of bleeding would increase, thus increasing surgery difficulty. At the same time, the level of tumor thrombus was also an indicator of the surgery complexity.

In our opinion, the main steps affecting the surgery complexity of small volume RCC combined with high-

Table 2: Univariate and multivariate Cox regression analyses of prognostic risk factors for patients with renal cell carcinoma and tumor thrombosis.

		Univariate analysis		Multivariate analysis	
Features	**CSS time (months), mean ± SD**	**HR (95% CI)**	***P***	**HR (95% CI)**	***P***
Distant metastasis		3.499 (1.726–7.091)	<0.001	3.839 (1.610–9.153)	0.002
M0	36.5 ± 1.9				
M1	21.5 ± 2.5				
Furmans classification		2.767 (1.137–6.735)	0.025	1.439 (0.553–3.749)	0.456
1–2	36.9 ± 2.7				
3–4	27.9 ± 2.3				
Sarcomatoid differentiation		4.039 (1.962–8.314)	<0.001	7.923 (3.132–20.042)	<0.001
No	33.7 ± 2.0				
Yes	15.8 ± 2.6				
Severe post-operative complications		5.166 (1.936–13.786)	0.001	10.326 (2.762–38.608)	0.001
No	32.4 ± 1.9				
Yes	10.7 ± 2.7				
Hemoglobin		3.071 (1.454–6.487)	0.003	1.677 (0.656–4.287)	0.280
>LLN	37.7 ± 1.8				
≤LLN	24.0 ± 2.4				
Albumin		2.871 (1.240–6.645)	0.014	0.511 (0.170–1.540)	0.233
>LLN	35.6 ± 2.3				
≤LLN	27.7 ± 2.4				
Clinical symptoms		4.878 (1.479–16.090)	0.009	3.498 (0.917–13.345)	0.067
No	39.4 ± 2.0				
Yes	27.4 ± 2.3				
Ipsilateral adrenalectomy		2.607 (1.205–5.640)	0.015	1.485 (0.657–3.356)	0.342
No	36.8 ± 2.2				
Yes	26.4 ± 2.5				
Pathology type		2.850 (1.337–6.075)	0.007	2.292 (0.895–5.870)	0.084
Clear cell carcinoma	34.4 ± 1.8				
Non-clear cell carcinoma	18.7 ± 1.8				
Alkaline phosphatase		3.120 (1.474–6.604)	0.003	2.661 (1.132–6.252)	0.025
<ULN	33.3 ± 2.0				
≥ULN	19.8 ± 4.1				

CSS: Cancer-specific survival; SD: Standard deviation; HR: Hazard Ratio; CI: Confidence interval; LLN: Lower limit of normal; ULN: Upper limit of normal.

level tumor thrombus focused on thrombectomy, not nephrectomy. On the other hand, the main steps affecting the surgery complexity of large volume RCC combined with low-level tumor thrombus focused on nephrectomy, not thrombectomy. Surgical operation emphasized to regard radical nephrectomy and IVC thrombectomy as a whole to manage. So what are the roles of renal tumor diameter and thrombus level in surgical complexity? Which index affects the complexity of surgery more? Among the 67 patients, group 1 (small tumors with high-level thrombus) had smaller tumor diameter, nearly half the diameter of group 2 (large tumors with low-level thrombus). In terms of surgical methods, open surgery was chosen more often for patients in group 1. Open surgery was a traditional method for the treatment of IVC tumor thrombus. Compared with laparoscopic approach, it has more traumas, more pain and longer recovery time. However, it also has some advantages, such as wide field vision and low technical requirements for the operator. In group 2, more patients underwent laparoscopic surgery. With the improvement of laparoscopic technology, low-grade IVC tumor thrombus could be successfully completed by completely retroperitoneal laparoscopy or retroperitoneal combined with transperitoneal approach. In the past, it was believed that the larger the diameter of the tumors, the smaller the space created by pneumoperitoneum, thus affecting the effect of surgery. However, in this study, the increase in tumor diameter was not an absolute contraindication for laparoscopic approach.

The resection of IVC vessel wall was also a reference index reflecting the surgical complexity. Literature had shown that the invaded vascular wall should be removed to achieve radical resection of all tumor loads, in order to reduce the local recurrence rate and improve the prognosis.[13,14] Patients in group 1 had a higher incidence of IVC wall resection than those in group 2. The height of the tumor thrombus affected the choice of the surgical method, whether the IVC vessel wall needed resecting or not. For low-grade thrombus, removal of the IVC wall was rarely required. The complications of vascular wall resection, such as bilateral lower extremity edema and renal insufficiency, might also affect the surgery complexity.

Patients in group 1 (small tumors with high-level thrombus) had greater surgical complexity than those in group 2 (large tumors with low-level thrombus). This was manifested in longer operation time, more bleeding, more surgical blood transfusion, more plasma transfusion and higher incidence of complications. Therefore, we believed that the height of the tumor thrombus was more important than the diameter of the primary kidney tumor in affecting the complexity of surgery.

The effect of IVC tumor thrombus on prognosis was controversial. Some believed the presence of IVC tumor thrombus affected the prognosis with poor prognosis,[15] while others believed that tumor thrombus had little effect on prognosis.[16,17]

In terms of the prognostic significance of primary renal tumor diameter and the tumor thrombus height, we found no significant between small volume tumor with high-level thrombus and large tumor with low-level thrombus. After univariate and multivariate analyses of prognostic factors, only distant metastasis, sarcomatoid differentiation, alkaline phosphatase, severe post-operative complications were independent predictors of prognosis. In the same T3 stage, neither the renal tumor diameter nor the tumor thrombus height was an independent risk factor for prognosis.

Our study had some limitations. The samples were limited to only patient treated by the same hospital and hence similar treatment procedures and practice. Because RCCs with venous extension are relatively uncommon, more extensive study through a consortium that includes more institutes to accumulate more patient data will be very useful. Additionally, the present study was limited by its retrospective and single-center nature. Prospective study and external validation is needed in the future.

In conclusions, the level of the tumor thrombus was more important than the diameter of the primary kidney tumor in affecting the complexity of surgery. In the same T3 stage, neither the renal tumor diameter nor the tumor thrombus level was an independent risk factor for prognosis.

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Conflicts of interest

None.

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