

# Development and Validation of a Nomogram for Predicting Postoperative Deep Vein Thrombosis Risk in Patients After Laparoscopic Partial Nephrectomy

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**Objective:** To construct a nomogram model for individualized prediction of risk of deep vein thrombosis (DVT) in renal cell carcinoma (RCC) patients after laparoscopic partial nephrectomy (PN).

**Methods:** A retrospective study was conducted on 556 RCC patients admitted to our hospital from January 2015 to January 2025. Patients were randomly divided into a modeling group (n=389) and a validation group (n=167) at a ratio of 7:3. The modeling group was further subdivided into DVT and non-DVT groups based on postoperative DVT occurrence. Clinical data were collected. Logistic regression was used to analyze the influencing factors. R software was used to construct the nomogram. ROC curves were generated to evaluate the discrimination ability of the nomogram. Decision curve analysis (DCA) was performed to assess its clinical utility.

**Results:** Of 556 patients, 100 (17.98%) developed DVT, including 70 (17.99%) in the modeling group. Logistic regression identified age, operation time, time in bed, pneumoperitoneum pressure, duration of indwelling drains, total cholesterol (TC), and D-dimer as significant risk factors ( $P < 0.05$ ). The area under the curve (AUC) was 0.889 for the modeling group and 0.866 for the validation group. Hosmer-Lemeshow test indicated good calibration (modeling group:  $\chi^2=7.120$ ,  $P=0.714$ ; validation group:  $\chi^2=7.058$ ,  $P=0.724$ ). DCA showed clinical utility for predicted probabilities between 0.08 and 0.96.

**Conclusion:** Age, operation time, time in bed, pneumoperitoneum pressure, duration of indwelling drains, TC, and D-dimer are risk factors for DVT in patients after laparoscopic PN. The constructed nomogram demonstrates good predictive performance and can be used for individualized risk assessment of postoperative DVT in RCC patients.

**Keywords:** renal cell carcinoma, partial nephrectomy, deep vein thrombosis, risk factors, nomogram

## Introduction

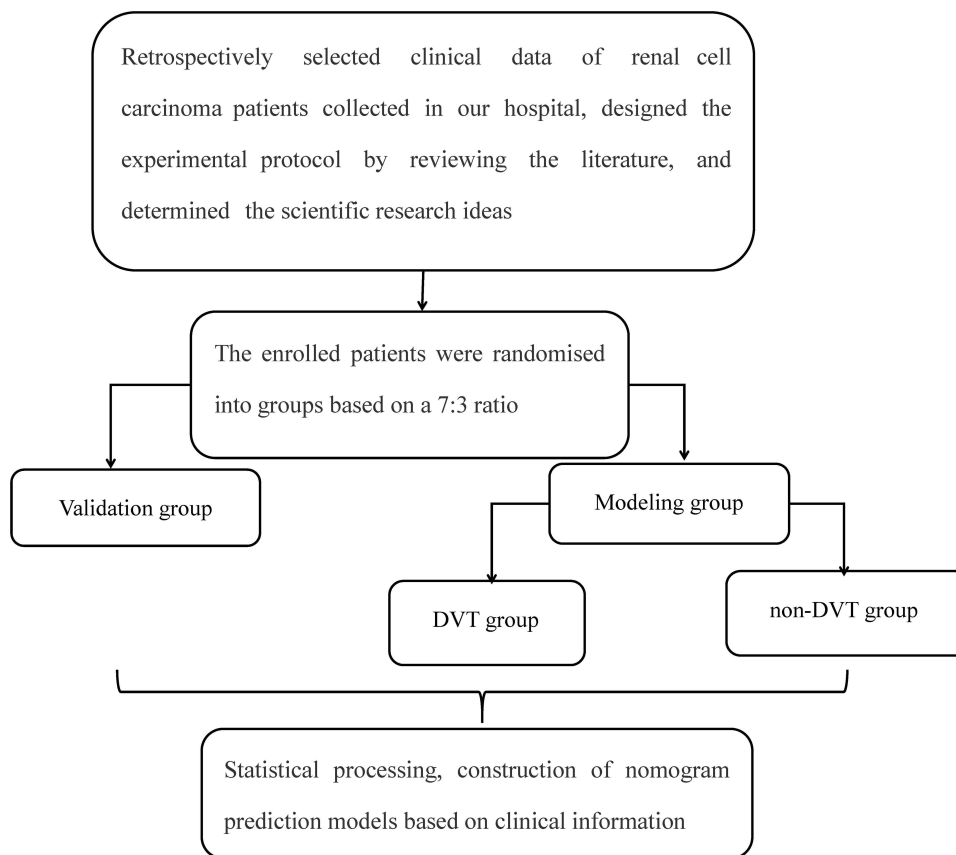
Renal cell carcinoma (RCC) is a common malignancy, originating from the epithelium of the renal tubules and accounting for approximately 80% of malignant tumors of the kidney. It mainly affects middle-aged and elderly patients, and its incidence is increasing annually worldwide, posing a serious threat to patient survival.<sup>1,2</sup> Partial nephrectomy (PN) is the main clinical treatment for early-stage RCC. Compared with traditional open surgery, laparoscopic PN offers the advantages of less trauma, greater precision, faster postoperative recovery, and better preservation of surrounding renal tissue. These benefits allow for the effective treatment of localized RCC while maximizing renal function, ultimately improving surgical outcomes and patient prognosis.<sup>3,4</sup> The incidence of DVT with conventional surgery may reach 25%, whereas laparoscopic surgery may reduce it to around 10%. However, postoperative complications remain unavoidable. Due to VHL gene mutations, RCC exhibits an inherent hypercoagulable state, leading to HIF-mediated overexpression of procoagulant factors. Combined with surgical stress, this forms a high-risk condition, and some patients still develop deep vein thrombosis (DVT) of the lower extremities after surgery. If a thrombus dislodges, it may cause pulmonary embolism, and in the long term, it may trigger post-thrombotic syndrome, or even lead to death.<sup>5</sup>

Therefore, identifying the risk factors that influence DVT in clinical practice is particularly important for preventing this complication and improving patient outcomes. Nomogram prediction models can more accurately predict adverse outcomes by transforming a relatively complex regression equation into an easily understandable graphical tool, thereby assisting clinicians in calculating the values of various variables using the figure and determining the incidence of adverse outcomes.<sup>6</sup> For instance, a predictive model for postoperative lower extremity DVT in gastric cancer patients demonstrated good predictive value in both the training and validation cohorts.<sup>7</sup> While there have been many studies analyzing the risk factors for DVT after PN in patients with RCC, research on a nomogram in this context remains limited. Therefore, this study aimed to develop and validate a nomogram prediction model for the individualized DVT risk in RCC patients after PN.

## Materials and Methods

### Study Population

A retrospective analysis was conducted on 556 RCC patients admitted to our hospital from January 2015 to January 2025. They were randomly divided into a modeling group (389 cases) and a validation group (167 cases) at a ratio of 7:3. According to whether postoperative DVT occurred, the modeling group was further subdivided into a DVT group and a non-DVT group. The flowchart of case collection is shown in Figure 1. Inclusion criteria: (1) meeting the standards for RCC,<sup>8</sup> confirmed by pathology; (2) unilateral RCC, all at early stage; (3) all underwent PN; (4) no preoperative radiotherapy or chemotherapy; (5) complete clinical data. Exclusion criteria: (1) history of DVT; (2) presence of other malignant tumors; (3) diabetic nephropathy; (4) failure of vital organs such as the liver; (5) immunodeficiency; (6) cognitive impairment; (7) hematological diseases; (8) any surgical contraindications. This study was approved by the hospital's ethics committee.



**Figure 1** Case flow collection diagram.

## Methods

### Surgical Procedure

Under general anesthesia, the patient was placed in the healthy-side lateral decubitus position. After skin disinfection and draping, a pneumoperitoneum was established with carbon dioxide, maintaining the pressure at 12–15 mmHg. The dorsal and ventral aspects of the kidney were separated along the renal fascia to fully expose the lesion. The renal artery was then clamped with a vascular clip, and the tumor was excised using an ultrasonic scalpel. After suturing the wound surface, the vascular clip was removed, and once renal blood supply was restored, a drainage tube was placed and the incision was closed. Low-molecular-weight heparin prophylaxis was administered according to the patient's condition.

### DVT Determination Criteria

Postoperatively, patients underwent Wells scoring<sup>9</sup> and D-dimer tests. Those with moderate/high DVT risk based on the Wells score, together with elevated D-dimer levels, were subjected to lower-extremity deep venous ultrasonography. Ultrasonic imaging revealing solid echo filling in the lower-extremity deep venous lumen was indicative of DVT.<sup>10</sup>

## Clinical Data Collection

Collect data from the patients' electronic medical record database, mainly including clinical data: age, gender, body mass index (BMI), diabetes, hypertension, smoking history, drinking history, coronary heart disease, side of the tumor, TNM stage, tumor location, tumor diameter, operation time, intraoperative blood loss, bed rest time, surgical approach, pneumoperitoneum pressure, indwelling drainage time, time to recovery of bowel sounds, use of intermittent pneumatic compression devices; Lipid metabolism indicators: total cholesterol (TC), triglycerides (TG), LDL cholesterol (LDL-C), HDL cholesterol (HDL-C); Blood pressure indicators: systolic pressure, diastolic pressure; Complete blood count (CBC) indicators: white blood cell count (WBC), hemoglobin (HGB), platelet count (PLT); Inflammatory markers: total protein (TP), high-sensitivity C-reactive protein (HsCRP), fibrinogen (FIB); Glucose metabolism indicators: fasting blood glucose (FBG); Renal function indicators: urinary microalbumin (UmAlb),  $\beta$ 2 microglobulin ( $\beta$ 2-MG), urinary retinol-binding protein (RBP), creatinine (Cr), urea nitrogen (BUN), D-dimer; Coagulation function indicators: prothrombin time (PT), and activated partial thromboplastin time (APTT).

## Statistical Analysis

SPSS 25.0 software was used to perform independent sample *t*-test and  $\chi^2$  test. Logistic regression analysis was conducted to identify the influencing factors of postoperative DVT risk in RCC patients after PN. R software (version 4.5.1) with the rms package was used to construct the nomogram model for predicting postoperative DVT risk. The Receiver Operating Characteristic (ROC) curves were applied to evaluate the discriminatory ability of the nomogram; Calibration curves were used to assess the model's consistency; and Decision Curve Analysis (DCA) was performed to evaluate the clinical utility of the nomogram model. A *p*-value < 0.05 was considered statistically significant.

## Results

### Comparison of Clinical Data Between the Modeling Group and the Validation Group

There were no differences in age, sex, or other clinical data between the modeling group and the validation group (*P* > 0.05). See [Table 1](#).

### Comparison of Clinical Data Between the DVT Group and the Non-DVT Group

Among the 389 patients in the modeling group, 70 developed DVT, with an incidence rate of 17.99%. The groups showed differences (*P* < 0.05) in age, operation time, bed rest time, pneumoperitoneum pressure, indwelling drainage time, TC, and D-dimer. There were no significant differences (*P* > 0.05) in other clinical data between the two groups. Details were shown in [Table 2](#).

**Table 1** Comparison of Clinical Data Between the Modeling Group and the Validation Group

Factor	Modeling Group (n=389)	Validation Group (n=167)	t/ $\chi^2$	P
Age (years)			0.034	0.853
≥60	197 (50.64)	86 (51.50)		
<60	192 (49.36)	81 (48.50)		
Gender			0.166	0.684
Male	196 (50.39)	81 (48.50)		
Female	193 (49.61)	86 (51.50)		
BMI (kg/m <sup>2</sup> )			0.137	0.711
≥24	179 (46.02)	74 (44.31)		
<24	210 (53.98)	93 (55.69)		
Diabetes			0.647	0.421
Yes	79 (20.31)	29 (17.37)		
No	310 (79.69)	138 (82.63)		
Hypertensive			0.546	0.460
Yes	100 (25.71)	38 (22.75)		
No	289 (74.29)	129 (77.25)		
Smoking history			0.181	0.671
Yes	195 (50.13)	87 (52.10)		
No	194 (49.87)	80 (47.90)		
Drinking history			0.088	0.767
Yes	201 (51.67)	84 (50.30)		
No	188 (48.33)	83 (49.70)		
Coronary heart disease			1.303	0.254
Yes	131 (33.68)	48 (28.74)		
No	258 (66.32)	119 (71.26)		
Tumour lateralisation			0.050	0.824
Left side	202 (51.93)	85 (50.90)		
Right side	187 (48.07)	82 (49.10)		
TNM staging			0.885	0.347
T1a stage	231 (59.38)	92 (55.09)		
T1b stage	158 (40.62)	75 (44.91)		
Tumour location			0.192	0.909
Upper pole	126 (32.39)	53 (31.74)		
Middle pole	137 (35.22)	62 (37.13)		
Lower pole	126 (32.39)	52 (31.14)		
Tumour diameter (cm)	5.30±1.19	5.28±1.20	0.181	0.856
Operation time (min)	105.59±13.67	104.62±13.85	0.764	0.445
Intraoperative haemorrhage (mL)	83.45±5.37	83.37±5.29	0.162	0.872
Time in bed (d)			0.576	0.448
≥3	186 (47.81)	74 (44.31)		
<3	203 (52.19)	93 (55.69)		
Surgical access			0.265	0.607
Transabdominal PN	33 (8.48)	12 (7.19)		
Retroperitoneal PN	356 (91.52)	155 (92.81)		
Pneumoperitoneum (mmHg)	11.01±1.48	10.99±1.53	0.145	0.885
Duration of indwelling drains (d)	3.13±0.79	3.14±0.75	0.139	0.890
Bowel sound recovery time (h)	23.96±2.80	23.92±2.81	0.154	0.877
Intermittent Inflatable Pressurisation Unit			0.396	0.529
Yes	186 (47.81)	75 (44.91)		
No	203 (52.19)	92 (55.09)		
TC (mmol/L)	3.51±0.62	3.49±0.52	0.365	0.715
TG (mmol/L)	2.88±0.34	2.85±0.32	0.971	0.332

(Continued)

**Table 1** (Continued).

Factor	Modeling Group (n=389)	Validation Group (n=167)	t/ $\chi^2$	P
LDL-C (mmol/L)	3.77±0.38	3.74±0.35	0.873	0.383
HDL-C (mmol/L)	1.22±0.26	1.25±0.28	1.218	0.224
Systolic blood pressure (mmHg)	139.25±14.41	139.12±14.53	0.097	0.923
Diastolic blood pressure (mmHg)	84.01±7.50	84.12±7.53	0.158	0.874
WBC ( $\times 10^9/L$ )	9.14±1.96	9.12±1.89	0.111	0.911
HGB (g/L)	115.94±19.92	115.79±19.64	0.082	0.935
PLT ( $\times 10^9/L$ )	253.37±20.39	253.28±20.21	0.048	0.962
TP (g/L)	59.91±12.49	59.72±12.34	0.165	0.869
HsCRP (mg/L)	6.84±1.92	6.81±1.91	0.169	0.866
FIB (g/L)	2.99±0.42	2.96±0.38	0.794	0.428
FDP ( $\mu g/mL$ )	27.32±3.04	27.34±3.08	0.071	0.944
FBG (mmol/L)	5.25±1.09	5.26±1.06	0.100	0.920
UmAlb (mg/L)	68.71±6.60	68.63±6.59	0.131	0.896
$\beta_2$ -MG (mg/L)	2.19±0.34	2.17±0.32	0.647	0.518
RBP (mg/L)	1.47±0.27	1.45±0.31	0.765	0.445
Cr ( $\mu mol/L$ )	82.39±7.30	82.34±7.28	0.074	0.941
BUN (mmol/L)	5.91±0.92	5.93±0.94	0.233	0.815
(mg/L)	0.66±0.16	0.64±0.14	1.401	0.162
PT (s)	10.97±1.89	10.89±1.84	0.461	0.645
APTT (s)	33.51±4.25	33.48±4.15	0.077	0.939

**Table 2** Comparison of Clinical Data Between DVT and Non-DVT Groups

Factor	DVT Group (n=70)	Non-DVT Group (n=319)	t/ $\chi^2$	P
Age (years)			19.090	<0.001
≥60	52 (74.29)	145 (45.45)		
<60	18 (25.71)	174 (54.55)		
Gender			0.519	0.471
Male	38 (54.29)	158 (49.53)		
Female	32 (45.71)	161 (50.47)		
BMI ( $kg/m^2$ )			0.224	0.636
≥24	34 (48.57)	145 (45.45)		
<24	36 (51.43)	174 (54.55)		
Diabetes			0.066	0.797
Yes	15 (21.43)	64 (20.06)		
No	55 (78.57)	255 (79.94)		
Hypertensive			0.367	0.545
Yes	20 (28.57)	80 (25.08)		
No	50 (71.43)	239 (74.92)		
Smoking history			0.590	0.442
Yes	38 (54.29)	157 (49.22)		
No	32 (45.71)	162 (50.78)		
Drinking history			0.559	0.455
Yes	39 (55.71)	162 (50.78)		
No	31 (44.29)	157 (49.22)		
Coronary heart disease			0.459	0.498
Yes	26 (37.14)	105 (32.92)		
No	44 (62.86)	214 (67.08)		

(Continued)

**Table 2** (Continued).

Factor	DVT Group (n=70)	Non-DVT Group (n=319)	t/ $\chi^2$	P
Tumour lateralisation			0.030	0.864
Left side	37 (52.86)	165 (51.72)		
Right side	33 (47.14)	154 (48.28)		
TNM staging			0.013	0.908
T1a stage	42 (60.00)	189 (59.25)		
T1b stage	28 (40.00)	130 (40.75)		
Tumour location			0.223	0.637
Upper pole	24 (34.29)	102 (31.97)		
Middle pole	25 (35.71)	112 (35.11)		
Lower pole	21 (30.00)	105 (32.92)		
Tumour diameter (cm)	5.25±1.12	5.31±1.21	0.381	0.704
Operation time (min)	120.35±14.35	102.35±13.52	9.975	<0.001
Intraoperative haemorrhage (mL)	84.25±5.32	83.27±5.38	1.383	0.168
Time in bed (d)			16.837	<0.001
≥3	49 (70.00)	137 (42.95)		
<3	21 (30.00)	182 (57.05)		
Surgical access			0.954	0.329
Transabdominal PN	8 (11.43)	25 (7.84)		
Retroperitoneal PN	62 (88.57)	294 (92.16)		
Pneumoperitoneum (mmHg)	13.25±1.46	10.52±1.48	14.009	<0.001
Duration of indwelling drains (d)	4.25±1.01	2.89±0.74	12.963	<0.001
Bowel sound recovery time (h)	24.28±2.86	23.89±2.79	1.054	0.292
Intermittent Inflatable Pressurisation Unit			0.841	0.359
Yes	30 (42.86)	156 (48.90)		
No	40 (57.14)	163 (51.10)		
TC (mmol/L)	5.02±1.11	3.18±0.51	21.176	<0.001
TG (mmol/L)	2.92±0.37	2.87±0.33	1.123	0.262
LDL-C (mmol/L)	3.82±0.41	3.76±0.37	1.204	0.229
HDL-C (mmol/L)	1.19±0.24	1.23±0.27	1.144	0.253
Systolic blood pressure (mmHg)	140.56±14.58	138.96±14.37	0.841	0.401
Diastolic blood pressure (mmHg)	84.26±7.52	83.95±7.49	0.283	0.777
WBC ( $\times 10^9/L$ )	9.32±2.01	9.10±1.95	0.850	0.396
HGB (g/L)	117.25±20.25	115.65±19.85	0.673	0.501
PLT ( $\times 10^9/L$ )	254.26±19.68	253.18±20.54	0.401	0.688
TP (g/L)	61.25±12.67	59.61±12.45	0.995	0.320
HsCRP (mg/L)	7.06±2.04	6.79±1.89	1.067	0.287
FIB (g/L)	3.05±0.45	2.98±0.41	1.271	0.205
FDP ( $\mu g/mL$ )	26.89±3.14	27.42±3.02	1.320	0.188
FBG (mmol/L)	5.32±1.12	5.24±1.08	0.557	0.578
UmAlb (mg/L)	69.56±6.85	68.52±6.54	1.195	0.233
$\beta_2$ -MG (mg/L)	2.12±0.45	2.20±0.31	1.787	0.075
RBP (mg/L)	1.42±0.24	1.48±0.28	1.663	0.097
Cr ( $\mu mol/L$ )	81.53±7.24	82.58±7.31	1.090	0.276
BUN (mmol/L)	6.02±0.81	5.89±0.94	1.073	0.284
D-dimer (mg/L)	1.02±0.21	0.58±0.15	20.536	<0.001
PT (s)	11.08±1.98	10.94±1.87	0.561	0.575
APTT (s)	32.89±4.12	33.65±4.28	1.354	0.176

**Table 3** Assignment Methods of Argument Variables

Variable	Assignment Method
Age	≥60 years old=1, <60 years old=0
Operation time	Continuous variable
Time in bed	≥3 d=1, <3 d=0
Pneumoperitoneum	Continuous variable
Duration of indwelling drains	Continuous variable
TC	Continuous variable
D-dimer	Continuous variable

**Table 4** Multifactorial Analysis of Factors Influencing DVT After PN in RCC Patients

Variable	β-value	SE Variable	Wald $\chi^2$ Variable	P Variable	OR Variable	95% CI
Age	0.219	0.104	4.440	0.035	1.245	1.045~1.526
Operation time	0.089	0.027	11.063	0.001	1.093	1.037~1.152
Time in bed	1.838	0.780	5.557	0.018	6.284	1.363~28.966
Pneumoperitoneum	0.406	0.155	9.153	0.001	1.598	1.179~2.164
Duration of indwelling drains	0.501	0.227	4.853	0.028	1.650	1.057~2.576
TC	1.567	0.429	13.364	<0.001	4.792	2.069~11.103
D-dimer	1.177	0.410	8.243	0.004	3.245	1.453~7.248
Constant	-34.898	5.569	39.262	<0.001	<0.001	

## Analysis of Influencing Factors for DVT in Patients with RCC After PN

DVT occurrence after PN in RCC patients was used as the dependent variable (yes = 1, no = 0), with independent variables and their coding shown in Table 3. Collinearity diagnostics were performed on seven influencing factors, revealing variance inflation factors (VIF) all less than 10, indicating no multicollinearity or interaction among the variables. Logistic regression (stepwise forward method) indicated that age, operation time, bed rest time, pneumoperitoneum pressure, indwelling drainage time, TC, and D-dimer were risk factors ( $P < 0.05$ ). Details were shown in Table 4.

## Construction of a Nomogram Model for DVT in RCC Patients After PN

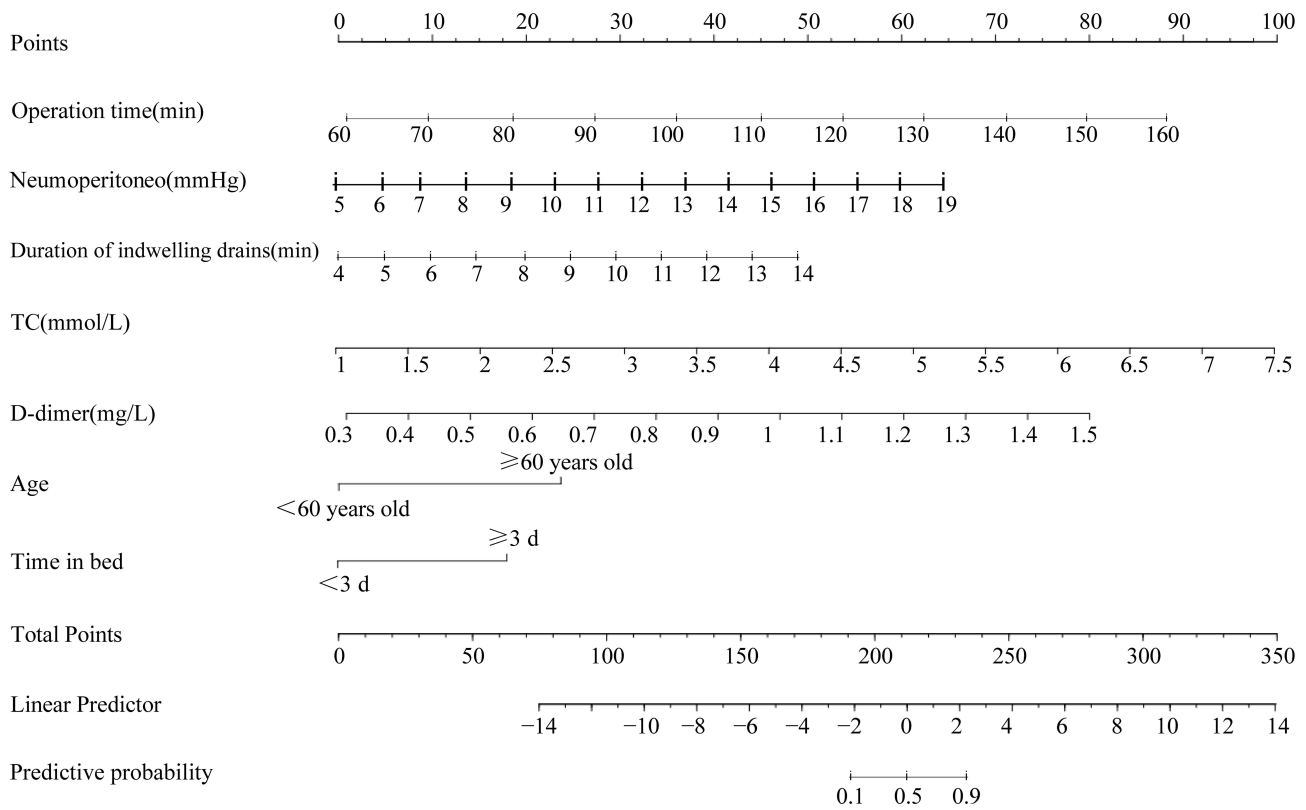
The nomogram model was constructed using the following equation:  $P=e^x/(1+e^x)$ ,  $x=-34.898+0.219 \times \text{age}+0.089 \times \text{operation time}+1.838 \times \text{bed rest time}+0.406 \times \text{pneumoperitoneum pressure}+0.501 \times \text{indwelling drainage time}+1.567 \times \text{TC}+1.177 \times \text{D-dimer}$ . In this model, the most important influencing factors is TC, followed in order by operation time, D-dimer, pneumoperitoneum pressure, indwelling drainage time, age, and bed rest time. Each indicator corresponds to a specific score, and the total score is the sum of the scores for all indicators. A higher total score indicates a greater probability of developing DVT; for example, when the total score ranges from 220 to 230, the probability of occurrence is 71% to 83%. Details were shown in Figure 2.

## Validation of the Nomogram Model for DVT in RCC Patients After PN

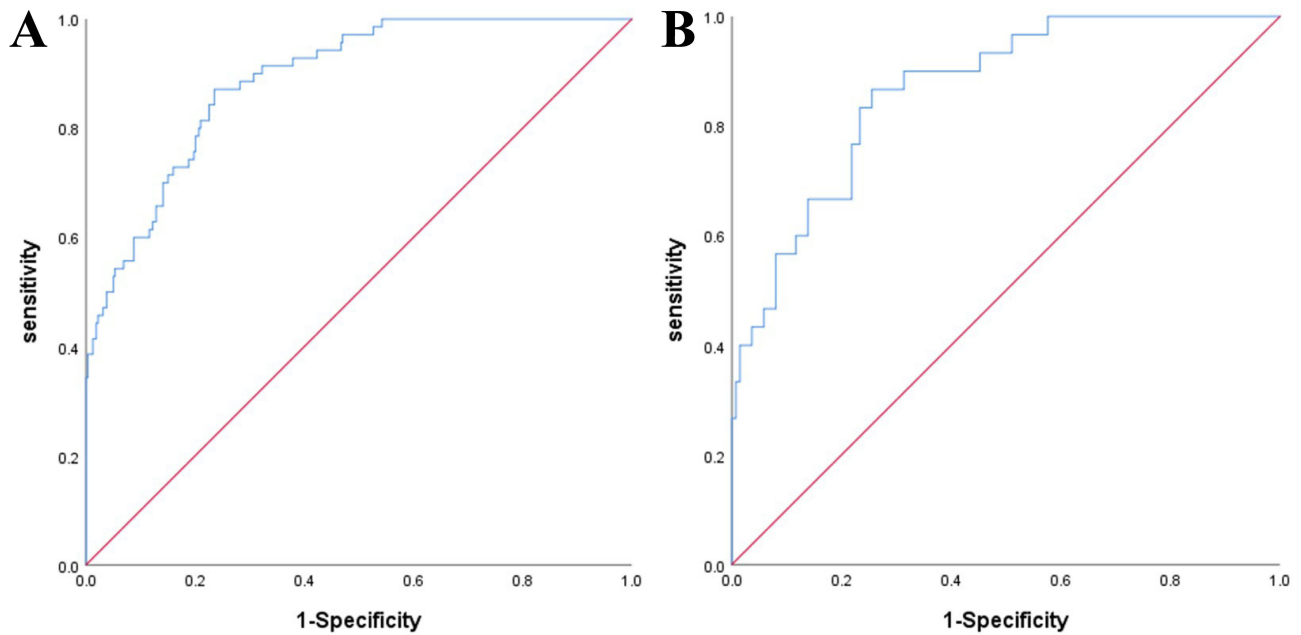
An ROC curve was plotted. The area under the curve (AUC) was 0.889 (95% CI = 0.851–0.927) for the modeling group, and 0.866 (95% CI = 0.801–0.931) for the validation group. Details were shown in Figure 3. The Hosmer-Lemeshow (H-L) test result for the modeling group was  $\chi^2 = 7.120$  ( $P = 0.714$ ), and the result for the validation group was  $\chi^2 = 7.058$  ( $P = 0.724$ ). Details were shown in Figure 4.

## Curve of the Nomogram Model

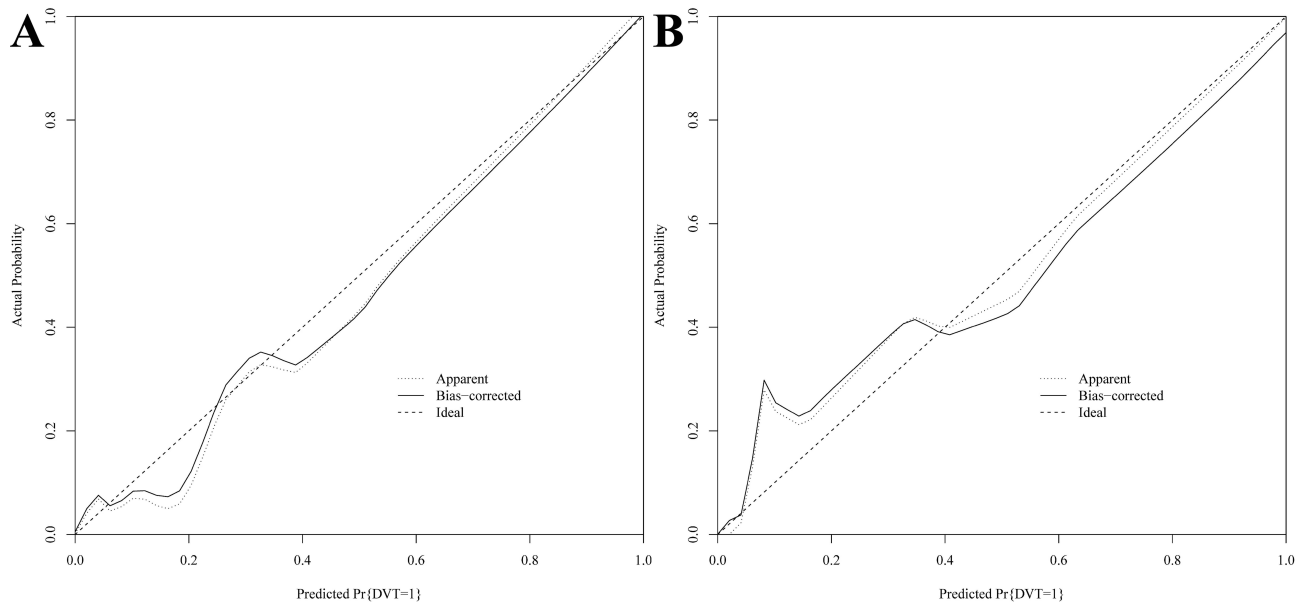
According to the DCA curve, when the probability is between 0.08 and 0.96, the nomogram model has a relatively high clinical value in assessing DVT in RCC patients after PN. Details were shown in Figure 5.



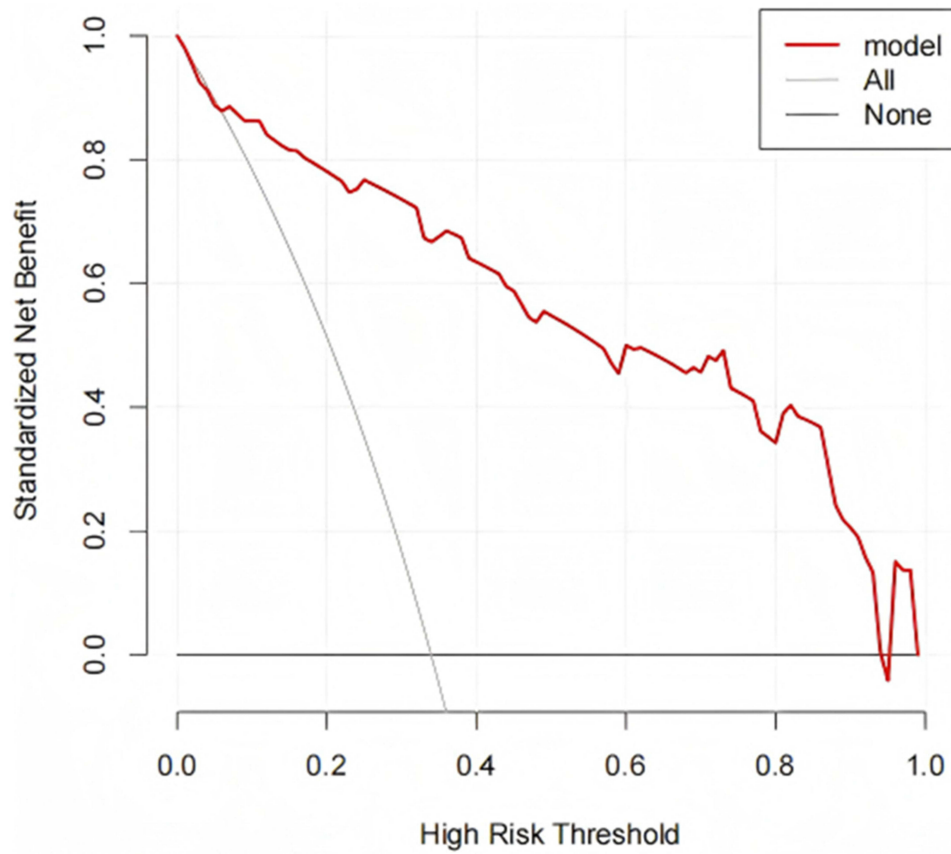
**Figure 2** The nomogram model for DVT after PN in RCC patients.



**Figure 3** ROC curve (A) ROC curve of modeling group; (B) ROC curve of validation group.



**Figure 4** Calibration curve (A) Calibration curve of modeling group; (B) Calibration curve of modeling group.



**Figure 5** DCA curve for the nomogram.

## Discussion

Currently, the pathogenesis of RCC is not fully understood. Its mechanism is relatively complex. Research has shown that the von Hippel-Lindau (VHL) tumor suppressor gene may be involved during tumor onset. When this gene mutates and its function is lost, it leads to an accumulation of downstream hypoxia-inducible factors, causing excessive expression of vascular endothelial growth factor and other factors. By binding to corresponding receptors, these factors increase vascular permeability, thereby promoting cell proliferation and migration and playing a role in the progression of RCC.<sup>11,12</sup> In clinical treatment, compared with open surgery, laparoscopic surgery for early-stage RCC involves less trauma. However, the incidence of postoperative deep vein thrombosis (DVT) remains relatively high, severely impacting patient prognosis. DVT mainly occurs when blood abnormally clots in the deep veins, blocking blood vessels and thus affecting surgical outcomes, prolonging hospital stays, and possibly leading to pulmonary embolism.<sup>13</sup> This study revealed that among 389 patients, 70 developed DVT (17.99%), indicating a relatively high incidence. It may be because the selected patients were older and had more severe conditions, leading to a higher incidence. Therefore, early identification of the factors influencing DVT after surgery is crucial for improving patient prognosis.

This study found that age is a risk factor for DVT after PN in RCC patients, mainly because older patients experience vascular endothelial aging, which affects the fibrinolytic function of the endothelium and may lead to DVT. In addition, older patients often have underlying conditions. Inflammatory mediators released by these conditions can activate and induce the coagulation cascade, causing endothelial cell death and increasing DVT risk.<sup>14,15</sup> Operation time is a risk factor for DVT after PN in RCC patients, mainly because PN is performed under general anesthesia, during which patients are kept in the same position for a prolonged period, and muscle relaxants slow venous blood flow, thus increasing DVT risk. Additionally, muscle relaxants can raise the incidence of hypercapnia, which affects coagulation and further predisposes patients to DVT.<sup>16</sup> Bed rest time is a risk factor for DVT after PN in RCC patients. For patients with prolonged bed rest, reduced physical activity leads to loss of the muscle pump effect. Long-term bed rest can decrease venous return from the lower limbs, promote thrombosis formation, and increase the risk of DVT.<sup>17</sup> Pneumoperitoneum pressure is a risk factor for DVT after PN in RCC patients. In laparoscopic surgery, pneumoperitoneum pressure typically ranges from 12 to 15 mmHg, whereas the normal physiological range is 2 to 5 mmHg. Higher pneumoperitoneum pressure exerts force on the inferior vena cava, slowing blood flow. When the body is in a hypercoagulable state, endothelial damage occurs, activating platelets and causing their adhesion and release, thereby increasing the risk of DVT.<sup>18,19</sup>

Indwelling drainage time is a risk factor for DVT after PN in RCC patients because respiratory movements create negative pressure in the thoracic cavity, promoting venous return from the lower limbs. The presence of an indwelling drainage tube increases the risk of infection, and the tube may affect respiratory mechanics and further raise infection risk, thereby promoting thrombosis formation. Additionally, the drainage tube can cause discomfort and affect normal breathing, and prolonged indwelling time increases the risk of DVT.<sup>20</sup> Total cholesterol (TC) is a risk factor for DVT after PN in RCC patients. Elevated TC levels indicate that patients are more likely to have chronic diseases, which may induce a hypercoagulable blood state and predispose them to thrombosis. A study has shown that patients who develop DVT after fracture surgery have higher TC levels, which aligns with our findings.<sup>21</sup> D-dimer is a risk factor for DVT after PN in RCC patients. D-dimer is a nonspecific marker of thrombosis. Monitoring it can help assess the coagulation state of the body. Elevated D-dimer suggests a possible thrombotic process in the blood. When clots form, coagulation factors in the blood are activated. D-dimer is also a degradation product of fibrin, so an elevated level indicates an abundance of degradation products in the blood, promoting DVT formation.<sup>22</sup>

The nomogram model can integrate multiple influencing factors into a single statistical model, allowing for relatively accurate prediction of the patient's condition and demonstrating high clinical utility. In this study, the constructed nomogram yielded an AUC of 0.889 in the modeling group and 0.866 in the validation group, with a good Hosmer-Lemeshow (H-L) goodness of fit test, indicating satisfactory predictive capability. The decision curve analysis (DCA) showed that when the probability range was 0.08–0.96, the nomogram model for assessing DVT after PN in RCC patients had good clinical applicability, aiding clinicians in targeted interventions.

In summary, age, operation time, bed rest time, pneumoperitoneum pressure, indwelling drainage time, TC, and D-dimer are factors influencing DVT after PN in patients with RCC. The nomogram model constructed based on this can effectively predict the risk of postoperative DVT in patients and assist clinicians in implementing targeted prevention based on relevant factors. This study is a retrospective single-center investigation with selection bias, a small sample size, and a lack of independent external validation. Additionally, there is heterogeneity among the patient population, limiting the generalizability of the results. Subsequent multicenter prospective studies with expanded samples will be conducted for further validation.

## Data Sharing Statement

The original contributions presented in the study are included in the article.

## Ethics Approval

This study involving human participants was in accordance with the ethical standards of the Medical Ethics Committee of The Central Hospital of Yongzhou (No.2025032501) and with the 1964 Helsinki Declaration. The need for informed consent was waived by the Medical Ethics Committee of The Central Hospital of Yongzhou.

## Funding

Guiding Science and Technology Plan Projects in Yongzhou City in 2023 (2023YZ030).

## Disclosure

The authors declare that they have no conflicts of interest in this work.

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