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Design Appropriate Incision Length for Uniportal Video-Assisted Thoracoscopic Lobectomy: Take into Account Safety and Minimal Invasiveness

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Abstract

Background There is no criterion on the length of the uniportal video-assisted thoracoscopic surgery (UVATS) incision when performing lobectomy. We aimed to develop a nomogram to assist surgeons in designing incision length for different individuals.
Methods A cohort consisting of 290 patients were enrolled for nomogram development. Univariate and multivariate logistic regression analyses were performed to identify candidate variables among perioperative characteristics. *C*-index and calibration curves were utilized for evaluating the performance of the nomogram. Short-term outcomes of nomogram-predicted high-risk patients were compared between long incision group and conventional incision group.
Results Of 290 patients, 150 cases (51.7%) were performed incision extension during the surgery. Age, tumor size, and tumor location were identified as candidate variables related with intraoperative incision extension and were incorporated into the nomogram. *C*-index of the nomogram was 0.75 (95% confidence interval: 0.6961–0.8064), indicating the good predictive performance. Calibration curves presented good consistency between the nomogram prediction and actual observation. Of high-risk patients identified by the nomogram, the long incision group ($n = 47$) presented shorter duration of operation ($p = 0.03$), lower incidence of total complications ($p = 0.01$), and lower incidence of prolonged air leak ($p = 0.03$) compared with the conventional incision group ($n = 55$).
Conclusion We developed a novel nomogram for predicting the risk of intraoperative incision extension when performing uniportal video-assisted thoracoscopic lobectomy. This model has the potential to assist clinicians in designing the incision length preoperatively to ensure both safety and minimal invasiveness.

Keywords
► lobectomy
► minimally invasive surgery
► uniportal video-assisted thoracoscopic surgery

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Introduction

Nowadays, video-assisted thoracoscopic surgery (VATS) approach has become one of the mainstream minimally invasive techniques for lobectomy.[1] With the maturity of experience and the improvement of surgical techniques, an increasing number of thoracic surgeons have preferred the uniportal VATS (UVATS) approach as an alternative to multiport VATS (MVATS) approach.[2] The UVATS is generally performed through a 3.5- to 4-cm incision at the fifth intercostal space in the anterior or middle-anterior axillary line. Some studies have shown that UVATS lobectomy is associated with better perioperative outcomes including lower incidence of complications, shorter duration of chest tube, shorter hospital stay, etc.[2–4] However, considering these studies lack the description of whether the incision was extended during the surgery, whether a $\leq$ 4-cm single-incision is appropriate for all patients (especially for tumor in large diameter) remains controversial. A $>$ 4-cm incision might be necessary during the specimen removal when the resected lesion is too large. In this study, we sought to identify the variables that resulted in incision extension during the UVATS lobectomy and utilize them to develop a nomogram for predicting high-risk patients (patients with a tendency to extend the incision intraoperatively). For these high-risk patients identified by the nomogram, we also assess the perioperative clinical outcomes of long incision group (4.5–5 cm) and conventional incision group (3.5–4 cm).

Methods

Patient Population and Study Design

This is a retrospective observational study design. A cohort for nomogram development was composed of 290 patients from Nanjing Hospital of Chinese Medicine ($n = 157$, from January 2019 to September 2021) and the First Affiliated Hospital of Nanjing Medical University ($n = 133$, from November 2020 to December 2021). The inclusion criteria were as follows: (1) patients who underwent UVATS lobectomy, and (2) patients who were over 25 years old. Exclusion criteria were: (1) patients with missing perioperative clinical data, (2) patients with previous thoracic operation history, (3) conversion to thoracotomy or MVATS, (4) patients with serious thoracic adhesion, and (5) patients performed wedge resection or segmentectomy before lobectomy. By identifying high-risk patients (patients with a tendency to extend the incision during the UVATS lobectomy) using the constructed nomogram, another cohort consisting of 47 patients (from Nanjing Hospital of Chinese Medicine, from August 2021 to April 2022) was enrolled as long incision group. The other inclusion and exclusion criteria were consistent with the above. All surgeries were performed by experienced thoracic surgeons and all patients provided written informed consent before surgery. The ethical approval was approved by the Research Ethics Committee.

Data Collection

The perioperative characteristics of all patients were collected, including demographics, smoking history, drinking history, comorbidities, American Society of Anesthesiologists score, tumor location, tumor size, duration of operation, intraoperative blood transfusion, pathological stage, histologic type, dissected lymph node station number, number of lymph nodes resected, postoperative Visual Analogue Scale (VAS) within 24 hours, postoperative blood transfusion, duration of chest tube, complications, postoperative hospital stay, and the description of intraoperative incision extension.

Nomogram Development for Predicting High-Risk Patients

Intraoperative incision extension was defined as converting the conventional UVATS incision (3.5–4 cm) to 4.5 to 5 cm incision when removing the resected specimen. A cohort consisting of 270 patients was utilized for developing the nomogram. Univariate logistic regression analyses were performed to identify potential variables. Variables with a p-value of < 0.05 in univariate logistic analysis were further analyzed in multivariate analysis. Candidate variables were selected in multivariable logistic regression based on the Akaike's information criterion. Then, these candidate variables were incorporated into the nomogram model to predict incision extension during the surgery. The concordance index (C-index) and calibration curves were used to evaluate the predictive performance of the constructed nomogram.

Surgical Procedure and the Comparison between Conventional/Long Incision Group

UVATS lobectomy via conventional incision: A 3.5- to 4-cm incision was performed at the fifth intercostal space in the anterior or middle-anterior axillary line. Plastic wound protector was used to stretch open the incision. A 30-degree, 10-mm camera thoracoscope was placed at the posterior angle of the incision to avoid the overlap of multiple instruments. The surgeon and assistant stood at the anterior side during the UVATS procedure. Pulmonary arteries and veins were dissected by endoscopic staplers or Hem-o-lock as appropriate; the bronchus was dissected by endoscopic staplers. Systematic mediastinal lymph node dissection was performed according to oncologic criteria. The resected lesion was put into a specimen bag and was removed through the incision protector. When the specimen is too large, we would extend the incision appropriately to prevent the specimen bag from bursting during remove. A 24-F chest tube was placed at the posterior extremity of the incision; this tube was removed when no air leak was observed, the drainage was $\leq$ 200 mL/day, and the chest X-ray image was normal. Postoperative pain was evaluated using VAS within 24 hours. Of patients performed with UVATS lobectomy via conventional incision, high-risk patients (nomogram-predicted risk probability $\geq$ 70%) screened by nomogram would be included into the conventional incision group.

UVATS lobectomy via long incision: Another cohort composed of high-risk patients (nomogram-predicted risk probability $\geq$ 70%) identified by nomogram was enrolled as the long incision group. For these patients, a 4.5- to 5-cm incision was made at the fifth intercostal space in the anterior or middle-anterior axillary line. The rest of the procedure was consistent with the above. The short-term clinical outcomes were compared between the long incision group and conventional incision group.

Statistical Analysis

The chi-square or Fisher's exact test was used to assess the categorical variables, as appropriate. The continuous variables were compared using Student's t or Mann–Whitney nonparametric tests according to the results of the Shapiro–Wilk test. For all the analyses, $p < 0.05$ was considered to be statistically significant and all tests were two-tailed. All analysis was performed by SPSS Statistics (version 20.0; Chicago, Illinois, United States) and R statistical software (version 3.4.3).

Results

Baseline Characteristics

A total of 290 patients from Nanjing Hospital of Chinese Medicine ($n = 157$) and the First Affiliated Hospital of Nanjing Medical University ($n = 133$) were eligible and enrolled to develop the predictive nomogram model. Among these patients, 140 cases (140/290, 48.3%) underwent incision extension during the surgery. Perioperative characteristics of patients from these two medical institutions are presented in ►**Table 1**. Except for the history of coronary artery disease, there were no significance observed in the remaining variables studied between the cohorts ($p > 0.05$), indicating that these two sets were statistically comparable. Based on the

Table 1 Perioperative characteristics of patients

Variables	Nanjing Hospital of Chinese Medicine ($n = 157$)	The First Affiliated Hospital of Nanjing Medical University ($n = 133$)	p-Value
Gender			0.87
Male	83 (52.9%)	69 (51.9%)	
Female	74 (47.1%)	64 (48.1%)	
Age (y)	60.92 ± 8.89	61.35 ± 10.18	0.70
Height (m)	1.65 ± 0.07	1.64 ± 0.07	0.82
Weight (kg)	63.66 ± 10.64	64.47 ± 9.73	0.50
BMI (kg/m^2)	23.45 ± 3.22	23.46 ± 4.24	0.98
Smoking history	49 (31.2%)	38 (28.6%)	0.63
Drinking history	25 (15.9%)	13 (9.8%)	0.12
Comorbidities	59 (37.6%)	52 (39.1%)	0.79
Hypertension	49 (31.2%)	41 (30.8%)	0.94
COPD	4 (2.5%)	4 (3.0%)	0.71
Diabetes	19 (12.1%)	18 (13.5%)	0.72
Coronary artery disease	4 (2.5%)	11 (8.3%)	0.03
Previous stroke	11 (7.0%)	6 (4.5%)	0.37
ASA score			0.08
1	105 (66.9%)	72 (54.1%)	
2	38 (24.2%)	46 (34.6%)	
3	14 (8.9%)	15 (11.3%)	
Tumor location			0.55
Left upper lobe	25 (15.9%)	18 (13.5%)	
Left lower lobe	23 (14.6%)	17 (12.8%)	
Right upper lobe	48 (30.6%)	47 (35.3%)	
Right middle lobe	30 (19.1%)	32 (24.1%)	
Right lower lobe	31 (19.7%)	19 (14.3%)	
Tumor size (cm)			0.34
< 3.5	128 (81.5%)	114 (85.7%)	
≥ 3.5	29 (18.5%)	19 (14.3%)	
Duration of operation (h)	2.35 ± 0.81	2.23 ± 0.61	0.15

Table 1 (*Continued*)

Variables	Nanjing Hospital of Chinese Medicine ($n = 157$)	The First Affiliated Hospital of Nanjing Medical University ($n = 133$)	*p*-Value
Intraoperative blood transfusion	2 (1.3%)	0 (0.0%)	0.19
Pathological stage			0.69
I a	106 (67.5%)	90 (67.7%)	
I b	7 (4.5%)	9 (6.8%)	
I I a	5 (3.2%)	1 (0.8%)	
I I b	18 (11.5%)	13 (9.8%)	
I I I a	20 (12.7%)	19 (14.3%)	
I I I b	1 (0.6%)	1 (0.8%)	
Histologic type			0.46
AC	100 (63.7%)	96 (72.2%)	
SCC	17 (10.8%)	12 (9.0%)	
MIA	14 (8.9%)	10 (7.5%)	
Other	26 (16.6%)	15 (11.3%)	
Dissected lymph node station number	4.23 ± 1.38	4.08 ± 1.53	0.37
Number of lymph nodes resected	12.23 ± 6.59	12.92 ± 4.43	0.29
Postoperative VAS within 24 h			0.77
0	70 (44.6%)	54 (40.6%)	
1	66 (42.0%)	60 (45.1%)	
2	14 (8.9%)	15 (11.3%)	
3	6 (3.8%)	4 (3.0%)	
4	1 (0.6%)	0 (0.0%)	
Postoperative blood transfusion	8 (5.1%)	3 (2.3%)	0.21
Duration of chest tube (d)	3.8 ± 2.17	3.4 ± 1.53	0.09
Total complications	32 (20.4%)	34 (25.6%)	0.29
Respiratory infection	7 (4.5%)	5 (3.8%)	0.77
Prolonged air leak	19 (12.1%)	24 (18.0%)	0.16
Postoperative bleeding/hematoma	8 (5.1%)	5 (3.8%)	0.58
Postoperative hospital stay (d)	5.62 ± 2.67	5.34 ± 2.44	0.35
Intraoperative extension of the incision			0.26
No	86 (54.8%)	64 (48.1%)	
Yes	71 (45.2%)	69 (51.9%)	

results of univariate analysis (►**Table 2**), gender, age, weight, smoking history, tumor location, tumor size, and pathological stage were significantly different ($p < 0.05$). In addition, patients with intraoperative incision extension were associated with longer duration of operation ($p < 0.001$), longer duration of chest tube ($p = 0.01$), higher incidence of total complications ($p = 0.003$), higher incidence of prolonged air leak ($p = 0.02$), and longer postoperative hospital stay ($p < 0.001$).

Development and Evaluation of the Nomogram

After univariate analysis, gender, age, weight, smoking history, tumor location, and tumor size were further entered into the multivariable logistic regression analysis. However, gender, weight, and smoking history missed significance according to the results of multivariable analysis. Based on the excellent *C*-index and log-likelihood ratio achieved through step-down selection,[5] age, tumor size, and tumor location were identified as candidate variables related with intraoperative incision extension and were employed for the development of the nomogram (►**Table 3**). As illustrated in ►**Fig. 1**, a nomogram incorporating three variables was constructed. Each value of candidate variables was given certain score on the point scale axis at the top. The total score could be calculated by summing up these points of each variable; the probability could also be obtained by drawing a straight line from total point scale to the

Table 2 Perioperative characteristics of patients with/without intraoperative incision extension

Variables	Intraoperative incision extension		*p*-Value
	Yes ($n = 140$)	No ($n = 150$)	
Gender			< 0.001
Male	92 (65.7%)	60 (40.0%)	
Female	48 (34.3%)	90 (60.0%)	
Age (y)	63.0 ± 8.58	59.35 ± 9.98	0.001
Height (m)	1.66 ± 0.07	1.63 ± 0.07	0.21
Weight (kg)	65.58 ± 10.51	62.59 ± 9.77	0.01
BMI (kg/m^2)	23.57 ± 3.70	23.34 ± 3.74	0.60
Drinking history	22 (15.7%)	16 (10.7%)	0.21
Smoking history	56 (40.0%)	31 (20.7%)	< 0.001
Comorbidities	61 (43.6%)	50 (33.3%)	0.07
Hypertension	49 (35.0%)	41 (27.3%)	0.16
COPD	3 (2.1%)	5 (3.3%)	0.54
Diabetes	20 (14.3%)	17 (11.3%)	0.45
Coronary artery disease	8 (5.7%)	7 (4.7%)	0.69
Previous stroke	8 (5.7%)	9 (6.0%)	0.92
ASA score			0.56
1	81 (57.9%)	96 (64.0%)	
2	44 (31.4%)	40 (26.7%)	
3	15 (10.7%)	14 (9.3%)	
Tumor location			< 0.001
Left upper lobe	30 (21.4%)	13 (8.7%)	
Left lower lobe	28 (20.0%)	12 (8.0%)	
Right upper lobe	44 (31.4%)	51 (34.0%)	
Right middle lobe	8 (5.7%)	54 (36.0%)	
Right lower lobe	30 (21.4%)	20 (13.3%)	
Tumor size (cm)			< 0.001
< 3.5	104 (74.3%)	138 (92.0%)	
≥ 3.5	36 (25.7%)	12 (8.0%)	
Duration of operation (h)	2.53 ± 0.82	2.09 ± 0.57	< 0.001
Intraoperative blood transfusion	2 (1.4%)	0 (0.0%)	0.23
Pathological stage			0.04
I a	82 (58.6%)	114 (76.0%)	
I b	11 (7.9%)	5 (3.3%)	
I I a	4 (2.9%)	2 (1.3%)	
I I b	18 (12.9%)	13 (8.7%)	
I I I a	23 (16.4%)	16 (10.7%)	
I I I b	2 (1.4%)	0 (0.0%)	
Dissected lymph node station number	4.32 ± 1.43	4.01 ± 1.46	0.07
Number of lymph nodes resected	12.52 ± 5.43	12.57 ± 5.97	0.94

Table 2 (*Continued*)

Variables	Intraoperative incision extension		*p*-Value
	Yes ($n = 140$)	No ($n = 150$)	
Postoperative VAS within 24 h			0.32
0	52 (37.1%)	72 (48.0%)	
1	67 (47.9%)	59 (39.3%)	
2	16 (11.4%)	13 (8.7%)	
3	5 (3.6%)	5 (3.3%)	
4	0 (0.0%)	1 (0.7%)	
Postoperative blood transfusion	6 (4.3%)	5 (3.3%)	0.67
Duration of chest tube (d)	3.91 ± 2.01	3.35 ± 1.77	0.01
Total complications	45 (32.1%)	26 (17.3%)	0.003
Respiratory infection	7 (5.0%)	5 (3.3%)	0.48
Prolonged air leak	28 (20.0%)	15 (10.0%)	0.02
Postoperative bleeding/hematoma	9 (6.4%)	4 (2.7%)	0.12
Postoperative hospital stay (days)	6.27 ± 2.90	4.77 ± 1.96	< 0.001

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; VAS, Visual Analogue Scale.
Note: Continuous variable (tumor size) was transformed into categorical variables and the cutoff value was 3.5cm.

Table 3 Univariable and multivariable logistic regression analysis of variables associated with intraoperative incision extension

Characteristics	Univariable analysis		Multivariable analysis		Selected variables for model	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Gender						
Female	Reference		Reference		–	–
Male	2.88 (1.78–4.64)	< 0.001	0.55 (0.23–1.31)	0.18	–	–
Age (y)	1.04 (1.02–1.07)	0.001	1.05 (1.02–1.08)	0.003	1.05 (1.02–1.08)	0.003
Height (m)	0.96 (0.90–1.02)	0.21	–	–	–	
Weight (kg)	1.03 (1.00–1.05)	0.01	1.02 (0.98–1.05)	0.38	–	
BMI (kg/m^2)	1.02 (0.96–1.08)	0.60	–	–	–	–
Drinking history						
No	Reference		–	–	–	–
Yes	1.56 (0.78–3.11)	0.21	–	–	–	–
Smoking history						
No	Reference		Reference		–	–
Yes	2.56 (1.52–4.31)	< 0.001	0.78 (0.36–1.71)	0.54	–	–
Comorbidities						
No	Reference		–	–	–	–
Yes	1.54 (0.96–2.49)	0.07	–	–	–	–
Hypertension						
No	Reference		–	–	–	–
Yes	1.43 (0.87–2.36)	0.16	–	–	–	–
COPD						
No	Reference		–	–	–	–
Yes	0.64 (0.15–2.71)	0.54	–	–	–	–

(*Continued*)

Table 3 (*Continued*)

Characteristics	Univariable analysis		Multivariable analysis		Selected variables for model	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Diabetes						
No	Reference		–	–	–	–
Yes	1.30 (0.65–2.61)	0.45	–	–	–	–
Coronary artery disease						
No	Reference		–	–	–	–
Yes	1.24 (0.44–3.51)	0.69	–	–	–	–
Previous stroke						
No	Reference		–	–	–	–
Yes	0.95 (0.36–2.53)	0.92	–	–	–	–
ASA score						
1	Reference		–	–	–	–
2	1.30 (0.78–2.19)	0.32	–	–	–	–
3	1.27 (0.58–2.79)	0.55	–	–	–	–
Tumor location						
Left upper lobe	Reference		Reference		Reference	
Left lower lobe	1.01 (0.40–2.59)	0.98	0.93 (0.34–2.56)	0.89	1.00 (0.38–2.66)	0.99
Right upper lobe	0.37 (0.17–0.80)	0.01	0.29 (0.13–0.67)	0.004	0.36 (0.16–0.77)	0.01
Right middle lobe	0.06 (0.02–0.17)	< 0.001	0.06 (0.02–0.20)	< 0.001	0.07 (0.03–0.19)	< 0.001
Right lower lobe	0.65 (0.27–1.54)	0.33	0.53 (0.21–1.34)	0.53	0.60 (0.24–1.45)	0.26
Tumor size (cm)						
< 3.5	Reference		Reference		Reference	
≥ 3.5	3.98 (1.98–8.03)	< 0.001	2.46 (1.09–5.54)	0.03	2.37 (1.04–5.87)	0.04

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; COPD, chronic obstructive pulmonary disease; OR, odds ratio.

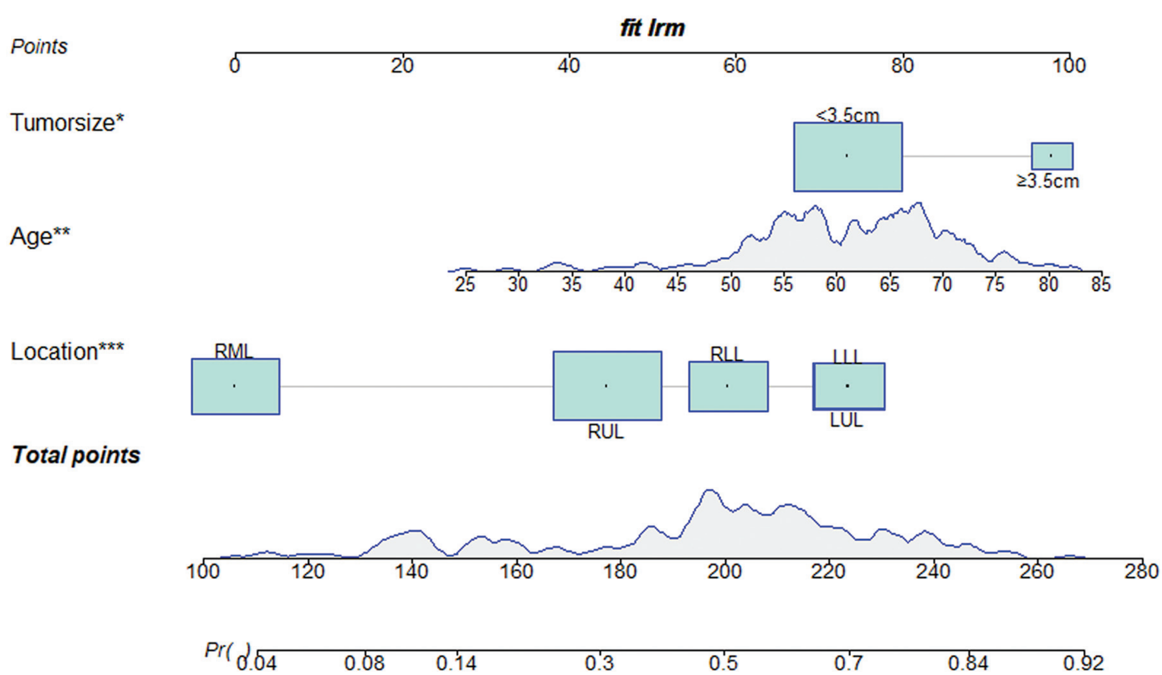

Fig. 1 A nomogram predicting the probability of intraoperative incision extension during the uniportal video-assisted thoracoscopic surgery (UVATS) lobectomy.

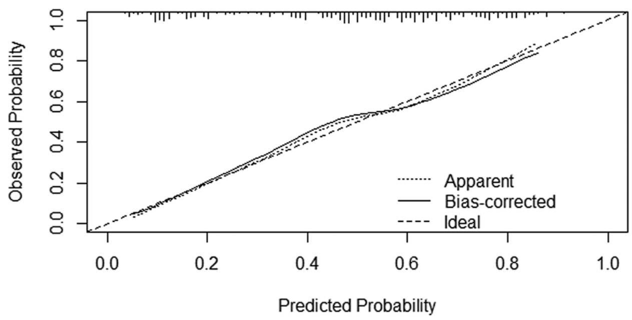

Fig. 2 Calibration curves for the constructed nomogram. By plotting nomogram-predicted probability on *x*-axis and actual observed probability on *y*-axis, the closer the drawn line is to 45 degrees, the better the calibration model is (it means the predicted probabilities are more identical to the actual outcomes).

probability scale. The *C*-index of the constructed nomogram was 0.75 (95% confidence interval: 0.6961–0.8064), indicating the good predictive accuracy in predicting the risk of intraoperative incision extension. As displayed in ►**Fig. 2**, the calibration curve proved that the probability predicted by the nomogram presented good consistency with actual observed probability.

Comparison between the Long Incision Group and Conventional Incision Group

Subsequently, we calculated the total score of every patient and obtained the individual probability of intraoperative incision extension. The high-risk patients were defined as nomogram-predicted risk probability $\geq$ 70% (total score $\geq$ 223). Among the 270 patients, 55 cases were found out to be high-risk patients and entered into the conventional incision group. Besides, another cohort consisting of 47 nomogram-predicted high-risk patients undergoing UVATS lobectomy via longer incision was included into the long incision group. The comparison between the two groups was only performed among nomogram-predicted high-risk patients to avoid the potential bias. As summarized in ►**Table 4**, high-risk patients undergoing UVATS lobectomy via long incision were associated with shorter duration of operation ($p = 0.03$), lower incidence of total complications ($p = 0.01$), and lower incidence of prolonged air leak ($p = 0.03$).

Discussion

Yi Miao put forward an impressive opinion that minimally invasive approach is not exactly equivalent to minimally invasive surgery.[6] Surgical trauma should be defined as the sum of trauma during surgical-related treatment, including trauma to the surgical approach (incision), trauma to the main surgical procedure, trauma from perioperative treatment (especially complications), etc. The trauma to incision is just part of the surgical trauma. When complex and demanding surgical procedures are expected, an undersized or inappropriate incision might complicate the surgical procedure and could increase the surgical risk, operation time, and the incidence of the perioperative complications. Therefore, it is essential to design appropriate incision for different individuals taking into account safety and minimal invasive.

Few literatures reported the criteria of the incision length when performing UVATS lobectomy. In 2019, 31 experts from 18 countries participated in three rounds of questionnaires and sought to standardize the perioperative procedure of UVATS lobectomy using the Delphi method (75% agreement was requested for reaching consensus).[7] Twenty-two (71%) experts agreed that the incision should be $\leq$ 4 cm, while the other 9 experts (29%) insisted that the maximum length of the incision should be 6 cm. Another randomized control trail compared the clinical outcomes of patients undergoing UVATS lobectomy with 4 cm/8 cm incision. Patients performed with long incision were related with shorter operative time while no significance was observed in any other short-term outcomes. However, this study only enrolled cases with stage I lung cancer and neglected cases with more advanced stage or with tumors in large diameter.

Nomograms have been accepted as reliable tools to quantify the probability of a clinical event and have been increasingly applied to diagnosis, predict prognosis and complications, etc.[5,8–10] The data-based nomogram model could assist clinicians in decision making and clinical management. In this study, a nomogram for predicting the probability of intraoperative incision extension was developed. The *C*-index and plotted calibration curve revealed the good predictive performance of the nomogram. For these nomogram-predicted high-risk patients, we found that the long incision procedure resulted in shorter duration of operation, lower incidence of total complications, and lower incidence of prolonged air leak.

Three variables related with intraoperative incision extension were incorporated into the constructed nomogram, including tumor size, tumor location, and age. Tumors larger than 4 cm in diameter were regarded as relative contraindications of UVATS.[11] The simultaneous presence of multiple risk factors (older age, larger tumor size, and relatively large lobes) might mean an increase of the complexity of the surgery. This was consistent with our findings: patients with intraoperative incision extension were associated with longer duration of operation ($p < 0.001$), longer duration of chest tube ($p = 0.01$), higher incidence of total complications ($p = 0.003$), higher incidence of prolonged air leak ($p = 0.02$), and longer postoperative hospital stay ($p < 0.001$). In addition, the comparison between the long incision group and conventional incision group demonstrated that a longer incision could significantly reduce the operation time and the incidence of complications. This could be explained by the fact that a larger incision facilitates the exposure and resection of anatomical structures.

Several drawbacks still existed in our study. First, small number of patients and the retrospective nature limited the generalizability of research findings. Besides, this study only enrolled patients performed with UVATS lobectomy and neglected patients performed with UVATS wedge resection or segmentectomy. The data utilized for developing the nomogram model were only derived from Chinese population. Thus, the constructed nomogram still needs to be verified by external data from other populations. In the future, incorporating more related variable (such as

Table 4 Perioperative characteristics of nomogram-predicted high-risk patients who underwent UVATS lobectomy via conventional incision and long incision

Variables	Conventional incision group ($n = 55$)	Long incision group Yes ($n = 47$)	p-Value
Gender			0.35
Male	42 (76.4%)	32 (68.1%)	
Female	13 (23.6%)	15 (31.9%)	
Age (y)	67.05 ± 6.39	67.09 ± 6.32	0.98
Height (m)	1.67 ± 0.07	1.68 ± 0.07	0.47
Weight (kg)	64.27 ± 11.22	64.72 ± 10.28	0.83
BMI (kg/m^2)	23.01 ± 3.40	22.91 ± 3.14	0.88
Smoking history	26 (47.3%)	22 (46.8%)	0.96
Drinking history	14 (25.5%)	10 (21.3%)	0.62
Comorbidities	29 (52.7%)	26 (55.3%)	0.79
Hypertension	23 (41.8%)	17 (36.2%)	0.56
COPD	1 (1.8%)	2 (4.3%)	0.47
Diabetes	14 (25.5%)	9 (19.1%)	0.45
Coronary artery disease	4 (7.3%)	3 (6.4%)	0.86
Previous stroke	2 (3.6%)	1 (2.1%)	0.65
ASA score			0.93
1	25 (45.5%)	20 (42.6%)	
2	26 (47.3%)	24 (51.5%)	
3	4 (7.3%)	3 (6.4%)	
Tumor location			0.97
Left upper lobe	21 (38.2%)	18 (38.3%)	
Left lower lobe	22 (40.0%)	20 (42.6%)	
Right upper lobe	2 (3.6%)	1 (2.1%)	
Right middle lobe	0 (0%)	0 (0%)	
Right lower lobe	10 (18.2%)	8 (17.0%)	
Tumor size (cm)			0.66
< 3.5	10 (18.2%)	7 (14.9%)	
≥3.5	45 (81.8%)	40 (85.1%)	
Duration of operation (h)	2.69 ± 0.96	2.33 ± 0.59	0.03
Intraoperative blood transfusion	1 (1.8%)	1 (2.1%)	0.91
Histologic type			0.92
AC	32 (58.2%)	29 (61.7%)	
SCC	14 (25.5%)	12 (25.5%)	
MIA	2 (3.6%)	2 (4.3%)	
Other	7 (12.7%)	4 (8.5%)	
Dissected lymph node station number	4.76 ± 1.66	4.68 ± 1.39	0.79
Number of lymph nodes resected	12.15 ± 4.33	12.68 ± 4.08	0.52
Postoperative VAS within 24 h			0.60
0	23 (41.8%)	16 (34.0%)	
1	23 (41.8%)	23 (48.9%)	
2	9 (16.4%)	7 (14.9%)	
3	0 (0%)	1 (2.1%)	

Table 4 (*Continued*)

Variables	Conventional incision group ($n=55$)	Long incision group Yes ($n=47$)	*p*-Value
4	1 (0.6%)	0 (0.0%)	
Postoperative blood transfusion	4 (7.3%)	4 (8.5%)	0.82
Duration of chest tube (d)	4.71 ± 2.81	4.15 ± 1.59	0.21
Total complications	21 (38.2%)	7 (14.9%)	0.01
Respiratory infection	5 (9.1%)	2 (4.3%)	0.34
Prolonged air leak	10 (18.2%)	2 (4.3%)	0.03
Postoperative bleeding/hematoma	5 (9.1%)	2 (4.3%)	0.45
Postoperative hospital stay (d)	7.55 ± 3.89	6.38 ± 1.80	0.05

Abbreviations: AC, adenocarcinoma; ASA, American Society of Anesthesiologists; BMI, body mass index; COPD, chronic obstructive pulmonary disease; MIA, minimally invasive adenocarcinoma; SCC, squamous cell carcinoma; VAS, Visual Analogue Scale; UVATS, uniportal video-assisted thoracoscopic surgery.

radiomics, etc.), expanding the sample size, external validation based on multicenter data, and prospective study will be the strategy to improve the universality of our findings.

Conclusion

A novel nomogram with good predictive performance was developed for predicting the probability of intraoperative incision extension for patients undergoing UVATS lobectomy. This nomogram might assist surgeons in designing incision lengths for different individuals. For nomogram-predicted high-risk patients, a larger incision might be the appropriate strategy to ensure both safety and minimal invasiveness.

Note

Written informed consent was obtained from all individual participants included in the study.

Authors' Contribution

Conception and design: X.L.L., C.Y.S., G.H.D., S.Y. Administrative support: X.L.L., G.H.D., S.Y. Provision of study materials or patients: C.H.L., Q.H.R., C.Y.S. Collection and assembly of data: C.H.L., Q.H.R., C.Y.S., X.L.L. Data analysis and interpretation: X.L.L., C.Y.S., Q.H.R. Manuscript writing: All authors. Final approval of manuscript: All authors.

Conflict of Interest

None declared.

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