Original Article

Inter-multisegmental veins (IMSVs): a new positional indication for pulmonary segmentectomy

Chengyu Bian[1,2#], Chenghao Fu[2#^], Yuheng Wang[2#], Jingjing Huang[3], Mei Yuan[4], Liang Chen[2], Qianyun Wang[1], Jun Wang[2]

[1]Department of Thoracic Surgery, The First People's Hospital of Changzhou and The Third Affiliated Hospital of Soochow University, Changzhou, China; [2]Department of Thoracic Surgery, Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University, Nanjing, China; [3]Department of Cardiothoracic Surgery, Affiliated Hospital of Jiangsu University, Zhenjiang, China; [4]Department of Radiology, Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University, Nanjing, China

Contributions: (I) Conception and design: C Bian, C Fu, Y Wang, J Wang; (II) Administrative support: Q Wang, L Chen, M Yuan, J Huang, J Wang; (III) Provision of study materials or patients: C Bian, C Fu; (IV) Collection and assembly of data: C Bian, C Fu; (V) Data analysis and interpretation: C Bian, C Fu; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work.

Correspondence to: Jun Wang, MD, PhD. Department of Thoracic Surgery, Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Road, Nanjing 210029, China. Email: drwangjun@njmu.edu.cn; Qianyun Wang, MD. Department of Thoracic Surgery, The First People's Hospital of Changzhou and The Third Affiliated Hospital of Soochow University, 185 Juqian Street, Changzhou 213003, China. Email: wqy1976@163.com; Liang Chen, MD, PhD. Department of Thoracic Surgery, Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Road, Nanjing 210029, China. Email: clbright0909@njmu.edu.cn.

Background: Positional indications for sublobar resection have been increasingly focused by clinical surgeons while the surgical strategies for cases involving inter-multisegmental veins (IMSVs) remain underreported. We want to further clarify the positional indications for sublobar resection in patients with clinical T1a–bN0 non-small cell lung cancer (NSCLC).

Methods: The clinical data of 686 patients from August 2021 to July 2022 were retrospectively analyzed. In the three-dimensional (3D) reconstruction images, we analyzed the prevalence and drainage patterns of typical IMSVs, specifically focusing on the lateral vein (Vl) in the upper lobes and the branches of the superior segmental vein (V^6b) in the lower lobes. The potential association between lesion locations and surgical strategy was also analyzed.

Results: The prevalence of Vl, V^6b2, and V^6b3 was 58.5% (231/395), 98.3% (286/291), and 25.1% (73/291), respectively. Vl mainly drained into V^2a+b (70/110, 63.6%) on the right and into V^{1+2}b+c (72/121, 59.5%) on the left. V^6b2 and V^6b3 mainly converged with other branches of the superior segmental vein. Limited resection was more feasible when the 2 cm simulated cutting margin of nodules did not involve IMSVs, or when lesions were located in the outer region. Multivariable logistic regression analyses identified four independent predictors for surgical procedure selection: (I) whether the 2 cm simulated cutting margin involves IMSVs; (II) diameter; (III) consolidation-to-tumour ratio (CTR); and (IV) depth ratio.

Conclusions: IMSVs exhibited high prevalences, with Vl showing diverse drainage patterns, while V^6b2 and V^6b3 displayed little variation. Depth ratio and the lesion's relative location to the IMSVs were identified as longitudinal and transverse positional indications, respectively, for sublobar resection in patients with clinical T1a–bN0 NSCLC.

Keywords: Pulmonary nodule; three-dimensional reconstruction (3D reconstruction); inter-multisegmental vein (IMSV); sublobar resection

^ ORCID: 0009-0008-1668-9179.

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Introduction

With the widespread use of low-dose chest computed tomography (CT), not only has the detection rate of early non-small cell lung cancer (NSCLC) greatly increased, but significant changes in the epidemiological characteristics of the disease have also prompted the development of corresponding surgical modalities (1,2).

In particular, the results of the recently published Japan Clinical Oncology Group (JCOG) 0802 and Cancer and Leukemia Group B (CALGB) 140503 studies strongly support the implementation of sublobar resection in early-stage NSCLC with tumors smaller than 2 cm in diameter. Sublobar resection, increasingly recognized as a crucial option for early-stage lung cancer, offers oncological outcomes comparable to lobectomy while preserving more lung tissue (3,4).

It should be noted that the indications for sublobar resection, according to current guidelines and previous studies, focus primarily on the radiological characteristics of the lesion, including its diameter, consolidation-to-tumour ratio (CTR), and depth within the lung field (5). As stratified studies on the diameter and CTR of ground-glass nodules (GGNs) in the JCOG trial series are gradually published, clinical surgeons have increasingly focused on the positional indications (6-9).

The longitudinal depth of a pulmonary nodule within the lung field, along with its proximity to transverse adjacent structures, significantly influences the surgical strategy. There are an increasing number of methods for quantitatively determining the depth of lesions in three-dimensional (3D) space (10-12). Lesions located in the inner regions, near the hilus pulmonis, challenge the achievement of adequate surgical margins. Surgeons often use intersegmental veins as resection boundaries in sublobar resections (13). Preoperative planning becomes more complex when the lesion is adjacent to the inter-multisegmental veins (IMSV), as the resection may involve multiple pulmonary segments (14). However, the surgical strategies for such cases remain underreported and warrant further investigation.

Therefore, exploring the spatial location of lesions, including their longitudinal depth and proximity to transverse adjacent structures, is of utmost significance in achieving successful anatomical sublobar resection, ensuring safe margins, and maintaining surgical quality control. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1799/rc).

Highlight box

Key findings

- Inter-multisegmental veins (IMSVs) exhibited high prevalences in our study, with the lateral vein (Vl) demonstrating diverse drainage patterns, contrasting with the minimal variation observed in the branches of the superior segmental vein (V^6b). The depth ratio and the lesion's relative position to the IMSVs were identified as critical factors for determining the longitudinal and transverse positional indications, respectively, for sublobar resection in patients with clinical T1a–bN0 non-small cell lung cancer (NSCLC).

What is known and what is new?

- Traditional indications for sublobar resection focus primarily on the radiological characteristics of the lesion while positional indications associated with IMSVs remain underreported and warrant further investigation.
- Positional indicators, such as depth ratio and the lesion's relative location to the IMSVs, along with traditional indications such as diameter and consolidation-to-tumour ratio, were identified critical for sublobar resection in patients with clinical T1a–bN0 NSCLC.

What is the implication, and what should change now?

- It is crucial to emphasize the spatial location of lesions, including their longitudinal depth and proximity to transverse adjacent structures, including IMSVs, in achieving successful anatomical sublobar resection, ensuring safe margins, and maintaining surgical quality control.

Methods

Study cohort

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University Ethics Review Board (No. 2019-SR-450). Individual consent for this retrospective analysis was waived.

Our surgical team of Jiangsu Province Hospital and The

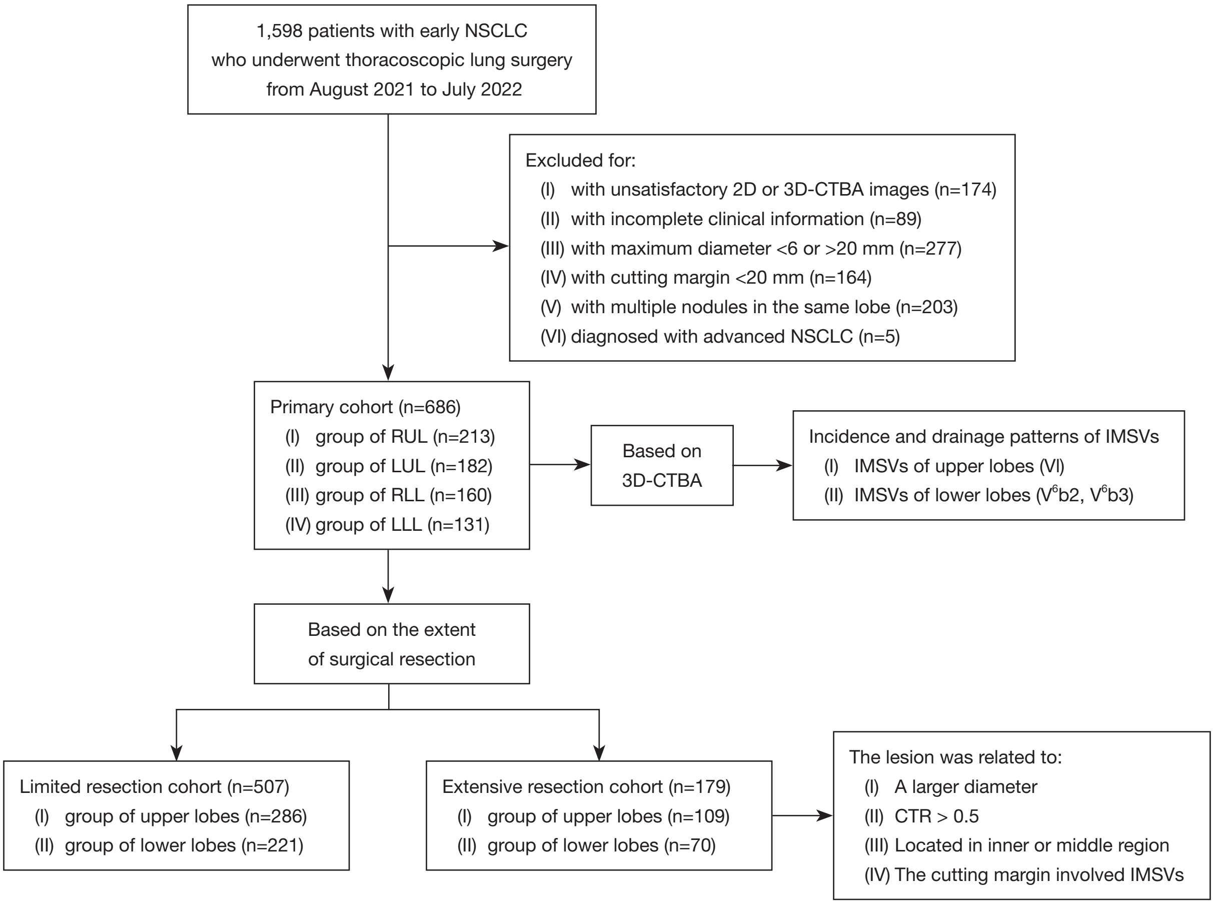

Figure 1 Flow chart of patient selection. NSCLC, non-small cell lung cancer; 2D, two-dimensional; 3D-CTBA, three-dimensional computed tomography bronchography and angiography; RUL, right upper lobe; LUL, left upper lobe; RLL, right lower lobe; LLL, left lower lobe; CTR, consolidation tumor ratio; IMSV, inter-multisegmental vein.

First Affiliated Hospital of Nanjing Medical University now performs more than 2,000 pulmonary operations per year, with all surgical procedures were collectively planned by two senior thoracic surgeons based on the clinical data and 3D CT bronchography and angiography (3D-CTBA) information before surgery. In principle, all planned surgical procedures must ensure a minimum margin of at least 2 cm. The sufficient volume of surgeries and the uniform standards for surgical planning provided a solid foundation and background for our research.

Clinical data of patients with clinical T1a–bN0 NSCLC who underwent thoracoscopic surgery by our surgical team from August 2021 to July 2022 were retrospectively analyzed. These patients met the following inclusion criteria: (I) with complete DICOM data of chest CT before hospitalization; (II) diagnosed with clinical T1a–bN0 NSCLC; (III) underwent thoracoscopic lobectomy or sublobar resection. Exclusion criteria: (I) unsatisfactory 2D or 3D-CTBA image; (II) with incomplete clinical information; (III) cutting margin <20 mm; (IV) with multiple nodules in the same lobe. Finally, 686 patients were eligible for further analysis (*Figure 1*).

Firstly, we first calculated the prevalence and drainage patterns of the IMSVs. Secondly, considering factors such as the depth ratio (describing the spatial position), CTR (associated with radiological invasion of the nodule), and the maximum diameter, we processed and grouped 686 cases. Cases were classified based on a CTR threshold of 50% into noninvasive groups and invasive groups (15,16). We also stratified cases by depth ratio into inner/middle and outer regions. Finally, based on the influence of IMSVs on surgical strategy, we categorized cases into non-involved groups, which either lacked IMSVs or where the 2 cm simulated cutting margin did not involve IMSVs, and involved groups, where the margin did involve IMSVs.

Definition of two types of IMSVs

Referring to previous literature and the clinical experience of our center, the collateral vein in upper lobes, the lateral vein (Vl), is defined as a type of intersegmental vein running along the intersegmental plane between S^1, S^2, and S^3 in the right upper lobe or running along the intersegmental plane between S^{1+2} and S^3 in the left upper division, which often originates from the confluent trunk of several intersegmental veins and participates in the drainage of venous blood from adjacent pulmonary segments; the superior segmental vein in lower lobes, V^6b, is defined as a type of intersegmental or intersubsegmental vein running along the intersubsegmental plane between S^6b and S^6c (V^6b1), running along the intersegmental plane between S^6b and S^9a (V^6b2), and running along the intersegmental plane between S^6b and S^8a (V^6b3). The IMSV in lower lobes, V^6b, discussed in this study were V^6b2 and V^6b3.

Specific measurement method of CTR and depth ratio

In the study, the CTR and depth ratio of a pulmonary nodule were quantified using CT data in the lung window setting. The consolidation component was characterized as an opacified area fully obscuring underlying vascular structures. In contrast, ground-glass opacity (GGO) was identified by a hazy increase in density that allowed visibility of the vascular structures beneath. The CTR was calculated as the ratio of the maximum dimension of the consolidation to the overall maximum tumor dimension (17).

Measurements commenced at the bronchial opening's center (O) in the lobe's cross-section. A radial line was drawn from O to the lesion's center (A) and extended to the pleural surface at point B. This line, OB, was segmented into three equal parts: 0–33.3%, 33.4–66.6%, and 66.7–100%, representing the lung field's inner, middle, and outer regions, respectively. The depth ratio of the lesion (BA/BO) was subsequently calculated (12).

3D reconstruction

The CT images were converted into 3D-CTBA images using the "InferVision" software. The lesion and its 2 cm simulated cutting margin were automatically generated. The 2 cm simulated cutting margin was a quasi-sphere with a shape similar to that of the nodule, which was based on the outer surface of the nodule and uniformly expanded by 2 cm.

Statistical analysis

The statistical analysis was performed with the R platform (version 4.1.2). A two-sided P value <0.05 was considered statistically significant. The continuous variables were presented as mean ± standard deviation (SD) or as medians with interquartile ranges (IQRs). The categorical variables were expressed as frequencies with percentages (%). Z-test was utilized to evaluate the differences between the two probabilities.

For analyzing the factors affecting the determination of surgical procedures, univariable analysis were conducted by the Chi-squared test and then variable with P<0.05 and classical factor diameter were added into multivariable logistic regression analyses. To rigorously evaluate the predictive capability of the model, the receiver operating characteristic (ROC) curve analyses were conducted and the area under curves (AUCs) were calculated utilizing the "pROC" package. Variance Inflation Factor (VIF) values were calculated using the "vif" function from the "car" package to assess the multicollinearity among the independent variables in our logistic regression models.

Results

The prevalence of Vl in bilateral upper lobes

The overall prevalence of Vl was 58.5% (231/395) in the bilateral upper lobes, 51.6% (110/213) in the right upper lobe, and 66.5% (121/182) in the left upper lobe (Table S1). The prevalence of Vl on the left side was significantly higher than that on the right side (P<0.05).

The drainage patterns of Vl in bilateral upper lobes

Vl mainly drained into V^2a+b (70/110, 63.6%) in the right upper lobe and into V^{1+2}b+c (72/121, 59.5%) in the left upper lobe. Detailed information on drainage patterns was presented in Table S2. Typical 2D and 3D-CTBA diagrams were shown in *Figure 2* and Figure S1. Other drainage patterns of Vl in the right upper lobe included 14 cases into V^1a (14/110, 12.7%), 5 cases into V^1a+V^2a (5/110, 4.5%), 10 cases into V^2a (10/110, 9.1%), 3 cases into V^2b (3/110, 2.8%), and 8 cases into V^2c (8/110, 7.3%). Other drainage patterns of Vl in the left upper lobe included 11 cases into

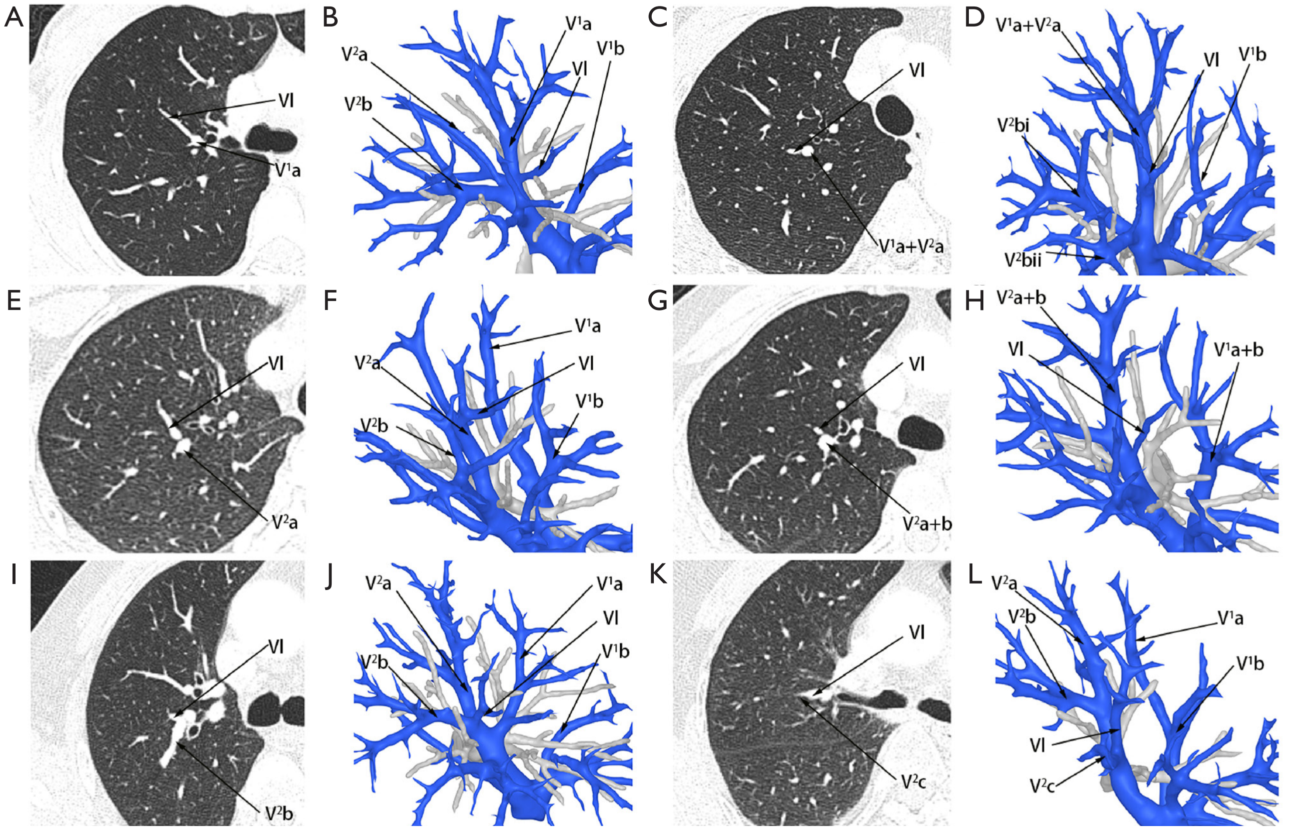

Figure 2 Vl in the right upper lobe drained into (A,B) V^1a, (C,D) V^1a+V^2a, (E,F) V^2a, (G,H) V^2a+b, (I,J) V^2b, (K,L) V^2c. Vl, lateral vein; V^1, apical segmental vein; V^2, posterior segmental vein.

$V^{1+2}a$ (11/121, 9.1%), 27 cases into $V^{1+2}b$ (27/121, 22.3%), 10 cases into $V^{1+2}c$ (10/121, 8.3%), and 1 case into $V^{1+2}d$ (1/121, 0.8%).

The branching patterns of V^6b in bilateral lower lobes

The overall prevalence of V^6b1 was 100% (291/291) in the bilateral lower lobes. The overall prevalence of V^6b2 was 98.3% (286/291) in the bilateral lower lobes, 97.5% (156/160) on the right and 99.2% (130/131) on the left respectively with no significant difference between both sides ($P>0.05$). The overall prevalence of V^6b3 was 25.1% (73/291) in the bilateral lower lobes, with a higher prevalence of 31.3% (50/160) on the right than that of 17.6% (23/131) on the left ($P<0.05$) (Table S3).

The drainage patterns of V^6b in bilateral lower lobes

There was little variation in the drainage patterns of V^6b. Detailed information on drainage patterns was presented in Table S4. Typical 2D and 3D-CTBA diagrams were shown in *Figure 3*. All V^6b1 converged with other branches of the superior segmental vein and then drained into the inferior pulmonary vein. V^6b2 converged with other branches of the superior segmental vein in 267 cases and converged with the common basal vein in 19 cases. V^6b3 converged with other branches of the superior segmental vein in 60 cases and converged with the common basal vein in 13 cases.

The influence of IMSVs and other determinants on surgical procedure selection

Detailed demographic and clinical characteristics of the 686 patients (254 men and 432 women) with a median age of 52 years (IQR, 44–70 years) were presented in Table S5. The median diameter of their lesions was 11.0 mm (IQR, 9.0–14.0 mm). The surgical procedures were also shown.

In bilateral upper lobes, cases undergoing lobectomy

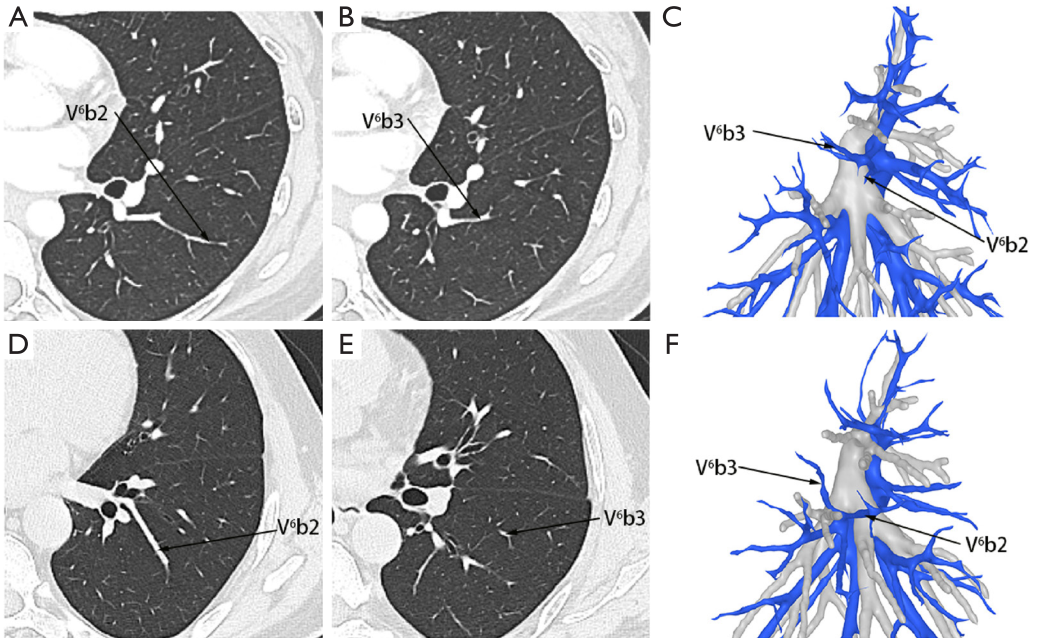

Figure 3 V^6b2 and V^6b3 converged with other branches of the superior segmental vein (A-C) and converged with the common basal vein (D-F). V^6, superior segmental vein.

and left upper division resection were combined into the extended resection group, while those undergoing segmentectomy, subsegmentectomy, or wedge resection were combined into the limited resection group. We conducted χ^2 tests to explore factors affecting surgical procedures, with detailed outcomes in *Table 1*. Firstly, the CTR of lesions significantly affected surgical procedures (P<0.001). Secondly, sublobar resection was more feasible when the 2 cm simulated cutting margin did not involve Vl (P<0.001). Thirdly, lesions in the outer region had a higher probability of sublobar resection compared to those in the inner or middle regions (P=0.01). Finally, multivariable logistic regression analysis indicated that diameter, CTR, depth ratio, and the lesion's location relative to IMSVs were independent factors affecting surgical planning (P<0.05, *Table 2*). The logistic regression model had an AUC of 0.900, indicating high model value in aiding surgical planning (*Figure 4A*). Specifically, the VIF values for the factors were 1.057532, 1.168781, 1.02954, and 1.183905, respectively (Table S6), indicating minimal multicollinearity among the factors.

In bilateral lower lobes, cases undergoing lobectomy and basal segmentectomy were combined into the extended resection group, while those undergoing segmentectomy, subsegmentectomy, or wedge resection were combined into the limited resection group. Similar analyses to those in the bilateral upper lobes were conducted, with detailed outcomes in *Table 1*. When CTR ≤0.5, the 2 cm simulated cutting margin did not involve V^6b, or lesions were in the outer region, sublobar resection was more feasible (P<0.001). Multivariable logistic regression analysis indicated that diameter, CTR, depth ratio, and the lesion's location relative to IMSVs were independent factors affecting surgical planning (P<0.05, *Table 2*). The model had an AUC of 0.906, indicating high value in aiding surgical planning (*Figure 4B*). The VIF values for the factors were 1.085095, 1.097818, 1.15931, and 1.096872, respectively (Table S6), confirming the robustness of the inferred relationships between the dependent factors.

Unveiling new positional indications: a significant complement to traditional criteria for the selection of resection extent

In terms of limited resections planned based on diameter and CTR, 285 cases were for the bilateral upper lobes, with 236 actually completed. The failure to complete the remaining cases was predominantly due to the depth ratio and relative positioning of nodules to IMSV, accounting for 69.4% (34/49). For the bilateral lower lobes, 197 were

Table 1 The factors of surgical procedures by surgery location

Factors	Bilateral upper lobes			Bilateral lower lobes		
	Limited resection (n=286)	Extended resection (n=109)	P	Limited resection (n=221)	Extended resection (n=70)	P
CTR, n (%)			<0.001			<0.001
Noninvasive	236 (82.5)	49 (45.0)		173 (78.3)	24 (34.3)	
Invasive	50 (17.5)	60 (55.0)		48 (21.7)	46 (65.7)	
IMSVs, n (%)			<0.001			<0.001
Involved	15 (5.2)	42 (38.5)		30 (13.6)	29 (41.4)	
Uninvolved	271 (94.8)	67 (61.5)		191 (86.4)	41 (58.6)	
Depth ratio, n (%)			0.01			<0.001
Inner or middle region	58 (20.3)	36 (33.0)		35 (15.8)	32 (45.7)	
Outer region	228 (79.7)	73 (67.0)		186 (84.2)	38 (54.3)	

CTR, consolidation-to-tumour ratio; IMSV, inter-multisegmental vein.

Table 2 Multivariate logistic regression analyses predicted risk factors for surgery strategy

Variables	Bilateral upper lobes		Bilateral lower lobes	
	OR (95% CI)	P value	OR (95% CI)	P value
Diameter	1.38 (1.25, 1.51)	<0.001	1.42 (1.27, 1.58)	<0.001
CTR (>0.5/≤0.5)	9.23 (4.78, 17.82)	<0.001	6.66 (3.15, 14.05)	<0.001
IMSV (involved/not involved)	18.41 (7.95, 42.6)	<0.001	3.46 (1.53, 7.82)	0.003
Depth ratio	1.02 (1, 1.04)	0.04	1.04 (1.01, 1.06)	0.003

OR, odds ratio; CI, confidence interval; CTR, consolidation-to-tumour ratio; IMSV, inter-multisegmental vein.

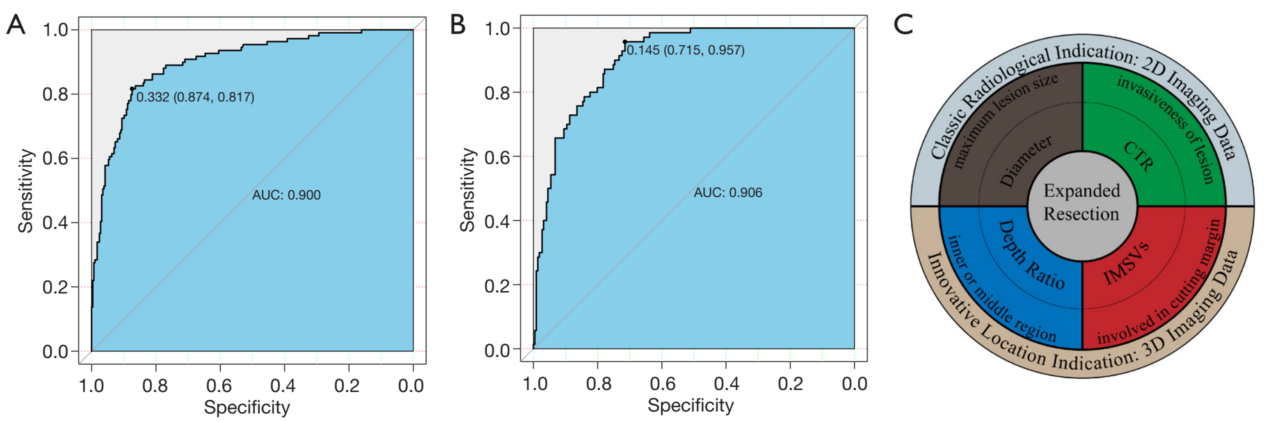

Figure 4 The multivariable logistic regression analyses. (A,B) ROC curves illustrating the predictive performance of the models. The data presented include the AUC values, which quantify the diagnostic accuracy, as well as the optimal cutoff points with corresponding sensitivity and specificity. (C) Interpretation diagram of independent factors influencing procedures selection. AUC, area under the curve; 2D, two-dimensional; 3D, three-dimensional; CTR, consolidation tumor ratio; IMSV, inter-multisegmental vein; ROC, receiver operating characteristic.

planned with 173 completed, and failures largely attributed to depth ratio and IMSV, accounting for 95.8% (23/24).

Among all cases that underwent extended resection, 109 were for the bilateral upper lobes, with 49 lesions primarily consisting of ground-glass opacity. Of these, nodules in 27 cases involved the Vl within a 2 cm simulated cutting margin, nodules in 19 cases were located in the inner or middle region, and 12 met both positional indications. However, 15 cases did not meet either of the two positional indications. In the bilateral lower lobes, out of 70 cases, 24 had lesions with a CTR of less than 50%. Among these, the 2 cm simulated cutting margin of nodules involved V^6b in 17 cases, nodules were located in the inner or middle region in 14 cases, eight met both positional indications, and one case did not meet any positional indications.

In the cases of extended resection for the bilateral upper lobes, 55.0% met the criteria for traditional surgical indications. This percentage increased to 86.2% when both traditional and positional indications were considered together. Similarly, for the bilateral lower lobes, the proportion of cases meeting traditional surgical indications alone was 65.7%, which rose to 98.6% with the inclusion of positional indications. Therefore, we conclude that the integration of transverse positional indication (related to IMSV) and longitudinal positional indication (related to depth ratio) alongside traditional indications—based on diameter and CTR—markedly broadens the scope of applicable guidelines for determining the extent of resection (*Figure 4C*). This study highlights the critical role of incorporating these additional parameters to improve the precision and effectiveness of surgical interventions in treating lung disease.

Discussion

In this study, we analyzed the anatomical characteristics of IMSVs using 3D-CTBA and explored how the lesion's position relative to the IMSVs influences surgical strategy. The IMSV in the upper lobes, specifically Vl, was found to be highly prevalent with diverse drainage patterns, originating deeply and centrally. Conversely, the IMSV in the lower lobes, either V^6b2 or V^6b3, showed an extremely high prevalence and ran transversely between several adjacent segments with minimal variation in drainage patterns. Factors such as diameter, CTR (as an invasive indication), depth ratio (indicating longitudinal location), and the lesion's relative position to the IMSVs (indicating transverse location) were identified as independent predictors for the choice of limited resection ($P<0.05$). The multivariable logistic regression models demonstrated high utility in determining surgical procedures, each achieving an AUC of 0.900.

Pulmonary veins, lying between segments or subsegments, are crucial in targeting the surgical region and determining the intersegmental or intersubsegmental planes (18,19). Several scholars have analyzed the classification of pulmonary veins in detail, using traditional anatomy and 3D-CTBA (20-22). The increasing prevalence of segmentectomy or subsegmentectomy has led surgeons to study the IMSVs crossing multiple pulmonary segments. Such veins include Vl located in bilateral upper lobes, V^{1+2}d in the left upper lobe, and V^6b in the bilateral lower lobes.

Vl runs along the intersegmental plane between S^1, S^2, and S^3 in the right upper lobe, and between S^{1+2} and S^3 in the left upper division. Yamashita originally identified this vein as V^1l in the right upper lobe, but did not name its counterpart in the left upper lobe. We observed that Vl is present in both bilateral upper lobes, with a significantly higher prevalence on the left side than the right side. Given Vl's origin from the confluent trunk of several intersegmental veins and its location between adjacent segments on both sides, we recommend consistently naming this vein V1, whether it is on the right or left side. Vl primarily drains into V^2a+b (70/110, 63.6%) in the right upper lobe, and into V^{1+2}b+c (72/121, 59.5%) in the left upper lobe. The manifold drainage patterns of Vl also confirm its positioning between several adjacent segments.

Yamashita defined the superior segmental vein in the lower lobes as an intersegmental or intersubsegmental vein. This includes V^6a, running along the intersubsegmental plane between S^6a and S^6b; V^6b1, running between S^6b and S^6c; V^6b2, running between S^6b and S^9a; and V^6b3, running either between S^6b and S^{10}a or between S^6c and S^7b. He noted diverse drainage patterns for V^6a and V^6c, with little variation in V^6b's patterns (23). However, under the guidance of 3D-CTBA, we often observed a superior segmental vein branch, V^6b2 or V^6b3, running transversely along the intersegmental plane, with adjacent lesions often involving multiple segments. Given its clinical significance and relative rarity in reports, we propose naming the intrasegmental vein between S^6b and S^6c as V^6b1, and the IMSVs between S^6b and S^9a, S^6b and S^8a as V^6b2 and V^6b3, respectively. In most cases, at least one of these IMSVs (V^6b2 or V^6b3) was present in the lower lobes (288/291, 99.0%).

Currently, the indications of sublobar resection for early lung cancer mainly include diameter, CTR, and location which was described roughly as “peripheral lesions” (3,4). The formulation of such indications obviously paid attention to the influence of diameter and depth on ensuring sufficient cutting margin and operation difficulty. In the practice of segmentectomy, the depth of lesions and the individual anatomical characteristics determine the individualized surgical strategy. Given the bronchus distribution resembles tree branches, it’s easy to understand why lesions of the same diameter involve fewer anatomical units in the periphery than deeper areas. Smaller-diameter lesions more likely ensure adequate surgical margins than larger ones at the same depth. In surgical practice, deeper lesions involve more subsegmental units, significantly increasing the complexity of sublobar resections. Additionally, the lesion’s transverse adjacent structures are crucial for developing individualized surgical strategies. The IMSV, with its numerous neighboring anatomical structures compared to the intersegmental vein, adds complexity to the surgical procedure. Effective surgical planning must integrate analyses of invasiveness, diameter, depth, and adjacent anatomical structures to ensure safe margins and meet oncological resection goal. Based on the above analysis, we found that diameter, CTR, depth ratio, and whether the 2 cm simulated cutting margin of nodules involved IMSVs were all independent factors affecting the determination of surgical procedures in upper lobes. When the 2 cm simulated cutting margin did not involve IMSVs, wedge resection or segmentectomy was more feasible. Patients with IMSVs involved in the 2 cm simulated cutting margin were more likely to undergo lobectomy, basal segmentectomy, or left upper division resection to guarantee sufficient cutting margins. Thus, due to their unique locations which often necessitate extensive resection of adjacent lesions to achieve adequate margins, Vl and V^6b can be considered ‘trouble veins’.

Additionally, it should be noted that the IMSV in the left upper lobe, like Vl and V^6b, also includes V^{1+2}d in the left upper lobe. V^{1+2}d1 runs between S^{1+2}c and S^3a, V^{1+2}d2 runs between S^{1+2}c and S^4a, and V^{1+2}d3 runs between S^3a and S^4a. Due to the rarity of cases with V^{1+2}d, no specific analysis was conducted in this study. Figure S2 illustrates a typical case where the lesion with 2 cm simulated cutting margin involving V^{1+2}d1 was resected through an S^{1+2}c+S^3a+S^4a resection.

We acknowledge several limitations and shortcomings of this study. Firstly, the precise definitions of Vl and V^6b have not yet been universally agreed upon by experts in anatomy, radiology, and surgery, which may introduce variability in the interpretation of their roles in surgical planning. Secondly, the study relied exclusively on 3D-CTBA for analysis, which, while effective, requires further validation through human anatomical studies to account for the diversity of drainage patterns. Thirdly, as a retrospective study, the endpoint reviewed in this study was the surgical procedures. However, the surgical procedure may be influenced by multiple factors. Preoperatively, changes may occur due to variations in pulmonary function or the patient’s personal preferences, while intraoperatively, modifications may result from technical challenges, pathological findings, or unforeseen complications. These changes could impact the conclusions of our study. Additionally, the lack of detailed pulmonary function testing data for the patients included in this study is a limitation. During the coronavirus disease 2019 (COVID-19) pandemic, preoperative pulmonary function tests were conducted at referring facilities, and only patients meeting minimum standards were referred to our center. Consequently, detailed pulmonary function metrics were unavailable, which limits the ability to evaluate their influence on surgical decision-making and outcomes. Finally, the impact of intraoperative sectioning of IMSVs on postoperative complications and recovery remains unclear. This aspect requires further investigation to clarify its clinical significance.

Conclusions

IMSVs demonstrated high prevalence, with Vl exhibiting diverse drainage patterns, whereas V^6b2 and V^6b3 showed minimal variation. The depth ratio and the lesion’s relative position to the IMSVs were identified as key indicators for longitudinal and transverse positioning, respectively, in guiding sublobar resection for patients with clinical T1a–bN0 NSCLC.

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Footnote

Reporting Checklist: The authors have completed the

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Jiangsu Province Hospital and The First Affiliated Hospital of Nanjing Medical University Ethics Review Board (No. 2019-SR-450). Individual consent for this retrospective analysis was waived.

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