Appendix 1

Patients in the internal dataset underwent preoperative chest CT scans using four CT scanners from three vendors: the Toshiba Aquilion 16-row, the GE Light Speed VCT 64-row, the Philips Ingenuity 64-row, and the Brilliance iCT 128-row CT machine. In the external set, The Toshiba Aquilion 16-row, the GE Revolution 256-row, and the GE Discovery CT 750HD 64-row CT machine were used for patients in the First Affiliated Hospital of Soochow University. The Siemens SOMATOM Definition AS, AS+ 64 row, and the Philips Brilliance 16 row CT machine were used for patients in the Zhejiang Provincial People's Hospital.

The patients were supine during the scan, which included the entire lung field. The parameters were set as follows: tube voltage: 120 kVp; tube current: 150–250 mAs or automatic tube current regulation; scanning slice thickness and slice increment: 5 mm; reconstruction slice thickness and slice increment: 0.625, 1, and 1.5 mm; reconstruction algorithm: lung algorithm or standard algorithm; and images: non-contrast enhanced.

Appendix 2

Hematoxylin-eosin staining was used to observe the degree of tumor invasion of the pleura under a light microscope. Elastic fiber staining was used to evaluate whether the tumor had invaded the elastic fiber layer when diagnosis was difficult. According to the 8th edition of TNM staging criteria for lung cancer. The degree of pleural invasion of tumors can be divided into three categories: PL0: tumors exist in the lung parenchyma or invade the connective tissue below the elastic fiber layer of the pleura; PL1: tumor invasion broke through the elastic fiber layer; PL2: invasion to the visceral pleural surface; PL3: invasion of the parietal pleura or chest wall. PL1 and PL2 were VPI. Additionally, the growth pattern of tumor cells, the size of invasive components, the presence or absence of lymphatic and vascular invasion, and spread through air space were observed. The pathological grading of the tumors was divided into minimally invasive adenocarcinoma (MIA) and invasive adenocarcinoma (IA).

Appendix 3

The Shapiro-Wilk test was used to analyze data normality. Normally distributed data are expressed as mean ± standard deviation and the student *t*-test was used for group comparison. Non-normally distributed data are expressed as medians (Q1, Q3) and compared using the Mann–Whitney *U* test. Categorical data are expressed as case numbers and compared using Pearson's chi-square test, Yate's correction for continuity, or Fisher's exact test. $P<0.05$ was considered statistically significant in the univariate analysis. Variables with $P<0.1$ in univariate logistic regression were included in multivariate logistic regression using backward stepwise selection. The multivariate logistic regression model was established, and its efficiency was tested on the independent internal and external validation sets. The area under the curve (AUC), accuracy, sensitivity, specificity, and positive and negative predictive values were used to evaluate the efficiency of the model. The Kappa coefficient and intra-class correlation coefficient (ICC) were used to assess the consistency of qualitative and quantitative parameters among observers. $P < 0.05$ was considered statistically significant.

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Table S1 The definitions of CT features

Features	Definition
Pleural	
Pleural indentation sign	The pleura is displaced from its initial position because of tumor pulling at the lung window.
Classification of morphology and density	Type A showed no morphological and density change at the pleural end; Type B is pleural indentation with no density change; Type C is pleural indentation with fat density; Type D is pleural indentation with water density; Type E is pleural indentation with soft tissue density.
Tumor	
Tumor size	The maximum dimension of the entire tumor on the MPR image at the lung window.
Solid component size	The maximum dimension of the solid part of the tumor on the MPR image at the lung window.
CTR	consolidation-to-tumor ratio.
Location	The lung lobe where the tumor is located.
Density	mGGN, manifestation of ground-glass and solid density part; solid, includes only the solid density component.
Shape	Tumor shapes on MPR images include round, oval, and irregular forms.
Tumor-lung interface	The tumor-lung boundary, which may be well-defined or ill-defined.
Lobulation sign	The margins of the tumor exhibit a wavy or petaloid appearance.
Spiculation sign	Linear, short, and thin strands extending around the tumor's surface without contacting the pleural surface.
Vacuole sign	An air space of 5mm or less in the tumor, representing lung tissue that remains uninvaded by the tumor.
Cavity or cystic airspace	An air space larger than 5mm in the tumor could be caused by intratumoral necrosis or might represent preserved parenchyma, normal or widened bronchi, or localized emphysema.
Bronchial change	The presence of an air-filled bronchus can manifest as natural, dilated, distorted, or cut-off within the lesions, or it may be cut-off at the lesion boundaries.
Vascular convergence sign	Pulmonary vessels converging towards the lesion around the tumor
ELLC	Emphysema detected in the lung lobe with cancer through visual inspection.
Tumor and pleura	
Indirect contact type	
DLP	The shortest vertical distance between the tumor and the nearby pleura was assessed in MPR lung window images.
Pleural tags sign	High-density linear strands, one or more, linking the tumor margin and the pleura.
Classification of pleural tags sign	Type I, the tumor was connected to the pleura by thin line or thick strip, without pleural indentation sign, which was the Rat-tail sign; Type II, the tumor was connected to the pleura by the thin line with pleural indentation sign, which was the Fish-tail sign; Type III, the tumor was connected to the pleura by a thick strip with pleural indentation sign, which was the Peacock-tail sign
Bridge sign	An arched line is visible between the tumor and the pleura on the CT lung window, and the tumor margin is flattened.
Direct contact type	
Whole tumor contact length	The largest dimension of the entire tumor touching the pleura was measured linearly on the MPR image.
Solid component contact length	The largest dimension of the solid component touching the pleura was measured linearly on the MPR image.
Solid component contact pleura	The MPR image showed direct contact between the solid parts of the tumor and the pleura.
Pleural tags sign	For tumors directly touching the pleura, one or more linear strands between the tumor and the pleura was seen in other directions.
Classification based on the proportion of tumors contacting the pleura and pleura morphology	Type I, the proportion of tumors contacting the pleura ≤50% without pleura indentation sign; Type II, the proportion of tumors contacting the pleura >50% without pleura indentation sign; Type III, the proportion of tumors contacting the pleura ≤50% with pleura indentation sign; Type IV, the proportion of tumors contacting the pleura >50% with pleura indentation sign;

Note: MPR, multiplanar reconstruction; CTR, consolidation-to-tumor ratio; ELLC, emphysema in the lobe of lung cancer; DLP, the minimum distance from the lesion to the pleura.

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Table S2 Clinical and pathological characteristics of patients in indirect pleural contact type

Characteristics	Training set (n=114)			Internal validation set (n=52)			External validation set (n=36)		
	VPI (-) (n=65)	VPI (+) (n=49)	P value	VPI (-) (n=23)	VPI (+) (n=29)	P value	VPI (-) (n=25)	VPI (+) (n=11)	P value
Gender			0.21[a]			0.37[a]			>0.99[c]
Female	42 (64.6%)	26 (53.1%)		17 (73.9%)	18 (62.1%)		17 (68.0%)	7 (63.6%)	
Male	23 (35.4%)	23 (46.9%)		6 (26.1%)	11 (37.9%)		8 (32.0%)	4 (36.4%)	
Age (year)	60.2±10.0	59.3±9.2	0.63[d]	55.7±9.6	60.6±10.7	0.09[d]	60.5±8.2	64.5±6.7	0.17[d]
Location			0.56[c]			0.66[c]			0.03[c]
RUL	21 (32.3%)	21 (42.9%)		9 (39.1%)	8 (27.6%)		12 (48.0%)	3 (27.3%)	
RML	5 (7.7%)	2 (4.1%)		2 (8.7%)	1 (3.4%)		4 (16.0%)	1 (9.1%)	
RLL	11 (16.9%)	6 (12.2%)		4 (17.4%)	10 (34.5%)		6 (24.0%)	1 (9.1%)	
LUL	21 (32.3%)	12 (24.5%)		6 (26.1%)	7 (24.1%)		0 (0.0%)	4 (36.4%)	
LLL	7 (10.8%)	8 (16.3%)		2 (8.7%)	3 (10.3%)		3 (12.0%)	2 (18.2%)	
Surgery type			0.11[a]			0.65[a]			0.57[c]
Sublobectomy	22 (33.8%)	10 (20.4%)		6 (26.1%)	6 (20.7%)		2 (8.0%)	2 (18.2%)	
Lobectomy	43 (66.2%)	39 (79.6%)		17 (73.9%)	23 (79.3%)		23 (92.0%)	9 (81.8%)	
Pathological type			0.04[c]			0.44[c]			>0.99[c]
MIA	6 (9.2%)	0 (0.0%)		1 (4.3%)	0 (0.0%)		2 (8.0%)	0 (0.0%)	
IA	59 (90.8%)	49 (100.0%)		22 (95.7%)	29 (100.0%)		23 (92.0%)	11 (100.0%)	

Note: The P value represents the univariate analysis. Data are presented as n (%). [a], Pearson's chi-square test; [c], Fisher's exact test; [d], the student *t*-test. VPI, visceral pleural invasion; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LUL, left upper lobe; LLL, left lower lobe; MIA, minimally invasive adenocarcinoma; IA, invasive adenocarcinoma.

Table S3 Clinical and pathological characteristics of patients in direct pleural contact type

Characteristics	Training set (n=169)			Internal validation set (n=69)			External validation set (n=45)		
	VPI (-) (n=84)	VPI (+) (n=85)	P value	VPI (-) (n=38)	VPI (+) (n=31)	P value	VPI (-) (n=23)	VPI (+) (n=22)	P value
Gender			0.39[a]			0.54[a]			0.10[a]
Female	50 (59.5%)	45 (52.9%)		23 (60.5%)	21 (67.7%)		16 (69.6%)	10 (45.5%)	
Male	34 (40.5%)	40 (47.1%)		15 (39.5%)	10 (32.3%)		7 (30.4%)	12 (54.5%)	
Age (year)	57.5 (51.0, 65.0)	62.0 (55.0, 68.0)	0.043[e]	57.0±9.2	57.8±7.9	0.72[d]	60.0±8.8	61.5±9.8	0.60[d]
Location			0.07[a]			0.94[a]			0.73[c]
RUL	25 (29.8%)	19 (22.4%)		11 (28.9%)	8 (25.8%)		10 (43.5%)	10 (45.5%)	
RML	6 (7.1%)	19 (22.4%)		5 (13.2%)	6 (19.4%)		4 (17.4%)	3 (13.6%)	
RLL	23 (27.4%)	24 (28.2%)		7 (18.4%)	6 (19.4%)		7 (30.4%)	4 (18.2%)	
LUL	19 (22.6%)	13 (15.3%)		8 (21.1%)	7 (22.6%)		1 (4.3%)	2 (9.1%)	
LLL	11 (13.1%)	10 (11.8%)		7 (18.4%)	4 (12.9%)		1 (4.3%)	3 (13.6%)	
Surgery type			0.10[a]			0.29[a]			0.21[b]
Sublobectomy	26 (31.0%)	17 (20.0%)		13 (34.2%)	7 (22.6%)		5 (21.7%)	1 (4.5%)	
Lobectomy	58 (69.0%)	68 (80.0%)		25 (65.8%)	24 (77.4%)		18 (78.3%)	21 (95.5%)	
Pathological type			<0.001[c]			0.006[c]			0.07[c]
MIA	23 (27.4%)	0 (0.0%)		10 (26.3%)	0 (0.0%)		5 (21.7%)	0 (0.0%)	
IA	61 (72.6%)	85 (100.0%)		28 (73.7%)	31 (100.0%)		18 (78.3%)	22 (100.0%)	

Note: The P value represents the univariate analysis. Normally distributed data are expressed as mean ± SD. Non-normally distributed data are expressed as medians (Q1, Q3). Categorical data are expressed as n (%). [a], Pearson's chi-square test; [b] , Yate's correction for continuity; [c], Fisher's exact test; [d], the student *t*-test; [e], the Mann–Whitney *U* test. VPI, visceral pleural invasion; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LUL, left upper lobe; LLL, left lower lobe; MIA, minimally invasive adenocarcinoma; IA, invasive adenocarcinoma.

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Table S4 Consistency analysis of CT features among observers in indirect pleural contact type

Qualitative	Kappa (95% CI)	Quantitative	ICC (95% CI)
Density type	0.948 (0.897–0.999)	Tumor size	0.972 (0.897–0.987)
Shape	0.840 (0.756–0.924)	Solid component size	0.907 (0.694–0.958)
Lobulation	0.823 (0.652–0.994)	DLP	0.887 (0.847–0.917)
Spiculation	0.918 (0.853–0.983)		
Tumor-lung interface	1.000		
Bronchial change	0.909 (0.850–0.968)		
Vacuole sign	0.915 (0.852–0.978)		
Cavity or cystic airspace	0.856 (0.712–0.993)		
Vascular convergence sign	0.949 (0.892–1.000)		
ELLC	1.000		
Bridge sign	0.835 (0.735–0.935)		
Classification of pleural tags sign	0.928 (0.888–0.968)		
Classification of pleural density	0.981 (0.961–1.000)		

Note: ELLC, emphysema in the lobe of lung cancer; DLP, the minimum distance from the lesion to the pleura.

Table S5 Consistency analysis of CT features among observers in direct pleural contact type

Qualitative	Kappa (95% CI)	Quantitative	ICC (95% CI)
Density type	0.937 (0.888–0.986)	Tumor size	0.941 (0.864–0.968)
Shape	0.893 (0.834–0.952)	Solid component size	0.986 (0.983–0.989)
Lobulation	0.839 (0.702–0.976)	Whole tumor contact length	0.962 (0.951–0.970)
Spiculation	0.911 (0.850–0.972)	Solid component contact length	0.993 (0.991–0.994)
Tumor-lung interface	1.000		
Bronchial change	0.918 (0.871–0.965)		
Vacuole sign	0.948 (0.907–0.989)		
Cavity or cystic airspace	0.825 (0.707–0.943)		
Vascular convergence sign	0.846 (0.724–0.968)		
ELLC	1.000		
Pleural tags sign	0.964 (0.933–0.995)		
Solid component contact pleural	0.913 (0.850–0.976)		
Pleural indentation sign	0.962 (0.929–0.995)		
Classification of pleural contact surface	0.967 (0.941–0.996)		
Classification of pleural density	0.969 (0.937–1.000)		

Note: ELLC, emphysema in the lobe of lung cancer.

Table S6 Pleural indentation sign between interlobar and non-interlobar pleura groups in indirect pleural contact type

Pleural indentation sign	Interlobar (n=9)			Non-interlobar (n=105)		
	VPI (-)	VPI (+)	P value	VPI (-)	VPI (+)	P value
Absent	2 (28.6%)	0 (0.0%)	1.000[c]	26 (44.8%)	3 (6.4%)	< 0.001[a]
Present	5 (71.4%)	2 (100.0%)		32 (55.2%)	44 (93.6%)	

Note: The P value represents the univariate analysis. Data are presented as n (%). [a], Pearson's chi-square; [c], Fisher's exact test. VPI, visceral pleural invasion.

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Table S7 Pleural indentation sign between interlobar and non-interlobar pleura groups in direct pleural contact type

Pleural indentation sign	Interlobar (n=84)			Non-interlobar (n=85)		
	VPI (-)	VPI (+)	P value	VPI (-)	VPI (+)	P value
Absent	5 (13.2%)	2 (4.3%)	0.290[b]	33 (71.7%)	19 (48.7%)	0.03[a]
Present	33 (86.8%)	44 (95.7%)		13 (28.3%)	20 (51.3%)	

Note: The P value represents the univariate analysis. Data are presented as n (%). [a], Pearson's chi-square; [b], Yate's correction for continuity; VPI, visceral pleural invasion.

Table S8 Classification based on the morphology and density changes of the pleura in indirect pleural contact type

Group	Type A	Type B	Type C	Type D	Type E	P value
VPI-Negative	28 (43.1%)[a]	0 (0.0%)	14 (21.5%)[b]	16 (24.6%)[b]	7 (10.8%)[b]	< 0.001
VPI-Positive	3 (6.1%)[a]	0 (0.0%)	15 (30.6%)[b]	19 (38.8%)[b]	12 (24.5%)[b]	

Note: "[a] and [b]" represent a subset of the classification based on the morphology and density changes of the pleura in indirect pleural contact type, with the same letter indicating that they are not significantly different from each other at the P<0.05 level. Data are presented as n (%). Chi-square test and pairwise comparison showed that the difference between type A and type C/D/E was statistically significant (χ^2=36.353, P<0.001), indicating that there were significant differences in pleural morphological changes (with or without pleural indentation sign) between the two groups. However, type C/D/E reflected the change of pleural end density, and there was no significant difference between each group after pairwise comparison (P>0.05), indicating that there was no significant difference in evaluating the change of pleural end density between the two groups.

Table S9 Classification based on the morphology and density changes of the pleura in direct pleural contact type

Group	Type A	Type B	Type C	Type D	Type E	P value
VPI-Negative	38 (45.2%)[a]	38 (45.2%)[a]	5 (6.0%)[a]	1 (1.2%)[a]	2 (2.4%)[a]	0.02
VPI-Positive	21 (24.7%)[a]	43 (50.6%)[a]	10 (11.8%)[a]	4 (4.7%)[a]	7 (8.2%)[a]	

Note: "[a]" represents a subset of the classification based on the morphology and density changes of the pleura in indirect pleural contact type, with the same letter indicating that they are not significantly different from each other at the P<0.05 level. Data are presented as n (%). For direct contact with pleural tumors, based on the morphology and density changes of the pleura, the Fisher's exact test, found that the overall difference was statistically significant (P=0.020), but all kinds of classification there was no statistically significant difference comparing the two, may be the result of more as a result of the comparison group P values penalties to strengthen or adjusted inspection level is reduced, The results were at the boundary level leading to an overall difference but not a significant difference in pairwise comparisons. Therefore, we further classification to pleural indentation area density change (C/D/E) two comparison, found that each model there was no statistically significant difference between the two groups (P=0.866).

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Table S10 CT features of patients in indirect pleural contact type

Features	Training set (n=114)			Internal validation set (n=52)			External validation set (n=36)		
	VPI (-) (n=65)	VPI (+) (n=49)	P value	VPI (-) (n=23)	VPI (+) (n=29)	P value	VPI (-) (n=25)	VPI (+) (n=11)	P value
Tumor size (mm)	20.0 (15.9, 26.0)	25.2 (19.5, 27.5)	0.002[e]	19.5±6.3	23.4±5.0	0.02[d]	19.0±6.0	24.0±5.7	0.02[d]
Solid component size (mm)	11.1 (5.8, 15.7)	18.8 (13.2, 22.5)	<0.001[e]	12.3±5.7	18.9±6.1	<0.001[d]	12.2±6.0	17.8±8.2	0.03[d]
CTR (%)	53.0 (31.5, 79.6)	79.8 (66.1, 100.0)	<0.001[e]	70.5 (49.4, 91.4)	87.9 (70.7, 100.0)	0.03[e]	77.4 (39.0, 84.3)	82.5 (58.2, 94.2)	0.28[e]
DLP (mm)	2.7 (1.9, 3.8)	3.1 (2.0, 4.5)	0.17[e]	3.2 (2.0, 5.0)	2.8 (2.1, 3.8)	0.42[e]	2.2 (1.8, 4.2)	2.8 (2.5, 4.0)	0.42[e]
Density type			0.03[a]			0.16[a]			>0.99[c]
MGGN	56 (86.2%)	34 (69.4%)		17 (73.9%)	16 (55.2%)		21 (84.0%)	9 (81.8%)	
Solid	9 (13.8%)	15 (30.6%)		6 (26.1%)	13 (44.8%)		4 (16.0%)	2 (18.2%)	
Shape			0.84[a]			0.87[a]			>0.99[c]
Irregular	17 (26.2%)	12 (24.5%)		6 (26.1%)	7 (24.1%)		8 (32.0%)	4 (36.4%)	
Round/Oval	48 (73.8%)	37 (75.5%)		17 (73.9%)	22 (75.9%)		17 (68.0%)	7 (63.6%)	
Lobulation			>0.99[b]			>0.99[b]			>0.99[c]
Absent	2 (3.1%)	2 (4.1%)		2 (8.7%)	2 (6.9%)		2 (8.0%)	1 (9.1%)	
Present	63 (96.9%)	47 (95.9%)		21 (91.3%)	27 (93.1%)		23 (92.0%)	10 (90.9%)	
Spiculation			<0.001[a]			0.044[a]			0.31[c]
Absent	56 (86.2%)	28 (57.1%)		20 (87.0%)	18 (62.1%)		25 (100.0%)	10 (90.9%)	
Present	9 (13.8%)	21 (42.9%)		3 (13.0%)	11 (37.9%)		0 (0.0%)	1 (9.1%)	
Interface			0.43[c]			N/A			N/A
Ill-defined	0 (0.0%)	1 (2.0%)		0 (0.0%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Well-defined	65 (100.0%)	48 (98.0%)		23 (100.0%)	29 (100.0%)		25 (100.0%)	11 (100.0%)	
Bronchial change			0.37[a]			0.42[a]			0.07[c]
Absent	32 (49.2%)	20 (40.8%)		7 (30.4%)	12 (41.4%)		16 (64.0%)	3 (27.3%)	
Present	33 (50.8%)	29 (59.2%)		16 (69.6%)	17 (58.6%)		9 (36.0%)	8 (72.7%)	
Vacuole			0.34[a]			0.84[a]			>0.99[c]
Absent	49 (75.4%)	33 (67.3%)		18 (78.3%)	22 (75.9%)		17 (68.0%)	7 (63.6%)	
Present	16 (24.6%)	16 (32.7%)		5 (21.7%)	7 (24.1%)		8 (32.0%)	4 (36.4%)	
Cavity/Cystic airspace			>0.99[b]			0.32[c]			0.54[c]
Absent	61 (93.8%)	46 (93.9%)		23 (100.0%)	26 (89.7%)		22 (88.0%)	11 (100.0%)	
Present	4 (6.2%)	3 (6.1%)		0 (0.0%)	3 (10.3%)		3 (12.0%)	0 (0.0%)	
Vascular convergence sign			<0.001[a]			0.12[b]			0.04[c]
Absent	63 (96.9%)	30 (61.2%)		22 (95.7%)	22 (75.9%)		24 (96.0%)	7 (63.6%)	
Present	2 (3.1%)	19 (38.8%)		1 (4.3%)	7 (24.1%)		1 (4.0%)	4 (36.4%)	
ELLC			0.02[b]			>0.99[b]			0.22[c]
Absent	64 (98.5%)	42 (85.7%)		21 (91.3%)	26 (89.7%)		24 (96.0%)	9 (81.8%)	
Present	1 (1.5%)	7 (14.3%)		2 (8.7%)	3 (10.3%)		1 (4.0%)	2 (18.2%)	
Bridge sign			0.01[a]			>0.99[a]			0.003[c]
Absent	60 (92.3%)	37 (75.5%)		19 (82.6%)	24 (82.8%)		22 (88.0%)	4 (36.4%)	
Present	5 (7.7%)	12 (24.5%)		4 (17.4%)	5 (17.2%)		3 (12.0%)	7 (63.6%)	
Pleural tags sign			<0.001[a]			0.002[a]			<0.001[c]
I	28 (43.0%)	3 (6.1%)		9 (39.2%)	1 (3.4%)		19 (76.0%)	1 (9.1%)	
II	30 (46.2%)	25 (51.0%)		11 (47.8%)	16 (55.2%)		4 (16.0%)	3 (27.3%)	
III	7 (10.8%)	21 (42.9%)		3 (13.0%)	12 (41.4%)		2 (8.0%)	7 (63.6%)	

Note: The P value represents the univariate analysis. Normally distributed data are expressed as mean ± SD. Non-normally distributed data are expressed as medians (Q1, Q3). Categorical data are expressed as n (%). [a], Pearson's chi-square test; [b], Yate's correction for continuity; [c], Fisher's exact test; [d], the student *t*-test; [e], the Mann–Whitney *U* test. VPI, visceral pleural invasion; CTR, consolidation-to-tumor ratio; DLP, the minimum distance from the lesion to the pleura; MGGNs, mixed ground glass nodules; ELLC, emphysema in the lobe of lung cancer.

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Table S11 Collinearity test of multivariate logistic regression analysis variables in indirect pleural contact type

Variables	Collinearity test statistics (model 1)		Collinearity test statistics (model 2)	
	Tolerance	Variance inflation factor	Tolerance	Variance inflation factor
Classification of Pleural tags sign	0.767	1.304	0.772	1.296
Bridge sign	0.918	1.089	0.919	1.088
Density type	0.539	1.856	0.552	1.813
Tumor size	0.147	6.796	0.542	1.845
Solid component size	0.042	23.627	0.363	2.753
CTR	0.057	17.401	—	—
Spiculation	0.656	1.525	0.665	1.504
Vascular convergence sign	0.793	1.260	0.799	1.252
ELLC	0.893	1.120	0.893	1.120

Note: CTR, consolidation-to-tumor ratio; ELLC, emphysema in the lobe of lung cancer.

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Table S12 CT features of patients in direct pleural contact type

Features	Training set (n=169)			Internal validation set (n=69)			External validation set (n=45)		
	VPI (-) (n=84)	VPI (+) (n=85)	P value	VPI (-) (n=38)	VPI (+) (n=31)	P value	VPI (-) (n=23)	VPI (+) (n=22)	P value
Tumor size (mm)	18.1 (14.7, 21.1)	23.0 (19.9, 26.6)	<0.001[e]	20.1 (14.5, 22.3)	24.6 (20.0, 27.8)	0.001[e]	18.0±5.7	21.6±5.9	0.044[d]
Solid component size (mm)	7.9 (4.2, 12.8)	19.6 (15.1, 23.0)	<0.001[e]	9.1±5.0	18.8±6.6	<0.001[d]	8.5±5.2	17.1±8.1	<0.001[d]
CTR (%)	42.4 (25.6, 67.0)	89.5 (66.2, 100.0)	<0.001[e]	45.8 (31.9, 63.6)	85.2 (63.1, 100.0)	<0.001[e]	46.1 (33.4, 73.4)	79.5 (62.5, 98.0)	0.001[e]
Whole tumor contact length (mm)	12.2 (8.9, 17.1)	15.4 (11.5, 21.1)	0.001[e]	12.0±4.6	15.9±5.7	0.003[d]	13.3±4.7	14.7±5.7	0.38[d]
Solid component contact length (mm)	4.2 (0.0, 9.7)	11.7 (8.8, 17.1)	<0.001[e]	4.8 (2.8, 6.7)	10.4 (7.2, 17.8)	<0.001[e]	3.5 (0.0, 8.4)	10.8 (6.4, 15.2)	0.001[e]
Proportion of whole tumor contact length and tumor size (%)	74.7 (52.8, 91.6)	69.8 (56.5, 85.9)	0.33[e]	64.5±18.5	68.1±18.8	0.43[d]	74.1±13.2	66.8±13.6	0.07[d]
Density type			<0.001[a]			0.006[b]			0.051[c]
MGGN	80 (95.2%)	46 (54.1%)		37 (97.4%)	22 (71.0%)		23 (100.0%)	17 (77.3%)	
Solid	4 (4.8%)	39 (45.9%)		1 (2.6%)	9 (29.0%)		0 (0.0%)	5 (22.7%)	
Shape			0.09[a]			0.72[a]			0.01[a]
Irregular	17 (20.2%)	27 (31.8%)		10 (26.3%)	7 (22.6%)		11 (47.8%)	3 (13.6%)	
Round/Oval	67 (79.8%)	58 (68.2%)		28 (73.7%)	24 (77.4%)		12 (52.5%)	19 (86.4%)	
Lobulation			0.77[a]			0.20[c]			0.49[c]
Absent	5 (6.0%)	6 (7.1%)		0 (0.0%)	2 (6.5%)		2 (8.7%)	0 (0.0%)	
Present	79 (94.0%)	79 (92.9%)		38 (100.0%)	29 (93.5%)		21 (91.3%)	22 (100.0%)	
Spiculation			<0.001[a]			0.02[b]			0.051[b]
Absent	80 (95.2%)	47 (55.3%)		36 (94.7%)	22 (71.0%)		23 (100.0%)	17 (77.3%)	
Present	4 (4.8%)	38 (44.7%)		2 (5.3%)	9 (29.0%)		0 (0.0%)	5 (22.7%)	
Interface			>0.99[c]			N/A			0.49[c]
Ill-defined	0 (0.0%)	1 (1.2%)		0 (0.0%)	0 (0.0%)		0 (0.0%)	1 (4.5%)	
Well-defined	84 (100.0%)	84 (98.8%)		38 (100.0%)	31 (100.0%)		23 (100.0%)	21 (95.5%)	
Bronchial change			0.047[a]			0.03[a]			0.26[a]
Absent	57 (67.9%)	45 (52.9%)		25 (65.8%)	12 (38.7%)		19 (82.6%)	15 (68.2%)	
Present	27 (32.1%)	40 (47.1%)		13 (34.2%)	19 (61.3%)		4 (17.4%)	7 (31.8%)	
Vacuole			0.13[a]			0.44[a]			0.27[b]
Absent	66 (78.6%)	58 (68.2%)		21 (55.3%)	20 (64.5%)		17 (73.9%)	20 (90.9%)	
Present	18 (21.4%)	27 (31.8%)		17 (44.7%)	11 (35.5%)		6 (26.1%)	2 (9.1%)	
Cavity/Cystic airspace			0.43[a]			0.41[b]			>0.99[b]
Absent	78 (92.9%)	76 (89.4%)		32 (84.2%)	29 (93.5%)		21 (91.3%)	21 (95.5%)	
Present	6 (7.1%)	9 (10.6%)		6 (15.8%)	2 (6.5%)		2 (8.7%)	1 (4.5%)	
Vascular convergence sign			0.02[a]			>0.99[b]			0.22[c]
Absent	81 (96.4%)	73 (85.9%)		36 (94.7%)	29 (93.5%)		23 (100.0%)	3 (86.4%)	
Present	3 (3.6%)	12 (14.1%)		2 (5.3%)	2 (6.5%)		0 (0.0%)	19 (13.6%)	
ELLC			0.02[b]			0.81[b]			0.09[b]
Absent	82 (97.6%)	75 (88.5%)		36 (94.7%)	28 (90.3%)		22 (95.7%)	16 (72.7%)	
Present	2 (2.4%)	10 (11.5%)		2 (5.3%)	3 (9.7%)		1 (4.3%)	6 (27.3%)	
Pleural tags sign			<0.001[a]			0.09[a]			0.005[a]
Absent	64 (76.2%)	26 (30.6%)		26 (68.4%)	15 (48.4%)		21 (91.3%)	12 (54.5%)	
Present	20 (23.8%)	59 (69.4%)		12 (31.6%)	16 (51.6%)		2 (8.7%)	10 (45.5%)	
Solid component contact pleura			<0.001[b]			0.07[b]			0.002[b]
Absent	27 (32.1%)	1 (1.2%)		8 (21.1%)	1 (3.2%)		10 (43.5%)	1 (4.5%)	
Present	57 (67.9%)	84 (98.8%)		30 (78.9%)	30 (96.8%)		13 (56.5%)	21 (95.5%)	
Pleural indentation sign			0.005[a]			0.73[a]			0.44[a]
Absent	38 (45.2%)	21 (24.7%)		15 (39.5%)	11 (35.5%)		11 (47.8%)	8 (36.4%)	
Present	46 (54.8%)	64 (75.3%)		23 (60.5%)	20 (64.5%)		12 (52.2%)	14 (63.6%)	

Note: The P value represents the univariate analysis. Normally distributed data are expressed as mean ± SD. Non-normally distributed data are expressed as medians (Q1, Q3). Categorical data are expressed as n (%). [a], Pearson's chi-square test; [b], Yate's correction for continuity; [c], Fisher's exact test; [d], the student *t*-test; [e], the Mann–Whitney *U* test. VPI, visceral pleural invasion; CTR, consolidation-to-tumor ratio; MGGNs, mixed ground glass nodules; ELLC, emphysema in the lobe of lung cancer.

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Table S13 Collinearity test of multivariate logistic regression analysis variables in direct pleural contact type

Variables	Collinearity test statistics (model 1)		Collinearity test statistics (model 2)	
	Tolerance	Variance inflation factor	Tolerance	Variance inflation factor
Age	0.902	1.109	0.909	1.100
Density type	0.338	2.959	0.350	2.855
Tumor size	0.089	11.271	0.176	5.682
Solid component size	0.025	39.738	0.103	9.669
CTR	0.049	20.424	-	-
Pleural indentation sign	0.816	1.226	0.817	1.223
Pleural tags sign	0.619	1.616	0.621	1.610
Whole tumor contact length	0.248	4.025	0.260	3.853
Solid component contact pleura	0.411	2.430	0.523	1.913
Solid component contact length	0.122	8.219	0.131	7.639
Shape	0.931	1.074	0.933	1.072
Spiculation	0.369	2.707	0.370	2.703
Bronchial change	0.708	1.413	0.714	1.401
Vascular convergence sign	0.790	1.265	0.792	1.262
ELLC	0.732	1.365	0.745	1.342

Note: CTR, consolidation-to-tumor ratio; ELLC, emphysema in the lobe of lung cancer.

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