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solid volume ratio in predicting pathological features of cT1 lung adenocarcinoma

yu liu, ning jiang, zhiqiang zou, hongxiu liu, chuanhang zang, jia gu, ning Xin.

Affiliations below.

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Abstract:
Background: More effective methods are urgently needed for predicting the pathological grade and lymph node metastasis of cT1-stage lung adenocarcinoma.
Methods: We analyzed the relationships between CT quantitative parameters (including three-dimensional parameters) and pathological grade and lymph node metastasis in cT1-stage lung adenocarcinoma patients of our center between January 2015 and December 2023.
Results: A total of 343 patients were included, of which there were 233 males and 110 females, aged 61.8 ± 9.4 (30-82) years. The area under the receiver operating characteristic (ROC) curve for predicting the pathological grade of lung adenocarcinoma using the consolidation tumor ratio (CTR) and the solid volume ratio (SVR) were 0.761 and 0.777, respectively. The areas under the ROC curves (AUCs) for predicting lymph node metastasis were 0.804 and 0.873, respectively. Multivariate logistic regression analysis suggested that the SVR is an independent predictor of highly malignant lung adenocarcinoma pathology, while the SVR and pathological grade are independent predictors of lymph node metastasis. The sensitivity of predicting the pathological grading of lung adenocarcinoma based on SVR>5% is 97.2%, with a negative predictive value of 96%. The sensitivity of predicting lymph node metastasis based on SVR>47.1% is 97.3%, and the negative predictive value is 99.5%.
Conclusions: The SVR has greater diagnostic value than the CTR in the preoperative prediction of pathologic grade and lymph node metastasis in stage cT1-stage lung adenocarcinoma patients, and the SVR may replace the diameter and CTR as better criteria for guiding surgical implementation.

Corresponding Author:
Dr. yu liu, PLA 960th Hospital, Thoracic disease, Jinan, China, sunnyday0816@126.com

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Affiliations:
yu liu, PLA 960th Hospital, Thoracic disease, Jinan, China
ning jiang, The Second Hospital of Shandong University, Jinan, China
zhiqiang zou, PLA 960th Hospital, Jinan, China
[...]
ning Xin, PLA 960th Hospital, Jinan, China

The solid volume ratio is better than the consolidation tumor ratio in predicting the malignant pathological features of cT1 lung adenocarcinoma

Yu Liu[1*]Doctor degree, **Ning Jiang**[2*] Doctor degree**, Zhiqiang Zou**[1] Doctor degree, **Hongxiu Liu**[3]**,**Master degree**, Chuanhang Zang**[4] Bachelor **degree, Jia Gu**[5]Bachelor **degree, Ning Xin**[1]Master degree

1 Department of Thoracic Surgery, PLA 960th Hospital, Jinan, China

2 Department of Thoracic Surgery, The Second Hospital of Shandong University, Jinan, China.

3 Department of Medical Imaging, PLA 960th Hospital, Jinan, China

4 Department of Thoracic Surgery, PLA 964th Hospital, Changchun, China

5 Department of Pathology, PLA 960th Hospital, Jinan, China

*** Yu Liu and Ning Jiang made qual contribution in this article.**

Correspondence

Ning Xin, Department of Thoracic Surgery, PLA 960th Hospital, Jinan, China

Email: xinning1112@163.com

Synopsis for Table of Contents.

We evaluated the value of CT three-dimensional quantitative parameters in predicting pathological grading and lymph node metastasis of lung adenocarcinoma, and found that SVR has a higher diagnostic value than CTR in preoperative prediction of pathologic grade and lymph node metastasis in stage T1 lung adenocarcinoma.

Abstract

Background: More effective methods are urgently needed for predicting the pathological grade and lymph node metastasis of cT1-stage lung adenocarcinoma.

Methods: We analyzed the relationships between CT quantitative parameters (including three-dimensional parameters) and pathological grade and lymph node metastasis in cT1-stage lung adenocarcinoma patients of our center between January 2015 and December 2023.

Results: A total of 343 patients were included, of which there were 233 males and 110 females, aged 61.8 ± 9.4 (30-82) years. The area under the receiver operating characteristic (ROC) curve for predicting the pathological grade of lung adenocarcinoma using the consolidation tumor ratio (CTR) and the solid volume ratio (SVR) were 0.761 and 0.777, respectively. The areas under the ROC curves (AUCs) for predicting lymph node metastasis were 0.804 and 0.873, respectively. Multivariate logistic regression analysis suggested that the SVR was an independent predictor of highly malignant lung adenocarcinoma pathology, while the SVR and pathological grade were independent predictors of lymph node metastasis. The sensitivity of predicting the pathological grading of lung adenocarcinoma based on SVR>5% was 97.2%, with a negative predictive value of 96%. The sensitivity of predicting lymph node metastasis based on SVR>47.1% was 97.3%, and the negative predictive value was 99.5%.

Conclusions: The SVR has greater diagnostic value than the CTR in the preoperative prediction of pathologic grade and lymph node metastasis in stage cT1-stage lung adenocarcinoma patients, and the SVR may replace the diameter and CTR as better criteria for guiding surgical implementation.

Keywords: Lung adenocarcinoma; Predictive factor; Lymph node metastasis; Pathological grading.

INTRODUCTION

There are still many controversies regarding the surgical resection range, lymph node dissection method, clinical prognosis, and postoperative intervention methods for T1-stage lung adenocarcinoma. Since 2002, the Japan Clinical Oncology Group (JCOG) has been conducting a series of studies on T1 stage lung adenocarcinoma [1-3], selecting nodule diameter and the CTR as grading criteria for different extents of pulmonary resection. However, there is still controversy over whether the CTR and tumor diameter are related to the prognosis of patients with partial solid non-small cell lung cancer [4-6]. Kim's [7] study revealed that the CTR is not an independent predictor of prognosis for patients with cT1N0M0 stage lung adenocarcinoma, neither in the entire population nor in partial solid nodules. Ye [8] and his colleagues reported that the CTR, solid partial diameter, and tumor size are not independent predictors of prognosis for partially solid lung adenocarcinoma patients. In addition, a considerable portion of solid lung nodules have an irregular or scattered distribution of solid parts, which has strong subjectivity and uncertainty in selecting the optimal CT plane. Even the tumor length and CTR measured by the same expert have poor reproducibility. Therefore, using only diameter and CTR as the layering standard is not the optimal approach. With the application of various lung nodule analysis software, such as Lung VCAR, Syngo, In house, and Advanced Lung Analysis [9-10], we could measure the three-dimensional composition information of tumor size, shape, and density more accurately, comprehensively, and conveniently. Therefore, we analyzed the CT data and postoperative pathological information of T1-stage lung adenocarcinoma patients who underwent lung cancer resection at the 960th Hospital of the People's Liberation Army to identify better predictive indicators for surgical implementation.

METHODS

Patient eligibility criteria

This retrospective study included 956 T1 stage lung cancer patients who underwent lung cancer resection at our center between January 2015 and December 2023. The inclusion criteria were as follows: (1) Plain scan multiple-slice spiral CT DICOM images within 2 weeks prior to surgery; (2) partial or pure solid nodules with a diameter less than 3 cm in the solid portion (if multiple pulmonary nodules were present, the largest nodule in the solid portion was taken as the research object); (3) standardized lymph node dissection or sampling procedures; and (4) all nodules confirmed by surgical pathology as primary lung adenocarcinoma. The exclusion criteria were as follows: (1) Preoperative imaging with suspected lymph node or organ metastasis. (2) Patients who had undergone preoperative treatments such as chemotherapy, radiation therapy, targeted therapy, and immunotherapy. (3) The postoperative pathological type was a preinvasive lesion or contains other pathological components, such as adenosquamous cell carcinoma, adenoid cystic carcinoma, and mucoepidermoid carcinoma. (4) The clinical, imaging, and pathological data were not complete or accurate enough. This study was reviewed and approved by the Ethics Committee of the 960th Hospital of the People's Liberation Army (Approval No. S2023-025).

Instrument and parameters

An Aquilion ONE 320-row spiral CT machine (Toshiba, Japan) was used for Non-enhanced CT scan. The scanning parameters were as follows: Tube voltage of 120 kVp and a tube current of 50 to 150 mAs; beam pitch, 0.516 to 0.98; slice thickness, 5mm; matrix, 512x512. The imaging data were reconstructed into 0.625 mm and/or 1 mm slice thickness with a soft-tissue algorithm was used for the mediastinal window image, and a lung algorithm for the lung window image. After anonymous processing of the two-dimensional image data, the original DICOM image (lung window image) was imported into pulmonary nodule CT image-assisted detection software (AI target reconstruction of pulmonary nodules) to automatically analyze the following CT quantitative parameters of pulmonary nodules, with a nodule solidity threshold of -145 hounsfield unit (HU).

Observation indicators

General information: age, sex, smoking history, cancer antigen status, tumor location, and surgical method. Pathological information: Pathological type, pathological subtype (classified according to the 2020 WHO histological subtype classification criteria for lung adenocarcinoma and the proportion of each subtype), vascular invasion, pleural invasion, air cavity dissemination, and lymph node metastasis status were recorded. CT quantitative parameters (Figure 1) included the maximum diameter of the tumor, maximum diameter of the solid part, total volume of the nodule, volume of the solid part, average CT value (HU value) of the nodule, average CT value of the solid part, nodule mass, and mass of the solid part of the lung nodule, and the CTR and SVR were calculated. The CTR was defined as the ratio of the maximum solid diameter of the tumor to the maximum diameter of the tumor in the lung window on HRCT [11]. The nodule mass formula was M=V*(A+1000)/1000, where M was the body mass of the SSN in mg, V was the volume of the SSN in mm^3, and A was the three-dimensional average CT value of the SSN in HU. The 2020 IASLC pathological new grading system [12] divides lung adenocarcinoma into three levels: level 1 was highly differentiated: the adherent growth type was dominant, and the high-grade pattern (solid, micropapillary or complex glandular type) did not exceed 20%; grade 2 was moderately differentiated: mainly acinar or papillary, and the high-grade pattern did not exceed 20%; and level 3 was poorly differentiated: with 20% or more high-level patterns. In this study, pathological malignancies were divided into low-grade and highly malignant groups, with the low-grade malignancy group corresponding to IASLC grading system levels 1 and 2 and the highly malignant group corresponding to IASLC grading system level 3.

Statistical methods

SPSS 25.0 statistical software was used for statistical analysis of the data. The normality test (K-S test) was performed on quantitative data, and data that conformed to or approximated a normal distribution were measured as the mean ± standard deviation (±s). Two independent sample t tests were used for intergroup mean comparisons. If the data showed a skewed distribution, the data were measured as the median (interquartile range) [M (P25, P75)], and the median between groups was compared using the Mann–Whitney U test (nonparametric test). If the data showed a normal distribution, Pearson correlation analysis was used. Receiver operating characteristic (ROC) curves were drawn for quantitative data, and the optimal cutoff value was determined. In the multivariate analysis, variables with statistical significance ($P<0.1$) according to univariate analysis were included in the multivariate logistic regression model. For the bilateral test, $P<0.05$ indicated a statistically significant difference.

RESULTS:

1. Summary of the general data (Table 1)

There were 956 lung cancer surgical patients in our center from January 2015 to December 2023, including 343 patients who met the above inclusion criteria, 166 males and 177 females, aged 61.8 ± 9.4 (30-82) years. A total of 171 cases (49.9%) underwent lobectomy (including combined segmental or wedge resection), 85 cases (24.8%) underwent segmental resection, and 87 cases (25.4%) underwent wedge resection (pure ground glass nodules less than 2cm and located outside one-third of the lungs).

2. Statistical analysis of pathological grade and lymph node metastasis status in lung adenocarcinoma patients (Table 2)

Univariate analysis (using t tests and Mann–Whitney U tests) revealed that the maximum diameter of the solid part, CTR, total volume of the nodule, solid part volume, SVR, average CT value of the nodule, average CT value of the solid part, total mass of the nodule, solid part mass, CEA, and pleural invasion were significantly correlated with the pathological grade of lung adenocarcinoma. The maximum diameter of the nodules, maximum diameter of the solid parts, CTR, total volume of the nodules, solid part volume, SVR, average CT value of the nodules, average CT value of the solid parts, total mass of the nodules, solid part mass, CEA, and pleural invasion were significantly correlated with lymph node metastasis. Multivariate analysis (logistic regression analysis) suggested that the SVR was an independent predictor of highly malignant lung adenocarcinoma pathology (Table 3), while the SVR and pathological grade are independent predictors of lymph node metastasis (Table 4).

3. Comparison of pathological grading prediction parameters for lung adenocarcinoma (Tables 5 and 6)

The AUCs of the CTR, average CT value of nodules, and SVR for predicting the pathological grade of lung adenocarcinoma were 0.761, 0.768, and 0.777, respectively (Figure 2a). By analyzing coordinates on the ROC curve, we could work out that using an SVR>5% as the standard, the sensitivity for predicting the pathological grade of lung adenocarcinoma was 97.2%, and the negative predictive value was 96%. The sensitivity of predicting the pathological grade of lung adenocarcinoma patients with a CTR>0.45 was 95.5%, and the negative predictive value was 91.5%. The sensitivity of predicting the pathological grade of lung adenocarcinoma based on the average CT value of nodules>-470 was 95.5%, and the negative predictive value was 91.8%.

4. Comparison of predictive parameters for lymph node metastasis (Tables 5 and 6)

The areas under the ROC curves of the CTR, average CT value of nodules, and

SVR for predicting lymph node metastasis were 0.804, 0.858, and 0.873, respectively (Figure 2b). The sensitivity of predicting lymph node metastasis based on SVR>47.1% was 97.3%, and the negative predictive value was 99.5%. The sensitivity of predicting lymph node metastasis based on CTR>0.67 was 97.3%, with a negative predictive value of 99.3%. The sensitivity of predicting lymph node metastasis based on CT values>-211 was 97.3%, and the negative predictive value was 98.9%.

DISCUSSION:

Postoperative pathological findings of lymph node metastasis lead to poor prognosis in patients with T1 stage lung adenocarcinoma [13]. In addition, for T1 stage lung adenocarcinoma, highly invasive components such as micropapillary components, solid subtypes, or complex acinar components are independent risk factors for lymph node metastasis and early recurrence and metastasis [14-16]. Preoperative prediction of pathological subtypes and lymph node metastasis is crucial for developing surgical or comprehensive treatment plans. The analysis results of this study indicated that in some solid lung nodules smaller than 3 cm, the average CT value and SVR had greater predictive power for predicting the pathological grade and lymph node metastasis of lung adenocarcinoma than does the CTR, of which the SVR having the highest accuracy. Multivariate analysis indicated that the SVR was an independent predictor of highly malignant lung adenocarcinoma pathology, while the SVR and pathological malignancy grade were independent predictors of lymph node metastasis.

For some solid nodules, in pathological examination, the infiltrating part usually corresponds to the solid part on imaging. The size of the solid portion of a nodule was closely related to its invasiveness [17-19]. Therefore, the 8th edition of the IASLC guidelines only uses solid components to determine the T stage for some solid nodules [20]. The statistical analysis of this study also revealed that there was no significant correlation between the total length or volume of nodules and the pathological grade or lymph node metastasis status of lung adenocarcinoma, on the contrary, the solid part and the total tumor size or volume can better reflect the degree of tumor invasion.

Regarding the equivalence of using two-dimensional measurements or three-dimensional volume analysis to diagnose lung cancer, the UK Lung Screening Test (UKLS) [21] divided lung nodule volume into four categories, and the results showed that volume analysis was superior to two-dimensional analysis. Yanagawa [22] performed computer-assisted volume measurements on preoperative thin-layer CT scans of stage 1 lung adenocarcinoma patients and reported that solid portion volumes greater than 1.5 cm3 or solid portion proportions greater than 63% were found to be independent risk factors for recurrence or death of stage 1 lung adenocarcinoma patients. Kitazawa et al. [23] studied 96 patients with less than 2 cm of GGN and reported that the three-dimensional average CT value was an important parameter for predicting infiltration, and the results were better than the two-dimensional average CT value. Wu et al. [24] conducted a multicenter study, dividing ground glass nodules into solid and ground glass components through 3D reconstruction, measuring their 3D volume and CT values, respectively, and establishing a predictive infiltration model, obtaining better diagnostic results than Brock et al.'s model. However, previous studies have mainly analyzed the diagnostic value of three-dimensional CT quantitative parameters for the invasive status of lung cancer patients, and there is no research on their predictive value for the pathological grade or LNM status of lung adenocarcinoma patients. In this study, multiple CT quantitative parameters, such as the CTR, solid-to-volume ratio (SVR), and average CT value of the nodules, were included. The analysis results indicated that three-dimensional parameters had better predictive performance than two-dimensional parameters in predicting the pathological grade and lymph node metastasis of lung adenocarcinoma. The AUCs for the CTR and SVR for predicting the pathological grade of lung adenocarcinoma were 0.761 and 0.777, respectively, and the areas under the ROC curve for predicting lymph node metastasis were 0.804 and 0.873, respectively. In addition, univariate and multivariate analyses incorporating multiple clinical factors, such as age, sex, smoking history, and cancer-associated antigens, suggested that the SVR is an independent predictor of highly malignant lung adenocarcinoma pathology, while the SVR and pathological malignancy grade are independent predictors of lymph node metastasis. This finding suggested that the SVR has greater clinical value for predicting pathological grade and lymph node metastasis in lung adenocarcinoma patients.

From a clinical application perspective, we focused more on the high sensitivity of prediction methods to reduce missed diagnoses. Based on the results of this study, with an SVR>5% as the standard, the sensitivity of predicting the pathological grade of lung adenocarcinoma was 97.2%, and the negative predictive value was 96%.

According to the above criteria, 97.2% of highly malignant lung adenocarcinomas could be screened out, and 96% of patients who tested negative had low-grade malignancies. Therefore, for T1-stage lung adenocarcinoma patients who meet the SVR<5% standard, sub-pulmonary lobectomy could be chosen. The sensitivity of predicting lymph node metastasis based on an SVR>47.1% was 97.3%, with a negative predictive value of 99.5%. According to the above criteria, 97.3% of lung adenocarcinomas with lymph node metastasis can be screened, and 99.5% of lung adenocarcinoma-negative patients have no lymph node metastasis. Therefore, T1-stage lung adenocarcinoma patients who meet the SVR<47.1% standard could be exempted from lymph node dissection or sampling.

Previous studies have used three-dimensional quantitative parameters of pulmonary nodules, such as volume, CT value, volume doubling time, and mass doubling time [23,25], to predict tumor invasiveness. This study was the first to use these parameters to predict the pathological grade and lymph node metastasis of lung adenocarcinoma, and the corresponding thresholds obtained have high sensitivity and negative predictive value. According to the above volume ratio standards, unnecessary lobectomy and lymph node dissection might be avoided for some patients, which would be of important clinical significance.

Study Limitations

First, this single-center study included a limited number of patients and has certain representative significance. In the future, multicenter studies will be conducted to increase the number of cases and expand the representativeness of this study. In addition, there is currently no unified standard for the segmentation methods and thresholds of real parts in clinical applications, and there is an urgent need to conduct more prospective studies to establish a unified threshold for solid part segmentation. Finally, due to the short follow-up time of the patients in this study, the prognostic significance of the above imaging parameters could not be analyzed. We will release corresponding follow-up data within the next 2-3 years.

CONCLUSIONS:

The proportion of solid volume is an independent predictive factor for the pathological grade and lymph node metastasis of T1 stage lung adenocarcinoma. The proportion of solid volume may replace the CTR as a better predictive indicator for the pathological grade and lymph node metastasis of T1-stage lung adenocarcinoma.

Authors' Contributions:

All authors had full access to the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Yu Liu and Ning Jiang made qual contribution in this article.

Conceptualization, Yu Liu, Ning Xin, Ning Jiang; *Methodology*, Yu Liu, Ning Xin; *Investigation*, Jia Gu; *Formal Analysis* Yu Liu, Ning Xin; *Resources*, Yu Liu, Hongxiu Liu, Chuanhang Zang; *Writing - Original Draft*, Yu Liu, Ning Jiang; *Writing - Review & Editing*, Ning Xin; *Visualization*, Yu Liu; *Supervision*, Zhiqiang Zou.

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Acronyms

Consolidation tumor ratio (CTR)

Solid volume ratio (SVR)

Japan clinical oncology group (JCOG)

Receiver operating characteristic curve (ROC)

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Figure 1: The four images correspond to the three-dimensional quantitative parameters obtained from spiral CT analysis of different lung cancer patients using the " Infervision" imaging assisted detection software. Taking Figure A as an example: total volume of the nodule is1277.9mm^3, volume of the solid part is 1052.7mm^3, average CT value of the nodule is -19Hu, nodule mass is 1558.78mg, mass of the solid part of the lung nodule.

Figure 2a: The areas under the ROC curve of CTR, average CT value of nodules, and SVR for predicting pathological grading of lung adenocarcinoma were 0.761, 0.768, and 0.777, respectively. CTR, Consolidation Tumor Ratio; ROC, Receiver operating characteristic curve, SVR, Solid Volume Ratio.

Figure 2b: The areas under the ROC curve of CTR, average CT value of nodules, and SVR for predicting lymph node metastasis were 0.804, 0.858, and 0.873, respectively. CTR, Consolidation Tumor Ratio; ROC, Receiver operating characteristic curve, SVR, Solid Volume Ratio.

Table-1 General clinical information

Items	Mean (95% CI) or proportion
Age (years)	61.83±9.378（30-82）
Gender (number)	
man	166（48.4%）
female	177（51.6%）
Removal range (number)	
Lobectomy (including combined segmental or wedge resection)	171（49.9%）
Pulmonary segmentectomy (including combined wedge resection)	85（24.8%）
Wedge resection	87（25.4%）
Number of lymph node dissection groups (groups)	2.83±1.867（0-7）
Number of lymph node dissection (number)	8.88±7.819（0-40）
Lymph node metastasis status (number)	
Lymph node metastasis	37（10.8%）
N1 Positive	30（8.7%）
N2 Positive	20（5.8%）

† N1 positive, N1 lymph node positive only; ‡ N2 Positive, N2 lymph node positive, accompanying N1 positive or not.

Table-2 Univariate analysis of pathological malignancy and lymph node metastasis

Items	Pathological grading				Lymph node metastasis			
	negative	Positive	t□Zor X^2	P	negative	Positive	t□Zor X^2	P
Age	61.64±9.064	62.27±10.066	-0.581	0.562	61.95±9.374	60.86±9.487	0.665	0.507
Gender			2.101	0.147			0.145	0.703
male	108	58			147	19		
female	128	49			159	18		
Smoking or not			4.725	0.030			0.181	0.671
no	163	61			201	23		
yes	73	46			105	14		
Pleural invasion			6.248	0.012			7.841	0.005
negtive	167	61			211	17		
positive	69	46			95	20		
CEA			15.439	0.000			7.478	0.006
negtive	217	82			272	27		
positive	19	25			34	10		
Maximum diameter of nodule	21□15-26□	22□18-27□	-1.350	0.177	20.3□15□26□	27□21□29□	-4.089	0.000
The maximum diameter of the solid part	13□7.08□19□	18.5□14□25□	-5.858	0.000	13.25□8.00□19.12□	25□19□28□	-6.870	0.000
CTR	0.666□0.4286□0.8925□	1□0.78□1□	-7.828	0.000	0.7236□0.4650□0.9622□	1□0.9354□1□	-6.018	0.000
Total volume of	2240□953.4	2946□1446□	-1.863	0.062	2256□998□	4664□3097	-4.455	0.000

nodules	-4203□	4856□			4161□	□6900□		
Solid part volume	417.6□100□	1968□721□3	-6.49	0.000	539□136□1	3459□2360	-7.221	0.000
	1618□	459□			933□	□5895□		
VSR	24.32□6.63	75.94□47.31	-8.213	0.000	32.93□8.94	94□75.68□1	-7.414	0.000
	□55.8□	□94.00□			□66.53□	00□		
Overall CT value	-322□-	-57□-	-7.968	0.000	-259.5□-	16□-69.5□-	-7.123	0.000
	465□-131□	198□19□			443.5□-	39□		
					87.75□			
CT value of the solid	-83.5□-	20□-35□29□	-7.844	0.000	-59.83□-	25□14.5□43	-6.948	0.000
part	127.5□-10□				122□12□	.0□		
Mass of nodule	1378□649□	2713□1227□	-4.019	0.220	1512□668□	3899□2922	-5.929	0.003
	3102□	4714□			3130□	□7099□		
Mass of solid portion	24.3□6.63□	2071□627□3	-6.582	0.000	514.8□117.	3597□2302	-7.230	0.000
of nodule	55.8□	552□			8□1929.4□	□5952□		
Pathological							43.017	0.000
malignancy								
Low degree					228	8		
High degree					78	29		

† CTR, Consolidation Tumor Ratio; ‡ VSR, Solid Volume Ratio.

Table-3 Multivariate regression analysis of pathological grading of lung adenocarcinoma

Risk factors	B	P value	OR(95%CI)
CTR	1.042	0.312	2.834(0.376-21.356)
Overall CT value	-0.002	0.530	0.998(0.993-1.004)
VSR	0.036	0.018	1.036(1.006-1.068)
CEA positive	0.000	0.968	1.000(0.977-1.022)
Pleural invasion	-0.055	0.842	0.946(0.549-1.630)
Constant	-3.716	0.021	0.024

† CTR, Consolidation Tumor Ratio; ‡ VSR, Solid Volume Ratio.

Table-4 Multivariate regression analysis of pathological grading of Lymph node metastasis

Risk factors	B	P value	OR(95%CI)
CTR	-0.073	0.976	0.930（0.008-105.785）
Overall CT value	-0.003	0.656	0.997（0.985-1.009）
VSR	0.061	0.041	1.063（1.003-1.127）
Pathological grading	-1.401	0.002	0.246（0.099-0.611）
CEA positive	-0.171	0.721	0.843（0.330-2.155）
Pleural invasion	-0.247	0.553	0.781（0.345-1.767）
Constant	-5.461	0.135	0.004

† CTR, Consolidation Tumor Ratio; ‡ VSR, Solid Volume Ratio.

Table-5 Comparison of diagnostic efficacy (area under ROC curve) of different CT quantitative parameters

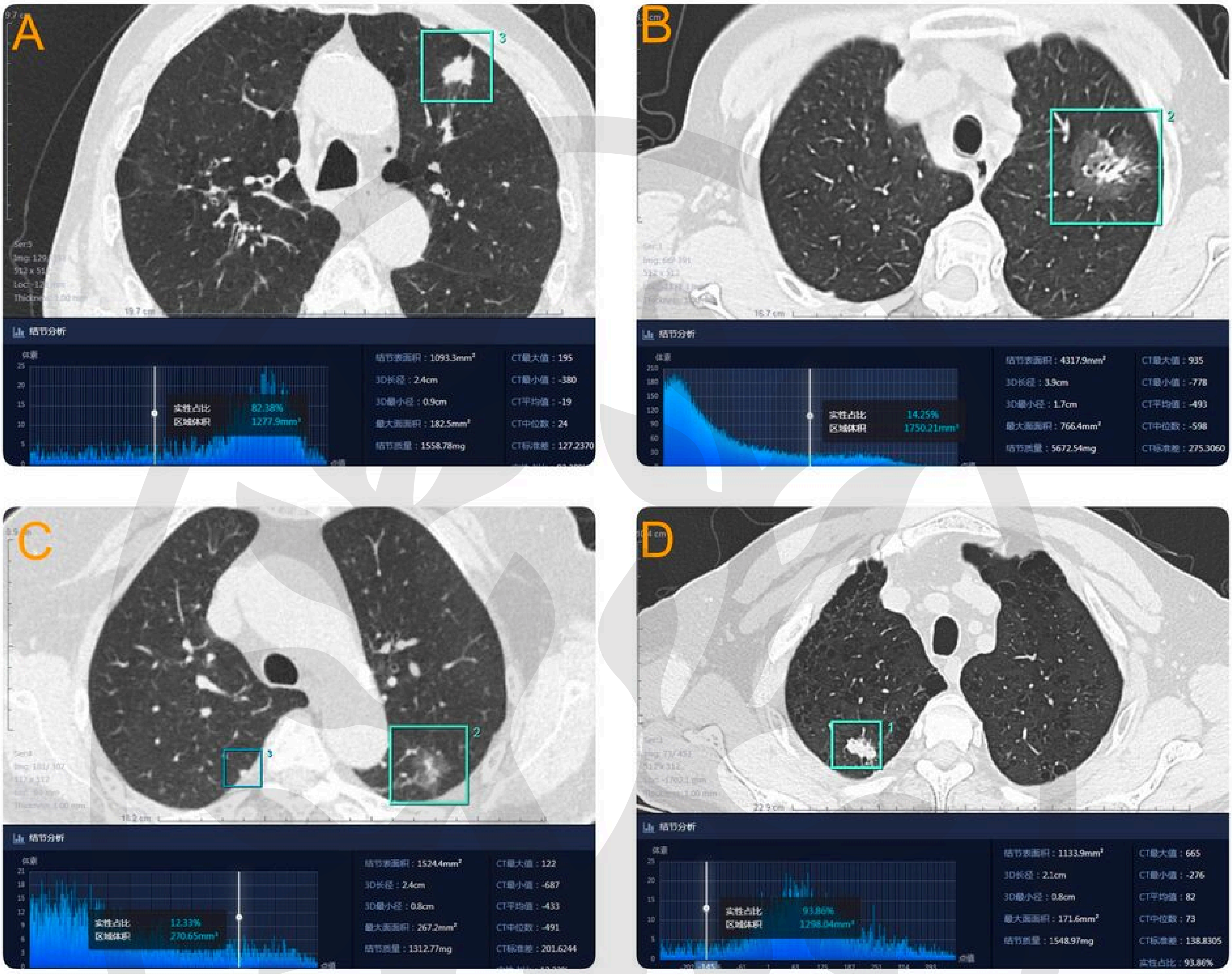
	Pathological grading	Lymph node metastasis
Maximum diameter of the tumor	0.545	0.705
Maximum diameter of the solid part	0.697	0.845
CTR	0.761	0.804
Total volume of the nodule	0.568	0.724
Volume of the solid part	0.719	0.863
VSR	0.777	0.873
Average CT value of the nodule	0.768	0.858
Average CT value of solid part	0.764	0.850
Nodule mass	0.638	0.798
Mass of the solid part	0.722	0.864

† CTR, Consolidation Tumor Ratio; ‡ VSR, Solid Volume Ratio.

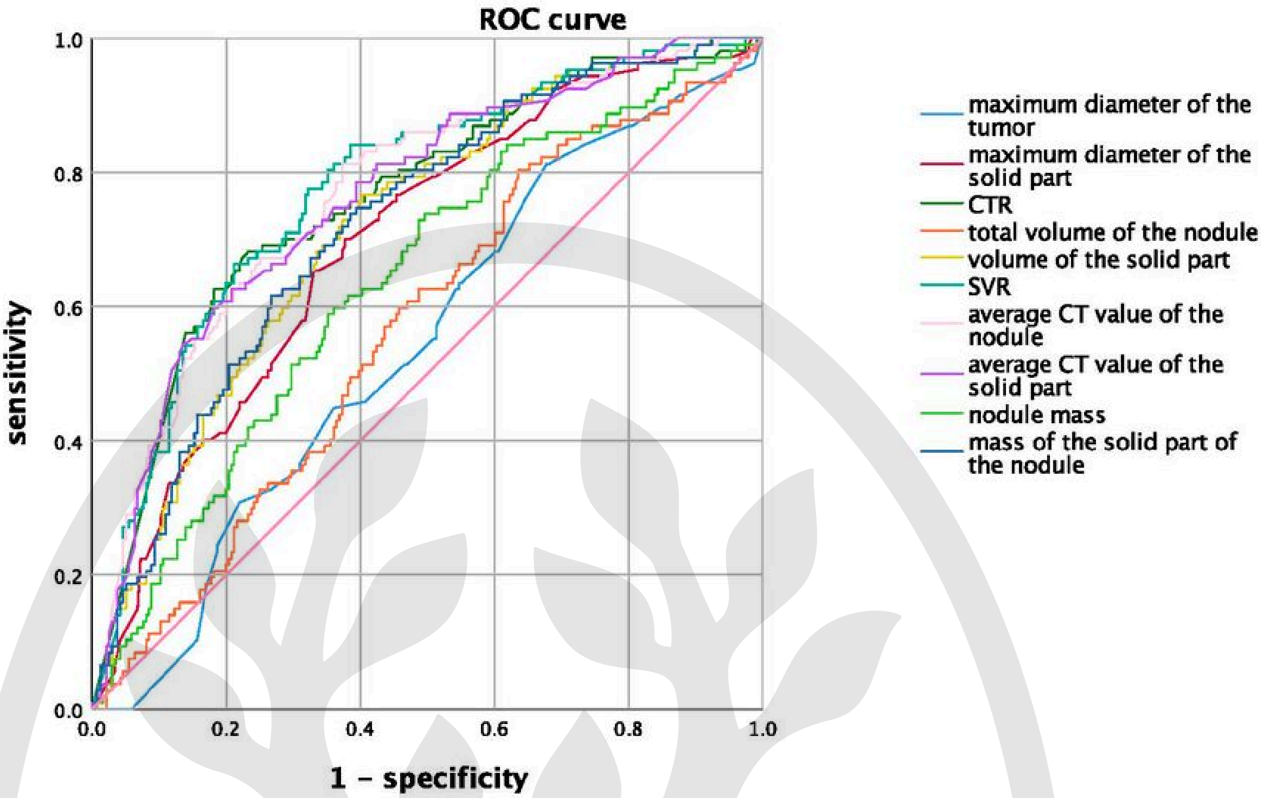
Table-6 Sensitivity and specificity corresponding to different diagnostic criteria

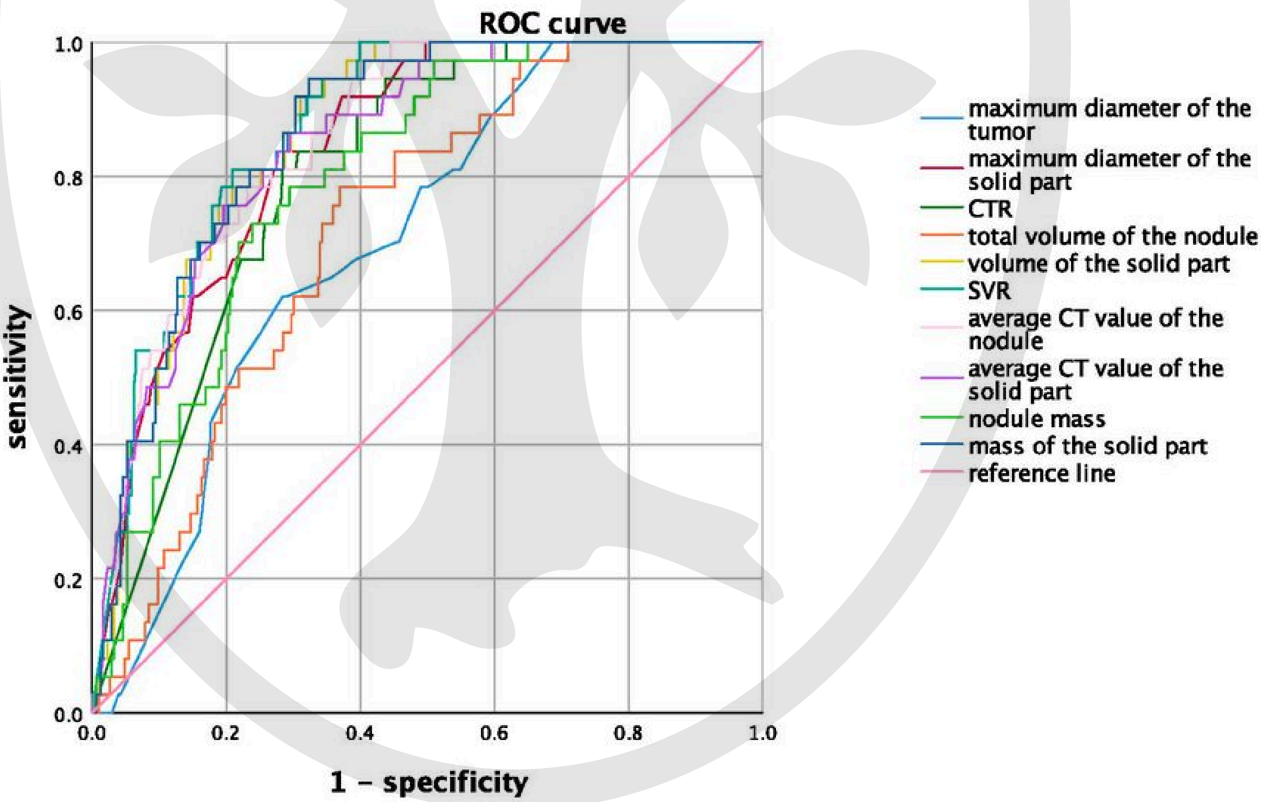
	Pathological grading			Lymph node metastasis		
	diagnostic criteria	**Sensitivity**	**specificity**	**diagnostic criteria**	**Sensitivity**	**specificity**
Maximum diameter of the tumor	11mm	95.3%	4.2%	18mm	94.6%	35.3%
Maximum diameter of the solid part	7 mm	95.3%	19.1%	15mm	97.3%	53.6%
CTR	0.45	95.3%	27.5%	0.67	97.3%	46.1%
Total volume of the nodule	389mm^3	95.3%	4.7%	1408	97.3%	36.3%
Volume of the solid part	134mm^3	95.3%	28.8%	995	97.3%	62.1%
VSR	5.0%	97.2%	20.8%	47.1%	97.3%	60.5%
Average CT value of the nodule	-470HU	95.3%	23.3%	-211	97.3%	56.5%
Average CT value of solid part	-130HU	96.3%	22.0%	-52	97.3%	51.3%
Nodule mass	415HUmm^3	95.3%	13.1%	1477	97.3%	49%
Mass of the solid part	100HUmm^3	95.3%	26.3%	836	97.3%	59.5%

† CTR, Consolidation Tumor Ratio; ‡ VSR, Solid Volume Ratio.



A
3
19.7 cm
结节分析
体素
实性占比 82.38%
区域体积 1277.9mm³
结节表面积：1093.3mm²
3D长径：2.4cm
3D最小径：0.9cm
最大面面积：182.5mm²
结节质量：1558.78mg
CT最大值：195
CT最小值：-380
CT平均值：-19
CT中位数：24
CT标准差：127.2370
B
2
16.7 cm
结节分析
体素
实性占比 14.25%
区域体积 1750.21mm³
结节表面积：4317.9mm²
3D长径：3.9cm
3D最小径：1.7cm
最大面面积：766.4mm²
结节质量：5672.54mg
CT最大值：935
CT最小值：-778
CT平均值：-493
CT中位数：-598
CT标准差：275.3060
C
2
3
18.2 cm
结节分析
体素
实性占比 12.33%
区域体积 270.65mm³
结节表面积：1524.4mm²
3D长径：2.4cm
3D最小径：0.8cm
最大面面积：267.2mm²
结节质量：1312.77mg
CT最大值：122
CT最小值：-687
CT平均值：-433
CT中位数：-491
CT标准差：201.6244
D
1
22.9 cm
结节分析
体素
实性占比 93.86%
区域体积 1298.04mm³
结节表面积：1133.9mm²
3D长径：2.1cm
3D最小径：0.8cm
最大面面积：171.6mm²
结节质量：1548.97mg
CT最大值：665
CT最小值：-276
CT平均值：82
CT中位数：73
CT标准差：138.8305
实性占比：93.86%


ROC curve
sensitivity
1 - specificity
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
maximum diameter of the tumor
maximum diameter of the solid part
CTR
total volume of the nodule
volume of the solid part
SVR
average CT value of the nodule
average CT value of the solid part
nodule mass
mass of the solid part of the nodule


ROC curve
sensitivity
1 - specificity
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
maximum diameter of the tumor
maximum diameter of the solid part
CTR
total volume of the nodule
volume of the solid part
SVR
average CT value of the nodule
average CT value of the solid part
nodule mass
mass of the solid part
reference line