Inflammation and Cell Signaling 2023; 10: e1259. doi: 10.14800/ics.1259; © 2023 by Lu Zhang, *et al*.
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RESEARCH ARTICLE

Analysis of the imaging and clinical features of subsolid pulmonary nodules in stage IA non-small cell lung cancer

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Received: July 02, 2023
Published: October 28, 2023

The subsolid pulmonary nodules (SSPNs) in the imaging diagnosis of stage IA non-small cell lung cancer (NSCLC) is very important since they are closely related to early lung cancer. The CT imaging and pathology data of 230 patients with solitary pulmonary nodules (SPNs) who underwent thoracoscopic treatment at Guizhou Provincial People's Hospital between July 2021 and June 2022 were collected. Based on postoperative pathology, the patients were divided into a benign group and a stage IA NSCLC group. The imaging and clinical features of SPNs in stage IA NSCLC were analysed. A total of 230 patients with SPNs were enrolled. There were 146 cases of SSPNs (including 34 cases of pure ground-glass opacities (pGGOs) and 112 cases of mixed GGOs (mGGOs)), and the incidence rate was significantly higher in the stage IA NSCLC group than in the benign group [96.7% (146/151) vs. 74.7% (59/79), $P<0.05$]. The overall malignancy rate of subsolid nodules was 71.2% (146/205); the malignancy rate of mGGO lesions was higher (75.2%) than that of pGGO lesions (60.7%) and solid nodules (20%). Malignant subsolid nodules mostly occurred in middle-aged women, mostly in the upper lobe of the lungs, with unclear edges and lobular signs, and accompanied by spur signs and pleural indentation signs ($P<0.05$). SSPNs are an important sign of lung cancer, and mGGO lesions have the highest malignant tendency. CT imaging findings such as unclear lesion edges, lobular signs, and pleural indentation signs are important for determining benign and malignant SSPNs. CT imaging manifestations are helpful for correctly assessing the nature of early SSPNs so that patients can receive timely and effective treatment.

Keywords: subsolid pulmonary nodules; IA non-small cell lung cancer; CT imaging

Abbreviations: SSPNs, subsolid pulmonary nodules; NSCLC, non-small cell lung cance; SPNs, solitary pulmonary nodules; pGGOs, pure ground-glass opacities; mGGOs, mixed ground-glass opacities; SNs, solitary nodules; CT, computed tomography.

To cite this article: Lu Zhang, *et al*. Analysis of the imaging and clinical features of subsolid pulmonary nodules in stage IA non-small cell lung cancer. Inflamm Cell Signal 2023; 10: e1259. doi: 10.14800/ics.1259.

Introduction

Lung cancer, a malignant tumour, has the highest morbidity and mortality among cancers in China[1]. Most individuals with early stage of lung cancer do not present typical symptoms, but once symptoms such as cough and haemoptysis occur, most patients progress to the middle and late lung cancer, with metastasis occurring in some

patients. Therefore, early diagnosis is important. Solitary pulmonary nodules (SPNs) are round or round-like lesions with a diameter ≤ 3 cm in the lung parenchyma, with clear or unclear edges, and without atelectasis, obstructive pneumonia, or mediastinal lymphadenopathy [2]. Studies have confirmed that subsolid pulmonary nodules (SSPNs) are closely related to early lung cancer [3], and with the widespread popularization of low-dose CT scanning, the detection rate of SSPNs is increasing [4-5]. We aimed to demonstrate the imaging features and clinical features of stage IA non-small cell lung cancer (NSCLC) patients in our hospital who had CT manifestations of SSPNs after thoracic surgery to provide a scientific basis for the diagnosis of early stage of lung cancer.

Patients and Methods

Between January 2020 and August 2021, 230 SPN patients were collected with definite pathological results after thoracic surgery.

The inclusion criteria were as follows: (1) chest imaging findings of solitary single pulmonary nodules; (2) lung nodules ≤3 cm in diameter; (3) unaccompanied by atelectasis, obstructive pneumonia, pleural effusion or mediastinal lymphadenopathy; and (4) definite pathological results (stage I NSCLC). The exclusion criteria were as follows: (1) chest CT showing ≥2 intrapulmonary nodules; (2) diameter of pulmonary nodules > 3 cm; (3) accompanied by atelectasis, pleural effusion, obstructive pneumonia, or mediastinal lymphadenopathy; and (4) pathological result indicative of non-stage I lung cancer or small cell lung cancer.

Statistical Analysis

SPSS 24.0 software was used for data analyses. Measurement data are expressed as the mean ± standard deviation; groups were compared using the t test. Count data are expressed as percentages; groups were compared using the x^2 test. $p<0.05$ was considered statistically significant.

Results

Malignancy rate of pure ground-glass opacity (pGGO), mixed GGO (mGGO), and SNs

This study included a total of 230 SPN patients (92 males and 138 females); the ages of the patients ranged from 22 to 80 years (mean age, 52.3±10.5). There were 25 cases of SNs and 205 cases of SSPN; the latter included 34 cases of pGGO lesions and 112 cases of mGGO lesions, with 59 cases of benign lesions and 146 cases of stage IA lung cancer (including 144 cases of lung adenocarcinoma and 2 cases of lung squamous cell carcinoma). Table 1 shows the malignancy rate of SSPNs, pGGO lesions, mGGO lesions, SNs and SPNs. The malignancy rate was significantly different between the SSPN and SN groups (P <0.05). For SSPNs, the mGGO group had the highest malignancy rate. Based on different maximum diameters, mGGO lesions were divided into two groups, ≤2 cm and 2-3 cm, and the effect of lesion size on the malignancy rate of mGGO lesions was analysed. mGGO lesions that were 2-3 cm had a higher malignancy rate than did mGGO lesions ≤2 cm (Table 2).

Distribution of pGGO lesions and mGGO lesions at different stages of stage IA lung cancer

A total of 151 stage IA lung cancer patients were divided into a $T_{1a}N_0M_0$ maximum diameter ≤2 cm group and a $T_{1b}N_0M_0$ maximum diameter 2-3 cm group; there were 102 cases and 49 cases of SPNs in these two groups, respectively, among which SSPNs accounted for 98.03% (100/102) and 93.9% (46/49), respectively, and the difference was not statistically significant (P>0.05). However, the distribution of pGGO and mGGO lesions was statistically significant between the two groups (P<0.05), that is, pGGO lesions were more common in the $T_{1a}N_0$ group, and mGGO lesions were more common in the $T_{1b}N_0M_0$ group. The distribution of pGGO and mGGO lesions in the two groups are shown in Table 3.

Comparison of SSPNs between stage IA NSCLC and benign lesions

A total of 205 lesions (97.6%) manifested as SSPNs on CT, with 146 being stage IA lung cancer and 59 being benign lesions. The incidence of SSPNs was higher in stage IA lung cancer than in benign lesions [96.7% (146/151) vs. 74.7% (59/79), P<0.05]. For patients with stage IA lung cancer and benign lesions manifesting as SSPNs, there were significant differences in age [(55.6±10.1) years vs. (50.8±10.5) years, P<0.05], sex [male/female: 43/92 vs. 95/138, P <0.05], and maximum diameter of the lesions [(14.25±5.7 mm vs. (11.88±5.4) mm, P<0.05]. Furthermore, a comparison of the CT imaging features of the two groups of lesions revealed that in the stage IA lung cancer group, SSPNs mostly occurred in the upper lobe, with unclear edges, lobular signs, vacuole signs, spur signs, and pleural indentation signs (P<0.05); however, there was no significant difference in the incidence of calcification signs and vascular bunching signs between the two groups (P>0.05). The comparison and analysis of SSPN imaging features is shown in Table 4.

Discussion

Tumours, inflammatory reactions, dysplasia, granulomas, and pulmonary fibrosis can all lead to a decrease in alveolar

Table 1. Malignancy rate of pGGO lesions, mGGO lesions and SNs.

Group	Stage IA lung cancer	Benign nodule	Total	Malignancy rate	P value
SSPN	146	59	205	71.2%	<0.05*
pGGO	34	22	56	60.7%	
mGGO	112	37	149	75.2%	
SN	5	20	25	20%	
SPN	151	79	230	65.7%	

*: The P value represent for the comparison between SSPN and SN.

Table 2. Malignancy rate of mGGO lesions with different diameters.

Diameter (cm)	Stage IA lung cancer	Benign nodule	Total	Malignancy rate	P value
≦2	72	32	104	69.2%	<0.05*
2-3	40	5	45	88.9%	
Total	112	37	149	75.2%	

*: mGGO lesions that were 2-3 cm had a higher malignancy rate than did mGGO lesions ≤2 cm.

Table 3. Distribution of pGGO and mGGO lesions in stage IA lung cancer at different stages.

Stage	pGGO	mGGO	Total	P value
$T_{1a}N_0M_0$	28	72	100	<0.05*
$T_{1b}N_0M_0$	6	40	46	
Total	34	112	146	

*: The distribution of pGGO and mGGO lesions was statistically significant between the two groups (P<0.05), that is, pGGO lesions were more common in the T1aN0 group, and mGGO lesions were more common in the T1bN0M0 group.

air content, causing incomplete alveolar filling and the formation of SSPNs [6]. Currently, low-dose spiral CT is the most effective means for the early detection and diagnosis of lung cancer and has a high SSPN detection rate. The early and timely detection of lung tumours and early treatment can significantly improve the survival rate of patients [7-8]. Studies have shown that the size and morphology of nodules are critical for the early diagnosis of lung cancer [9].

This study classified stage IA lung cancer into $T_{1a}N_0M_0$ and $T_{1b}N_0M_0$ and analysed and compared the size of the nodules and the proportion of solid components of SSPNs. The proportion of pGGO lesions in the SSPNs of patients with $T_{1a}N_0M_0$ lung cancer was high, and the proportion of mGGO lesions was high in patients with $T_{1b}N_0M_0$ lung cancer. The reason for this difference may be that the pathological basis of pGGO lesions is the growth of pathological tissue along the alveolar wall without destruction of alveolar structure, and the alveoli contain sufficient air. However, with the increase in pathological tissue, the alveoli gradually collapse, and mGGO lesions form [10]; in this study, the malignancy rate of mGGO lesions was higher than that of pGGO lesions (75.2% vs. 60.7%), which is consistent with the conclusions of many studies. The greater the solid component of SSPNs, the greater is the likelihood of malignancy and the worse is the prognosis [11]. GGO is a favourable factor for a good patient prognosis [12-13]. In this study, mGGO lesions of different diameters were analysed, and the malignancy rate for mGGO lesions with a diameter of 2-3 cm was higher than that for pGGO lesions (P<0.05), a finding that is consistent with the conclusions of a study by Lee et al. [11, 14], who analysed 208 GGO nodules from 160 patients. All nodules remained stable in a 5-year follow-up. At a later follow-up, i.e., 10+ years, growth was observed in 27 GGO lesions (13.0%). Among these growing nodules, 95% were smaller than 6 mm, and they grew by 3.2 mm during the 8.5-year follow-up. Biopsy of 3 nodules confirmed lung adenocarcinoma. In addition, solid components were present in 8 cases of GGO lesion growth. Therefore, nodule size is an important factor affecting the malignancy rate of SSPNs.

The results of this study showed that in stage IA NSCLC, SSPNs were mostly distributed in the upper lobe, with more in the right lung than left lung. The clinical and radiological features of stage IA NSCLC and benign lesions manifesting as SSPNs were compared. Patients in the stage IA NSCLC group were older than those in the benign group, and the

Table 4. Comparison of the clinical and radiological features of patients with SSPNs.

	Stage IA lung cancer (n=146)	Benign (n=59)	Total	P value
Sex				<0.05*
Male	53	49	92	
Female	105	33	138	
Nodule location				
Upper lobe	114	25	139	
None upper lobe	72	13	85	
Unclear edge	128	50	178	
Lobular signs	131	15	146	
Spur signs	125	22	147	
Pleural indentation sign	119	18	137	
Vascular bunching signs	78	45	123	*P>0.05
Vacuole signs	128	21	149	
Calcification signs	141	52	193	

*: The distribution of pGGO and mGGO lesions was statistically significant between the two groups (P<0.05), that is, pGGO lesions were more common in the T1aN0 group, and mGGO lesions were more common in the T1bN0M0 group.

majority of patients were females with lung adenocarcinoma. Studies have shown [15-16] that the increase in female adenocarcinoma patients without a smoking history is mainly related to passive smoking, air pollution, oestrogen levels and other related factors. Therefore, females with no smoking history are an important screening population that cannot be ignored. CT imaging features of SSPNs in stage IA NSCLC included unclear edges, spur signs, and lobulated shapes, accompanied by vacuole signs and pleural indentation signs; the incidence of SSPNs was higher in stage IA NSCLC than in benign lesions (P<0.05). The results of this study also confirm the findings in the study by Lee et al. [11, 14], i.e., the risk factors for nodule growth are vacuole signs in nodules (p = 0.001), a history of tumours other than lung cancer (p = 0.036), and the presence of solid components. (p < 0.001). Therefore, the proportion of solid components in SPNs is very important; the more solid components there are, the more likely a lesion is invasive adenocarcinoma [17]. The imaging features of SSPNs were analysed by different pathological type. The results showed that the maximum diameter of nodules was related to the pathological type; irregular shapes were mostly distributed in MIA and invasive adenocarcinoma, and the pleural indentation sign was more prominent in invasive adenocarcinoma.

Conclusions

In summary, SSPNs are an important sign of lung cancer, and mGGO lesions have the highest malignant tendency. CT imaging findings such as unclear edges, lobulated lobes, vacuole signs, and pleural indentation signs of lesions are important for determining benign and malignant SSPNs. CT imaging manifestations are helpful for correctly assessing the nature of early SSPNs so that patients can receive timely and effective treatment.

Ethics Approval

Ethical approval was granted from the ethics committee of Guizhou Provincial People's Hospital.

Patient Consent for Publication

Before enrollment, all patients were informed fully and written informed consent was obtained from the patients for the publication of clinical information.

Availability of Data and Material

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicting Interest

The authors declare that they have no conflict of interests.

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