

Acta Medica Okayama

Volume 47, Issue 1

1993

Article 9

FEBRUARY 1993

Evaluation of radiograph signs for the diagnosis of solitary peripheral pulmonary nodules less than 3 cm.

Hiroshi Date*

Akio Andou†

Nobuyoshi Shimizu‡

Shigeru Teramoto**

Takeyuki Numata††

*Okayama University,

†Okayama University,

‡Okayama University,

**Okayama University,

††Okayama University,

Evaluation of radiograph signs for the diagnosis of solitary peripheral pulmonary nodules less than 3 cm.*

Hiroshi Date, Akio Andou, Nobuyoshi Shimizu, Shigeru Teramoto, and
Takeyuki Numata

Abstract

Ten radiograph signs were assessed by two experts for their usefulness in the diagnosis of small solitary peripheral pulmonary nodules less than 3 cm. The ten categories included notching, spicula formation, pleural indentation, vascular convergence, contour, paleness, homogeneity, cavitation, air bronchogram, and calcification. The cases included 134 lung cancers and 44 benign lung lesions resected between 1972 and 1988 at the Second Department of Surgery, Okayama University Medical School. Notching, spicula formation, pleural indentation, vascular convergence, contour, and air bronchogram were useful signs in differentiating lung cancer from benign lung lesions. However, since the radiograph signs exhibited great variation in both lung cancer and benign lung lesions, a diagnostic operation is sometimes inevitable.

KEYWORDS: lung cancer, pulmonary nodule, notching, spicula, pleural indentation

*PMID: 8460555 [PubMed - indexed for MEDLINE]

Copyright (C) OKAYAMA UNIVERSITY MEDICAL SCHOOL

Evaluation of Radiograph Signs for the Diagnosis of Solitary Peripheral Pulmonary Nodules Less Than 3 cm

Hiroshi Date*, Akio Andou, Nobuyoshi Shimizu, Shigeru Teramoto and Takeyuki Numata^a

Second Department of Surgery, Okayama University Medical School and ^aOkayama Anti-Tuberculosis Association, Okayama 700, Japan

Ten radiograph signs were assessed by two experts for their usefulness in the diagnosis of small solitary peripheral pulmonary nodules less than 3 cm. The ten categories included notching, spicula formation, pleural indentation, vascular convergence, contour, paleness, homogeneity, cavitation, air bronchogram, and calcification. The cases included 134 lung cancers and 44 benign lung lesions resected between 1972 and 1988 at the Second Department of Surgery, Okayama University Medical School. Notching, spicula formation, pleural indentation, vascular convergence, contour, and air bronchogram were useful signs in differentiating lung cancer from benign lung lesions. However, since the radiograph signs exhibited great variation in both lung cancer and benign lung lesions, a diagnostic operation is sometimes inevitable.

Key words : lung cancer, pulmonary nodule, notching, spicula, pleural indentation

Since the introduction of the radiographic chest survey system in our country, the number of small peripheral pulmonary lesions detected has increased dramatically (1). Though the development of bronchoscopic examination such as transbronchial lung biopsy has improved the rate of accurate diagnosis (2), the differential diagnosis is still difficult, especially when the diameter of the lesion is small. If a previous roentgenogram of the patient's chest is available, it may provide useful information about the nodule's rate of growth. Almost all malignant nodules have doubling times between 20 and 450 days (3-8), whereas most benign lesions have doubling times less than 20 or greater than 450 days (8). Unfortunately, a previous roentgenogram of the chest often cannot be obtained.

Therefore, we often encounter the case of a small peripheral pulmonary lesion in which a decision between immediate surgery and observation alone must be made based on the roentgenogram findings at the time. A diagnostic operation is usually chosen in this circumstance.

This retrospective study was carried out to analyze various radiographic signs of malignant and benign small pulmonary nodules, and to assess the value of the diagnostic operation.

Materials and Methods

Between 1972 and 1988, 202 cases of solitary peripheral pulmonary lesions less than 3 cm in diameter, excluding metastatic lung tumors, were resected in the Second Department of Surgery, Okayama University Medical School. Standard roentgenogram, standard tomography and computed tomography were obtained in 178 of these cases, which included 134 lung cancers and 44 benign lung lesions. The radiographs were carefully read independently by two experts; a surgeon and a physician, without the knowledge of pathological diagnosis. The ten categories evaluated included notching, spicula formation, pleural indentation, vascular convergence, contour, paleness, homogeneity, cavitation, air bronchogram, and calcification. Each category was assessed by giving a score, 0 to 2 points, such that malignant appearing lesions would be given higher scores (Table 1). A radiographic score was obtained by adding together the points of the ten categories. The

* To whom correspondence should be addressed.

Table 1 Radiographic score for 10 categories of tumor signs

| Categories of tumor signs | Radiographic score (point) | | |
|---------------------------|----------------------------|---|-------------|
| | 2 | 1 | 0 |
| Notching | + | ± | — |
| Spicula formation | + | ± | — |
| Pleural indentation | + | ± | — |
| Vascular convergence | + | ± | — |
| Contour | Unclear | ↔ | Clear |
| Paleness | Pale | ↔ | Dense |
| Homogeneity | Nonhomogeneous | ↔ | Homogeneous |
| Cavitation | — | ± | + |
| Air bronchogram | + | ± | — |
| Calcification | — | ± | + |

results of the two experts were averaged and analyzed.

Statistical analysis was performed using the Wilcoxon *t*-test. Statistical significance was accepted at a 95 % confidence level, $p < 0.05$. All values are presented as mean plus or minus one standard deviation (SD).

Results

Pathologic diagnosis. About 75 percent of the cases were lung cancers and 25 percent were benign lung lesions (Table 2). Adenocarcinoma was the leading type of lung cancer (81 %), followed by squamous cell carcinoma (12 %) and small cell carcinoma (6 %). Benign lung lesions included various diseases. Hamartoma (30 %), tuberculosis (27 %) and pulmonary arteriovenous malformation (14 %) were relatively common.

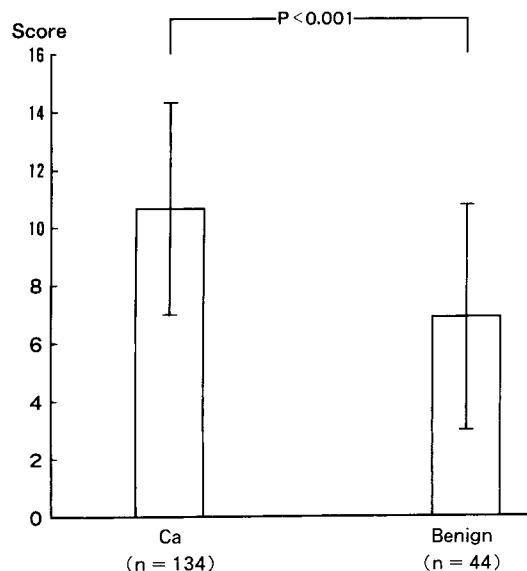
Radiographic score. The radiographic score of the lung cancers was significantly higher than that of benign lung lesions: 10.6 ± 3.6 versus 7.0 ± 3.9 , $p < 0.001$ (Fig. 1).

The scores of the categories of notching, spicula formation, pleural indentation, vascular convergence, contour, and air bronchogram were significantly higher in lung cancers than in benign lung lesions: $p < 0.05-0.01$. However, the scores of the categories of paleness, homogeneity, cavitation, and calcification were not significantly different between malignant and benign lesions (Fig. 2).

Among lung cancer cases, radiographic scores of adenocarcinoma and squamous cell carcinoma were significantly higher than that of small cell carcinoma: 10.9 ± 3.7 and 10.8 ± 3.4 , respectively, versus 6.3 ± 2.1 , $p < 0.005$ (Fig. 3). The radiographic score of small

Table 2 Pathological diagnosis of solitary peripheral pulmonary nodules less than 3 cm in diameter

| Pathological diagnosis | Number of patients |
|-------------------------|--------------------|
| Lung cancer | |
| Adenocarcinoma | 108 |
| Squamous cell carcinoma | 16 |
| Small cell carcinoma | 8 |
| Large cell carcinoma | 1 |
| Carcinoid | 1 |
| Total | 134 |
| Benign lung lesion | |
| Hamartoma | 13 |
| Tuberculosis | 12 |
| A-V malformation | 6 |
| Aspergilloma | 3 |
| Lung abscess | 2 |
| Filariasis | 2 |
| Sequestration | 2 |
| Bronchogenic cyst | 1 |
| Pneumonitis | 1 |
| Sclerosing hemangioma | 1 |
| Angioleiomyomatosis | 1 |
| Total | 44 |

**Fig. 1** Radiographic score of lung cancers (Ca) and benign lung lesions (Benign) less than 3 cm in diameter.

cell carcinomas was not significantly different from that of benign lung lesions.

Adenocarcinoma cases were subdivided into three

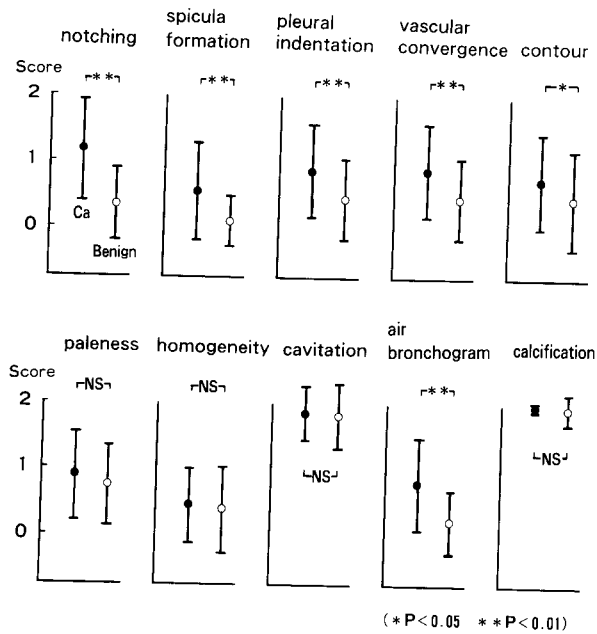


Fig. 2 Radiographic score points for the 10 categories in lung cancers (Ca) and benign lung lesions (Benign).

groups according to diameter. Radiographic scores of the group less than 1.5 cm (n = 23), the group between 1.5 to 2.0 cm (n = 27) and the group between 2.0 to 3.0 cm (n = 54) did not differ significantly from each other: 11.9 ± 3.0 , 10.2 ± 3.9 and 11.0 ± 3.5 , respectively (Fig. 4).

Preoperative diagnosis and radiographic score. Among the 134 cases of lung cancer, 100 cases (74 %) were preoperatively diagnosed as lung cancer by bronchoscopic examination while 34 cases (26 %) were post-operatively diagnosed as lung cancer. Among 44 cases of benign lung lesions, 21 cases (48 %) underwent operation because lung cancer was suspected. These included 11 tuberculomas, 6 hamartomas, 2 lung abscesses, one filariasis and one pneumonitis. In short, a total of 55 cases underwent diagnostic operation because lung cancer was suspected, and 34 cases (62 %) were found to be positive for lung cancer.

Radiographic scores of these 55 cases are shown in Fig. 5. Although the average radiographic score of lung cancer was significantly higher than that of benign lung lesions (9.3 ± 2.7 versus 7.4 ± 3.3 , $p < 0.01$), great variation was noted in the radiographic scores of both lung cancer and benign lung lesions.

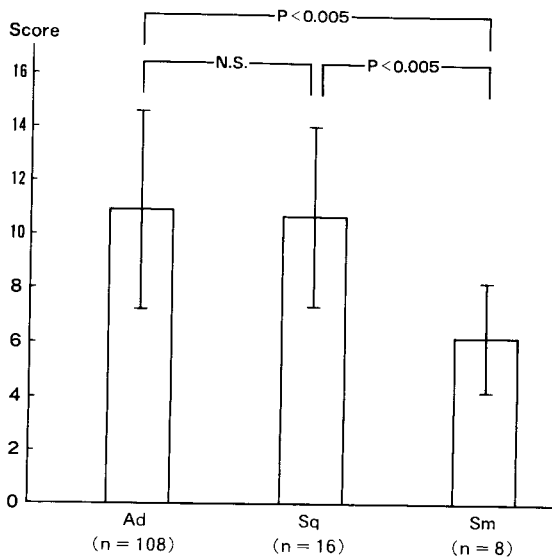


Fig. 3 Radiographic score of adenocarcinoma (Ad), squamous cell carcinoma (Sq) and small cell carcinoma (Sm).

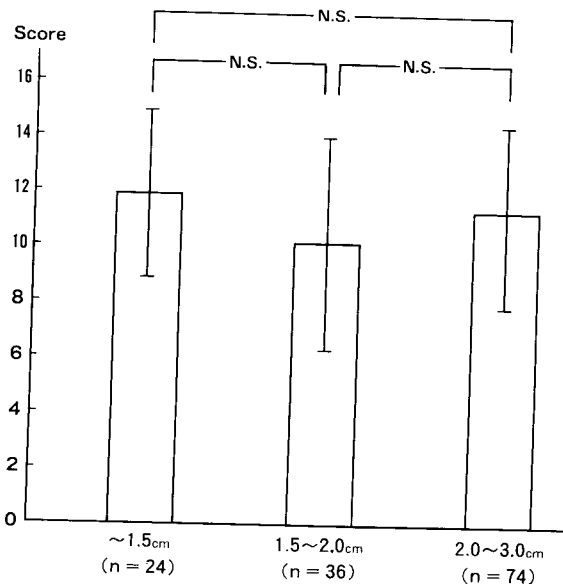


Fig. 4 Radiographic score of adenocarcinoma of different diameters.

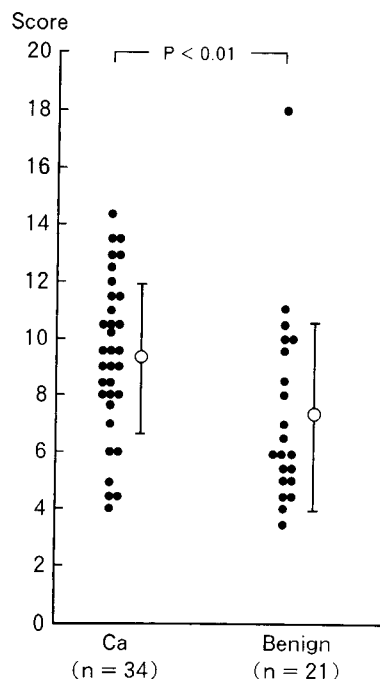


Fig. 5 Radiographic score of 55 cases which underwent diagnostic operation suspecting lung cancer. Ca; lung cancer, Benign; benign lung lesion.

Discussion

Various radiograph signs have been reported to be characteristic of lung cancer (7, 9-12). However, few studies (13, 14) have objectively assessed the value of those signs for the purpose of differential diagnosis. A radiographic score was introduced in this study for the purpose of such an objective evaluation. Notching, spicula formation, pleural indentation, vascular convergence, contour, and air bronchogram proved to be useful categories in differentiating lung cancer from a benign lung lesion. Using the receiver operating characteristic (ROC) curve, Tokuda *et al.* (14) reported that an ill-defined contour, the presence of fine spicula and paleness were relatively useful as diagnostic indices, but notching was not useful in differentiating benign from malignant lesions. The difference in the conclusions of the two studies might be attributed to a difference in the methods of analysis. Standard roentgenogram, standard tomographs and computed tomographs were all read at the same time in our study, but only standard tomography was used for the evaluation in the latter study.

Tokuda *et al.* (14) have reported that great variations

in interpretation of radiograph signs existed among five thoracic specialists. In our study, the difference in radiographic scores between the two readers was 2.64 ± 2.31 (0-9), which we believe to be acceptable to analyze the data.

The radiographic score of adenocarcinoma less than 1.5 cm in diameter was not significantly different from that of larger adenocarcinoma. Futami *et al.* (13) were also able to differentiate adenocarcinoma appearing as a small, solid solitary mass density from non neoplastic lesions based on findings of spicula formation plus lobulation. Precise evaluation of the roentgenogram findings is especially important to detect this type of cancer at an early stage because the possibility of N2 disease increases to 12 % when the diameter exceeds 2 cm (1).

The radiographic score of small cell carcinoma was similar to that of the benign lung lesion. We must keep in mind the possibility of small cell carcinoma with poor prognosis, even when the radiograph looks benign.

Some patients with solitary pulmonary nodules have potentially curable malignancies that, ideally, should be resected without delay while others have benign nodules and should not be exposed to the risks of surgery. The best approach to the management of a case remains controversial when the transbronchial lung biopsy and brushings fail to prove whether the lesion is benign or malignant (15, 16). We have advocated surgery for diagnosis without delay unless there is firm evidence that the nodule is benign based on comparison with a previous radiograph. Unfortunately, a previous radiograph is often not available.

Among 55 cases of pulmonary nodules which underwent operation for suspected lung cancer, 34 cases (62 %) were confirmed to be lung cancer and 21 cases (38 %) were benign lung lesions. Although the radiographic score of lung cancer was significantly higher than that of the benign lesions in these 55 cases, a wide variation in radiographic scores was noted in both malignant and benign lesions. If we choose a strategy in which we observe the nodule's rate of growth by periodic radiological examination of the chest when the radiographic score is less than 8, an invasive procedure may be avoided in 62 % of the benign lesions. However, 21 % of the lung cancers would assume the risk of progression caused by the delay in treatment.

These results lead us to conclude that a diagnostic operation is sometimes inevitable, although precise analysis of radiographic findings along with various laboratory

data is of value in the differential diagnosis of small peripheral pulmonary nodules.

References

1. Shimizu N, Ando A, Okabe K, Date H and Teramoto S: Prognosis for patients undergoing resection of small peripheral lung cancers. *Jpn J Chest Dis* (1991) **50**, 894-899 (in Japanese).
2. Fletcher EC and Levin DC: Flexible fiberoptic bronchoscopy and fluoroscopically guided transbronchial biopsy in the management of solitary pulmonary nodules. *West J Med* (1982) **136**, 477-483.
3. Chahainian P: Relationship between tumor doubling time and anatomical features in 50 measurable pulmonary cancers. *Chest* (1972) **61**, 340-345.
4. Geddes DM: The natural history of lung cancer: A review based on rates of growth. *Br J Dis Chest* (1979) **73**, 1-17.
5. Hayabuchi N, Russel WJ and Murakami J: Slow growing lung cancer in a fixed population sample: Radiologic assessments. *Cancer* (1983) **52**, 1098-1104.
6. Meyer JA: Growth rate versus prognosis in resected primary bronchogenic carcinoma. *Cancer* (1973) **31**, 1468-1472.
7. Steele JD: The solitary pulmonary nodule: Report of cooperative study of resected asymptomatic solitary nodules in males. *J Thorac Cardiovasc Surg* (1963) **46**, 21-39.
8. Weiss W, Boucot KR and Cooper DA: Survival of men with peripheral lung cancer in relation to histologic characteristics and growth rate. *Am Rev Respir Dis* (1968) **98**, 75-78.
9. Godwin JP, Speckman JM and Fram EK: Distinguishing benign from malignant pulmonary nodules by computed tomography. *Radiology* (1982) **144**, 349-352.
10. Sawada K, Seki T, Ishida I, Matsumura K, Hukuma S and Shimura A: Problems in X-ray differential diagnosis of pulmonary tuberculosis and lung cancer. *Jpn J Chest Clin* (1985) **44**, 97-103 (in Japanese).
11. Siegelman SS, Zerohouni EA, Leo FP, Khouri NF and Stitik FP: CT of the solitary pulmonary nodule. *Am J Roentgenol* (1980) **135**, 1-3.
12. Suzuki A, Shimosato Y and Ishikawa H: The limitation of chest roentgenogram diagnosis. *Lung Heart* (1971) **3**, 160-171.
13. Futami H, Eguchi K, Ikeda S, Tsuchiya R, Noguchi M and Irino S: Analysis of Xerotomographic findings of small peripheral adenocarcinoma of the lung less than 2 cm in diameter. *Jpn J Lung Cancer* (1988) **28**, 173-182 (in Japanese).
14. Tokuda H, Aoki M and Isoe K: The efficacy of X-ray signs for the diagnosis of small lung nodules. *Jpn J Lung Cancer* (1989) **29**, 679-688.
15. Cummings SR, Lillington GA and Richard RJ: Estimating the probability of malignancy in solitary pulmonary nodules: A Bayesian approach. *Am Rev Respir Dis* (1986) **134**, 449-452.
16. Cummings SR, Lillington GA and Richard RJ: Managing solitary pulmonary nodules: The choice of strategy is a "close call". *Am Rev Respir Dis* (1986) **134**, 453-460.

Received March 9, 1992; accepted June 8, 1992.