

THALLIUM-201 SPECT FOR PULMONARY TUMORS

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ABSTRACT

This study was undertaken to examine the ability of SPECT in differentiation of a pulmonary lesion suspicious of lung cancer. A total of 170 patients with suspected lung cancer were studied. A dose of Tl-201 chloride (148-296 MBq) was injected intravenously and tomographic early and delayed scans were obtained at 15 minutes and 3 hours post injection, respectively. Delayed Tl-201 SPECT visualized all of the 147 malignant pulmonary lesions which were clearer than those obtained by the early SPECT. Tl-201 SPECT seems to be a useful method for assessing pulmonary tumors and it offers the retention index useful for differentiating malignant from benign lesions, and mediastinal involvement from lung cancer.

Key words: SPECT; ^{201}Tl ; Pulmonary tumors

INTRODUCTION

Thallium-201 has very unique characteristics. The distribution of Tl-201 in the organs and tissues is determined in the initial perfusion at the rate of 80-90%. This behavior is also seen in malignant lesions and benign conditions with viable cells. Tl-201 chloride has been described by Cox et al (1), Salvator et al (2), and Tonami et al (3) as a positive indicator for lung neoplasms. The development of SPECT encouraged evaluation of Tl-201 scintigraphy in patients with suspected lung cancer, in detecting minute lung cancer and in the evaluation of mediastinal lymph node metastases of lung cancer.

Tl-201 accumulation in the lesions seems to change in time and the retention of Tl-201 in malignant lesions seems to be longer than in benign conditions (4). Therefore, it is possible to differentiate malignant pulmonary lesions from benign lesions with semiquantitative index obtained by Tl-201 SPECT. This study was focussed on the ability of Tl SPECT in the

differentiation of a pulmonary lesion suspicious of lung cancer in a large number of patients.

MATERIALS AND METHODS

A total of 170 patients with suspected lung cancer were studied. All of the lesions were greater than 20 mm on the longest diameter confirmed by the surgical specimens. A dose of Tl-201 chloride (148-296 MBq) was injected intravenously. Tomographic scans were obtained at 15 minutes and 3 hours post injection as the early and delayed scans, respectively using a dual-headed rotating gamma camera with low energy, and high resolution collimators. Sixty projection data with an acquisition time of 30 to 40 seconds were stored on magnetic disk. Transverse, coronal, and sagittal sections were reconstructed without attenuation correction.

In one hundred and forty seven patients with histologically proven untreated malignant pulmonary

lesions there were 140 primary lung cancers and 7 other malignancies. One hundred and forty primary lung cancers comprised 62 adenocarcinomas, 51 squamous cell carcinomas, 10 adenosquamous cell carcinomas, 13 small cell carcinomas, 4 large cell carcinomas and 7 other malignant lesions. Twenty three benign lesions included 9 pneumonial lesions, 4 infarctions, 3 tuberculoses, 3 abscesses, 2 granulomas, 1 cryptococcus and 1 aspergillus.

Regions of interest were set in the area with abnormal Tl-201 radioactivity and in the contralateral normal lung on the transverse sections for both early and delayed scans. The mean voxel counts in the regions of interest were measured and uptake ratios of the lesion to the contralateral normal lung were calculated on both scans and expressed as early ratio and delayed ratio. The retention index was obtained to evaluate quantitatively the degree of Tl-201 retention in the lesions as follows: the difference of delayed and early ratios was divided by early ratio and expressed as a percentage.

RESULTS AND DISCUSSION

The delayed Tl-201 SPECT visualized all of the 147 malignant pulmonary lesions and 16 out of 23 benign pulmonary lesions and generally exhibited the lesion more clearly than the early SPECT.

Fig. 1 shows the results of the delayed ratios in malignant and benign lesions visualized and for each histological group. Delayed ratio was 2.4 in all malignant pulmonary lesions and 2.0 in 16 benign lesions with abnormal Tl-201 accumulation. The highest delayed ratio was 2.4 in the adenocarcinoma and small cell carcinoma groups. The lowest ratio was 2.1 in the benign lesions. There was a significant difference in delayed ratio between the adenocarcinoma and large cell carcinoma groups, however, no significant differences were noted between the malignant and benign lesions and among other different histology groups.

Fig. 2 shows the results of retention index. The retention index was 25 in the malignant lesions and 6 in the benign lesions. The highest retention index was 38 in the large cell carcinoma group. There was a significant difference of the retention index between the malignant and benign lesions. However, a significant difference of this index was not found among the different histology groups in malignant lesions. Representative cases are presented in Figs. 3 and 4. The delayed Tl-201 SPECT visualized all of the malignant pulmonary lesions greater than 20 mm in diameter. Tl-201 SPECT can exclude the possibility of malignancy for the lesions without abnormal Tl-201 uptake. Tl-201 SPECT can differentiate malignant from

benign lesions using the Tl-201 retention index if the lesion shows abnormal Tl-201 accumulation.

Detection of minute lung cancer

Fig. 5 is an example of radiologically occult lung cancer detected by the first generation SPECT system (5). A 66-yr-old man underwent chest screening examination for asymptomatic smokers and presented positive cytology for lung cancer. There was no abnormal findings on the tomograms of computed radiography. Computed tomograms revealed no abnormal mass. Tl-201 SPECT of the chest demonstrated an abnormal accumulation near the right hilum. At surgery, a lesion with an irregular mucosal surface involved about 15 mm of the right bronchus. Microscopic examination confirmed that the lesion was a well-differentiated squamous cell carcinoma with longitudinal growth along the bronchial lumen without extension into the bronchial cartilage, indicating early lung cancer. Fig. 6 shows the results of detectability of 27 malignant and 6 benign pulmonary lesions and the size of the lesions with the second generation SPECT system (Toshiba digital gamma camera GCA-9300A).

Twenty six out of 27 malignant lesions were detected. The smallest lesion detected was an adenocarcinoma of $11 \times 7 \times 7$ mm in size in a case of double lung cancer (Fig. 7). One false negative with Tl-201 SPECT was a radiologically occult early lung cancer of squamous cell carcinoma with an irregular mucosal surface of 15 mm in length in the left main bronchus. From these results it is believed that a small lung cancer of 10 mm in diameter with viable cells can be detected by dedicated SPECT system.

Detection of mediastinal lymph node metastasis from lung cancer

Evaluation of mediastinal lymph node metastasis is essential to operability and prognosis in patients with lung cancer. Eighty patients with lung cancer underwent thoracotomy and mediastinal lymph node dissection within one week after the SPECT study. None of the patients presented any abnormal shadows suggesting mediastinal involvement on the conventional chest radiographs.

Tl-201 SPECT was judged as truly positive when at least one area of increased radioactivity in the mediastinum other than in the myocardium and spinal cord was noted, and when the accumulation was shown to correspond to the metastatic lymph node confirmed by surgical-pathological examination. Thereafter, each abnormal accumulation was identified by comparing to the anatomy and pathology of mediastinal lymph nodes. Since the real size of the metastatic lesion in the

mediastinal lymph node was difficult to measure, we estimated the size of the lesion from the long-axis length of resected lymph node specimen and the proportion of involvement in the lymph node. Out of 29 patients with mediastinal lymph node metastasis, 16 were positive and 6 of 51 patients without mediastinal involvement showed false positive accumulation in the mediastinum on the Tl-201 early SPECT.

Table 1 shows the results of Tl-201 delayed SPECT. Out of 29 patients with mediastinal metastasis, 22 were positive (sensitivity 75.9%) and 6 of 51 patients without mediastinal involvement showed false positive accumulation (specificity 88.2%). A significant difference was not noted in the sensitivity of lesion

detectability between the early and delayed scans. However, these metastatic lymph nodes were generally visualized much better on the delayed scan.

In all the patients with true positive results on the delayed scan, the mediastinal metastatic lymph nodes were plural, with a lesion of more than 14 mm in size. And these patients had multiple lesions of various sizes. In one of 6 positives the areas of increased accumulation were seen in the silicotic nodes and the lesion of tuberculous lymphadenitis, however in the remaining 5 patients, no abnormal mediastinal lesions were confirmed. The accuracy of 83.8% on the delayed scan was higher than that of 76.3% on the early scan. A representative case is presented in Fig. 8.

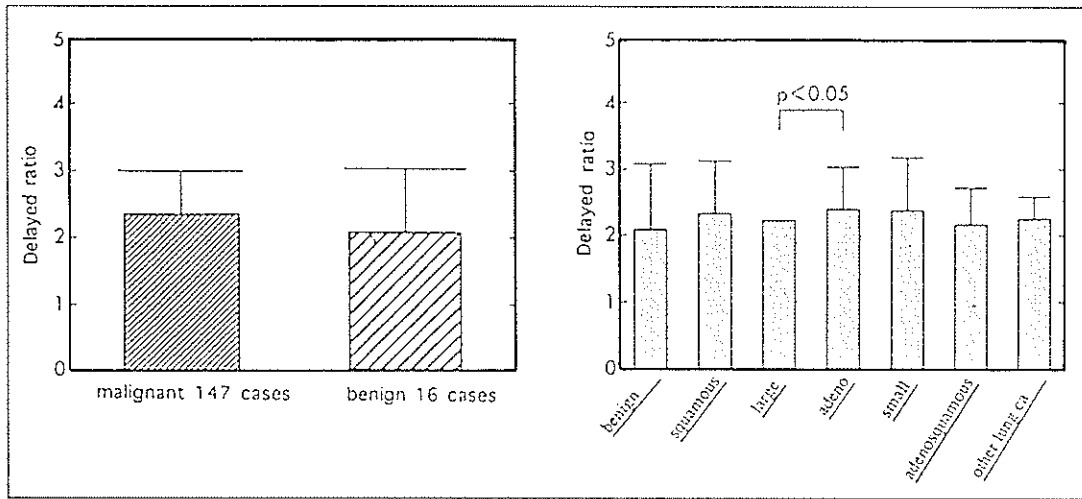


Fig. 1. Delayed ratio in 147 malignant pulmonary lesions and 16 benign lesions and for each histological group.

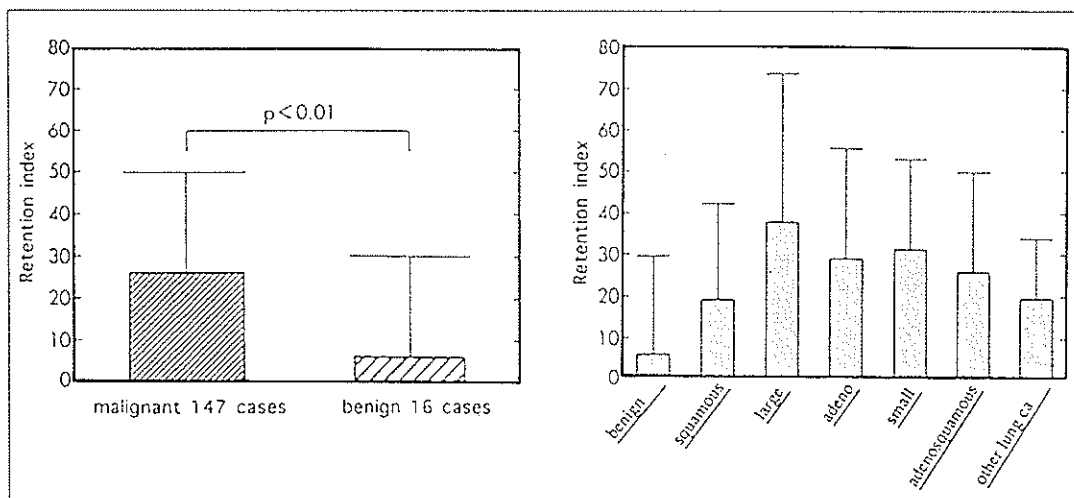


Fig. 2. Retention index in 147 malignant pulmonary lesions and 16 benign lesions and for each histological group.

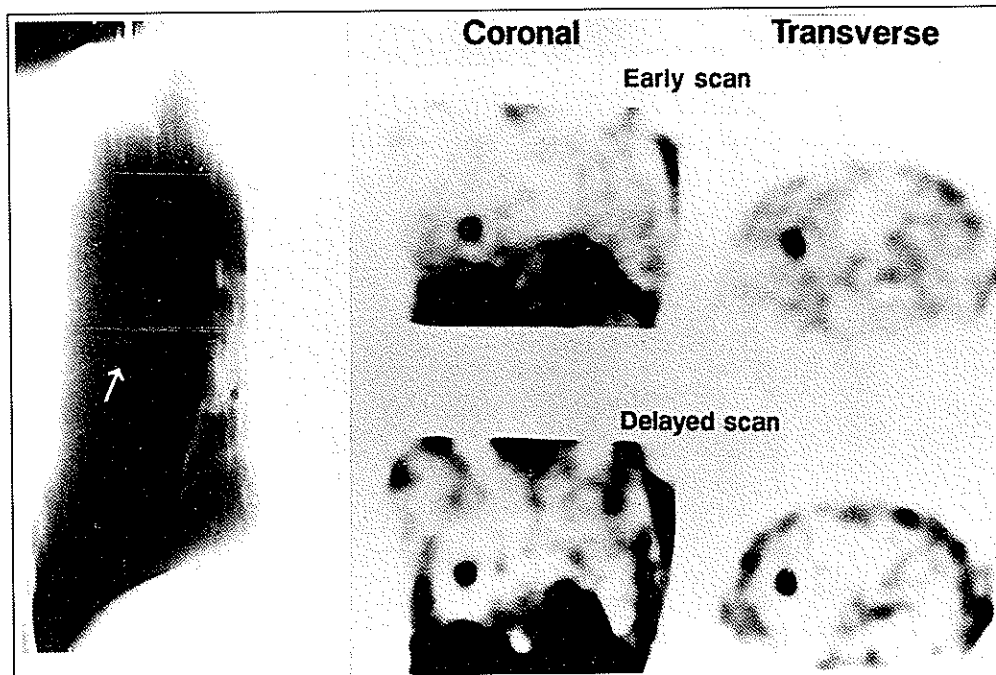


Fig. 3. Primary lung cancer of right S2b (adenocarcinoma, 22×17×15 mm) chest computed tomogram showing a mass shadow at the middle part of the right lung (arrow). Both of Tl-201 early and delayed scans demonstrated an abnormal accumulation corresponding to the pulmonary lesion. Delayed ratio and retention index were 2.1 and 21, respectively.

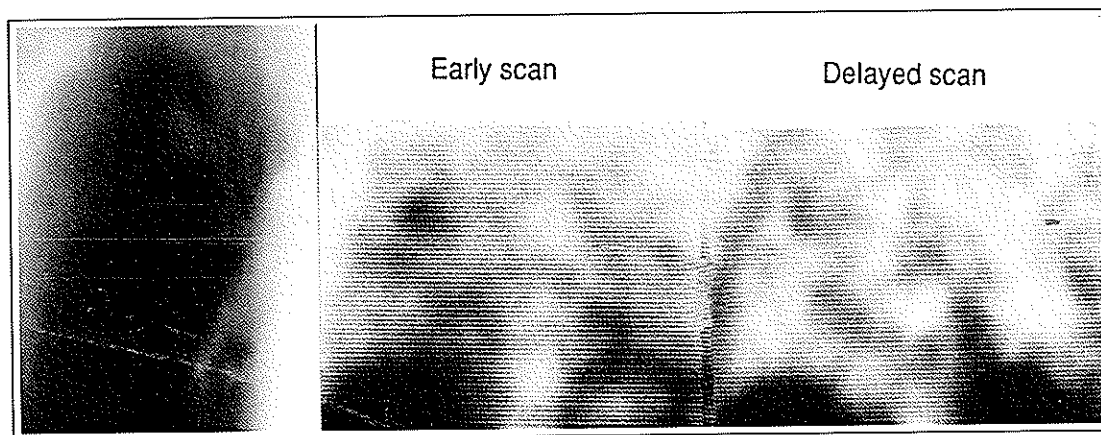


Fig. 4. Pulmonary tuberculosis of right S1b (20×15×20 mm) chest computed tomogram showing a mass shadow at the upper part of the right lung. Tl-201 early coronal SPECT demonstrated an abnormal accumulation corresponding to the pulmonary lesion while Tl-201 delayed SPECT showed faint accumulation. Delayed ratio and retention index were 1.4 and - 20, respectively.

From these results, it is concluded that Tl-201 delayed SPECT showed higher sensitivity than the early SPECT and better visualization of mediastinal metastatic lesions. The overall accuracy of 84% for the

delayed SPECT seemed to be satisfactory. This method is thought to be a good noninvasive indicator for mediastinal involvement of lung cancer.

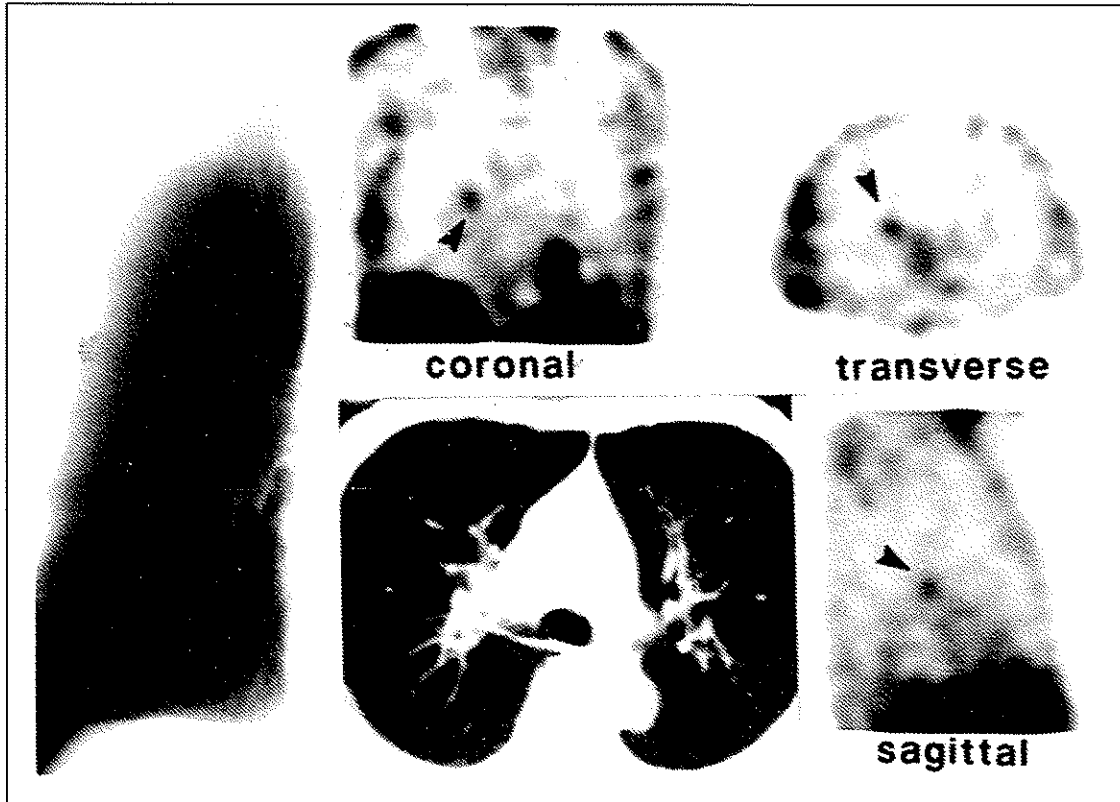


Fig. 5. Tomograms of computed radiography of the right chest and computed tomogram revealed no abnormal mass. Tl-201 delayed scans clearly demonstrate abnormal accumulation near the right hilum (arrowhead).

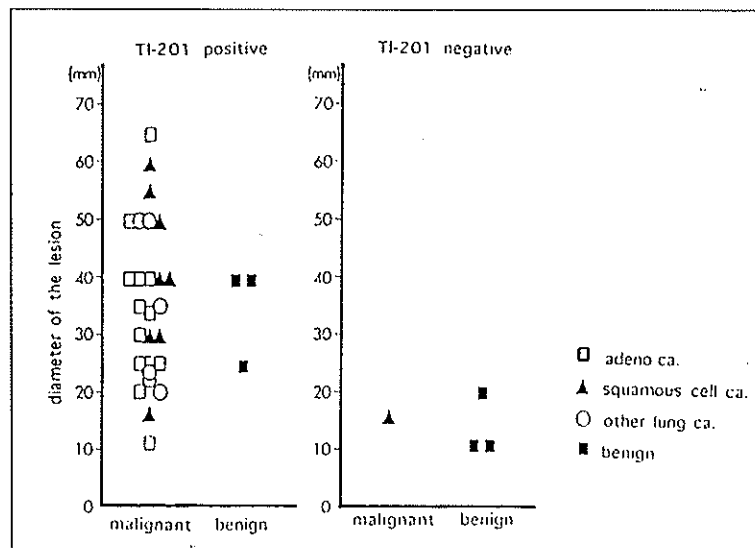


Fig. 6. Detectability with Tl-201 SPECT and size of 27 malignant and 6 benign pulmonary lesions.

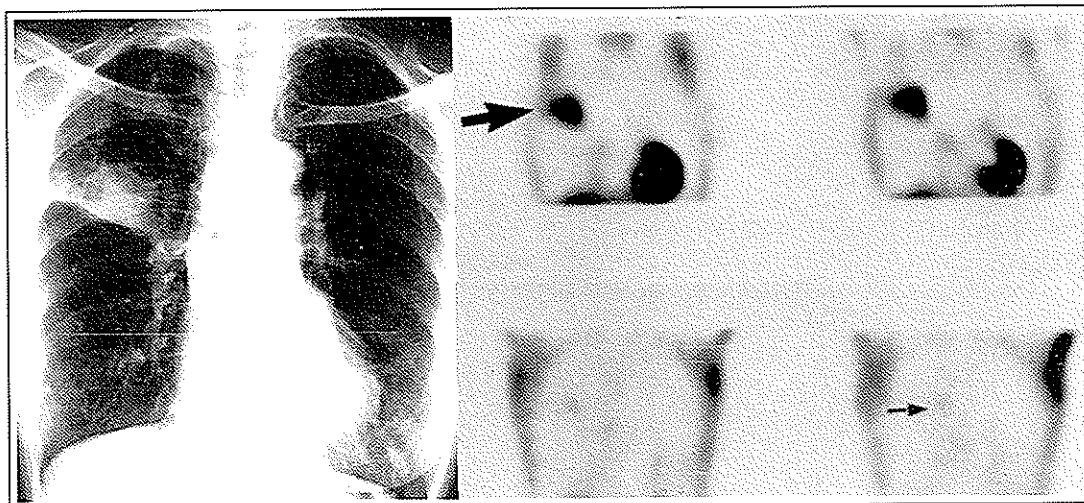


Fig. 7. An abnormal shadow was found in the upper right lung on a chest x-ray. TI-201 SPECT delayed coronal images using second generation system showed abnormal accumulation at the same location (large arrow). As seen by the abnormal shadow found on chest x-ray and another vague accumulation in the posterior right lung indicated by small arrow. A mucoepidermoid carcinoma in the right segment 3 and an adenocarcinoma with a small cell carcinoma component, $11 \times 7 \times 7$ mm in the right segment 6 were confirmed.

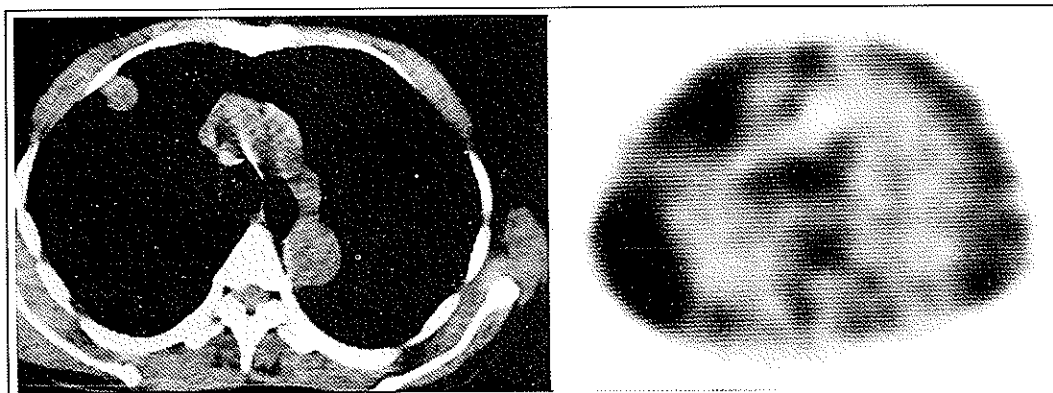


Fig. 8. Computed tomogram of the chest showing a mass shadow at the upper part of the right lung and enlarged mediastinal lymph nodes. TI-201 delayed SPECT clearly demonstrated an abnormal accumulation corresponding to the primary lesion and the mediastinum. The area of abnormal TI-201 accumulation in the mediastinum is larger than that of enlarged mediastinal lymph node on CT. Pathological findings proved an adenocarcinoma in S3a of the right lung, and mediastinal lymph node metastases 18 mm in size in the pretracheal area and metastases less than 10 mm in size in the anterior mediastinal and tracheobronchial areas.

Table 1. Detection of mediastinal metastasis with TI-201 delayed SPECT.

Type of disorder	TI-201 delayed SPECT		
	(+)	(-)	Total
Mediastinal metastasis (+)	22	7	29
Mediastinal metastasis (-)	6	45	51
Total	28	52	80

CONCLUSION

TI-201 SPECT seem to be a useful method for assessing pulmonary tumors in routine clinical work. It offers the retention index useful for differentiating malignant from benign lesions, and mediastinal involvement from lung cancer.

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