Subtle Pleural Metastasis without Large Effusion in Lung Cancer Patients: Preoperative Detection on CT

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Objective: We wanted to describe the retrospective CT features of subtle pleural metastasis without large effusion that would suggest inoperable lung cancer.

Materials and Methods: We enrolled 14 patients who had open thoracotomy attempted for lung cancer, but they were proven to be inoperable due to pleural metastasis. Our study also included 20 control patients who were proven as having no pleural metastasis. We retrospectively evaluated the nodularity and thickening of the pleura and the associated pleural effusion on the preoperative chest CT scans. We reviewed the histologic cancer types, the size, shape and location of the lung cancer and the associated mediastinal lymphadenopathy.

Results: Subtle pleural nodularity or focal thickening was noted in seven patients (50%) having pleural metastasis and also in three patients (15%) of control group who were without pleural metastasis. More than one of the pleural changes such as subtle pleural nodularity, focal thickening or effusion was identified in eight (57%) patients having pleural metastasis and also in three patients (15%) of the control group, and these findings were significantly less frequent in the control group patients than for the patients with pleural metastasis ($p = 0.02$). The histologic types of primary lung cancer in patients with pleural metastasis revealed as adenocarcinoma in 10 patients (71%) and squamous cell carcinoma in four patients (29%). The location, size and shape of the primary lung cancer and the associated mediastinal lymphadenopathy showed no significant correlation with pleural metastasis.

Conclusion: If any subtle pleural nodularity or thickening is found on preoperative chest CT scans of patients with lung cancer, the possibility of pleural metastasis should be considered.

T he diffuse pleural involvement of malignancy in lung cancer is an indicator of a very poor prognosis, and such patients usually show little sensitive to chemotherapy with the only exception being those patients that have small cell carcinoma.

Malignant cells can exist in the pleural cavity without any pleural fluid collection or there can be no visible indications of pleural tumor seeding on the cytology examination (1). Furthermore, unnecessary thoracotomy is sometimes performed in this group of patients. The presence of malignant cells in the pleural cavity of patients without pleural effusion may be attributed to either exfoliation from tumors abutting the pleural surface and so this represents localized disease, or this may represent disseminated disease (2). If malignant cells are found in the pleural cavity of patients who have otherwise early stage lesions, it may signify a much more aggressive tumor biology (2).

In this paper, we retrospectively describe the CT features of pathologically proven

subtle pleural metastases that were without or with a small amount of associated pleural effusion on preoperative chest CT scans, and these finding can suggest T4 or M1 inoperable lung cancer.

MATERIALS AND METHODS

From December 1995 to March 1999, we experienced 14 patients who had open thoracotomy attempted for lung cancer, but these were proven to be inoperable cases due to pleural metastasis on the gross operative findings and subsequent pathologic examinations. Ten of the patients were women and four of the patients were men. The mean age of patients was 61 years (range: 38−74 years). None of the 14 patients had a history of previous thoracotomy or other thoracic diseases.

Preoperative percutaneous transthoracic needle biopsy of a primary lung mass was performed in nine patients, and bronchoscopic biopsy was done in five patients. All 14 patients underwent preoperative chest CT scanning and most of the chest CT scans was obtained before the preoperative transthoracic procedures, except for two patients. Yet in those two patients, no definite evidence of pleural changes was noticed on chest radiographs that were obtained before the procedures. The time interval between the preoperative transthoracic procedures and the CT scan was one and five days in those two patients, respectively. Open thoracotomy with pleural biopsy was performed in all 14 patients. The interval between the chest CT scan and surgery was from five to 46 days (mean interval: 18.6 days). Intraoperative pleural lavage just after open thoracotomy was performed in only two patients.

We also included 20 control patients who had undergone operation for lung cancer during the same period, and 20 these patients were proven to have no pleural metastasis on the pathologic findings. We included these control patients because we wanted to compare their findings with the frequency and significance of the retrospective findings on chest CT scan in our study group. The control group included five female patients and 15 male patients. The mean age of control group was 62 years (range: 40−79 years). None of the patients of the control group had a history of previous thoracotomy.

Preoperative percutaneous transthoracic needle biopsy of a primary lung mass was performed in 12 patients of control group, and bronchoscopic biopsy was done in eight patients. All 20 patients of the control group underwent preoperative chest CT scanning. The interval between the chest CT scan and surgery was from three to 41 days (mean interval: 14.5 days). Intraoperative pleural lavage was not performed in any of the control group patients.

We retrospectively reviewed the operative findings and pathology records of all 14 patients with pleural metastasis and also the 20 patients of the control group. We reviewed the gross findings on the surgical field, the pathologic results of the pleural biopsy obtained with open thoracotomy, and the histology of the primary lung cancer obtained through either preoperative percutaneous transthoracic needle biopsy or bronchoscopic biopsy.

All the 14 patients with pleural metastasis and the 20 patients of the control group underwent preoperative chest CT scanning. The pre-contrast and post-contrast enhanced chest CT scans were performed in all patients with a Somatom plus scanner (Siemens, Erlangen, Germany) and a CT W2000 (Hitachi Medical, Tokyo, Japan). Ten-milli meter collimation sections were obtained through the thorax at 8-mm intervals and with a pitch of one. The technical factors used were 120−140 kVp and 170−250 mA. The images were reconstructed using a standard algorithm. A limited number of thin-section CT scans were obtained for all 14 patients and also for the 20 control group patients before contrast enhancement, and image reconstruction was performed with a high spatial frequency algorithm for parenchymal analysis. The techni-cal factors we used included 140 kVp, 170 mA and a 1.0-sec scanning time. Two chest radiologists retrospectively reviewed the preoperative chest CT scans and then a consensus was reached. We evaluated such pleural changes as the nodularity of the fissures or the costal pleural surface, pleural thickening, the presence or absence of pleural effusion, and the amount of pleural effusion, if any, that was detected. We reviewed the preoperative chest CT scans for the size, shape and location of the primary lung tumor. We regarded tumors as being either central or peripheral lung cancers when the major part of each tumor was located within or beyond the division of the subseg-mental bronchus, respectively. We also evaluated the presence or absence of any associated mediastinal lymphadenopathy.

RESULTS

According to the gross operative findings in the patients with pleural metastasis, diffuse pleural nodularity ipsilat-eral to the primary malignancy was seen in 12 patients (86%) and foci of seeded pleural nodules or masses were seen in the remaining two patients (14%). A small amount of associated pleural effusion was noted in two patients (14%) at the time of surgery.

All the pathologic results of the pleural biopsies obtained from the 14 patients with pleural metastasis at the time of open thoracotomy were positive for malignancy. The

histologic types of primary lung cancer revealed as adenocarcinoma in 10 patients (71%) and as squamous cell carcinoma in four patients (29%).

On the retrospective review of the preoperative chest CT scans in the patients with pleural metastasis, subtle nodularity of the fissures or of the costal pleural surfaces ipsilateral to the malignancy was found in five patients (36%) (Fig. 1). Ipsilateral subtle focal thickening of the pleura or plaque-like pleural lesions found either adjacent to (Fig. 2) or apart from (Fig. 3) the primary lung mass were noted in three patients (21%). Subtle pleural nodularity or focal pleural thickening ipsilateral to the malignancy was noted in seven (50%) of the 14 patients. A small amount of pleural effusion (less than 5 mm maximum thickness on the CT scan) ipsilateral to the primary malignancy (Fig. 4) was noted in four patients

(29%). Consequently, more than one of the above pleural changes, such as pleural nodularity, focal thickening or a small amount of pleural effusion ipsilateral to the malignancy was retrospectively detected in eight patients (57%), although these findings were not reported on the preoperative evaluations. The remaining six (43%) of our 14 patients revealed none of above pleural changes upon retrospective review of the preoperative chest CT scans.

The findings on the preoperative chest CT scans and the CT staging of the primary lung cancers in patients with pleural metastasis are summarized in Table 1. The mean maximum diameter of the primary lung cancers was about 3.9 cm (range: 2.5–6.0 cm). The shape of the primary lung masses was spiculated or lobulated in 11 cases (11/14) and there were indistinct peripheral margins in three (3/14) cases. The locations of primary lung masses were central in

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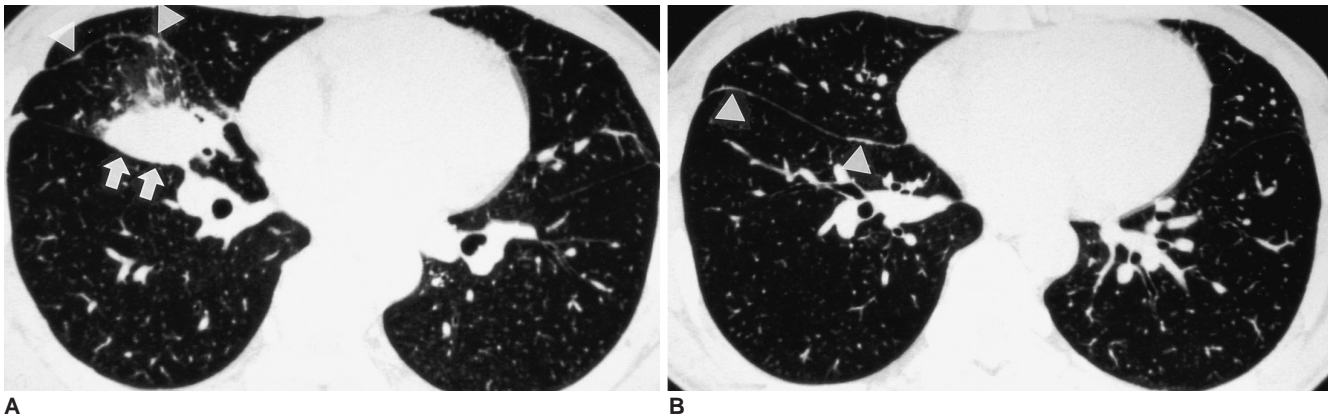
Fig. 1. Preoperative chest CT scans in a 37-year-old man with adenocarcinoma.
A. Lung cancer is centrally located in the right middle lobe with mild contour bulging of the abutting interlobar fissure (arrows). The right minor fissure shows mild nodular thickening on the thin-section CT scan (arrowheads).
B. The more inferior portion of the right major fissure is also thickened with nodularity (arrowheads). Open thoracotomy revealed diffuse nodularity of the pleura, and pleural metastasis was proven on biopsy.

A   **B**
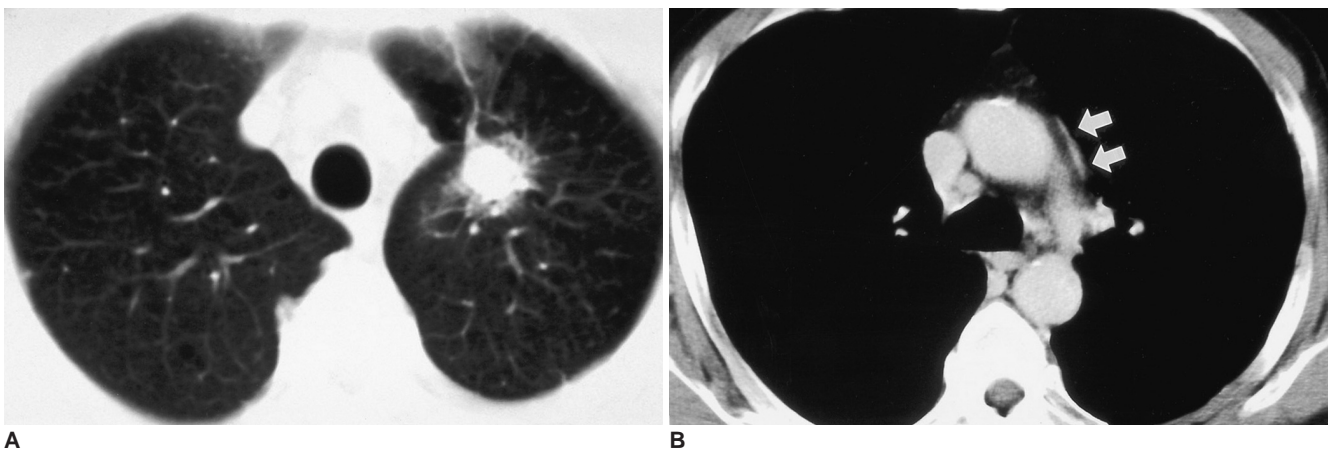
Fig. 2. Preoperative chest CT scans in a 74-year-old man with adenocarcinoma.
A. There is a primary lung cancer with spiculated peripheral margin in the left upper lobe.
B. On the mediastinal window scan, plaque-like focal pleural thickening is noted in the mediastinal pleura (arrows) apart from the primary lung mass. Pleural metastasis of lung cancer was pathologically confirmed on open thoracotomy with biopsy.

six patients (43%) and peripheral locations were seen in the remaining eight patients (57%). Regarding the preoperative CT staging of the primary lung tumors, one patient (7%) had T1 staging, 12 patients had T2 staging (86%), and one patient had T3 staging (7%). N staging of the lung cancers on CT revealed N0 in eight (57%) patients, N1 in one (7%) and N2 in five (36%) patients. No evidence of distant metastasis to other organs was identified on the preoperative chest CT scans. The size, shape and location of the primary lung cancers and associated mediastinal lymphadenopathy revealed no significant correlation with pleural metastasis.

On the pathologic review of the control group patients having lung cancer without pleural metastasis, the histologic types of primary lung cancer were revealed as adenocarcinoma in 10 patients (50%) and squamous cell carcinoma in 10 patients (50%).

On retrospective review of the preoperative chest CT scans for the 20 patients of the control group with no pleural metastasis, focal pleural thickening or plaque-like pleural lesion was not noted in any of the patients. Instead, only focal pleural tags or pleural retraction abutting to the
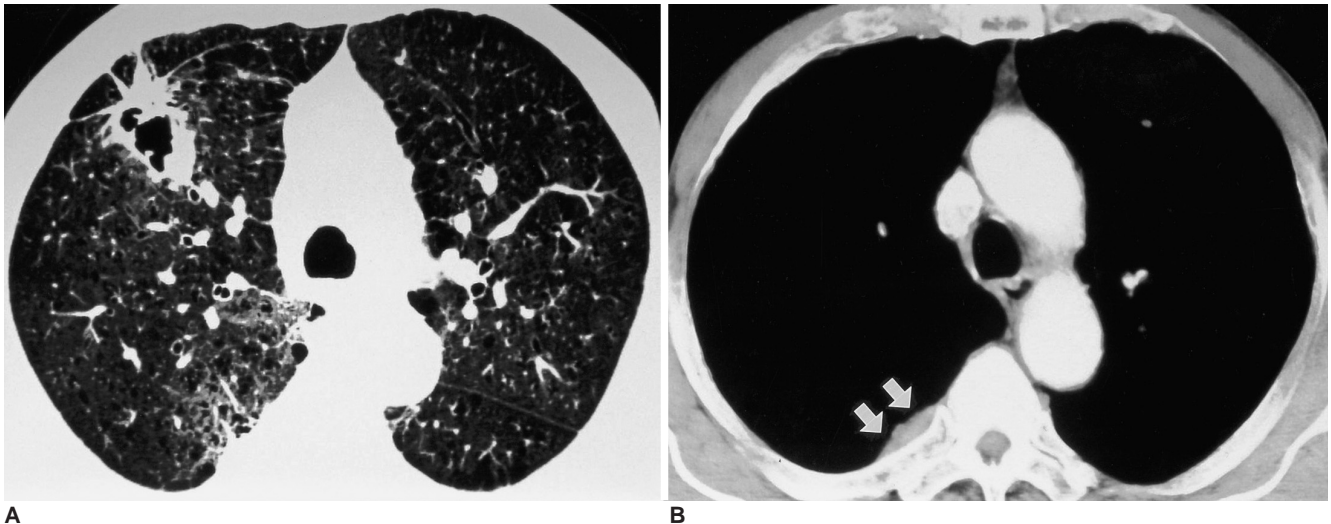
Fig. 3. Preoperative chest CT scans in a 67-year-old man with adenocarcinoma.
A. On the lung window scan, there is a cavitary peripheral lung cancer in the right upper lobe.
B. There is focal plaque-like pleural thickening in the right posterior costal pleura (arrows) apart from the primary lung mass. Multifocal pleural thickening was also noted in the remaining areas (not illustrated).
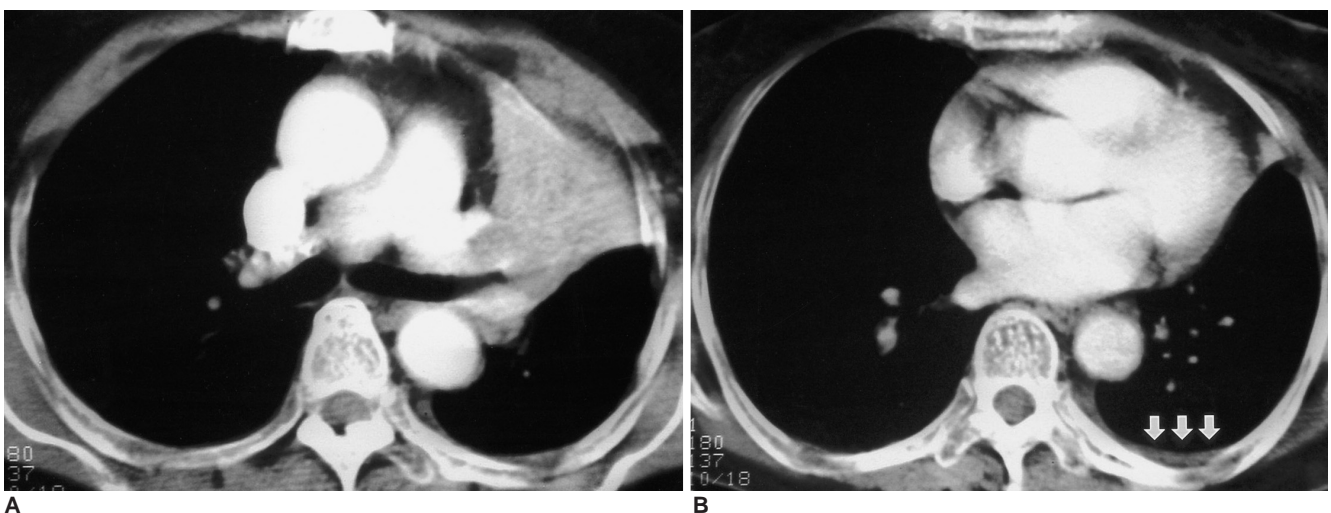
Fig. 4. Preoperative chest CT scans in a 68-year-old woman with squamous cell carcinoma.
A. There are luminal obliteration of the left upper lobar bronchus due to a central lung cancer and obstructive atelectasis in the distal lung.
B. Small amount of left pleural effusion (arrows) is noted without any evidence of pleural nodularity or thickening. Pleural metastasis of lung cancer was proven on cytologic examination performed through open thoracotomy.

peripheral primary lung mass was noted in 12 patients (60%). Focal nodularity of the pleura or fissure was noted in three patients (15%) and all of them were also closely abutting to the primary lung mass. A small amount of pleural effusion ipsilateral to the primary malignancy was seen in one patient (5%). Consequently, more than one of the above pleural changes such as pleural nodularity, focal thickening or a small amount of pleural effusion ipsilateral to the malignancy was retrospectively noted in three of the 20 patients (15%) of the control group. Either the ipsilateral pleural nodularity or the focal pleural thickening adjacent to or apart from the primary lung cancer was noted to be significantly less frequent on the preoperative chest CT scans of the control group with lung cancer and

Table 1. Findings on Preoperative Chest CT Scans and the CT Staging of Primary Lung Cancer with Pleural Metastasis

Age	Sex	Primary Tumor				CT Staging		Pleural Changes on CT		
		Size (cm)	Margin	Location	Histology	T	N	Nodularity	Thickening	Effusion
56	F	3×3×4	I	C	SqcCa	T2	N0	(−)	(−)	(−)
57	F	2.5×2×3	S/L	P	AdenoCa	T2	N0	(+)	(−)	(+)
69	F	2.5×2×3	S/L	P	AdenoCa	T2	N0	(+)	(−)	(−)
67	M	3.5×3×3	S/L	P	SqcCa	T2	N2	(+)	(+)	(−)
72	F	4×3×5	L	C	AdenoCa	T2	N1	(−)	(−)	(+)
64	M	6×4×3	L	C	SqcCa	T3	N2	(−)	(+)	(+)
38	M	3×2×2	I	P	AdenoCa	T2	N0	(+)	(−)	(−)
49	F	3×3×5	S/L	C	AdenoCa	T2	N2	(−)	(−)	(−)
71	F	3×2.5×4	S/L	P	AdenoCa	T2	N2	(−)	(−)	(−)
66	F	3×3×3	I	C	SqcCa	T2	N2	(−)	(−)	(+)
61	F	3×3×3	S/L	P	AdenoCa	T2	N0	(−)	(−)	(−)
74	M	3×2.5×6	S/L	P	AdenoCa	T2	N0	(−)	(−)	(−)
66	F	2.5×2×2	S/L	P	AdenoCa	T1	N0	(−)	(+)	(−)
40	F	3×3×2	S/L	p	AdenoCa	T2	N0	(−)	(−)	(−)

Note.—AdenoCa = adenocarcinoma, C = central, I = indistinct, P = peripheral, S/L = spiculated/lobulated, SqcCa = squamous cell carcinoma, (+) = yes, (−) = no.

Table 2. Findings on the Preoperative Chest CT Scans and the CT Staging of Primary Lung Cancer without Pleural Metastasis

Age	Sex	Primary Tumor				CT Staging		Pleural Changes on CT			
		Size(cm)	Margin	Location	Histology	T	N	Nodularity	Thickening	Pleural tag	Effusion
50	M	1.9×1.1×1.6	S/L	P	SqcCa	T1	N0	(+)	(−)	(+)	(−)
60	F	3.2×2.1×3	S/L	C	AdenoCa	T2	N0	(−)	(−)	(+)	(−)
40	F	2×2×2.4	S/L	P	AdenoCa	T1	N0	(−)	(−)	(−)	(−)
62	M	4.5×4.3×3.7	S/L	P	AdenoCa	T2	N2	(−)	(−)	(−)	(−)
62	M	2×1.7×2.1	S/L	P	SqcCa	T1	N0	(−)	(−)	(−)	(−)
70	M	6×5×3.5	S/L	C	SqcCa	T3	N2	(−)	(−)	(−)	(−)
70	M	4.2×4.1×3.5	S/L	P	AdenoCa	T2	N2	(+)	(−)	(+)	(−)
58	M	2.5×2.3×2	S/L	C	SqcCa	T3	N0	(−)	(−)	(−)	(−)
79	M	5×4×4.5	S/L	P	SqcCa	T2	N1	(+)	(−)	(+)	(+)
62	M	2×1.5×2	S/L	P	AdenoCa	T1	N0	(−)	(−)	(+)	(−)
59	M	2×1.7×2	S/L	P	BAC	T1	N2	(−)	(−)	(+)	(−)
57	F	1.8×1.2×2	S/L	P	AdenoCa	T1	N0	(−)	(−)	(+)	(−)
74	F	3×2×3	S/L	P	BAC	T2	N0	(−)	(−)	(−)	(−)
69	M	7×5×6.5	S/L	C	SqcCa	T3	N2	(−)	(−)	(+)	(−)
64	M	7×5×6.5	S/L	P	SqcCa	T2	N0	(−)	(−)	(−)	(−)
51	M	4×6×3	S/L	C	SqcCa	T3	N0	(−)	(−)	(−)	(−)
70	M	3×2×3	S/L	P	BAC	T2	N2	(−)	(−)	(+)	(−)
59	M	3×3×2.5	S/L	P	BAC	T2	N0	(−)	(−)	(+)	(−)
52	F	3×2.3×2	S/L	C	SqcCa	T2	N1	(−)	(−)	(+)	(−)
58	M	5×4.5×4	S/L	C	SqcCa	T2	N0	(−)	(−)	(+)	(−)

Note.—AdenoCa = adenocarcinoma, C = central, I = indistinct, P = peripheral, S/L = spiculated/lobulated, SqcCa = squamous cell carcinoma, (+) = yes, (−) = no.

there was no pleural metastasis as compared with the patients with lung cancer and pleural metastasis ($p = 0.03$).

The findings on the preoperative chest CT scans and the CT staging of the primary lung cancers in the 20 control group patients without pleural metastasis are summarized in Table 2. The mean maximum diameter of the primary lung cancers was about 3.7 cm (range: 1.8−7 cm). The shape of the primary lung masses was spiculated or lobulated in all 20 control patients. The locations of primary lung masses were central in seven control patients (35%) and peripheral in the remaining 13 control patients (65%). Regarding the preoperative CT staging of the primary lung tumors, there was T1 staging in six patients (30%), T2 in 10 patients (50%), and T3 in four patients (20%). N staging of the lung cancers on CT revealed N0 in 12 patients (60%), N1 in two patients (10%), and N2 in six patients (30%). No evidence of distant metastasis to other organs was identified on the preoperative chest CT scans of the control group.

DISCUSSION

Surgical resection provides the most reliable opportunity for curing primary lung cancer, especially in the early stages of the disease. However, discovering pleural tumor seeding in patients with primary lung cancer is considered an ominous sign and this is regarded as T4 or M1 disease. Tumor seeding of the pleura in patients with primary lung cancer is usually found to accompany frank malignant pleural effusion and this is treated using such conservative methods as tube thoracostomy, chemical pleurodesis, and/or pleurectomy (3−5). Curative resection cannot be performed for T4 lung cancer. Furthermore, incomplete resection of T4 lung cancers does not prolong the survival time, but can contribute to a significant increase of the hospital mortality (6).

Until now, only malignant pleural effusion was included in the TNM classification as a T4 spread of lung cancer. However, we sometimes discover pleural dissemination of malignancy at the time of thoracotomy for patients with presumed resectable lung cancer. In most of these patients, there is little or no associated pleural effusion, and this makes the preoperative detection of the intrapleural dissemination of malignancy more difficult (7). There have been many efforts to investigate the factors contributing to the occurrence of pleural tumor seeding that happens with or without a small amount of pleural effusion, and to evaluate the prognostic significance of these factors (1, 2, 8, 9, 10). Kondo et al. (1) have explained that the pleural cavity is a lymphatic space and that the exfoliation of cancer cells into the pleural cavity occurs not only when

the tumor is exposed on the pleural surface, but also when the subpleural lymphatics are invaded by the tumor, even if there is no blockage of the lymphatic drainage to the mediastinal lymph nodes that would cause the accumulation of significant pleural effusion. Therefore, pleural metastases do not precisely coincide with effusion at the same location (2). Panadero et al. (8) have suggested two mechanisms of malignant pleural tumor involvement: a) direct invasion from a neighboring tumor, and b) vascular invasion that's macroscopically detectable as pulmonary arterial tumor emboli or microscopic vascular invasion that occurs at the level of the primary tumor (8). They also found that the parietal pleura were less frequently involved in the metastatic process than the visceral pleura (8). This was true not only for cases of bronchopulmonary cancer, but also for those cancers of an extrapulmonary origin as well (9, 10). They also suggested that the tumor cells will first spread from the lungs to the visceral pleura and will then produce neoplastic implants that would cast off cells to the pleural cavity and next give rise to secondary tumor implants in the parietal pleura and the diaphragm (8). Willis (11) has suggested a similar "sedimentary" mechanism of pleural metastasis.

For those cases of pleural metastasis without large effusion in patients with primary lung cancer, the preoperative radiographic detection of pleural changes indicating pleural dissemination of malignancy is important for tumor staging so as unnecessary thoracotomy can be avoided. CT scanning appears to be an effective diagnostic method in those cases of equivocal T4 lung cancer (12, 13). However, recent reports have suggested that CT scanning is of limited predictive value in the cases of T3 and T4 tumors (6, 14, 15) and there have been few reports about predictable CT findings in those cases of pleural metastases without large effusion.

With our retrospective review of the preoperative chest CT scans of 14 patients with primary lung cancer that were proven at the time of open thoracotomy to be T4 or M1 stage disease due to pleural metastasis, the presence of subtle pleural nodularity or focal pleural thickening ipsilateral to the malignancy was noted in seven (50%) of the 14 patients. On the other hand, on retrospective review of the preoperative chest CT scans for 20 control group patients with no pleural metastasis, focal pleural thickening or plaque-like pleural lesion was not noted in any of the patients, and focal nodularity of the pleura or fissures was noted in only three patients (15%). Although this was a subtle finding that was only retrospectively identified in our study, the presence of either ipsilateral pleural nodularity or focal pleural thickening adjacent to or apart from the primary lung cancer was a significantly frequent

CT finding of pleural metastasis for those patients with lung cancer ($p = 0.03$).

It has been reported that pleural nodularity or fissural thickening is indicative of pleural metastases even in the absence of pleural effusion (16), and similar diagnoses for these findings have also been suggested in previous reports (17, 18). Mori et al. (18) suggested the diagnostic criteria for suspected pleural dissemination of lung cancer on CT images; these criteria included irregular convexities and concavities measuring up to several millimeters at the costal and mediastinal pleural surfaces. They also prospectively compared the usefulness of thick-section (10-mm collimation, pitch 1) and thin-section (2-mm collimation, pitch 1) helical CT scanning for the diagnosis of pleural dissemination of tumor in patients with adenocarcinoma of the lung. They concluded that thin-section helical CT scans provide more useful information than the thick-section helical CT scan for the evaluation of pleural dissemination in lung cancer patients (13). Yamada et al. (19) have also suggested the presence of irregular pleural thickening and small nodules at the interlobar fissure on the thin-section (with a slice thickness of 2 mm) chest CT scans as the diagnostic criteria for identifying pleural tumor dissemination. Their diagnostic rate of CT scanning was 89% with a sensitivity of 89%, a specificity of 100%, and an accuracy of 99% (19). In a few cases of our study group, subtle nodular thickening of the interlobar fissures was better delineated on the thin-section images, but the number of those cases was too limited for statistical analysis.

It is well known that adenocarcinoma of the lung shows a higher incidence of pleural tumor seeding than does squamous cell carcinoma (6). Eagan et al. (20) found that positive cytology of pleural lavage after resection for lung cancer seems to be related to the primary lung cancer cell type, i.e. adenocarcinoma more so than other types. Kjellberg et al. (2) also found that positive pleural cytology before lung resection has a significant correlation with adenocarcinoma as compared to squamous cell carcinoma (2). Our study supports those results, and the histology of the primary lung cancer in our patients revealed a high percentage of adenocarcinoma, as was seen in 10 (71%) of our 14 patients with pleural metastasis. Our study also revealed a high prevalence of pleural metastasis in women (10/14), and the histology of lung cancer in those patients showed as adenocarcioma in eight patients and squamous cell carcinoma in remaining two. We propose that these findings can reflect increasing incidence of lung cancer in the general population and especially in women, and adenocarcinoma is the most prominent histological type of lung cancer.

Several studies have suggested good utility for performing intraoperative pleural lavage either before or after resection of lung cancer in order to determine the importance of positive pleural cytology as a prognostic factor (1, 2, 8, 9, 20). However, pleural lavage in those lung cancer patients who are without pleural effusion and who are undergoing potentially curative resection has not yet been established as a routine staging practice.

Video-assisted thoracoscopic surgery (VATS) is assuming an increasingly important role in the diagnosis and treatment of various diseases of the thorax (21). One of the most outstanding features of VATS is that it is the only modality that allows for complete visualization of the pleural space (21−25). This is especially important when subtle findings can indicate pleural dissemination of malignancy or a small amount of pleural effusion is suspected on preoperative chest CT scanning (21−25). In addition, VATS can allow for various interventional procedures, e.g. biopsy of a suspected pleural lesion or of a swollen lymph node and aspiration of a small amount of pleural effusion (21−25). Recent reports have suggested that preoperative VATS exploration can identify inoperable factors that cannot be found on routine check-up and thus, this procedure can be of significant benefit as complicated and painful thoracotomy can be avoided (21−25). Yet we think that the cost effectiveness of this procedure according to the outcomes should be proven in future studies. Further, the use of PET (positron emission tomography) or PET-CT scanning in the staging of lung cancer has increased dramatically (26, 27). Reports are beginning to surface for the detection of tiny lesions, on the order of a few millimeters. We think that PET or PET-CT scanning likely would have been a positive diagnostic addition for some of our study patients.

Our study has some limitations. First, this study was retrospectively performed with a relatively small number of the cases, and the radiologists who reviewed the cases were not completely blinded to the surgical results. Second, we could not directly correlate the CT findings with the findings at surgery. However, we think this not so important because diffuse dissemination of pleural nodularity ipsilateral to the primary malignancy was seen on the gross operation field in many (12/14, 86%) of our patients with pleural metastasis, and the comparable findings in the control group can prove the specificity of the CT findings, as we have suggested before. Third, we didn't perform a comparative analysis for the predictability of the CT findings on the 10-mm thick sections and the thinner sections, although all of our study patients underwent a limited number of thin-section scanning. However, we can suggest that the thinner section images showed subtle pleural changes better and they can

improve the diagnostic confidence and detectability of subtle pleural metastasis.

We can conclude that adenocarcinoma is the most common histologic type of lung cancer to cause pleural metastasis without or with a small amount of pleural effusion. If there are any subtle pleural abnormalities such as nodularity or focal pleural thickening on the preoperative chest CT scans of patients with primary lung cancer, one should consider the possibility of pleural metastasis even though there is only a small amount of associated pleural effusion or perhaps it is absent all together. Further preoperative diagnostic evaluation that includes PET, PET-CT scanning, thoracoscopic pleural biopsy or pleural lavage with cytology may be helpful to avoid unnecessary thoracotomy in these patients and it can also help reduce the hospital mortality.

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