Malignant vs. Benign Pleural Lesion: CT Findings

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Introduction

Pleural lesions are caused by a variety of diseases, including inflammatory diseases, primary or metastatic malignancies. Although the progress in the development of a real time scanners has expanded the application of ultrasonography in pleural pathology, pleural lesions are difficult to differentiate using conventional imaging methods[1,2]. Especially plural effusions associated with neoplasms are caused by several different
mechanisms: direct involvement of the pleural surfaces by tumor, lymphatic or venous obstruction, endobronchial obstruction with atelectasis, postobstructive pneumonitis with a parapneumonic effusion and severe hypoproteinemia. These latter four etiologies account for a large percentage of the negative cytologic and pleural biopsy findings in these patients.

Because of the improvement of resolution power of CT scan, it becomes possible to analyze the changes of pleural space, layer by layer. So, CT scan is well suitable for detection and characterization of pleural disease by analyzing the changes of anatomical layers. But the appearances of pleural disease at CT scan have not been extensively described and are less well known. To identify the reasonable criteria in differential diagnosis of pleural diseases, we reviewed the CT scans of 68 patients with documented pleural diseases.

Materials and Methods

We reviewed chest CT of 68 patients showing evidence of pleural pathology or pleural fluid at chest radiography without regard to any specific diagnosis between January 1988 and February 1990. This study group consisted of 19 female patients and 49 male patients ranging in age from 4 to 78 years (mean age, 49.4 years). 29 patients had empyema, 21 patients had pleural malignancy such as mesothelioma (n=3) or pleural metastasis associated with extrapleural primary malignancies (n=18), 10 patients had fibrothorax, and 8 patients had free pleural effusion without other pleural pathology.

Diagnoses were confirmed by operation, pleural biopsy, cytology of pleural fluid, bacteriology, or clinical history and course (Table 1). In malignant pleural lesions, the diagnosis was confirmed by pleural biopsy (n=8), cytology of pleural fluid (n=14), and operation (n=1). The diagnosis of empyema was based on pleural biopsy (n=7), operation (n=6), bacteriology of pleural fluid and sputum (n=12), and compatible clinical course and follow up radiography after treatment (n=5).

61 patients were scanned on a GE 9800 scanner (Geberak Electric Medical System, Milwaukee). In the remaining patients scans were done on Tosiba 80-A (n=4), Siemens Somatom DRG (n=2), and Shimadzu SCT 2000 T-11 (n=1). In 48 patients, contiguous 1 cm thick CT scan was obtained from the apex to the base of the lung. In 12 patients, high resolution CT scan was performed with a GE 9800 CT scanner (1.5 mm collimation, 140 KVP, 170 mA, 3 seconds). Both methods were obtained in 8 patients. An intravenous bolus of contrast dye (Telebrix 30 Meglumine, 2 ml/Kg) was given to all patients.

CT scans were evaluated to assess the following signs: 1) nodular pleural rind, 2) nodular mass, 3) interruption of pleural thickening, 4) aggressive fluid collection, 5) mediastinal pleural involvement, and 6) tissue characteristics of extrapleural space. We defined the

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<th>Diagnostic Methods</th>
<th>Pleural Biopsy</th>
<th>Cytology</th>
<th>Bacteriology</th>
<th>Operation</th>
<th>Clinical Course</th>
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<td>8</td>
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<td>1</td>
<td>0</td>
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<tr>
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<td>12</td>
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<td>5</td>
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interruption of pleural thickening as focal discontinuity of diffuse pleural thickening, and the aggressive fluid collection as multiloculated fluid collection which has abrupt bulging contoured tense fluid collection, acute angle between loculated fluid and pleura, and extensive atelectasis comparing with the amount of fluid. Pleural thickening was thought to be present, if there was visible soft tissue stripe between rib and lung. Because visceral pleural involvement could not definitely evaluate due to associated atelectasis, we evaluated parietal pleura only. CT density of extrapleural tissue was compared with adjacent fat, muscle, and fluid.

Results

All cases of the malignant pleural lesion and empyema showed pleural effusion, thickened parietal pleura and enhancement. But in the cases of free fluid, pleural thickening and contrast enhancement was not identified. The cases of fibrothorax revealed extrapleural fat accumulation and none of these showed pleural fluid-
(Fig. 1).

Malignant pleural lesions

The most characteristic CT features of malignant pleural lesions included nodular mass attached to parietal pleura(17/21), nodular pleural rind(13/21), interruption of pleural thickening(14/21), aggressive fluid collection(14/21) and mediastinal pleural involvement(20/21). Extrapleural tissue ranged in density from fat to muscle was demonstrated on CT in only 5 patients(Table 2).

Empyema

The most common findings were diffuse, uniform and smooth surfaced pleural thickening.
and contrast enhancement, which were present in all cases (Fig. 2). Nodular pleural thickening was a rare finding of empyema and seen in only 5 patients with tuberculous empyema (Fig. 3). In contrast to the malignant pleural lesions, aggressive fluid collection (n=2), nodular pleural rind (n=1), nodular mass (n=5), interruption of pleural thickening (n=0), and mediastinal pleural involvement (n=6) were unusual findings (Table 3). Another characteristic finding of empyema was extrapleural tissue accumulation between the chest wall and pleura, which was observed in 18 patients. This was a more pronounced feature in tuberculous empyema than in nontuberculous ones (Fig. 4). The densities of the accumulated tissue were ranged from fat to muscle, but mainly were that of fat (15/18).

**Sensitivity and Specificity**

The sensitivity and specificity of each finding for malignant pleural diseases were as follow: 77.3 % and 84.5 % for nodular mass, 92.9 % and 76.5 % for nodular pleural rind, 100 % and 79.4 % for interruption of pleural thickening, 87.5 % and 78.1 % for aggressive fluid collection, 74.1 %

<table>
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<th>Density</th>
<th>Malignancy(%) n=21</th>
<th>Empyema(%) n=29</th>
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<tr>
<td>Fluid</td>
<td>2(9.5)</td>
<td>4(13.8)</td>
</tr>
<tr>
<td>Muscle</td>
<td>1(4.8)</td>
<td>0 (0)</td>
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<tr>
<td>Fat</td>
<td>2(9.5)</td>
<td>15(51.7)</td>
</tr>
<tr>
<td>Total</td>
<td>5(23.8)</td>
<td>19(51.5)</td>
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**Table 3. Analysis of Extrapleural Tissue**

Fig. 2. CT scan in a patient with a tuberculous empyema confirmed by operation shows diffuse, uniform thickening and contrast enhancement of pleura.

Fig. 3. 1.5 mm collimation scan reveals nodular pleural thickening in a patient with a tuberculous empyema. But, note the fatty tissue beneath the thickened pleura (arrow).

Fig. 4. 1.5 mm collimation scan with a tuberculous empyema reveals a linear fatty tissue (arrow) beneath the smooth thickened pleura with a lentricular fluid collection. These are characteristic findings of empyema (especially, tuberculous empyema).
and 95.5 % for mediastinal pleural involvement and 78.3 % and 64.0 % for extrapleural tissue accumulation, respectively. The most sensitive and specific finding were interruption of pleural thickening and mediastinal pleural involvement, respectively.

**Discussion**

Normally the pleura and endothoracic fascia pass internal to the ribs. But they are not visible in this location on conventional and high resolution CT. Therefore, a soft tissue stripe demonstrated internal to the ribs on conventional CT can be used to diagnose pleural thickening or effusion. A number of articles have described the CT findings of pleural lesions, including pleural tuberculosis, empyema, mesothelioma, and pleural manifestation of lymphoma. But to our knowledge, no large series except one have compared benign and malignant pleural lesions focusing to differential diagnosis. Solanen et al. described that high contrast enhancement of the pleura was typical finding of active pleural disease; this, in combination with an infiltrative nature of lesion, was indicative of malignancy, but benign infectious process did not show infiltration. Our results were consistent with observation of Solanen et al.,

**Nodular mass and nodular pleural rind**

It is well documented that mesothelioma has extensive, lobular thickened irregular masses involving all pleural surfaces including the mediastinum. A similar configuration can be encountered in advanced metastatic carcinoma involving the pleura. And pleural based mass may be encountered in various malignant diseases such as lymphoma, metastasis and thymoma. But empyema shows wall characteristics that is distinctly thin, uniform and smooth on its luminal margin. The explanations are as followings: as an empyema progresses, a fibrin peel coats the visceral and parietal pleural surfaces. This peel organizes with ingrowth of capillaries and fibroblasts as early as 7 days after the onset of disease, forming the split pleura sign representing visualization of smooth thickened, separated visceral and parietal pleural surfaces. In the malignant pleural effusion, pleural fluid accumulation is attributed to increased net filtration of pleural fluid though serous membranes irritated by tumor implants.

In our series, nodular mass and nodular pleural rind was observed in 81.0 % and 61.9 % for malignant pleural lesions, respectively. These finding, however, were observed each in 5 and 1 patients with tuberculous empyema. Therefore these findings may be helpful in the differential diagnosis between malignant and benign pleural lesions.

**Interruption of pleural thickening**

The interruption of pleural thickening was observed in 14 cases of malignant pleural lesions. But this finding was not identified in the cases of empyema. This finding is the most sensitive finding of malignancy in our series, but has not been described yet. We consider that this finding may be caused by uneven distribution and growth of metastatic tumor implants and may be the earliest finding of metastatic pleural lesion that can be detected on CT.

**Aggressive fluid collection**

Atypical fluid collection in the pleural space is well documented finding in the previously diseased pleura such as tuberculosis. But the aggressive fluid collection was more common in the malignant than benign pleural lesions. Interestingly, 4 cases of these showed nodular mass or pleural thickening abutting the fluid collection. It is the possible explanation for
this finding that massive fluid collection between visceral and parietal pleura is loculated by pleural adhesion which is produced by metastatic tumor implants. In contrast, this finding is unusual in the empyema. Therefore, this may be another helpful finding to differentiate malignant from benign pleural lesion.

-Mediastinal pleural involvement-

The mediastinal pleura is especially difficult to evaluate on conventional imaging modalities. But mediastinal pleural pathology and other mediastinal lesions are well demonstrated by CT.

Fig. 5. a. CT scan in a patient with a metastatic adenocarcinoma shows uneven thickening and nodular mass(arrow). b. CT scan reveals nodular pleural thickening in the entire pleura including mediastinal and parietal pleura. This patient was confirmed to metastatic adenocarcinoma by pleural biopsy.

Fig. 6. a,b: CT scan in a same patient with metastatic adenocarcinoma show discontinuity of pleural thickening, interruption(arrow). It may be the earliest finding of metastatic lesion.

Fig. 7. CT scan shows multiple loculated fluid collection with bulging contour and acute angle between loculated fluid and pleura(arrow).
Fig. 8. CT scan in a patient with metastatic adenocarcinoma shows enhancing nodular mass abutting the fluid collection(arrow).

scan. Mediastinal pleural involvement in the mesothelioma has been reported in other articles\(^3,^4\). But, to our knowledge, only one paper described mediastinal pleural involvement regarding the differentiation of malignant from benign pleural lesion\(^5\).

In our series, mediastinal pleural involvement such as loculated fluid collection, nodular mass and nodular pleural thickening was relatively common in malignant pleural involvement(Fig. 9-A), but even loculated pleural effusion was a rare finding in benign lesion. 6 of our benign cases showed mediastinal pleural involvement, and 5 cases of these were tuberculous empyema(Fig. 9-B). Although mediastinal pleural involvement is the most specific finding of malignancy, it cannot distinctly exclude the possibility of benign lesion, especially tuberculous empyema. Conclusively, this finding may be helpful in the diagnosis of malignant pleural lesion.

Extrapleural tissue accumulation;

Normally, the layer of fatty connective tissue is located between the parietal pleura and endothoracic fascia. This layer is better demonstrated on high resolution CT than on conventional CT. In most of normal subjects, however, the intercostal fat layer is not clearly seen in all locations\(^4\). In patients with chronic pleural disease, the CT density of extrapleural tissue in comparison with that of adjacent organ or fluid was ranged from fat to muscle density. But, in comparison to malignancy or nontuberculous empyema, the

Fig. 9. a. CT scan in a patient with metastatic adenocarcinoma shows fluid collection in the mediastinal pleura(arrow). Also noted nodular pleural thickening in the parietal pleura. b. CT scan shows left sided mediastinal pleural thickening(arrow) and nodular pleural rind. Also note pleural thickening on the right. This 4 year old girl was confirmed to tuberculous empyema by pleural biopsy.
cases of tuberculous empyema showed mainly fat density. We believe that extrapleural fat accumulation may indicate rather a chronic process of the diseases and fluid accumulation a more acute process. Therefore, the extrapleural fat accumulation looks to represent rather a benign than a malignant disease.

**Conclusion**

Pleural thickening and enhancement indicate active pleural lesion either benign or malignant. Nodular mass, nodular pleural rind, interruption of pleural thickening, aggressive fluid collection and mediastinal pleural involvement are characteristic findings of malignant pleural involvement - are characteristic findings of malignant lesion. In contrast, diffuse, smooth and uniform pleural thickening with or without extrapleural fat accumulation indicated benign pleural lesion. Based on these findings presented in this report, CT is thought to be helpful to differentiate malignant from benign pleural lesions.

**REFERENCES**

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15. Leung AN, Muller NL, Miller RR. Differential diagnosis of diffuse pleural disease with CT. Radiology RSNA ’89 scientific program 1989; 173(p): 139