Pleural changes in malignant pleural effusions: appearance on computed tomography

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- **BACKGROUND** Tumors metastatic to the pleura are a leading cause of pleural effusions. The computed tomographic (CT) appearance of malignant pleural effusions varies from uniformly low attenuation without pleural abnormalities to thickened, irregular, contrast-enhanced pleura with or without discrete masses. There may be associated changes in the subcostal tissues.
- **OBJECTIVE** To determine the prevalence of abnormalities observed with CT scanning in patients with malignant pleural effusion.
- **METHODS** We analyzed the CT appearance of the pleura in 86 patients with documented malignant pleural effusions. Patients with primary malignancy of the pleura (mesothelioma) were excluded.
- **RESULTS** In 98% of the malignant effusions the fluid was homogeneous. Focal tumor masses were identified within the effusion in 10%. CT evidence of fluid loculation was seen in 40%. Pleural thickening, either smooth or irregular, was identified in 62%.
- **CONCLUSIONS** The transaxial anatomic display afforded by CT scanning facilitates demonstration of several features that should arouse the suspicion of the radiologist and the clinician to the possibility of malignancy involving the pleura.

■ INDEX TERMS: PLEURAL EFFUSION, MALIGNANT; TOMOGRAPHY, X-RAY COMPUTED; PLEURAL DISEASES ■ CLEVE CLIN J MED 1994; 61:127–131

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A LARGE NUMBER of pleural effusions result from neoplastic diseases that metastasize to the pleura. According to Stark,[1] metastasis to the pleura is the second most common cause of exudative pleural effusions. Chretien and Jaubert[2] found a significant increase in neoplastic effusions in the third and fourth decades and again in the seventh decade. The tumor most frequently associated with a malignant pleural effusion is bronchogenic carcinoma; 15% of these patients have an effusion at presentation. At least half of patients with disseminated lung cancer develop pleural effusions. Breast cancer is the second most common malignancy associated with pleural effusions; almost 50% of patients with disseminated breast cancer develop effusions.[3]

Pleural fluid is produced by the parietal pleura at the rate of 100 mL/hour.[3] The fluid is derived by filtration from the systemic capillaries and is normally transudative in nature. Under normal circumstances it is reabsorbed by both the parietal and the visceral pleura. Production and resorption of pleural fluid occur continuously, there normally being between 2 and 10

TABLE 1
SOURCE OF PRIMARY TUMOR IN 86 PATIENTS WITH MALIGNANT PLEURAL EFFUSIONS

Source	No.
Lung	37
Breast	10
Lymphoid tissue	6
Kidney	6
Pancreas	3
Colon or rectum	3
Esophagus	3
Ovary	1
Other gastrointestinal sites*	3
Miscellaneous sites†	5
Unknown	9
Total	86

*1 stomach, 1 tongue, 1 jejunum
†2 malignant melanomas, 2 neuroblastomas, 1 sarcoma

mL of fluid in the pleural space. Transudative pleural effusions accumulate in the presence of increased systemic or pulmonary capillary pressures, as in congestive cardiac failure, or decreased colloidal osmotic pressure, as in hepatocellular dysfunction.

Although metastasis to the pleura occasionally produces transudative effusions, by far the majority of malignant effusions are exudative in nature. Exudative effusions have a protein level in excess of 30 g/L, a ratio of pleural protein to serum protein in excess of 1:2, and a ratio of pleural lactate dehydrogenase to serum lactate dehydrogenase in excess of 3:5.[4]

In metastasis to the pleura, the malignant cells may invade the subserous layer or remain on the pleural surface. Invasion of the subserous layer results in a higher yield of malignant cells on thoracentesis.[4] Pleural metastases produce a reactive change in the mesothelium with increased permeability of the pleural surfaces and accumulation of proteinaceous fluid.[5] Tumors may produce plaque-like lesions, focal masses, or diffuse pleural thickening with associated restrictive lung disease. There is decreased clearance of fluid from the pleural space secondary to lymphatic obstruction. The presence of a tumor in the mediastinum or of an obstruction of the thoracic duct plays an integral role in fluid accumulation. Additional factors include bronchial obstruction with atelectasis; obstructive pneumonia and hypoproteinemia may also contribute to the process.

Conventional posterior-anterior and lateral chest films may demonstrate pleural abnormalities. Decubitus films are useful in demonstrating the mobility of fluid and in assessing the pulmonary parenchyma obscured by fluid in the upright position. Oblique films are useful in demonstrating pleural plaques. The transaxial anatomic display afforded by computed tomographic (CT) scanning facilitates detection of more subtle pleural abnormalities, differentiation of pleural from parenchymal processes, and accurate characterization of many pleural masses.[6]

TABLE 2
CHARACTERISTICS OF THE PLEURA ON COMPUTED TOMOGRAPHY IN 86 PATIENTS WITH MALIGNANT PLEURAL EFFUSIONS

	No.	(%)
Pleural enhancement with contrast (n = 83)	27	(33)
Smooth thickening of pleura	18	(21)
Irregular thickening of the pleura	35	(41)
Thickening of mediastinal pleura	13	(15)
Thickening of subcostal tissues	6	(7)

The combined thickness of the normal visceral and parietal pleura and the fluid-containing space is less than 0.4 mm.[7] Thus, the normal pleura is not resolved as a discrete entity on CT scanning. The purpose of this study was to assess the volume and appearance of malignant effusions on CT scanning and to analyze the type and frequency of changes involving the pleural membranes on CT scanning in patients with malignant effusions.

PATIENTS AND METHODS

Malignant pleural effusions were diagnosed in 215 patients over a 3-year period between January 1, 1989, and December 31, 1991, at the Cleveland Clinic Hospital. Diagnosis was made by cytologic study of the pleural fluid or by pleural biopsy, or both. Patients with a primary malignancy of the pleura (mesothelioma) were excluded. Review of the records revealed that 86 patients had had a CT study of the chest within 1 month of documentation of the malignant effusion. The primary tumors associated with the malignant effusions are listed in *Table 1*. The CT scans of these 86 patients were reviewed for the changes listed in *Tables 2* through 5.

Patients were scanned using either a Picker 1200 SX (Picker Corporation, Highland Heights, Ohio) or a Siemens Somatom DR (Siemens Corporation, Iselin, New Jersey). All patients were scanned at 1-cm contiguous intervals from the apices through the diaphragm. Eighty-three of the 86 patients re-

TABLE 3
CONCURRENT EVIDENCE OF METASTASES IN 86 PATIENTS WITH PLEURAL EFFUSIONS

	No.	(%)
Pericardial effusion	3	(3)
Pericardial thickening	12	(14)
Mediastinal adenopathy	37	(43)
Liver metastases	14	(16)
Adrenal metastases	4	(5)
Chest wall (bones, subcutaneous tissues)	10	(12)
Lymphangitis carcinomatosis	6	(7)
Suspicious lung masses, nodules, or infiltrates	46	(53)

ceived intravenous contrast, consisting of 100 mL of iohexol (Omnipaque 240) as a 50-mL bolus followed by a 50-mL infusion during the examination.

We reviewed the 86 CT films, estimated the volumes of the pleural effusions, and characterized their appearance. We also noted any associated pleural and subcostal changes, coexisting pulmonary parenchymal diseases, mediastinal adenopathy, pericardial or chest wall abnormalities, and abnormalities of the adrenal glands and liver. Of the 86 patients studied, the effusions were bilateral in 31 (36%) and unilateral in 55 (64%). If the effusion was bilateral, only the hemithorax that yielded a positive cytologic study or positive pleural biopsy was analyzed for size and appearance of the effusion and for pleural changes.

RESULTS

There were a number of different primary neoplasms (*Table 1*). Of the 86 malignant effusions, 37 were in patients with bronchogenic carcinoma. Breast carcinoma and lymphoma were next in order of frequency, accounting for 8.6% and 7% of cases, respectively. The primary tumor was unknown in 10%.

The most frequent pleural abnormality was thickening of the parietal pleura, which was seen in 53 (62%) of the patients (*Table 2*). There were two distinct CT patterns: the pleural thickening was irregular with or without discrete nodules in 35 patients (41%) and smooth in 18 patients (21%). Pleural thickening was assessed posteriorly, at least 5 cm lateral to the midline. This is critical, as closer to the vertebral body, normal structures such as intercostal vessels can mimic pleural thickening.[8]

Eighty-three patients received intravenous contrast material, and pleural enhancement was seen in 27 (33%) of them. The subcostal tissues were studied for thickening in all cases. Thickening (>2 mm) was present in 6 of 86 (7%). We also looked for concurrent evidence of metastasis (*Table 3*). Suspicious lung masses, nodules, or infiltrates were present in 53% of cases, mediastinal adenopathy was present in 43%, and liver metastases were present in 16%.

TABLE 4
SIZE OF EFFUSION IN 86 PATIENTS WITH MALIGNANT PLEURAL EFFUSIONS*

	No.	(%)
Large	31	(36)
Medium	37	(43)
Small	18	(21)

*See text for definition of small, medium, and large

TABLE 5
CHARACTERISTICS OF PLEURAL FLUID ON COMPUTED TOMOGRAPHY IN 86 PATIENTS WITH MALIGNANT PLEURAL EFFUSIONS

	No.	(%)
Homogeneous	84	(98)
Heterogeneous	2	(2)
With focal masses within fluid	9	(10)
Loculated	34	(40)

Of the 86 patients, 55 had unilateral pleural effusions and 31 had bilateral effusions. The effusions were separated into three groups on the basis of size (*Table 4*). Patients were scanned in the supine position. Fluid collections restricted to the posterior lower pleural space with little or no associated atelectasis were classified as small, effusions extending above the carina with associated lower lobe atelectasis were classified as medium, and those occupying all or almost all of the hemithorax were classified as large. Three large effusions produced diaphragmatic inversion.

Effusions were homogenous in 84 patients (98%) (*Table 5*). There was evidence on CT scanning of loculation of pleural fluid in 34 patients (40%). Two patients showed increased density in the most dependent portion of the fluid collection, suggesting hemorrhage.

DISCUSSION

CT scanning reveals features of malignant effusions that may suggest the nature of the effusion and that are not always appreciable on conventional

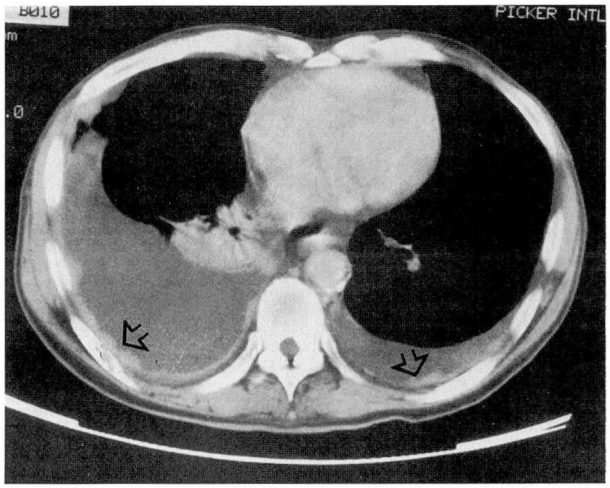

FIGURE 1. Thoracic computed tomographic scan showing irregularly thickened and contrast-enhanced pleura bilaterally (open arrows).

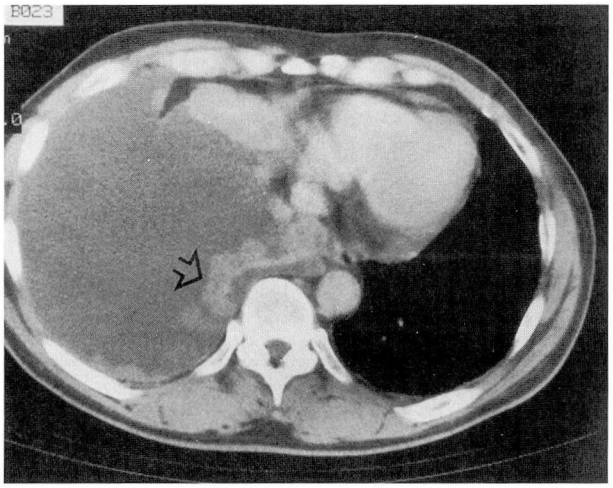

FIGURE 2. Thoracic computed tomographic scan showing the presence of pleural masses. Upon biopsy, these proved to be malignant.

chest radiographs. These include smooth or nodular thickening of the parietal pleura (*Figure 1*), parietal pleural enhancement with contrast material, the presence of pleural masses (*Figure 2*), and changes in the subcostal tissues. CT scanning also displays the underlying pulmonary parenchyma, often revealing encasement with restriction, parenchymal masses, and evidence of lymphangitic carcinomatosis. Secondary evidence of a tumor is often visible in the mediastinum in the form of masses or lymphadenopathy. Abnormalities in the liver, adrenal glands, and chest wall are also frequently encountered (*Table 3*). The extent and distribution of these changes may be helpful in suggesting the primary site.

The size of the malignant effusion is variable; however, complete obliteration of the hemithorax is not uncommon. In one series of massive effusions, metastatic malignancy was the underlying cause in 67%.[9] Effusions occupying all or almost all the hemithorax comprised 36% of this series. When large enough, an effusion may produce inversion of the diaphragmatic leaf on the involved side.[10] We found three cases of diaphragmatic inversion, two on the right side and one on the left.

The malignancies most frequently associated with pleural involvement in our series were bronchogenic carcinoma, breast carcinoma, and lymphoma, in descending order. This correlated well with the data from other series collected and published by Sahn.[11] In his series of 1783 cases of malignant pleural effusions, bronchogenic carcinoma was the primary tumor in 36%. Breast carcinoma and lymphoma were next in order of frequency, accounting for 25% and 10%. In our series, the primary tumor was unknown in 10%, compared with 7% in Sahn's series. Parietal pleural thickening, which was seen in 62% of our patients, was the most common pleural abnormality identified in our series. In contrast, Waite et al[12] found diffuse parietal pleural thickening in 8 of 30 patients (27%) with a malignant effusion.

Patients with malignant pleural mesothelioma were not included in this series. The imaging features of this condition have been described by Kawashima et al.[13] The radiographic appearance of primary pleural tumors may resemble that of metastases to the pleura. Primary pleural mesothelioma tends to spread by local extension rather than by hematogenous dissemination.[14] On CT scanning, advanced metastatic malignancy to the pleura may be indistinguishable from primary pleural mesothelioma.

Pleural empyema may also demonstrate some of the features associated with metastases to the pleura. CT changes associated with empyema have recently been described by Waite et al.[12] Contrasting empyema with malignant effusions, he noted that in empyema the attenuation of the fluid was higher and the subcostal tissues were usually thicker. Hounsfield unit values for the pleural effusions in this series were not available. The high prevalence of concomitant abnormalities involving the liver, adrenal glands, pericardium, and mediastinum is

useful in differentiating malignancy involving the pleura from empyema, as these abnormalities would not be expected in the latter.

CONCLUSION

CT evaluation of the chest in the presence of a malignant effusion will frequently demonstrate thickening of the parietal pleura with or without contrast enhancement. Pleural masses are well visualized and subcostal tissues can be assessed. The transaxial display affords an opportunity to evaluate the underlying lung, the mediastinum, and the upper abdominal organs. Comprehensive evaluation of these areas coupled with appropriate clinical information allows characterization of the pleural changes and frequently indicates the site of the primary tumor.

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