New perspectives in the imaging of pneumoconioses

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■ The plain, posteroanterior chest radiograph using the International Labour Office classification has been a critical element in the radiologic diagnosis of pneumoconioses. But advances in imaging technology, including high-resolution computed tomography, assure more objective diagnostic information. High-resolution computed tomography can separate nonpleural structures and abnormalities from true pleural disease; it also leaves little room for false interpretation of suspected parenchymal disease because it permits cross-sectional imaging of the lung parenchyma to the submillimeter level without overlap of the surrounding structures. The value of high-resolution computed tomography is already recognized by some courts involved in litigation over asbestos-related disease.

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THE DIAGNOSIS of pneumoconioses depends on the detection of inhaled inorganic dust and the resulting functional and morphological changes in the respiratory system, and is based on a multidisciplinary approach using various diagnostic modalities. The need for increased sensitivity and specificity in diagnostic methods has been driven not only by medical issues, but also from the growing challenge of sensitive legal issues. With the help of various diagnostic techniques and evolving technologies, radiology has played a major role in the diagnosis of pneumoconioses. In the recent past, new advances in imaging have opened the path to a different approach for the radiologic diagnosis of pneumoconioses.

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CHEST RADIOGRAPHY

Despite continuing controversy about its specificity and sensitivity, the plain, posteroanterior view of the chest is one of the most important methods available for detecting or ruling out the pleuro-parenchymal changes of pneumoconioses; it is sometimes the only tool available for epidemiologic reporting to document the morphologic changes affecting the chest.

Classification of findings

Under the guidance of the International Labour Office (ILO), an international classification system for the radiographic findings of pneumoconioses was designed more than 20 years ago for use by research epidemiologists in the study of the effect of inhaled dust and in comparisons of the prevalence rates of asbestosis, silicosis, and coal workers' pneumoconiosis. The standardized scoring system allowed researchers to eliminate some interobserver variations and create a consensus among the different interpretations of chest

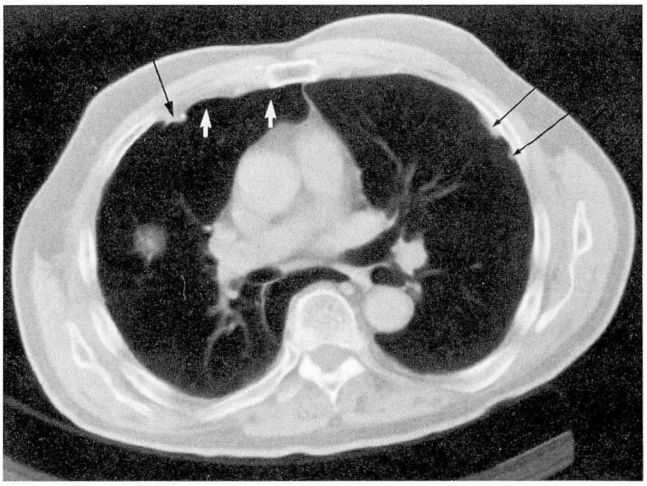

FIGURE 1. A 74-year-old man with a history of asbestos exposure. The chest radiograph showed questionable, vague, focal densities bilaterally. CT scan through the mid-lung demonstrates that the densities in question represent bilateral anterior pleural plaques. Right anterior calcified parietal pleural plaque (single black arrow) is clearly visualized because of the presence of a small pneumothorax (white arrows). Small pleural plaques are seen along the anterolateral margin of the left hemithorax (double black arrows).

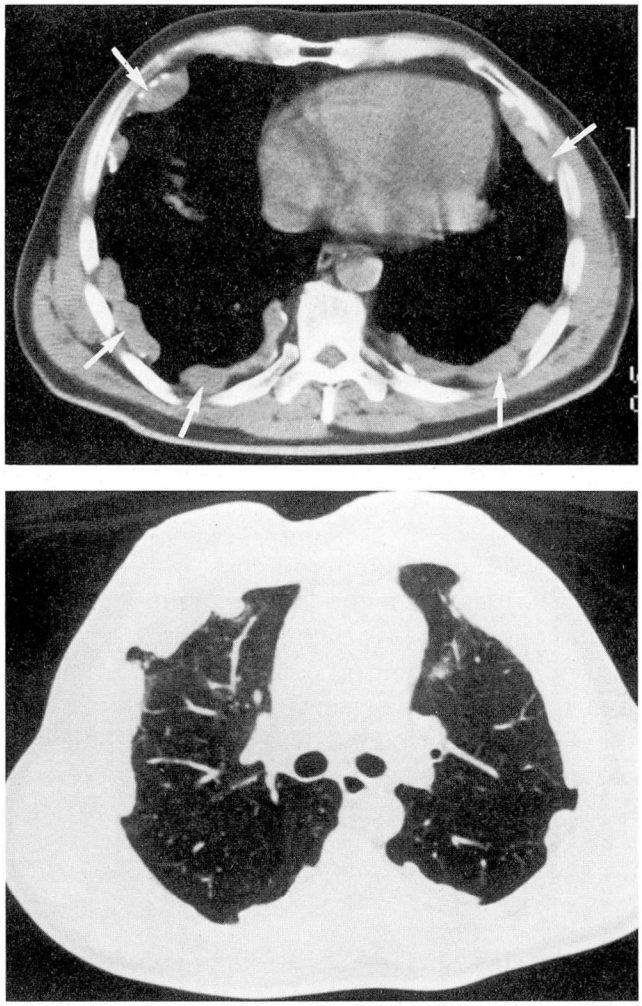

FIGURE 2. CT and high-resolution CT scans in a 69-year-old man with a history of prolonged heavy asbestos exposure. A CT scan (top) of the lower chest demonstrates multiple and bilateral minimally calcified large pleural plaques (arrows). Note the typical "squared" appearance of the pleural thickenings. The high-resolution CT scan through the mid-lung fields (immediately above) shows no evidence of interstitial fibrosis, which, if present, would suggest asbestosis.

radiographs in the pneumoconioses. The system allows for characterization of lung opacities by size and shape (rounded: p,q,r and irregular: s,t,u). A 12–grade scoring system allows the semiquantitative evaluation of the profusion of opacities through the lung fields. Classifications of pleural abnormalities such as pleural thickening, plaques, and calcifications were added to the system in 1980. In an attempt to eliminate interobserver variations, the National Institute of Safety and Health (NIOSH) requires chest physicians involved in the interpretation of chest radiographs in pneumoconioses to be familiar with the ILO classification (B-Reading certification). The system relies primarily on the sensitivity in the detection and characterization of the radiographic findings rather than the specificity of the findings. This is why the findings are judged to be compatible or consistent with pneumoconioses rather than pathognomonic.

Although initially intended for epidemiologic research and radiographic surveillance of patients exposed to inorganic dust, the ILO system has been used more extensively as an aid to clinical diagnosis and as a basis to determine legal compensation.

Problems in interpretation

Several factors limit the specificity and sensitivity of chest radiography. The chest radiograph, a two-dimensional medium, reflects the changes that occur in a three-dimensional structure (the chest). When subtle abnormalities are superimposed on normal structures, their detection and differentiation become difficult. Adding to the difficulty in interpretation of chest radiographs are the technical differences seen in exposure between different films, leading to more confusion and differences in interpretation between different observers, and sometimes for the same observer.

The chest radiograph will demonstrate morphologic changes involving the lung parenchyma (mainly interstitium) and pleura that are a result of injuries caused by inhaled inorganic dust. However, a certain amount of dust inhaled over a certain amount of time may be required before changes can be detected radiographically. Yet when present, the pleuro-parenchymal changes of pneumoconioses sometimes cannot be separated radiographically from numerous other conditions.

All of these limiting factors stress the relative lack of specificity and sensitivity of chest radiography. The advent of computed tomography (CT), particularly high–resolution (HRCT), should lead to more objective interpretation of thoracic disease, while eliminating some confusion and controversies created by the interpretation of plain radiographs in pneumoconioses.

COMPUTED TOMOGRAPHY

The chief advantage of CT over chest radiography is that it obtains a cross-sectional image of the chest without overlapping of different structures. Both the pleural margins and the lung parenchyma, where dust may cause morphologic changes, are well visualized. Information from the CT scan helps to distinguish parenchymal from pleural changes and pleural disease from chest–wall abnormalities—information that is unavailable with other imaging methods. CT virtually eliminates the variations on chest radiographs caused by technical or positional factors, patient size, or difference in degree of lung inflation.

Pleural disease

Compared to chest radiography, CT is more sensitive in the detection and characterization of pleural disease.[1,2] Pleural disease is not easily visualized on the posteroanterior chest radiograph unless it is localized along the lateral wall of the chest or on the top of the diaphragm. Lateral views and bilateral oblique views improve the detection of pleural disease localized in the posterior or anterior aspect of the chest. However, CT is more sensitive for the overall detection of pleural abnormalities and especially for the detection of "en face" or paraspinal pleural disease (*Figure 1*).

Calcifications—and, therefore, calcified pleural plaques—are more readily detected by CT. The pleural plaque typically appears as a raised, "squared," focal pleural thickening, which has been attributed to be specific for previous asbestos exposure (*Figure 2*). Normal variants such as thick intercostal muscles, the deposition of pleural or subpleural fat, and rib abnormalities may mimic pleural abnormalities on the chest radiograph. CT can separate nonpleural structures and abnormalities from true pleural disease, eliminating many false-positive diagnoses for asbestos-related disease (*Figure 3*).

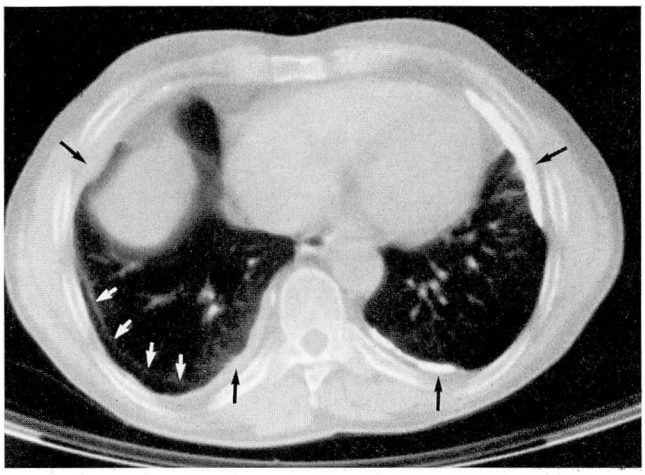

FIGURE 3. A 62-year-old man with a history of asbestos exposure. CT scan of the lower chest demonstrates bilateral calcified pleural thickening (black arrows). A curvilinear subpleural band of fibrosis, not demonstrated on the chest radiographs, is visualized in the right lower chest (white arrows).

Parenchymal disease

The use of chest radiography also offers the potential for false–positive or false–negative interpretation for parenchymal lung disease. HRCT in the evaluation of the lung parenchyma has shown to be a very sensitive diagnostic imaging modality, leaving less room for false interpretation.[3–5] With enhanced resolution over conventional imaging methods, HRCT can provide exquisite details of the different compartments of the lung parenchyma to the submillimeter level. The technique allows visualization of the secondary pulmonary lobule (SPL), the basic anatomic and physiologic unit of the lung. Both airspace and interstitial lung disease will manifest as a reflection of the morphologic changes that may affect the SPL. Pathologic correlation with HRCT has enhanced the understanding and characterization of these changes.[3] Its sensitivity in detecting early or minimal disease and its specificity in recognizing and separating pathologic processes are well documented.[3–6]

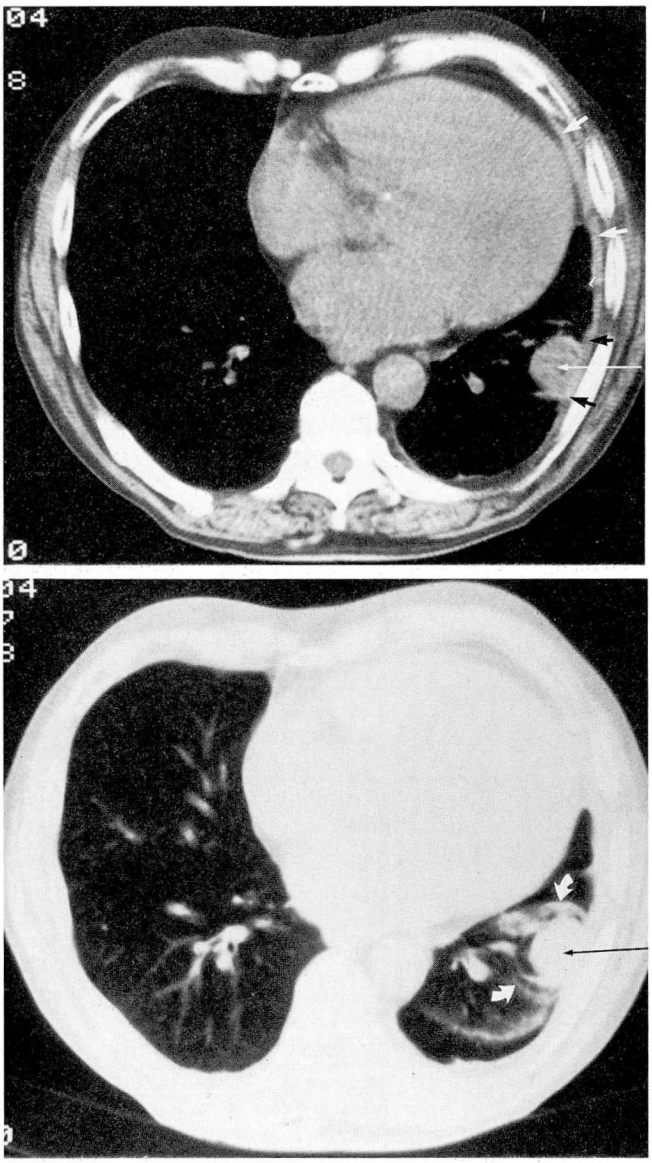

FIGURE 4. Two versions of the same CT scan through the lower chest in a 64-year-old man with a history of asbestos exposure. In the top photograph, note the 2.5-cm soft tissue lesion in the left lower lobe (long white arrow) adjacent to an area of pleural thickening (short black arrows), displaying the characteristics of a rounded atelectasis, or atelectatic pseudotumor. In the above photograph, vessels and bronchi (curved arrows) are seen converging toward the lesion (note comet-like appearance).

Pneumoconioses

HRCT has great potential in the diagnosis of pneumoconioses. Knowing the high spatial and contrast resolution of the imaging method, one can predict the high sensitivity in detecting the different pneumoconioses. Most of the preliminary studies have focused on the CT assessment of asbestos-related disease. The number of exposed patients, the public awareness of the disease, and the publicized legal ramifications have contributed to the need for better diagnostic methods. In the United States alone, at least 25 million individuals are estimated to have been exposed to asbestos in their work environments, with more than 150,000 individuals claiming compensation for personal injury. Although few reports on the CT findings of asbestos-related disease have been published, HRCT scans have already been used as evidence in California courts.[7]

Among the HRCT features characteristic of the early changes of asbestosis are signs of interstitial fibrosis, detected as thickened interstitial short lines and parenchymal bands, predominantly subpleurally and in the posterior regions of the lower lobes.[6] Curvilinear subpleural bands (*Figure 3*) and rounded atelectasis (*Figure 4*) are other processes believed to be signs of previous asbestos exposure.[8]

Although the appearance of interstitial disease caused by asbestos is indistinguishable from that of other causes of interstitial fibrosis, HRCT can differentiate asbestosis from pulmonary emphysema.

GALLIUM 67 SCANNING

Gallium 67 (^{67}Ga) thoracic scanning has recently been used to detect early inflammatory activity related to inhaled inorganic dust.[9] Used as an index of alveolitis, the pulmonary uptake of ^{67}Ga is primarily due to the local accumulation of activated macrophages. The intensity and distribution of ^{67}Ga uptake correlates with histopathologic and bronchoalveolar lavage cellularity. More active disease in the subpleural parenchyma in asbestosis correlates with the HRCT findings. Lack of specificity limits the use of ^{67}Ga scanning primarily to detecting the early inflammatory reaction that may precede radiographic or clinical evidence of interstitial lung disease.

CONCLUSION

With the help of new imaging modalities and evolving technology, the radiographic diagnosis of pneumoconioses no longer depends on the plain chest film alone. The need for better sensitivity and specificity has led to the use of more sophisticated radiologic methods such as HRCT and tomographic gallium scanning. With newly described criteria, CT findings are already

tipping the scales in asbestos litigation.

Without direct pathologic examination of the lung tissue, the diagnosis of pneumoconioses will continue to rely on a constellation of clinical, laboratory, and radiologic findings that complement one another. Although HRCT complements and sometimes supplements plain radiographs in the diagnosis of pneumoconioses, it does not replace the plain posteroanterior radiograph of the chest. Before the plain radiograph can be considered optional, large studies are needed to correlate specific CT scan findings with pathologic findings, the results of pulmonary function tests, and clinical criteria. Based on the ILO classification used for the plain film, a similar approach may lead to a new classification based on CT findings.

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