*Section Three*

# Evaluation and Treatment

*Chapter 11*

## Diseases of the Lung and Pleura

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## Introduction: The Chest Radiograph and Pulmonary Function Testing

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The sections that follow on different aspects of occupational and environmental respiratory diseases share one unifying diagnostic approach, namely, the need to characterize the respiratory disturbance regardless of suspect etiology. Each section identifies special features of the history, physical examination, and laboratory testing that are relevant for the entities under discussion, but common to all is the need to become familiar with two essential diagnostic tools—the chest radiograph and spirometry and fuller pulmonary function tests.

### CHEST RADIOGRAPHS AND THE INTERNATIONAL LABOUR ORGANIZATION CLASSIFICATION

A number of occupational and environmental lung diseases, such as asthma and chronic bronchitis, are characterized by airway dysfunction; the chest radiographs of patients with these disorders are normal unless other diseases are present. But parenchymal opacities—and pleural abnormalities in those who have been exposed to asbestos—are the common feature of the pneumoconioses, a number of other environmentally related pulmonary disorders, and a wide array of other conditions from which occupational and environmental diseases need to be distinguished. Because of the variability of interstitial markings and other parenchymal opacities, a uniform system of radiographic interpretation, the International Labour Organization (ILO) Classification, has been adopted. The current ILO classification now in use is the 1980 classification. This classification has the primary objective of increasing intra- and inter-reader reliability in epidemiologic investigations, an outcome that has been well demonstrated in many studies. The classification also has utility in clinical evaluation, but it should be recognized that a significant number (perhaps 15%) of individuals with histologic interstitial fibrosis have normal chest radiographs and, conversely, radiographic evidence of pneumoconiosis does not necessarily predict functional compromise. The chest radiograph is thus just one important tool in characterizing the respiratory process and its etiology; it must be considered in the fuller context of the exposure and health history, physical examination, and other laboratory findings.

In the United States, training and accreditation for the ILO Classification (all who undergo the training program are called A readers and those who pass a certification test are called B readers) are administered by the American College of Radiology and the National Institute for Occupational Safety and Health (NIOSH). Using the ILO system requires that readers have available to them the standard set of radio-

graphs, which are fundamental to the interpretation. A brief summary of the main features of the ILO classification follows.

### Film Quality and Type

The ILO Classification relies only on the posteroanterior radiograph at full inspiration on a 14 × 17 inch film; although additional information pertinent to clinical evaluation may be obtained from the lateral, oblique, or other standard radiographs, findings on these films must not be considered in classifiying radiographs by this system. Film quality also is considered and graded by the 1980 classification, from Grade 1, which is excellent, to Grade 4, which is deemed unreadable.

### Parenchymal Opacities

Parenchymal abnormalities are classified into two main types—large (exceeding 1 cm in diameter) and small. Small opacities are rounded or irregular and assigned letters of increasing size for each shape: p, q, and r for small, rounded opacites, and s, t, and u for small, irregular opacities. The predominant size and shape is scored for each radiograph in a system that allows designation of up to two sizes and shapes; for example, a common finding in asbestos-related fibrosis (asbestosis) is s/t, which indicates that s was the primary opacity and t was the secondary small, irregular opacity noted. Parenchymal opacities due to inhalation of silica and coal dust are commonly small and rounded and are predominantly distributed in the upper and middle portions of the lungs, compared with those from asbestos, which are not only predominantly irregular but mainly found in the lower and, to a lesser extent, the middle portions of the lungs.

For the purpose of the classification, the lung is arbitrarily divided into three zones on each side; the system allows designation of which zones are affected by parenchymal opacities and a scoring system that favors an averaging of those zones most heavily involved. Each film with identified small opacities is given a profusion score, a score that indicates the amount of small opacities—here, as in size and shape designations, intensity of profusion is assigned relative to a standard set of radiographs. The profusion score is effectively a 12-point scale, derived as follows: there are 4 main categories (0,1,2,3), with 0 being normal and 3 being most affected, and three minor categories within each main category. The 12-point scale ranges from 0/− (less than the profusion on the standard 0/0 radiograph) to 3/+ (more than the profusion on the standard 3/3 radiograph) (see Figs. 1 to 3). The grid used in the ILO Classification to score one of these 12 values is

| | | |
|---|---|---|
| 0/− | 0/0 | 0/1 |
| 1/0 | 1/1 | 1/2 |
| 2/1 | 2/2 | 2/3 |
| 3/2 | 3/3 | 3/+ |

Large opacities are designated A, B, and C, depending on the overall width of one or more opacities; when they are due to dust, large opacities usually are seen only in the setting of silica and coal dust exposure and they reflect complicated pneumoconiosis or progressive massive fibrosis (see Fig. 4 and Sections 11.8 and 11.7).

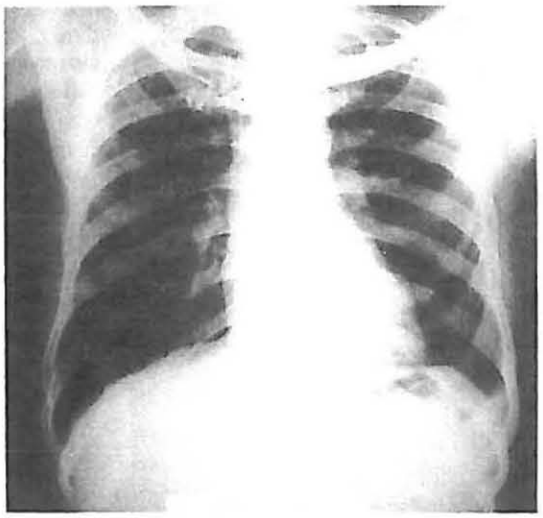

**FIGURE 1** Category 1/1 film demonstrating small rounded opacities predominantly in upper lung fields. (Courtesy of ILO U/C International Classification of Radiographs of Pneumoconiosis.)

### Pleural Abnormalities

The 1980 classification grades the presence and extent of pleural change associated with asbestos exposure (see Section 11.7). Pleural thickening is described as diffuse or discrete in type; within each of these two main categories, the width, extent, and presence or absence of calcification of thickening are described. Also identified is whether or not there is blunting of the costophrenic angle, an effect associated with diffuse pleural thickening.

## SPIROMETRY AND FULL PULMONARY FUNCTION TESTS

Spirometry is a measure of dynamic lung volumes, based on the forced vital capacity maneuver and recorded either as

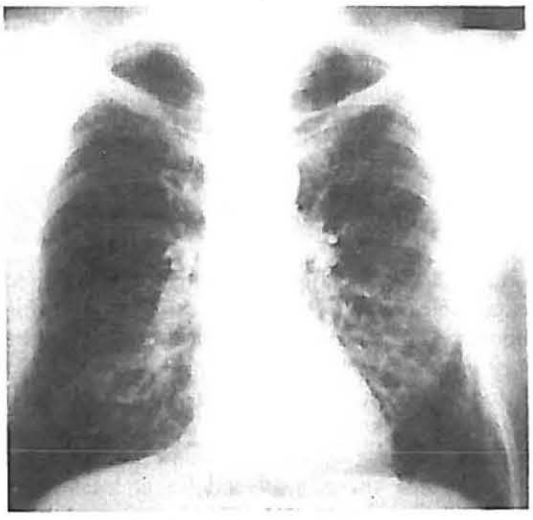

**FIGURE 2** Category 1/1 film of small irregular opacities predominantly in lower lung fields (Courtesy of ILO U/C International Classification of Radiographs of Pneumoconiosis.)

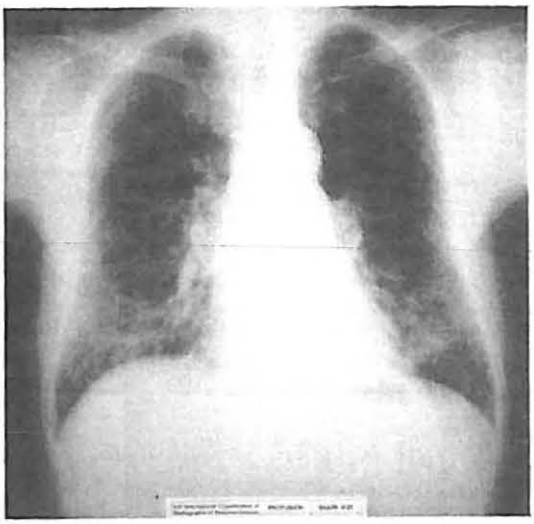

**FIGURE 3** Category 3/3 film of small irregular opacities throughout both lung fields. (Courtesy of ILO U/C International Classification of Radiographs of Pneumoconiosis.)

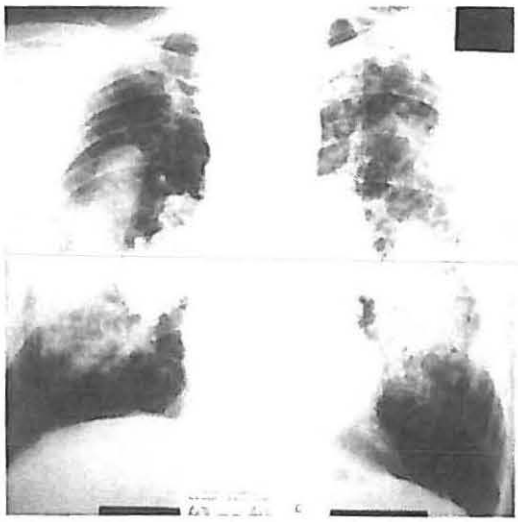

**FIGURE 4** Chest x-ray study demonstrating progressive massive fibrosis (category C large opacities) and egg shell calcification of lymph nodes. (Courtesy of ILO U/C International Classification of Radiographs of Pneumoconiosis.)

expired volume as a function of time or flow rate as a function of volume. By either method, the forced vital capacity (FVC), forced expiratory volume in one second ($FEV_1$), and flow rates at volumes less than vital capacity (e.g., $FEF_{25-75}$, or mid-expiratory flow) can be calculated. Spirometry is predominantly useful as a measure of airflow obstruction, although certain patterns suggest mixed obstructive and restrictive deficits or isolated restriction. In addition to measuring flows and volumes in this maneuver, spirometry can be used to assess reversibility of airflow obstruction by performing the maneuver before and after administration of an inhaled bronchodilator.

A decreased $FEV_1$ and preserved FVC suggest pure obstruction to air flow. A proportional decrease in flows at all volumes (e.g., decreased $FEV_1$, decreased FVC, and preserved FEV/FVC) suggests restriction; this same pattern, however, can be seen in severe and often reversible airflow obstruction. In the latter instance, administration of bronchodilators often reveals an increase of 10% or more in $FEV_1$, FVC, or both, a phenomenon not to be expected in isolated restrictive dysfunction. When spirometry suggests restriction, full pulmonary function testing is necessary to assess the true presence of reduced lung volumes (see discussion later). Table 1 provides a general guide to interpreting the results of spirometry.

It is important that the quality of spirometry be ensured for both clinical and epidemiologic studies. The following principles should be borne in mind: (1) machines should be calibrated and meet recommended standards, (2) the test should be performed by an individual trained in its use, and (3) at least two tracings should be obtained that are of acceptable quality, including appropriate shape to the flow-volume or time-volume curve, sustained for at least 6 seconds and until a plateau in FVC has been achieved, with no more than 5% difference in the FVC and $FEV_1$ obtained from the two best curves. In addition, the range of normal values is very broad such than an individual can have lost significant lung function and still have results within the normal range. Wherever possible, individual spirometric results should be compared to those obtained previously. For example, although there may be considerable day-to-day and test-to-test variation, a loss in $FEV_1$ or FVC of greater than 40 ml per year suggests a decline greater than expected. Further, as spirometry assesses function at only one point in time, normal values can be observed in the presence of transiently resolved significant reversible airflow obstruction.

### Full Pulmonary Function Tests

In addition to spirometry, full pulmonary function tests include a measurement of static lung volumes and gas exchange. Static lung volumes may be measured by nitrogen washout techniques or by plethysmography. The usual gold standard for whether or not restriction is present, total lung capacity (TLC), is measured directly, and residual volume (RV) and functional residual capacity (FRC) are calculated. The TLC is equal to the sum of the RV and the slow vital capacity (SVC); in isolated restriction, both the RV and SVC are reduced (the reduction in RV may precede other reductions in lung volumes), resulting in a lowered TLC. Air trapping results in an increase in the RV and FRC, with resultant normal (if SVC is reduced) or increased (if SVC is preserved) TLC. Accordingly, if FVC is normal on spirometry it is unlikely that significant restriction is present because

**TABLE 1 A Guide to Interpreting Spirometry**

| | Per cent predicted | | | Response to bronchodilators |
|---|---|---|---|---|
| | $FEV_1$ | FVC | $FEV_1$/FVC | |
| Obstruction | <80 | >80 | <75 | + or − |
| Restriction* | <80 | <80 | >80 | − |
| Mixed* | <80 | <80 | <80 | + or − |

*Isolated obstruction may also follow this pattern; measurement of lung volumes is necessary to establish whether or not restriction is also present.

only a reduction in RV could then account for a reduction in TLC. Plethysmography is a preferred measure of TLC in the presence of marked air trapping, because the latter may result in a falsely low or normal TLC when measured by dilution techniques.

However, if the FVC is low, this may indicate restriction (in which both the SVC and RV are reduced) or obstruction or mixed dysfuncton; the FVC may be reduced because of obstruction to air flow, in which case the SVC should be higher than the FVC because it is less sensitive to resistance to air flow.

Gas exchange is measured by the diffusing capacity for carbon monoxide (DLCO) and by arterial blood gases and the calculation of the alveolar-arterial oxygen gradient ($A\text{-}aO_2$ difference). Reductions in DLCO are seen in a number of conditions, including interstitial lung disorders and emphysema. A reduced DLCO may be the sole manifestation, for example, of functional abnormality in an individual with radiographic evidence of asbestosis. Reductions in $PO_2$ and widened alveolar-arterial oxygen gradients also are seen in an array of pulmonary diseases, including interstitial and airway disorders. Measures of gas exchange as well as static and dynamic lung volumes also depend on age. Predictive equations are available to calculate an individual's predicted $FEV_1$, FVC, FEV/FVC, DLCO, and are based on consideration of age and height. The choice of predictive equations is critical and may result in widely different per cent predicted values for a given observed value.

# Textbook of CLINICAL OCCUPATIONAL and ENVIRONMENTAL MEDICINE

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