Roentgenographic Underestimation of Early Asbestosis by International Labor Organization Classification*
Analysis of Data and Probabilities
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We analyzed the limitations of the International Labor Organization (ILO) classification of chest roentgenograms in predicting the presence of histologically determined early asbestosis. The ILO system is arbitrary, without histologic correlates, and does not consider the asbestos exposure history or clinical and laboratory information. We present data from the literature and our own work which demonstrate that the application of the ILO classification to an asbestos-exposed individual can result in a 10 to 20 percent probability of a “normal” roentgenographic interpretation in the presence of significant asbestosis at the histologic level, leading to an inappropriate conclusion regarding the presence of asbestosis. In view of the data and statistical analysis presented, we suggest that sole reliance upon the ILO classified chest roentgenogram for determination of the presence of early pulmonary asbestosis in individual cases is inappropriate.

The International Labor Organization (ILO) classification of roentgenograms of the pneumoconioses provides a method for recording abnormalities of the lungs and pleura resulting from the inhalation of inorganic dusts. First developed in the 1950s, and subsequently modified, it allows classification of the roentgenographic changes due to asbestosis as well as due to coal workers’ pneumoconiosis and silicosis.1

In addition to the clinical implications of determining the presence of asbestosis, we are in an era when the worker may receive compensation for the deleterious effects resulting from occupational exposure to asbestos dust. Originally intended primarily for epidemiologic surveys,2 there has been a growing tendency over the past 30 years to accept the ILO classified chest roentgenogram of an individual as the sole indicator of the presence or absence of asbestos-induced lung disease at the histologic level, giving the ILO classification an important role in reaching compensation decisions.

The extension of the ILO classification from its traditional role as an epidemiologic survey tool to its application to individual patients makes it imperative that we re-evaluate the significance of the ILO reading, especially in the diagnosis of early or evolving asbestosis in view of data which have emerged concerning the lack of roentgenographic-histologic correlation.

We have become aware that the chest roentgenogram tends to underestimate the presence of early interstitial lung disease. It is our purpose here to discuss those factors which lead to the underestimation of early asbestosis by the ILO classification and to calculate the frequency with which this may occur.

Problems with the Application of the ILO Classification to Individual Subjects

Many factors may make the application of the ILO classification to individual roentgenographic examinations of limited value in early asbestosis. In order to understand these factors, we reviewed the literature in search of studies describing the variables which affect the roentgenographic visualization of interstitial fibrosis. We also analyzed from the literature, as well as from our own clinical material, data describing the roentgenographic-histologic correlations in asbestos-induced lung disease.

Chest Roentgenograms Are Insensitive to Early Lung Scarring

It is well recognized that the early roentgenographic changes of pulmonary fibrosis are difficult to determine.3 The definition of what constitutes a “normal” chest roentgenogram is made even more difficult by factors such as the size of the subject being x-rayed, the x-ray technique used, the experience of the reader, and

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the bias of the ILO reader knowing that the interpretation relates to dust exposure.\textsuperscript{2,3} The finding of a "normal" chest roentgenogram in the presence of histologically significant interstitial pulmonary fibrosis can be understood by examination of known data. Parkes\textsuperscript{4} has stated that it is difficult to detect the earlier stages of diffuse pulmonary fibrosis on chest roentgenograms. The failure to visualize roentgenographically the lung lesions of patients with histologic evidence of significant interstitial lung disease may be that multiple individual lesions are too small to be resolved roentgenographically but that summation caused by the superimposition of many of such lesions along the course of an x-ray beam can account for their visibility.\textsuperscript{6,7} The resulting shadow is dependent upon the number of small lesions per unit of lung volume, and to some degree, on the repetition of the roentgenographic pattern.\textsuperscript{9} Very small lesions, or many lesions spread over a large volume of lung, are difficult to image roentgenographically until their summation effect exceeds the threshold of visibility. A well recognized example of this limitation is the failure to visualize roentgenographically the small pulmonary lesions of patients with diagnosed sarcoidosis.\textsuperscript{9,11}

The ILO Classification is Arbitrary

The ILO classification was developed by consensus rather than by reliance on histologic criteria and gives only a semiquantitative scale of increasing roentgenographic abnormality.\textsuperscript{8} It is purely descriptive and not interpretive in the histologic sense,\textsuperscript{10} although there has been some evidence in coal workers that, in general, the more opacities present on the x-ray film, the more retained dust is present in the lungs.\textsuperscript{13-15}

The ILO Classification Ignores Clinical and Laboratory Data

The ILO classification is applied by an x-ray reader without knowledge of the worker's dust exposure history, clinical symptoms, physical signs, or laboratory data.\textsuperscript{1} Further, the "B" reader qualification training program for applying the ILO classification requires neither demonstration of knowledge concerning nor expertise in any of these areas of pulmonary medicine. The ILO classification's main use has been described as being in the epidemiologic assessment of the incidence of pneumoconiosis and the efficacy of methods of dust control.\textsuperscript{18}

Marked Interobserver and Intraobserver Variations Exist

Studies have demonstrated marked differences in the interpretation of chest roentgenograms being classified by the ILO method, not only between different readers, but also with the same reader reviewing the same films at different times.\textsuperscript{16-18} For example, the interobserver variation for the assessment of the profusion of small irregular opacities of the type seen in asbestosis has been shown to be of the order of 18 percent.\textsuperscript{19}

Technical Factors Have a Great Influence on ILO Grading

There is difficulty in the ILO classification of the x-ray study of the same individual depending upon the x-ray techniques used. For instance, it has been shown that when examining films which are too "black," there is a tendency to relegate small discrete opacities to a lower category.\textsuperscript{20,21} Conversely, too high a category is apt to be assessed in underexposed films.\textsuperscript{22} Of significance in dealing with early or evolving asbestosis, observer error is recognized as being the highest for the lowest ILO classifications (ie, toward the most normal).\textsuperscript{2,3}

Failure of Roentgenographic-Histologic Correlation in Early Asbestosis

It has been axiomatic that chest roentgenograms are abnormal in the presence of diffuse interstitial pulmonary fibrosis. Reports of normal chest x-ray films in patients with diffuse interstitial fibrosis are few\textsuperscript{23} and published reports on the correlation between roentgenographic and histopathologic manifestations of asbestosis-related disease are sparse.\textsuperscript{24} In recent years, however, data have appeared which permit us to evaluate the occurrence of the normal chest roentgenogram in individuals with proven asbestosis.

Normal roentgenograms were mentioned in a series of patients with asbestosis as early as 1961.\textsuperscript{24} In 1978, in a study of a large group of patients with chronic diffuse interstitial pulmonary fibrosis, Epler and co-workers\textsuperscript{25} showed that 44 of 458 (9.6 percent) had normal prebiopsy chest x-ray films. Of these 458 patients, 58 had pulmonary asbestosis on biopsy, of which six (10 percent) had normal lungs according to the ILO classification.\textsuperscript{25}

In 1980, Gaensler and Carrington\textsuperscript{26} described 56 of 354 patients (15.8 percent) with a pathologic diagnosis of interstitial lung disease who had normal chest roentgenograms. Eight of this group had asbestosis.

In 1987, Kipen and co-workers\textsuperscript{27} studied the relationship between the roentgenographic and histologic manifestations of pulmonary asbestosis in insulation workers who had died of lung cancer and in whom tissue specimens were available to determine the extent of histologic fibrosis. Their series included 138 patients with adequate roentgenographic studies as well as adequate tissue samples of the lung, all of which showed parenchymal fibrosis. However, of the 138 cases, 25 (18 percent) had no roentgenographic evidence of parenchymal fibrosis. They concluded that a chest x-ray film which is negative for the presence of
interstitial fibrosis does not exclude asbestosis at the histologic level.

In a recent study evaluating the diagnostic implications of thickening of the visceral pleura in the interlobar fissures in asbestos exposure, we described eight of 57 patients (14 percent) with clinically diagnosed asbestosis who had normal or near normal lungs roentgenographically.27 Within this group of eight, four individuals had histologic evidence of interstitial pulmonary fibrosis associated with asbestos bodies or fibers or both.

From the literature,25-27 it is now beyond question that normal roentgenograms occur in cases of histologically-proven asbestosis. In order to help determine the frequency with which this may occur, an analysis of the conditional probability was undertaken using these data.

PROBABILITY OF A NORMAL CHEST ROENTGENOGRAM WITH HISTOLOGIC ASBESTOSIS

The probability that an individual has asbestosis despite a normal chest x-ray film can be estimated by Bayesian analysis.28 The compound probability of having both asbestosis and a normal chest roentgenogram, P(A and X-n), is expressed by the formula:

(I) \( P(A \text{ and } X_n) = P(A|X_n) \times P(X_n) \)

where \( P(A|X_n) \) is the conditional probability of having asbestosis (A) in the presence of a normal chest x-ray film \( (X_n) \), and \( P(X_n) \) is the probability of a normal chest x-ray film. Equation (I) can also be written as follows:

(2) \( P(A \text{ and } X_n) = P(X_n|A) \times P(A) \)

where, analogously, \( P(X_n|A) \) is the conditional probability of a normal chest x-ray film in the presence of asbestosis, the \( P(A) \) is the probability or prevalence of asbestosis.

In the general population, \( P(A) \), the prevalence of asbestosis, is small and \( P(X_n) \), the probability of a normal chest x-ray film, is close to one. Our analysis, however, is based upon two studies25,26 which examined the roentgenographic findings of patients with pathologically-proven pulmonary fibrosis. Epler et al.26 studied a population of patients with diffuse infiltrative lung disease and Kipen et al.28 examined a population of asbestos workers developing lung cancer who microscopically had asbestosis. In the former article, six of 58 patients with microscopically proven asbestosis had normal chest x-ray films while in the latter article, 25 of 138 patients with asbestosis had normal films. From these data, we can estimate \( P(X_n|A) \) ranges from 0.1 to 0.18. It is interesting to note that \( P(X_n|A) \) represents the false negative fraction of the chest roentgenogram's diagnostic capability to show the presence of asbestosis.

To approximate \( P(X_n) \), we note that Epler and colleagues26 achieved an overall 10 percent chance of a normal x-ray film in their accumulated population of diffuse infiltrative lung disease. The prevalence of asbestosis in their study population was 58 of 458 patients so that \( P(A) \) is approximately 0.13. Solving equations (1) and (2) above yields that \( P(A|X_n) \) is at least 0.13. Stated alternatively, within a defined population of diffuse lung disease or in asbestos workers developing lung cancers and having microscopic evidence of pulmonary asbestosis, there is a 10 to 20 percent chance that an individual has pulmonary asbestosis despite the presence of a normal chest roentgenogram.

Based upon the clinical studies described22,24-26 and the analysis of conditional probabilities performed, we conclude that the ILO classification of a “normal” roentgenogram in an asbestos-exposed individual has a significant false negative probability.

DISCUSSION

The chest roentgenogram plays a central role in the diagnosis of asbestosis, and "an abnormal chest film is routinely accepted as the only legal evidence of dust exposure in workmen's compensation cases and in industrial litigation."26 Thus, an ILO classification describing little or no roentgenographic changes in the lungs attributable to asbestos may be equated to the absence of asbestos-induced lung disease, and therefore, there being no merit to the person's claim.

We believe that, although well intentioned, the ILO classification for quantifying the roentgenographic changes in the lungs of occupationally exposed workers has become misconstrued as indicating the degree of pathologic changes present and, further, that the ILO reader has inappropriately become the definitive evaluator of the presence of early asbestosis in the lungs.

The roentgenographic diagnosis of asbestosis has historically been based upon the visualization of the typical roentgenographic patterns and the associated history of asbestos exposure.19,20 However, in the early stages of asbestos-induced interstitial fibrosis, serious problems arise when using roentgenographic determinants alone. It appears that fibrotic changes sufficient to produce the irregular opacities on the chest x-ray film indicate more advanced (or established) disease.25 The early stages of the disease, though significant pathologically, may be underestimated roentgenographically in 10 to 20 percent of the exposed individuals. These data would suggest it is time to correct the false negative bias introduced by the use of the ILO classification in early asbestos-induced disease of the lung. The presence of asbestos-induced lung disease can best be diagnosed by a complete review of clinical, roentgenographic, laboratory and, when available, pathologic data.

The analysis showing a significant false negative probability using the ILO classification or roentgenograms in early asbestosis has potentially impor
tant clinical implications. The early pulmonary lesion of asbestosis consists of discrete foci of peribronchial fibrosis with subsequent involvement of the respiratory bronchioles which spreads to alveolar walls and interlobular septae, eventually producing diffuse interstitial fibrosis. The early microscopic fibrotic changes involving the peribronchiolar regions could be responsible for symptoms, even though they are not causing sufficient fibrosis to be visible roentgenographically.

Based upon the data presented, which show a 10 to 20 percent probability of having a normal chest x-ray film in the presence of histologically-significant pulmonary asbestosis in asbestos-exposed populations, we believe that the ILO classification of "normal" should no longer be interpreted as the absence of lung disease in the asbestos-exposed individual. We believe that the ILO classified film, in isolation, is of limited usefulness in predicting the presence of early asbestos-induced disease in the individual subject and should better be reserved for epidemiologic studies, for which it was primarily developed.

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REFERENCES


3 Weill H. Diagnosis of asbestos-related disease (editorial). Chest 1987; 91:802-03


14 Rossiter CE. Relation of lung dust content to radiological changes in coal workers. Ann NY Acad Sci 1975; 200:465-77


18 Amandus HE, Pendergrass EP, Dennis JN, Morgan WKC. Pneumoconiosis: inter-reader variability in the classification of the type of small opacities in the chest roentgenograms. AJR 1974; 122:740-43


