Chest Roentgenogram in Pulmonary Tuberculosis*
New Data on an Old Test

Peter F. Barnes, M.D.;† Thomas D. Verdegem, M.D.;‡
Linda A. Vachon, M.D.;§ John M. Leedom, M.D.;∥
and Gary D. Overturf, M.D.¶

The utility of routine admission chest roentgenograms (CXR) was evaluated in detecting pulmonary tuberculosis and the relationship between roentgenographic patterns and the likelihood of finding acid-fast bacilli (AFB) on sputum smear. Of 58 patients whose chief complaints were unrelated to pulmonary tuberculosis, the CXR suggested tuberculosis in 52 cases (90 percent). In 45 cases, the emergency room physician failed to elicit the patient's respiratory symptoms and did not consider tuberculosis as a diagnostic possibility. In 18 individuals, the diagnosis was missed in the emergency room because of failure to obtain a CXR. Among patients whose roentgenograms showed cavitation or extensive alveolar infiltrate, sputum smears showed AFB in 98 percent of cases. If alveolar infiltrate was absent, or if the roentgenographic pattern was not that of adult reactivation disease, sputum smears revealed AFB in only one half of the cases. We conclude that routine admission CXRs are useful in hospitals serving populations where tuberculosis is still common, and the probability of detecting AFB on sputum smear is greatly influenced by the roentgenographic findings.

Though tuberculosis case rates continue to decline in the United States, this disease remains an important problem in certain regions, such as California and Texas. In 1986, the incidence of tuberculosis in Los Angeles county was 16.4 cases per 100,000. At our hospital, approximately 250 cases of active tuberculosis are diagnosed each year. In 1984, we began a predominantly prospective investigation to evaluate various facets of the clinical presentation of pulmonary tuberculosis.1-3 In this report, we discuss the utility of routine admission chest roentgenograms (CXR) in disease detection and the relationship of certain roentgenographic patterns to the likelihood of finding acid-fast bacilli (AFB) on sputum smear.

MATERIALS AND METHOD

From June 1984 through March 1985, 30,963 adults were admitted to the medical and surgical services of the Los Angeles County-University of Southern California Medical Center. During this period, 192 of these patients were found to have culture-proven pulmonary tuberculosis, an incidence of 6.2 cases per 1,000 adult admissions. In three cases, the CXR could not be located, and in one case, the hospital chart was unavailable. A standardized history, physical examination, and CXR were obtained for the remaining 188 patients. The history was obtained from the patient in 164 cases and from relatives or the hospital chart in 24 cases. Data were gathered prospectively in 176 patients whose sputum or tissue smears revealed AFB, or in whom tuberculosis was suspected on admission. In 12 cases diagnosed only after culture results were available, data were collected retrospectively.

Patients or their informants were questioned regarding a history of systemic symptoms (tactile fever, chills, night sweats, fatigue, weight loss of more than 2.3 kg) or pulmonary complaints (cough, sputum production, hemoptysis, chest pain, shortness of breath). The chief complaint was considered to be related to pulmonary tuberculosis if it included any of the above symptoms. Patients with pre-existing lung disease were considered symptomatic if they reported worsening of symptoms prior to admission.

During the study period, the initial CXRs of 392 patients admitted to our medical center with suspected tuberculosis were reviewed by a staff radiologist (L. V.). Of these, 188 were the patients included in the present analysis and 204 were patients in whom active tuberculosis was excluded by negative sputum and/or pulmonary tissue cultures. The radiologist was blinded to patient diagnosis and interpreted the CXRs in standardized fashion. The right and left lung fields were each divided into four zones. The area above the clavicle was considered to be the apex. The remainder of each lung was divided into thirds, termed the upper, middle and lower zones. The CXR was considered "typical" of adult reactivation tuberculosis if the apices or upper zones showed alveolar or interstitial infiltrate, or cavitation. Films without these features were considered "atypical." A "positive" CXR was defined as one that was "typical" or showed a miliary pattern. Lateral CXRs were not obtained in most cases.

The auramine-rhodamine fluorescent stain was used to detect acid-fast organisms on sputum smears. Sputum samples were spontaneously expectorated or induced by nebulization. Mycobacterial cultures were performed in our mycobacteriology laboratory, which is a reference laboratory for the College of American Pathologists. The chi-square test was used for statistical analysis.

RESULTS

Seventy-eight patients were Hispanic, 52 were black, 35 were white, 17 were Asian, and six were Native American. One hundred fifty-three patients...
were men and 35 women. The median age was 38 years, with a range of 17 to 91 years.

The frequencies of symptoms in our study population are shown in Table 1. Cough and weight loss occurred most commonly and only 5 percent of patients had neither respiratory nor systemic symptoms when specifically questioned. One hundred thirty patients (69 percent) had chief complaints commonly considered to be related to pulmonary tuberculosis. Strikingly, 58 patients (31 percent) had presenting complaints unrelated to pulmonary tuberculosis. Neurologic symptoms, abdominal pain, hematemesis, and trauma were the common reasons for medical evaluation in this subgroup. Four patients were referred to our hospital because of an abnormal CXR, obtained as part of a routine annual medical examination (Table 2).

Of the 58 patients whose chief complaints were unrelated to pulmonary tuberculosis, 45 had pulmonary or systemic symptoms upon questioning, though these symptoms were rarely elicited by the physician in the emergency medical department. The CXR was “positive” for tuberculosis in 52 cases (90 percent), including all nine persons who denied pulmonary or systemic symptoms, even on questioning (Table 3). Acid-fast bacilli were seen on sputum smears in 43 (74 percent) of these 58 patients.

Acid-fast bacilli were seen in expectorated sputum in 155 (82 percent) of 188 patients. One to eight specimens (median four) were obtained for acid-fast smear in each patient. Sputum smears revealed AFB significantly more often in patients with certain roentgenographic features (Table 4). In cavitary tuberculosis, 98 percent of cases had AFB seen on sputum smear, compared to 70 percent of cases without cavitary. Similarly, positive sputum smears were found in 90 percent of patients with roentgenographically typical adult reactivation disease, compared to half of those with atypical CXR findings. Sputum smears revealed AFB in almost all patients with extensive alveolar infiltrate (involvement of at least three lung zones). On the other hand, positive smears were found in fewer than one half of the patients without alveolar infiltrate, in whom roentgenographic abnormalities consisted of interstitial disease, nodules, scarring, or a miliary pattern. The roentgenographic findings in patients whose CXRs were “atypical” are shown in Table 5. Miliary disease and lower lung field infiltrates were the most common patterns observed. Pleural or parenchymal scarring or both were seen in several cases and normal CXRs in two patients.
Table 5—Roentgenographic Findings in 36 Patients with Atypical Chest X-Ray Findings

<table>
<thead>
<tr>
<th>Roentgenographic Findings</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miliary pattern</td>
<td>8</td>
</tr>
<tr>
<td>Infiltrate in middle and/or lower zones</td>
<td>14†</td>
</tr>
<tr>
<td>Cavities in middle and/or lower zones</td>
<td>4‡</td>
</tr>
<tr>
<td>Nodule(s) in upper zones and/or apices</td>
<td>3‡</td>
</tr>
<tr>
<td>Pleural scarring</td>
<td>2</td>
</tr>
<tr>
<td>Parenchymal scarring</td>
<td>2</td>
</tr>
<tr>
<td>Right middle lobe collapse and right hilar adenopathy</td>
<td>1</td>
</tr>
<tr>
<td>Normal CXR</td>
<td>2</td>
</tr>
</tbody>
</table>

*Three of these patients had hilar adenopathy, four had pleural or parenchymal scarring.
†One patient had hilar adenopathy.
‡One patient had hilar adenopathy, one had pleural scarring.

Eleven patients were referred to our hospital by community physicians for suspected tuberculosis. Of the remaining 177 patients evaluated in the emergency medical department, tuberculosis was not considered in 64 (36 percent). In 17 of these 64 cases, the roentgenographic findings were not suggestive of active tuberculosis. In the remaining 47 cases, tuberculosis should have been suspected on the basis of CXR abnormalities. However, the diagnosis was not made because of the following: (1) failure to obtain a CXR in patients whose chief complaints were unrelated to pulmonary tuberculosis (18 cases); (2) failure to consider tuberculosis despite the presence of apical or upper zone infiltrates (24 cases); and (3) failure to appreciate a miliary pattern on CXR (five cases). Without these errors, the possibility of tuberculosis would have been considered in the emergency room in 90 percent of cases.

**Discussion**

**Routine Admission Chest X-Ray Films**

Though unusual roentgenographic patterns in tuberculosis have recently been emphasized in the literature, the typical findings of reactivation disease are still seen in most adults with tuberculosis. These findings characteristically include upper lobe infiltrates and/or cavitation. Lower lung field tuberculosis, defined as pulmonary involvement confined to the area below an imaginary horizontal line drawn across the hila and including the parahilar regions, is seen in a minority of cases. Since lateral CXRs were usually not obtained in our patients, the exact anatomic location of the roentgenographic abnormalities could not be determined in some patients. However, in most cases, patients we classified as having disease in the apices or upper zones had tuberculosis in the upper lobes, while patients with disease in the middle and lower zones had tuberculosis of the middle or lower lobes.

To our knowledge, there are no published reports systematically evaluating the chief complaint in pulmonary tuberculosis. Our predominantly prospective study revealed that 31 percent of patients had presenting complaints unrelated to tuberculosis (Table 2). However, most of these patients admitted to respiratory and/or systemic symptoms when questioned in further detail (Table 3). If a careful history had been obtained, only nine patients would not have had a chest x-ray film performed on admission. Regrettably, the emergency room physician rarely elicited these symptoms, so that a CXR was often not ordered, and the diagnosis of tuberculosis not considered. In a busy emergency medical department, physicians tend to focus on the present chief complaint, and often do not perform a detailed review of systems. At our facility, CXRs are recommended for all admissions, though they are sometimes not obtained. During our ten-month study period, emergency room physicians missed the diagnosis of tuberculosis in 18 patients because of failure to obtain a CXR when the chief complaint was neither pulmonary nor systemic in nature. Thirteen of these cases were smear-positive, and thus, potentially highly infectious. This obviously underestimates the number of cases that would have been missed if screening CXRs were not done at all. Within the subgroup of patients whose presenting complaints were unrelated to pulmonary tuberculosis, the CXR was suggestive of tuberculosis in 90 percent of cases (Table 3). Our data do not allow us to assess the cost of roentgenographic screening for tuberculosis. Of the 30,900 adults admitted to our hospital during the study period, the majority require CXRs for medical reasons. In the absence of a prospectively performed study, we have no data on the number or cost of CXRs that are performed purely for screening purposes.

The cost-effectiveness of routine admission CXRs has recently been questioned. In one prospective study, no cases of tuberculosis were detected in 294 consecutive patients in whom screening admission CXRs were obtained. Specialty societies have recommended that the practice of screening chest roentgenography be discontinued. Feingold concluded that routine admission CXRs were not useful in detecting tuberculosis because patients usually had symptoms and should have had CXRs performed to evaluate them. However, in Feingold’s series of patients seen over a one-year period, six cases would have been detected on admission if screening CXRs had been obtained and properly evaluated. Though one can generally identify symptoms in retrospect as having been due to tuberculosis, our data and those of Feingold suggest that these symptoms are often not elicited by the emergency room physician. A routine admission CXR facilitates the diagnosis and treatment...
of pulmonary tuberculosis in patients whose presenting complaints are neither respiratory nor systemic in nature.

Routine admission CXRs are probably not indicated in most hospitals in the United States, where the prevalence of tuberculosis is low and continuing to decline. However, at least two recent reports have confirmed the utility of screening roentgenography in certain populations. Investigators in Texas found pre-operative CXR screening useful in detecting unsuspected tuberculosis,15 and 1.2 percent of inner-city Vancouver residents were found to have CXR findings suggestive of active tuberculosis when roentgenographic screening was performed.16 Our data suggest that in regions where tuberculosis remains a significant health problem, the screening admission CXR is useful in hospitals such as ours, serving predominantly indigent populations in whom the prevalence of tuberculosis is particularly high.

A disturbing finding of our study was the failure of the emergency room physician to consider the diagnosis of tuberculosis in 36 percent of patients. This occurred in 29 cases despite the presence of typical reactivation disease or a miliary pattern. We believe that this reflects the unfamiliarity with tuberculosis displayed by many recently-trained physicians. Tuberculosis may be given too little attention in the curricula of many medical schools. Because of the rarity of the disease in most parts of the United States, many physicians-in-training never see a case of tuberculosis. The failure to diagnose tuberculosis in patients admitted to the hospital has obvious public health consequences, exposing patients and hospital staff to a potentially life-threatening infection. More emphasis needs to be placed on the education of physicians regarding tuberculosis in regions such as southern California, where this disease continues to cause significant morbidity and mortality.

Sputum Smear Results and Roentgenographic Patterns

Eighty-two percent of our patients had AFB seen on sputum smears, compared to 41 to 72 percent smear positivity noted in the literature.4,17-19 Our higher percentage may reflect two factors—more extensive disease in our patients and the greater sensitivity of fluorescent microscopy in detecting AFB, compared to the Ziehl-Neelsen staining method.

It is generally accepted that patients with roentgenographic cavitation or extensive alveolar infiltrate are more likely to have AFB seen on sputum smear than patients without these features. Similarly, negative sputum smears are said to be more common in primary infections,5 miliary tuberculosis,8 and disease confined to the lower lung fields,8,21 compared to the typical CXR pattern of reactivation tuberculosis. Despite the well-known association between the likelihood of positive sputum smears and the various roentgenographic features noted above, no studies have attempted to quantify this relationship in a large series of patients.

Our data provide an estimate of the probability of a positive smear for AFB in the setting of various roentgenographic patterns. The presence of cavities or alveolar infiltrate involving three or more lung zones was associated with a positive sputum smear in 98 percent of cases. The absence of AFB on sputum smear in these situations should call into question the diagnosis of tuberculosis. Other entities which may mimic tuberculosis roentgenographically, such as fungal disease, cavitating carcinoma, and melioidosis, should be given serious diagnostic consideration.

In some patients, the CXR showed no alveolar infiltrate, ie, interstitial infiltrate; a miliary pattern, nodules, pleural or parenchymal scarring were the only abnormalities noted. Sputum smears revealed AFB in fewer than one half of these cases. Similarly, in patients whose CXRs did not show the typical pattern of reactivation tuberculosis, positive sputum smears were noted in only 50 percent. In these situations, a negative sputum smear for AFB does not allow one to exclude tuberculosis with confidence. Bronchoscopy is helpful in documenting tuberculosis when sputum smears fail to reveal AFB,8,23 and should be strongly considered in these patients if tuberculosis remains an important diagnostic possibility.

ACKNOWLEDGMENT: We would like to thank Dr. Om Sharma for critically reviewing the manuscript, the Mycobacteriology Laboratory staff for their assistance, and Jane Sindayen for her expert help in preparation of the manuscript.

REFERENCES

2 Barnes PF, Chan LS, Wong SF. The course of fever during therapy of pulmonary tuberculosis. Tubercle, 1987; 68:255-60
3 Barnes PF, Leedom JM, Chan LS, Wong SF, Vachon LA, Overturf GD. Predicting prognosis in pulmonary tuberculosis. Program and Abstracts of the 26th ICAAC 1986;103
5 Miller WT, MacGregor RR. Tuberculosis: frequency of unusual radiographic findings. Am J Roentgenol 1978; 130:867-75
6 Farman DE Speir WA. Initial roentgenographic manifestations of bacteriologically proven Mycobacterium tuberculosis: typical or atypical? Chest 1986; 99:75-77
7 Hadlock PF, Park SK, Awe RJ, Rivera M. Unusual radiographic findings in adult pulmonary tuberculosis. AJR 1980; 134:1015-18
8 Berger HW, Granada MG. Lower lung field tuberculosis. Chest 1974; 65:522-26
9 Tape TG, Mushlin AI. The utility of routine chest radiographs. Ann Intern Med 1986; 104:663-70
10 Robin ED, Burke CM. Routine chest x-ray examinations. Chest
17 Macgregor RR. A year’s experience with tuberculosis in a private urban teaching hospital in the postsanitorium era. Am J Med 1975; 58:221-27
18 Kecharananta P, Woolf CR. Active pulmonary tuberculosis in a large general hospital. Can Med Assoc J 1968; 98:30-33
19 Steininger WJ, Howard WL. A study of retreatment cases vs original treatment cases of pulmonary tuberculosis. Dis Chest 1959; 35:480-93
20 Munt PW. Miliary tuberculosis in the chemotherapy era: with a clinical review in 69 American adults. Medicine 1971; 51: 139-55