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## Radiographic Screening for Tuberculosis in a Large Urban County Jail

### SYNOPSIS

**Objective.** This study was designed to evaluate an innovative program of high speed radiographic screening for pulmonary tuberculosis (TB) at a large urban correctional institution, Cook County Jail in Chicago.

**Methods.** From March 1992 to February 1994, 126,608 inmates were screened on intake with a 100-mm mini-chest radiograph.

**Results.** Sixty-seven cases of active TB were identified by radiograph and 19 others from diagnostic work-up. The case finding rate for active disease with radiographic screening was approximately double the rate previously achieved with Mantoux skin testing. Mean time from jail entry to isolation was reduced from 17.6 days with Mantoux skin testing to 2.3 days with radiographic screening.

**Conclusions.** In large jail facilities, high speed X-ray screening for TB can minimize disruption of the intake process and lead to dramatic improvements in the efficiency of medical follow-up and isolation.

Jails, unlike prisons, are primarily short-term detention centers for people awaiting trial; they also house some convicted inmates serving short sentences. The jail population includes individuals who, although presumed innocent, are unable to secure bail and are thus detained until the allegations against them are adjudicated. In mid-1991, local jails in the U.S. held an estimated 426,000 men and women, and over the course of that year, they released approximately 10 million people.

Reported rates of tuberculosis (TB) in jails and prisons are more than six times higher than those for the general population.<sup>1-3</sup> Jails and prisons concentrate individuals at high risk for TB or noncompliance with therapy, including those who are alcoholic, homeless, HIV-infected, and foreign born. Rapid transmission of TB within correctional facilities, promoted by overcrowding and poor ventilation, has been described.<sup>4-8</sup> Because inmates' housing assignments change frequently, those who come into jail with infectious TB can expose the other inmates and members of the correctional staff to TB. In addition, those who acquire TB in jail will return to their families and communities and may expose others. In recent years, according to John Kuharich, Director of Tuberculosis Control at the Chicago Department of Health, more than 20% of TB patients registered with the Chicago Department of Health and about 30%

of TB patients who were on home-supervised therapy were released inmates from Cook County Jail. Despite detaining a high risk population, many jails provide little or no screening for TB. Radiographic screening was commonplace in jails and prisons during the 1940s and 1950s, but for a variety of reasons it has been replaced by Mantoux tuberculin skin testing in more recent years as a means of screening for active TB disease.

In 1992, Cermak Health Services, the health care provider for inmates in the Cook County Department of Corrections, began a program of radiographic screening for TB at Cook County Jail in Chicago. The decision to install a high speed X-ray screening unit was prompted by the inefficiencies of Mantoux tuberculin skin testing in detecting infectious TB; missed and delayed diagnosis of infectious TB resulted in prolonged inmate and staff exposure to detainees with active TB.

Mantoux skin tests are supposed to be read from 48 to 72 hours after administration. Assuming ideal medical follow-up of a positive Mantoux skin test, a chest X-ray to rule out TB should be done 72 hours after administration of the skin test. In practice, once an inmate leaves an intake area it is much more difficult to perform medical follow-up. This is particularly problematic at Cook County Jail, where approximately 9000 men and women are housed in 13 buildings scattered over 80 acres. Court appearances and family and attorney visits add to the difficulty in locating inmates.

A 1986 internal Cook County Jail audit, performed prior to the decision to install radiographic equipment, found that for 49% of a sample of inmates who tested positive, medical personnel took 50 days or more to completely follow up a positive Mantoux skin test. Mean time to isolation of inmates with active TB was 17.6 days. Delays in follow-up of Mantoux tuberculin skin testing in that period also led to 43% of inmates with positive skin tests being discharged from the jail before a diagnostic work-up was completed.

High speed radiographic screening was seen as a possible solution to these problems. Fast and low dose X-ray screening was also expected to reveal other illnesses that would be sensitive to early detection and treatment. This report describes the results of two years of chest X-ray screening for TB at Cook County Jail.

## Methods

**Population screened.** From 1988 to 1992 the Cook County Jail's average daily census increased 65%, from 5327 to

8789. The mean length of stay over this period varied from 30 to 45 days. The rated capacity of the jail was constantly exceeded, reflecting the rapid growth of incarceration nationwide. During this period, on an average day from 9% to 28% of inmates slept on the floor in an environment of recirculated air.

Typically, inmates are delivered to the jail from criminal courts throughout the county in the evening hours, between 4 PM and midnight. After correctional processing, inmates

are presented to health care personnel for screening. All inmates who enter the facility are screened for TB. On average, during the study period, approximately 175 detainees were screened for TB per day.

**Screening procedure.** Prior to 1992, screening for TB at Cook County Jail consisted of a Mantoux tuberculin skin test with a follow-up X-ray for those who reacted positively. This testing was part of an intake medical evaluation

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that included a self-administered questionnaire about prior health conditions and current symptoms. Since 1992, the TB screening procedure has consisted of a mini-chest radiograph taken with a Siemens T-57 Thorax unit with an image intensifier. Inmates receive chest X-rays followed by the self-administered questionnaire. Inmates are lined up, then one by one enter a lead-shielded room in which the film is taken. The entire process of taking a patient into the room, positioning the patient, and exposing the film takes between 45 seconds and one minute. The films are each produced as a single 100-mm-square radiograph, with 120 films per cassette. Because the 120 films are taken sequentially with no reload, the screening process is very fast. The mini-chest radiographs deliver only one-tenth the radiation dose of a standard 14-by-17-inch radiograph. This is a benefit in jails where recidivism may result in rescreening some inmates once or more a year.

Films are developed each evening and are ready for a radiologist to read the following morning. The radiologist classifies each film as normal, abnormal but not TB, suggestive of inactive TB, or suspicious for active TB. Inmates whose films are classified as suspicious for active TB are immediately evaluated by TB clinic staff during working hours and by an on-site staff physician during all other hours. There is a physician on duty at the jail 24 hours a day. Inmates with suspicious radiographs who require isolation are sent to Cook County Hospital.

**Study protocol.** With radiologic screening, individuals with potentially active TB can be identified within 16 hours of

the X-ray being taken. The evaluating physician, after a history and physical exam, decides whether the patient needs respiratory isolation. During working hours, one induced sputum is taken before a patient is sent to Cook County Hospital for isolation. Diagnosis of TB is confirmed based on a culture positive for *Mycobacterium tuberculosis*. Aside from patients who have cultures positive for *Mycobacterium tuberculosis*, patients are diagnosed as TB cases if their clinical and radiographic presentation is consistent with TB and there is radiographic improvement with therapy.

Patients are routinely classified on the basis of X-ray and culture using the American Thoracic Society Diagnostic Standards and Classification of Tuberculosis.<sup>9</sup> Patients with suspected TB who were discharged from the institution prior to diagnosis and were lost to follow-up by the local department of health were classified as TB suspect (Class 5, diagnosis pending).

For this study, we calculated positive screening rates for all screened inmates for active, Class 3 TB, including extrapulmonary TB; Class 4, inactive or previously treated TB; and Class 5, suspected cases. Detection rates are approximate given that a small proportion of inmates may have been incarcerated and screened more than once during the study period.

**Risk factors.** The authors reviewed the TB clinic staff records of all inmates with Classes 3,4, and 5 TB to determine the prevalence of the five known TB risk factors: homelessness; alcoholism (a risk for noncompliance with therapy); intravenous drug use; and for the subset of inmates undergoing HIV testing, HIV status.

**Results**

During the 12 months prior to the inception of high-speed radiographic screening, 46,711 skin tests were performed; this represented about 75% of the approximately 62,000 inmates admitted that year. A total of 30,743 (66%) of these tests were read, yielding 5438 positive tests. Twenty-six cases of Class 3 TB were identified, many during the diagnostic work-up. These 26 cases included inmates with extrapulmonary and newly diagnosed TB as well as inmates who knew they had TB prior to incarceration.

During the 24-month period from March 1, 1992, to February 28, 1994, a total of 126,608 screening chest X-rays were taken. From a total of 388 suspicious radiographs, 67 Class 3, 98 Class 4, and 65 Class 5 TB cases were tentatively identified (Table 1). Thirty-five of the 67 Class 3 cases were newly diagnosed at the jail; the other 32 cases had been diagnosed previously.

Nineteen additional Class 3 cases were identified during the diagnostic work-up in inmates whose radiographs were normal. These included six cases of extrapulmonary TB and 11 cases of known pulmonary TB patients under treatment (eight of these individuals were HIV-positive, one was HIV-negative, and two were of unknown serologic status).

**Table 1. Radiographic screening for tuberculosis, Cook County Jail, March 1992–February 1994 (N=126,608 inmates screened)**

	Cases identified	Approximate rate per 100,000
Class 3 (active disease) . . . . .	86	68
Class 4 (inactive or . . . . . previously treated)	98	77
Class 5 (suspected) . . . . .	65	51
<b>Total . . . . .</b>	<b>249</b>	<b>197</b>
<b>Class 3 cases</b>		
Identified with radiographic screening . . . . .	67	53
Newly diagnosed cases identified with radiographic screening . . . . .		
	35	28

Two additional inmates developed pulmonary TB while in jail, both cases of reactivation.

Thus, 86 cases of active TB were identified in the jail over the 24-month study period: 67 diagnosed by X-ray and 19 by diagnostic work-up. Seventy-four (86%) of these individuals were culture-positive; others were confirmed by improvement on radiograph after therapy. Of the 74 culture positives, 57 were studied for antibiotic sensitivities. Eleven showed resistance to one or more drugs; three showed resistance to two or more drugs. The overall case rate was approximately 68 per 100,000 inmates screened, with an approximate rate of 53 per 100,000 directly identified from X-rays. For patients needing respiratory isolation, the mean time from intake into the jail until the patient was sent into respiratory isolation was 2.3 days.

Table 2 presents a breakdown of self-reported risk factors (other than HIV, for which not all inmates were tested) for inmates with a positive TB screen. The risk behavior seen most often among Class 3 TB cases was alcoholism. Fifty-one of 86 (59%) inmates with TB described themselves as alcoholics. Twenty-one of 86 (26%) inmates with active TB reported being homeless; 32 of 86 inmates (37%) with active TB described themselves as intravenous drug users. These risk behaviors were seen more frequently in inmates with active TB than in other TB classes.

HIV rates were high in the Class 3 TB group. Of the 86 inmates with active TB, 48 (56%) were not HIV tested, 25 (29%) were HIV-positive, and 13 (15%) were seronegative. Based on an anonymous serological survey of 750 inmates at Cook County Jail, the current rate of HIV infection in the facility is about 4%.

Of the 388 suspicious radiographs, 158 were determined not to indicate TB. Table 3 summarizes the other illnesses detected. Forty-five of these 158 inmates (28%) had either confirmed or probable sarcoidosis. Notably, there were six cases of other mycobacterial illnesses.

**Table 2. Self-reported risk factors for inmates positively screened for tuberculosis, Cook County Jail, March 1992–February 1994**

TB Class	Total	Homeless	Alcoholic	Intravenous Drug Use	Multiple Risks	1 or More Risks
	Cases					
Class 3	86	21 (24%)	51 (59%)	32 (37%)	33 (37%)	68 (79%)
Class 4 (inactive or previously treated)	98	16 (16%)	59 (60%)	24 (24%)	24 (25%)	69 (70%)
Class 5 (suspected)	65	9 (14%)	23 (35%)	21 (32%)	16 (25%)	19 (29%)
Total	249	46 (18%)	133 (53%)	77 (31%)	106 (26%)	156 (63%)

NOTE: Self-reported rates of HIV infection are not included because not all inmates were tested for HIV.

## Discussion

Screening for TB infection remains problematic in large correctional settings. Many jails continue to screen for active disease using the Mantoux skin test with a follow-up chest X-ray. Two follow-up health care visits are required for skin test screening (reading the test and performing the follow-up radiograph), while only one follow-up visit is required to screen for TB disease using chest radiography.

For health care and correctional staff, finding a patient with infectious TB is a more urgent task than finding those with TB infection. The numbers of positive Mantoux skin tests are significantly higher than the numbers of positive x-ray films (for our study an estimated 22,400 positive skin tests in one year in contrast to 407 abnormal screening radiographs in two years), so the added burden to correctional staff to move around patients with positive skin tests cannot be overestimated.

Skin test screening for TB also results in delayed diagnosis and therefore a delay in isolating those with potentially infectious disease. In previous years, inmates with positive skin tests often waited many weeks before complete evaluation and isolation, as compared to 2.3 days with radiographic screening. This dramatic reduction in length of time until isolation has unquestionably reduced the exposure of noninfected inmates and jail staff to the disease.

Finally, the large number of homeless people among our active cases indicates the importance of case finding during

incarceration, which is facilitated by high speed radiologic screening. Once discharged, this population is difficult to locate. Future considerations might be to provide case management as well as congregate housing arrangements after discharge from jail in order to improve this group's chances of completing TB therapy.

**TB screening and HIV.** Since 1985, the HIV epidemic has produced a resurgence in TB in correctional institutions. Outbreaks in California and New York correctional institutions involving multidrug-resistant TB<sup>2,3,6</sup> have been driven, in part, by the HIV epidemic.<sup>10</sup> In our study population, eight of the 86 inmates with active TB were resistant to one drug while three were resistant to two or more drugs.

The prevalence of HIV infection also complicates skin testing for TB. The skin test lacks sensitivity in patients with active TB disease, possibly due to HIV-caused anergy. On average, from 10% to 25% of patients with active TB do not react to tuberculin.<sup>11</sup> The usefulness of skin tests will decrease as the numbers of HIV-infected increase in correctional settings. The rate of HIV infection in correctional settings varies, but overall the incidence of AIDS in state and Federal correctional facilities is approximately 20 times higher than in the U.S. population.<sup>12</sup> One concern with radiographic screening is that patients with HIV and pulmonary TB may have atypical presentations on radiographs, including normal chest X-rays.<sup>13</sup>

**Cost-effectiveness.** While a formal cost-effectiveness analysis of radiographic screening is not within the scope of this report, the costs of this screening method can be briefly approximated. Three extra radiological technicians and one clerk were added to staff this program. The staff radiologist reads all films each morning as part of assigned duties. Amortizing the equipment and construction costs over 10 years (estimating 70,000 screening films per year) yields a cost per study of \$0.57. The cost of film is \$0.25 per exposure. Labor cost is approximately \$1.85 per study. Other variable costs (including repairs, maintenance, and utilities) are estimated at approximately \$0.45 per study. This yields a total cost per inmate screened of a little more than \$3.00. Based on our screening data, these costs represent a total

**Table 3. Other diagnoses detected by radiographic tuberculosis screening, Cook County Jail, March 1992–February 1994 (N=126,608 inmates screened)**

Sarcoidosis/probable sarcoidosis	45
Other infections	23
Pleural disease other than tuberculosis	15
Probable cancer	14
Other mycobacteria	6
Coin lesions	6
Histoplasmosis	3
Other	46
Total	158

cost of about \$5700 per active case identified or about \$10,800 per new case identified. If Class 5 cases are included, the cost per case identified is about \$3000.

## Conclusions

Our data show that we approximately doubled the TB case finding rate by utilizing mini-chest X-ray screening. There is no evidence to suggest that this increase reflects an increase in disease prevalence in the Cook County Jail over the three years studied. Our screening process caused minimal disruption of the correctional intake process. In addition, using chest X-rays dramatically reduced the amount of time until a patient was identified as having active TB and then isolated. Radiological screening assisted us in identifying old cases and promptly restarting these inmates on therapy. Given the increased prevalence of risk factors, the Advisory Council on the Elimination of Tuberculosis's revised screening guidelines suggest that radiographic TB screening could be an important public health service in short-term correctional institutions.<sup>1,14</sup>

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