Transmission of Multidrug-Resistant Mycobacterium tuberculosis among Persons Exposed in a Medical Examiner's Office, New York

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TRANSMISSION OF MULTIDRUG-RESISTANT *MYCOBACTERIUM TUBERCULOSIS* AMONG PERSONS EXPOSED IN A MEDICAL EXAMINER'S OFFICE, NEW YORK

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ABSTRACT

OBJECTIVE: To determine the prevalence of and risk factors for having a positive tuberculin skin test (TST) result among employees at a medical examiner's office (MEO).

DESIGN: Cohort study, environmental investigation.

SETTING: Several employees at a medical examiner's office were found to have positive TST results after autopsies were performed on persons with multidrug-resistant tuberculosis (MDR-TB).

PARTICIPANTS: Employees of the MEO.

RESULTS: Of 18 MEO employees, 5 (28%) had a positive TST result; 2 of these 5 had TST conversions. We observed a trend between TST conversion and participation in autopsies on persons with MDR-TB (2 of 2 converters versus 3 of 13 employees with negative TST; relative risk = 4.3; 95% confidence interval 1.61 to 11.69; $P = 0.10$). The environmental investigation revealed that the autopsy room was at positive pressure relative to the rest of the MEO and that air from the autopsy room mixed throughout the facility.

CONCLUSIONS: A systematic approach to preventing transmission of *Mycobacterium tuberculosis* in autopsy suites should include effective environmental controls and routine tuberculin skin testing of employees (*Infect Control Hosp Epidemiol* 1995;16:160-165).

INTRODUCTION

In 1991 in upstate New York, an outbreak of multidrug-resistant (MDR) tuberculosis (TB) occurred among prisoners in a New York State prison with subsequent nosocomial transmission in the hospital where they were treated.[1,2] All of the inmates had human immunodeficiency virus (HIV) infection, and mortality rates were high. As required by law, after death, they underwent complete autopsies at the county Medical Examiner's Office (MEO).

In the fall of 1991, after the MEO instituted a tuberculin skin-test (TST) screening program for its employees, several MEO employees were found to have positive TST results. Employees and health officials were concerned that the TST results represented new tuberculous infection resulting from exposure to MDR-TB during the autopsies on inmates. In February 1992, we conducted an investigation to determine the extent of tuberculous infection among MEO employees and risk factors associated with having a positive TST result. We also conducted an environmental investigation at the MEO to assess engineering controls used to prevent TB transmission.

METHODS

The MEO is an 8,000-square-foot, single-story building constructed in the early 1970s, containing 11

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rooms and one autopsy suite. MEO personnel perform approximately 900 autopsies per year on persons who die within a 13-county catchment area. In addition to performing autopsies for all deaths that are not attributable to preexisting medical conditions, the MEO is required to perform complete autopsies on all persons who die while incarcerated in any of the 14 state correctional facilities in the MEO catchment area. HIV serologic testing is done routinely as part of all autopsies. Specimens are submitted for culture and smear examination for TB if the autopsy findings suggest active TB.

We reviewed the records of autopsies performed on all HIV-infected persons for findings suggestive of active TB. In addition, we asked MEO employees to recall autopsies performed during 1991 in which the findings on gross examination were consistent with active TB. We matched New York State (NYS) death certificates of persons who died of TB and the NYS TB registry to the MEO list of autopsies performed during 1991. We reviewed MEO autopsy records for persons with suspected or culture-confirmed TB who died during 1991. We noted the names of MEO employees who had participated in these autopsies, as well as the time and duration of each autopsy. Because infective aerosols that may have been generated from these autopsies might remain in the room after the autopsy, we defined exposure periods as the 2-, 4-, or 12-hour period after an autopsy on a person with TB. Work schedules were assessed to determine the presence of MEO employees in the building during these exposure periods. *Mycobacterium tuberculosis* isolates from persons with confirmed TB were tested for drug susceptibilities and restriction fragment length polymorphism (RFLP) patterns at the Centers for Disease Control and Prevention (CDC).[3,4]

Before 1991, the MEO did not have a written protocol for employee tuberculin skin testing. To determine the prevalence of tuberculous infection among MEO employees, we reviewed available TST results and the dates persons were present at the MEO during 1991. TSTs were performed by the Mantoux procedure, with the intradermal injection of 0.1 mL of purified protein derivative tuberculin containing 5 tuberculin units into the volar surface of the forearm. Induration was measured by staff from the county health department using standard techniques.[5] Because of the concern of possible recent transmission of TB during autopsies, a positive TST result was defined as ≥5 mm of induration 48 to 72 hours after injection. A negative TST result was defined as <5 mm of induration.

To identify risk factors associated with having a positive TST result, we administered questionnaires to MEO employees who had worked at the facility for at least 1 month during 1991. Information collected included demographic data, history of bacille Calmette-Guérin (BCG) vaccine, immunocompromising conditions, job description, previous employment, possible TB exposure outside the MEO, and the reported use of protective clothing and equipment during autopsies and while cleaning the room after autopsies.

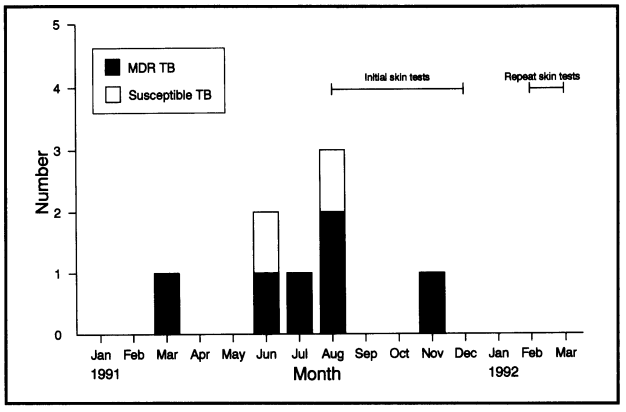

FIGURE. Autopsies performed at the medical examiner's office on persons with tuberculosis, 1991.

In March 1992, an environmental investigation was conducted by industrial hygienists from the National Institute for Occupational Safety and Health (NIOSH).[6] To evaluate air distribution within the autopsy room and adjacent office areas, hygienists measured airflow using a Shortridge Airdata Multimeter/Flowhood Model 860/8405 (Shortridge Instruments Inc, Scottsdale, AZ). Using the measured airflow rates, hygienists calculated the theoretical number of air changes per hour in the autopsy room. A fog-generating device (Rosco Model 1500, Port Chester, NY) was used to visualize airflow patterns. Smoke tubes (Sensidyne Smoke Tester Tube, Orr Safety, Louisville, KY) were used to make a visual assessment of the air pressure differential at the autopsy room door. Ultraviolet (UV) radiation measurements were made using a calibrated IL1400A radiometer and SEL 240 detector (International Light Inc, Newburyport, MA).

Categorical variables were analyzed using Mantel-Haenszel chi-square, or Fisher's Exact Test when appropriate. Relative risks (RR) with 95% confidence intervals (CI_{95}) were calculated using the methods of Taylor. Continuous variables were analyzed using the Kruskal-Wallis test. All analyses were performed with Epi Info version 5.01b (CDC, Atlanta, GA).

RESULTS

Of the 881 autopsies performed by MEO personnel during 1991, 35 (4%) were performed on inmates. Eight persons (1%) with autopsies either had TB confirmed by culture prior to death or, at the time of death, had acid-fast bacillus (AFB) smear-positive

TABLE
CHARACTERISTICS OF FIVE MEO EMPLOYEES WITH NEWLY DISCOVERED POSITIVE TUBERCULIN SKIN-TEST (TST) RESULTS

Age/Sex	Job Title	Possible Exposure to TB Outside MEO	Years at MEO	Date and Size of TST
34/M	Forensic investigator	Funeral director (1982 to 1985); Part-time police officer (present)	7	8/91, 50 mm
37/M	Morgue assistant	Respiratory therapist (1987 to 1988)	4	8/91, 24 mm
56/F	Secretary	None	27	8/91, 30 mm
44/M	Morgue assistant	None	16	9/91, 0 mm; 2/92, 21 mm
34/F	Morgue assistant	None	6	9/91, 0 mm; 2/92, 25 mm

specimens and were diagnosed with and were being treated for TB, but the positive culture results were not yet available. All eight were inmates of state correctional institutions. Autopsies were performed the day after death for seven inmates and 2 days after death for the eighth; dates of their autopsies are shown in the Figure. Of these eight, seven (88%) were coinfected with HIV. Six had MDR-TB, and two had drug-susceptible TB. Of the two inmates with drug-susceptible TB, one was not coinfected with HIV. He had been diagnosed with TB 15 months before he died, and he had completed antituberculous therapy. The other inmate with drug-susceptible TB was coinfected with HIV. He had been diagnosed with TB 3 months before he died, and he had received adequate antituberculous therapy for more than 2 months. This inmate died of other HIV-related illnesses. For both inmates, sputum smears and cultures had converted from positive to negative. For these reasons, the two inmates with drug-susceptible TB were not considered contagious at the time of death, and they were excluded from further analysis. In contrast, the six inmates with MDR-TB, all coinfected with HIV and all with CD4 T-lymphocyte cell counts less than 10 cells/μL, were considered contagious at the time of death. None had received adequate therapy for MDR-TB, and all six inmates had specimens obtained within the 2 days before death that were smear and culture positive. All had autopsy findings consistent with extensive disseminated disease.

For 5 of the 6 inmates with MDR-TB on whom an autopsy was performed, *M tuberculosis* isolates were resistant to isoniazid, rifampin, streptomycin, ethambutol, ethionamide, rifabutin, and kanamycin; these strains had identical RFLP patterns and were part of an outbreak in one of the New York state prisons.[1] The isolate for the sixth inmate showed resistance to isoniazid, rifampin, and ethambutol; however, because this isolate was not available, RFLP analysis could not be performed.

Twenty-one MEO employees had worked at the MEO for at least 1 month during 1991. The first period of tuberculin skin testing took place between August 1 and December 31, 1991 (Figure). Two employees, a physician and an administrator, had positive TST results before being employed at the MEO, and they were not retested; a third employee (a morgue assistant) refused to be tested. Of the remaining 18, 3 (17%) had positive TST results (all ≥20 mm); none of the 3 had received a baseline TST in the previous 2 years (Table).

The second period of tuberculin skin testing took place between February 1 and March 31, 1992. Thirteen of 15 employees who had negative TST results during the first testing were retested; 2 had TST conversions (0 mm to > 20 mm; Table). Neither of these two persons (both morgue assistants) had any identified exposure to *M tuberculosis* outside the MEO between July 1991 and February 1992. The two employees who were not retested in February were no longer employed by the MEO. However, they had received their first TST at least 3 months after they had left the MEO. Therefore, retesting in February was not necessary for these persons, and they were included in all analyses. All five MEO employees with positive TST results received chest radiographs; none had active TB. All began receiving preventive therapy with isoniazid; alternative therapy (pyrazinamide and a quinoline) was suggested by CDC because of known exposure to MDR-TB.[7]

To avoid difficulties in the interpretation of a positive TST result without baseline data, we included in our analysis of risk factors only the 13 MEO employees with negative TST results and the two converters. Of those 15 persons, 14 completed questionnaires. Twelve of the 14 were white and four were female. Ages ranged from 26 to 56 with a median age of 37. Converters and employees with negative TST results were similar with respect to age, race, sex, number of years employed by the MEO, and previous employment. All employees were born in the United States, and one person with a negative TST had received BCG vaccine. Two employees had other jobs where there was potential for exposure to TB. One

employee with negative TST results also worked as an emergency medical technician. One converter worked as a driver for a funeral home; however, investigation did not identify any potential exposure to TB during the time period this person converted his TST. Multiple interviews with the staff and investigations by the local health department failed to identify any possible exposure to TB outside of the MEO for the two persons with TST conversions. Analysis of questionnaire data revealed that converters and persons with negative TST results reported using the same type and amount of protective clothing during and after autopsies; however, authors who observed autopsies (XU, JB, SV) noted that masks were not worn by employees during clean-up.

An analysis of the work schedules of the 15 MEO employees suggested an association between TST conversion and participation in MDR-TB autopsies (2 of 2 converters versus 3 of 13 employees with negative TST results; RR = 4.3; CI_{95} = 1.61 to 11.69; P = 0.10). When only morgue assistants were investigated, a similar trend was observed (2 of 2 converters versus 1 of 8 employees with negative TST results; RR = 8.0; CI_{95} = 1.3 to 50.0; P = 0.07). For the 15 MEO employees, there was no association between TST conversion and the proportion of time spent in the building during the 2-, 4-, and 12-hour exposure periods after MDR-TB autopsies. Morgue assistants with TST conversions spent a threefold greater proportion of time in the building during the 2- and 4-hour exposure periods after MDR-TB autopsies than did morgue assistants with negative TST results, although this difference was not statistically significant.

Before November 1991, personal protective clothing was required only for autopsies performed on HIV-infected persons. For these autopsies, most employees wore plastic gowns, surgical masks, and latex gloves. For autopsies on persons who were not known to be HIV infected, surgical masks alone were required if TB was known or suspected, although many employees reported that they routinely wore latex gloves and a plastic apron.

Germicidal UV lamps were installed in the autopsy room in November 1991, after the last MDR-TB autopsy was performed (Figure). There were six 30-watt, ceiling-mounted, unshielded UV lamps. The autopsy room is approximately 36 × 29 × 8.6 ft. These lamps produced UV radiation levels that ranged from 4.7 to 61.5 $\mu W/cm^2$ when measured 5.5 ft from the floor. According to the NIOSH recommended exposure limit for UV radiation exposures from germicidal lamps,[8] permissible exposure times for employees with unprotected skin and eyes ranged from 1.6 to 21 minutes.

After the installation of UV lamps, employees performing autopsies were required to wear polycarbonate face shields, TYVEK and polyethylene gowns, surgical hoods (for neck protection), and latex gloves. Surgical masks were not required for routine autopsies, but disposable particulate respirators (NIOSH-approved dust-mist respirators) were required for autopsies performed on persons known to have or suspected of having TB.

The MEO had separate heating, ventilating, and air-conditioning (HVAC) units for the autopsy area and the office area. However, a common return-air plenum above the entire facility allowed free mixing of air between these two areas. A single supplemental exhaust fan had been installed recently at floor level to exhaust air from the autopsy room to the outside of the building. When the autopsy room HVAC unit was operating, the number of air changes per hour in the autopsy room ranged from 11 to 13. However, when the autopsy room HVAC system was turned off and only the supplemental exhaust fan was operating (as was done during high-risk autopsies on persons with HIV infection or TB), the number of air changes per hour dropped to between 4 and 5. The results of the smoke tube traces and visual assessment of airflow patterns indicated that the autopsy room was at positive pressure relative to the adjacent hallway, which connected the autopsy room with the office area.

DISCUSSION

During 1991, at least 2 of 18 MEO employees became infected with *M tuberculosis,* and three others had newly detected positive TST results. This demonstrates the importance of using control measures to limit occupational exposure to TB in this setting. Including the two employees who had positive TST results prior to MEO employment, a total of 7 (33%) of 21 MEO employees had positive TST results. By comparison, only 4% to 6% of the general population is estimated to be infected with *M tuberculosis*.[9]

Both of the persons with TST conversions had negative TST results in September 1991 and positive TST results in February 1992. It is unlikely that these conversions were a result of a boosted response to tuberculin antigen because both of these persons were relatively young, neither had received BCG vaccine, both had TST reactions that increased from 0 mm to greater than 20 mm induration, and both had documented recent exposure to persons with extensive disseminated MDR-TB. Their infection with *M tuberculosis* most likely occurred between July 1991 and February 1992. During this time, each of these persons participated in only one autopsy on a patient who had MDR-TB.

An analysis of MEO work schedules suggested an association between tuberculous infection and

participation in autopsies on persons with MDR-TB, although this association did not reach statistical significance. Because of their small size, infective aerosols generated during autopsy can remain airborne for long periods, particularly in a poorly ventilated room. For this reason, it may be prudent for autopsy workers to use respiratory protection not only during autopsy procedures[10] but also while cleaning the room after the autopsy.

For the three MEO employees who had positive TST results but no baseline TST results from the previous 2 years, we could not determine the period in which conversion might have occurred. Two of these persons spent little time in the autopsy suite, and their infection with *M tuberculosis* may have occurred elsewhere. Furthermore, their previous jobs placed them at increased risk for exposure to TB. However, the environmental investigation revealed that air from the autopsy room was not exhausted directly to the outside, and the common return-air plenum allowed air from the autopsy room to circulate throughout the building. Therefore, we cannot exclude the possibility that these persons were exposed to *M tuberculosis* during 1991, either during or after autopsies on persons with MDR-TB. This underscores the need for environmental controls in occupational settings where the risk of TB exposure may be high.

The high prevalence of positive TST results among MEO employees is consistent with other reports that suggest that pathologists and personnel performing autopsies are at higher risk for infection with *M tuberculosis* than the general population.[11-13] Presumably, this is because these workers are more likely to be exposed to infectious aerosols created when they perform autopsies or handle infected tissues. One suggested mechanism for aerosol generation during autopsies is the use of surgical power tools, such as the Stryker saw, to cut through bone. Studies indicate that during surgery these tools can create aerosols in the respirable range (<5 μm).[14] Another report suggests that during autopsies, the mere manipulation of tuberculous lung tissue is sufficient to generate infectious droplets.[15] Although the latter report did not quantify the size of the droplets, it suggested that the compression of lung tissue might disseminate material containing *M tuberculosis* in a manner that simulates the human cough.

Autopsies on persons with HIV infection and TB may present an especially high risk for TB transmission, not because HIV-infected persons with TB are more infectious,[16-18] but rather because of the greater likelihood of having disseminated disease and thus a high burden of viable tubercle bacilli that can be aerosolized during autopsy.[19,20] Precautions should be taken to minimize the generation of aerosols during autopsies and to limit their dispersal. Further research is needed to determine how aerosols are generated, to quantify their generation, and to determine how long they persist in settings like autopsy suites and how they can be removed or eliminated.

Because any person who undergoes an autopsy may harbor *M tuberculosis,* precautions to prevent the transmission of TB should be taken during all autopsy procedures. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the American Institute of Architects (AIA) recommend that autopsy rooms have at least 12 air changes per hour, be at negative pressure relative to adjacent areas, and exhaust air directly to the outside of the building.[21,22] These conditions did not exist in the autopsy suite we investigated. The extent to which all autopsy suites meet these guidelines is not known.

Germicidal UV irradiation is a supplemental approach to preventing the transmission of TB,[23] although it must be used continuously to be effective. Its safe use requires proper installation and maintenance, as well as the measurement of UV exposure levels to ensure that workers are not overexposed. Indirect UV irradiation to disinfect air in the upper room is a safer alternative to the direct irradiation that was used at the MEO. UV lamps should be installed in consultation with environmental engineers or other experts in this field.

Approximately 250,000 autopsies are performed each year in the United States (CDC, unpublished data). These autopsies take place in coroners' offices, MEOs, funeral homes, and hospitals. As the incidence of TB continues to rise in the United States, strategies to prevent occupational exposure and infection during autopsies will become more important. As the results of this investigation suggest, there is a risk for TB transmission in autopsy suites. A systematic approach to preventing TB transmission in autopsy suites should include effective environmental controls, routine tuberculin skin testing among employees, and a reduction in the amount of aerosols generated during autopsies. All of these conditions are necessary to ensure adequate protection for persons who perform autopsies.

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Difference in Antibody Response Rate Between Engerix-B and Recombivax-HB Has No Public Health Significance

by Gina Pugliese, RN, MS
Medical News Editor

Recent studies have suggested that there are differences in response rates between two recombinant hepatitis B vaccines licensed in the United States. Researchers from the Centers for Disease Control and Prevention recently conducted a study to evaluate possible differences between the two vaccines. A total of 1,766 persons completed the primary vaccination series and had post-vaccination serologic testing; 89% of Engerix-B recipients (778/875) compared with 86% of Recombivax-HB recipients (766/891) developed seroprotection (anti-HBs $\geq$10 mIU). For persons less than 40 years of age, 92% of recipients of each vaccine developed seroprotection. Among persons over 40 years of age, 86% of Engerix-B recipients (398/462) compared with 80% of Recombivax-HB recipients (373/465) developed seroprotection ($P = 0.02$). This difference in immunogenicity persisted after controlling for other risk factors for non-response.

A decision analysis comparing current usage patterns of hepatitis B vaccine to exclusive use of Engerix-B among older individuals resulted in no differences in the number of expected acute and chronic HBV infections among non-responders.

The researchers concluded that for persons under age 40 there are no differences in the response rate between the two vaccines. Based on the decision analysis, the higher response rate associated with the use of Engerix-B among older persons affords no greater protection against HBV and has no public health significance.

FROM: Averhoff F, Mahoney F, Coleman P., et al. Response to hepatitis B vaccination: a randomized trial comparing the immunogenicity of Engerix-B and Recombivax-HB. Presented at the 33rd Interscience Conference on Antimicrobial and Chemotherapeutics, Orlando FL (1994). Abstract # H18.