

Brief Report

TRANSMISSION OF
MYCOBACTERIUM TUBERCULOSIS
FROM A CADAVER TO AN EMBALMER

TIMOTHY R. STERLING, M.D., DIANA S. POPE, R.N., M.S.,
WILLIAM R. BISHAI, M.D., PH.D.,
SUSAN HARRINGTON, M.P.H.,
ROBYN R. GERSHON, M.H.S., DR.P.H.,
AND RICHARD E. CHAISSON, M.D.

THE risk of acquiring tuberculosis varies according to occupation and is high among funeral-home workers.¹ Embalmers are at particularly high risk for reactivity on tuberculin skin testing.² The increased risk may be due to exposure to *Mycobacterium tuberculosis* during the embalming process, which involves the aspiration of blood and other body fluids from the cadaver, resulting in the generation of potentially infectious aerosols. To our knowledge, however, the transmission of *M. tuberculosis* from a cadaver to an embalmer, with the subsequent development of active tuberculosis, has not been described.

DNA fingerprinting by restriction-fragment-length polymorphism (RFLP) analysis can be useful in identifying unusual routes of transmission of *M. tuberculosis* that may not be detected by conventional contact investigations.^{3,4} We report two cases of tuberculosis in which the *M. tuberculosis* isolates were identical on DNA fingerprinting. The only known contact between the affected patients occurred at the time of embalming. Information about Patient 1 was obtained by reviewing the medical record. Information about Patient 2 was obtained by reviewing the medical record and by interviewing the patient.

CASE REPORTS

Patient 1

Patient 1 was a 35-year-old man with the acquired immunodeficiency syndrome (AIDS) who was hospitalized after presenting

From the Division of Infectious Diseases (T.R.S., W.R.B., R.E.C.) and the Department of Pathology (S.H.), Johns Hopkins University School of Medicine; the Baltimore City Health Department Eastern Chest Clinic (T.R.S., D.S.P., R.E.C.); and the Departments of Epidemiology (T.R.S., D.S.P., R.E.C.), International Health (W.R.B., R.E.C.), and Environmental Health Sciences (R.R.G.), Johns Hopkins University School of Public Health — all in Baltimore. Address reprint requests to Dr. Sterling at the Division of Infectious Diseases, 1830 E. Monument St., Rm. 444, Baltimore, MD 21287, or at tsterl@jhmi.edu.

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with fever and a cough. A chest radiograph showed infiltrates in the upper and middle portions of both lungs. A tuberculin skin test performed two years before admission had shown reactivity. Preventive therapy with isoniazid was started at that time, but the patient discontinued it after three months. During his hospitalization, a sputum sample was obtained for staining for acid-fast bacteria and culture, but the patient died on the day it was obtained. After the patient's death, the acid-fast smear was reported to be positive, and the culture grew *M. tuberculosis*. Blood cultures for mycobacteria were not performed. The patient's only close contacts were four family members, of whom one had had a positive result on prior tuberculin skin testing. Of the other three family members, two had negative tuberculin tests, and one declined testing. None of the close contacts had evidence of active tuberculosis.

Patient 2

Patient 2 was a 45-year-old man who worked as an embalmer. He had a history of hypertension and chronic renal insufficiency (serum creatinine level, 1.4 mg per deciliter [123.8 μ mol per liter]). A test for antibodies to the human immunodeficiency virus (HIV), performed two years before presentation, had reportedly been negative. The patient did not have a history of tuberculosis and had not undergone tuberculin skin testing. He had been an embalmer for 15 years and could not remember ever embalming a cadaver that he knew had active tuberculosis. He performed at least 300 embalmings per year, always wearing gloves and usually wearing a mask. He had no history of percutaneous exposure to blood or of chronic skin lesions.

A chest radiograph obtained on routine health screening 31 months after Patient 1 had died showed right paratracheal and hilar adenopathy and an infiltrate in the left lung. A computed tomographic scan revealed extensive mediastinal adenopathy, minimal hilar adenopathy, and mild interstitial thickening in the lingula and both bases. A tuberculin skin test resulted in a 14-mm induration with vesiculation. After being told of the radiographic findings, the patient reported that he had had shortness of breath during the previous four to six months, without fever, chills, night sweats, cough, hemoptysis, weight loss, or fatigue. Treatment with isoniazid, rifampin, pyrazinamide, and ethambutol was started. Culture of a biopsy specimen from the right paratracheal lymph node grew *M. tuberculosis*. Sputum cultures were all negative. The patient declined an HIV test. Treatment was continued for six months without incident.

METHODS

As part of an ongoing study of the epidemiology of tuberculosis, DNA fingerprinting was performed with *M. tuberculosis* isolates from more than 90 percent of patients in Baltimore who had received a diagnosis of tuberculosis, confirmed by culture, between January 1994 and December 1998.⁵ Patients 1 and 2 were part of this study. *M. tuberculosis* isolates were cultivated on Lowenstein-Jensen medium, harvested, and heat-killed. Genomic DNA was isolated, and RFLP analysis was performed according to a standardized method,⁶ with the use of a 245-bp, right-sided probe (IS6110) and BioImage Whole Band Analyzer software, version 3.0 (Genomic Solutions, Ann Arbor, Mich.).

RESULTS

RFLP analysis showed that the *M. tuberculosis* isolates from Patient 1 and Patient 2 had an identical 10-band fingerprint pattern (Fig. 1). Because of the large number of bands after analysis with IS6110, testing with secondary probes (e.g., pTBN12) was not performed.⁷ Drug-susceptibility testing showed that both isolates were susceptible to all first-line antituberculosis agents.

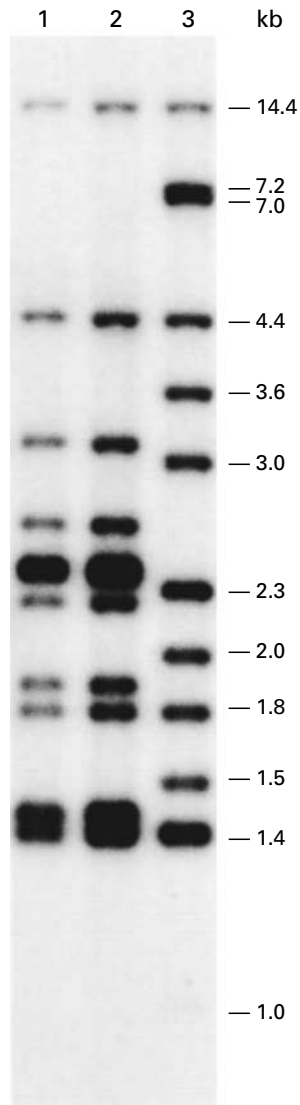


Figure 1. DNA-Fingerprint Patterns in *M. tuberculosis* Isolates from Patient 1 and Patient 2.

DNA fingerprinting was performed by restriction-fragment-length polymorphism analysis of *PvuII*-digested chromosomal *M. tuberculosis* DNA with the IS6110 probe. Lane 1 shows the isolate from Patient 1, lane 2 the isolate from Patient 2, and lane 3 the molecular-weight standard (Mt 14323). Band sizes (in kilobase pairs) are shown at the right.

To determine whether the two isolates were part of a larger cluster, the DNA-fingerprint pattern was compared with 178 unique fingerprint patterns identified by IS6110 testing of 335 *M. tuberculosis* isolates from patients in Baltimore who had received a diagnosis of tuberculosis between January 1994 and December 1998. None of the other isolates had a pattern that matched that of the isolates from Patients 1 and 2. In addition, no other cases of tuberculosis

were epidemiologically linked to either Patient 1 or Patient 2.

A retrospective chart review showed that Patient 2 had signed the death certificate of Patient 1. The two men had resided in different parts of Baltimore and had had no known contact before the embalming. Hence, there was no evidence that the transmission of tuberculosis from Patient 1 to Patient 2 had occurred before the embalming.

The embalming process included the aspiration of blood and other body fluids from the cadaver's hollow organs and the infusion of preservatives and disinfectants into the arteries under 1.4 to 2.3 kg (3 to 5 lb) of pressure. The aspirated body fluids and perfused liquids were then emptied into drains. Either part of the process may have resulted in the generation of aerosols. The frothing of fluids through the cadaver's nose and mouth or the release of trapped air bubbles through these orifices during cadaveric spasms may also have generated aerosols.

Patient 2 embalmed Patient 1 without assistance from other persons. No other employees of the funeral home contracted active tuberculosis. Patient 2 had no other known exposure to persons or other cadavers infected with *M. tuberculosis*.

DISCUSSION

Using molecular epidemiologic methods, we confirmed the transmission of *M. tuberculosis* from a cadaver to an embalmer, probably during the process of embalming. It was possible to obtain proof of transmission because active tuberculosis developed in Patient 2 and the organism could therefore be cultured for DNA fingerprinting.

The increased risk of *M. tuberculosis* infection among funeral-home employees was recently demonstrated in a large study with the use of tuberculin skin testing.² The employees who embalmed cadavers were twice as likely to have reactivity on tuberculin skin testing as those who did not perform embalming; this association was strongest among the persons who had worked as embalmers for the greatest number of years. However, the study did not include persons with active tuberculosis. Another study found that the rate of active tuberculosis was higher among funeral directors than in the general population, but the route of transmission was not determined.¹

Although it was initially reported that tubercle bacilli from embalmed cadavers used for medical-school anatomy classes were not infectious,⁸ a subsequent study showed that *M. tuberculosis* organisms remain viable and therefore infectious for at least 24 to 48 hours after an infected cadaver has been embalmed.⁹ *M. tuberculosis* has been transmitted from cadavers to persons working in autopsy rooms,^{10,11} but to our knowledge, there have been no reports of transmission to embalmers. The mode of transmission in this case was probably the inhalation of infectious aerosols gen-

erated during the embalming process. Although mycobacterial blood cultures were not obtained from Patient 1, who had AIDS, bacteremia with *M. tuberculosis* is more common in patients who have AIDS than in those who do not, and the presence of bacteremia may have increased the likelihood that aerosols generated during embalming were infectious.

The risk of transmission of *M. tuberculosis* has been thought to be lower during the embalming process than during an autopsy because embalming is less invasive. The guidelines established by the Centers for Disease Control and Prevention¹² and by the Occupational Safety and Health Administration¹³ to prevent nosocomial transmission of *M. tuberculosis* have not been specifically applied to funeral homes.

The strong epidemiologic and molecular link between the two cases of tuberculosis reported here, as well as the absence of other plausible epidemiologic links, supports the hypothesis that *M. tuberculosis* was transmitted from the cadaver to the embalmer during the embalming process. Given these findings, efforts should be made to prevent the transmission of *M. tuberculosis* in funeral homes.

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REFERENCES

1. McKenna MT, Hutton M, Cauthen G, Onorato IM. The association between occupation and tuberculosis: a population-based survey. *Am J Respir Crit Care Med* 1996;154:587-93.
2. Gershon RR, Vlahov D, Escamilla-Cejudo JA, et al. Tuberculosis risk in funeral home employees. *J Occup Environ Med* 1998;40:497-503.
3. Michele TM, Cronin WA, Graham NMH, et al. Transmission of *Mycobacterium tuberculosis* by a fiberoptic bronchoscope: identification by DNA fingerprinting. *JAMA* 1997;278:1093-5.
4. Behr MA, Small PM. Molecular fingerprinting of *Mycobacterium tuberculosis*: how can it help the clinician? *Clin Infect Dis* 1997;25:806-10.
5. Bishai WR, Graham NMH, Harrington S, et al. Molecular and geographic patterns of tuberculosis transmission after 15 years of directly observed therapy. *JAMA* 1998;280:1679-84.
6. van Embden JD, Cave MD, Crawford JT, et al. Strain identification of *Mycobacterium tuberculosis* by DNA fingerprinting: recommendations for a standardized methodology. *J Clin Microbiol* 1993;31:406-9.
7. Burman WJ, Reves RR, Hawkes AP, et al. DNA fingerprinting with two probes decreases clustering of *Mycobacterium tuberculosis*. *Am J Respir Crit Care Med* 1997;155:1140-6.
8. Meade GM, Steenken W Jr. Variability of tubercle bacilli in embalmed human lung tissue. *Am Rev Tuberc* 1949;59:429-37.
9. Weed LA, Baggenstoss AH. The isolation of pathogens from tissues of embalmed human bodies. *Am J Clin Pathol* 1951;21:114-20.
10. Templeton GL, Illing LA, Young L, Cave D, Stead WW, Bates JH. The risk for transmission of *Mycobacterium tuberculosis* at the bedside and during autopsy. *Ann Intern Med* 1995;122:922-5.
11. Kantor HS, Pobleto R, Pusateri SL. Nosocomial transmission of tuberculosis from unsuspected disease. *Am J Med* 1988;84:833-8.
12. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care facilities, 1994. *MMWR Morb Mortal Wkly Rep* 1994; 43(RR-13):1-132.
13. Enforcement procedures and scheduling for occupational exposure to tuberculosis. OSHA directives CPL 2.106. February 9, 1996.

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