

Transmission of Tuberculosis from Patient to Healthcare Workers in the Anaesthesia Context

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Abstract

Introduction: Pulmonary tuberculosis (PTB) is prevalent in our population. We report an incident of healthcare workers (HCWs) suspected of being infected by a patient with undiagnosed active PTB in the operating theatre. **Clinical Picture:** A 60-year-old patient admitted for intestinal obstruction, underwent an emergency laparotomy. Preoperative chest X-ray (CXR) showed diffuse reticular-nodular shadowing and postoperative sputum was positive for acid-fast bacilli. **Treatment:** The patient was isolated and treated for active tuberculosis. The anaesthetist and her assistants in the operating theatre that day were referred to the infectious disease physician and some were started on tuberculosis prophylaxis. **Outcome:** The patient and the HCWs involved recovered. **Conclusion:** Thus, all PTB-susceptible patients with suggestive CXR should be treated as potentially infective. Adequate personnel protection should include highly efficient facemasks and shields. Risk of patient-to-patient transmission of tuberculosis through the anaesthetic circuit is low if effective bacterial/viral filters are used.

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Key words: Breathing circuit, Immunocompromised, Mycobacteria, Prophylaxis, Reticular-nodular shadows

Introduction

Tuberculosis poses a very real problem to healthcare workers (HCWs). In Singapore, the prevalence of tuberculosis in the general population remains high at 44 per 100,000 in the year 2001.¹ The re-emergence of tuberculosis is becoming a major healthcare problem, associated with the increasing trend of human immunodeficiency virus (HIV) infection.

Anaesthetists are at constant risks of acquiring airborne diseases from their patients, especially during airway manipulation.

We report an incident of HCWs in the operating theatre who were suspected to have been infected by a patient with unrecognised pulmonary tuberculosis (PTB) who underwent an emergency laparotomy. The confirmation of PTB of the patient later caused anxiety to the operating theatre staff and the other patient who used the same anaesthetic circuit.

Case Report

The index case was a 60-year-old Chinese woman with a past history of adenocarcinoma of the stomach, for which she underwent a subtotal gastrectomy and chemotherapy in 1997.

She was later diagnosed with left breast cancer and had a simple mastectomy with axillary clearance followed by radiotherapy in 1999. She also had non-productive cough 1 month prior to the current admission. She was treated with a course of antibiotics by a family physician. Apparently, the same family physician took a pharyngeal swab for acid-fast bacterial (AFB) staining and the result was negative. Her husband was treated for PTB 10 years ago.

She was admitted this time for acute intestinal obstruction due to adhesions with perforation of viscus. An emergency laparotomy was done. Her preoperative chest X-ray (CXR) showed diffuse reticulonodular shadowing. The surgeons and anaesthetists attributed the CXR appearance to lymphangitis carcinomatosa.

During induction of anaesthesia, universal precautions were observed. All the other HCWs in the operating theatre also wore surgical masks. The principal anaesthetist was pregnant in the first trimester. A medical officer assisted her. There was no coughing prior to rapid sequence induction of anaesthesia, the patient was intubated by the medical officer, with an anaesthetic nurse assisting him. The anaesthetic circuit included

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a heat and moisture exchanger bacterial/viral filter (HMEF) (Sterivent mini, Mallinkrot) situated between the Y-piece and the adapter mount, and a breathing system microbial filter between the expiratory limb and the soda lime absorber. The HMEF was changed for every patient but breathing circuit change was not required according to department policy. Subsequently, a young boy had an appendectomy done using the same anaesthetic circuit.

Postoperatively, the patient was ventilated in the intensive care unit (ICU) for 1 day. In view of the possibility of active PTB, the patient was nursed in an isolation room, comprising of a connecting negative pressure anteroom. A transtracheal aspirate was sent for acid-fast bacilli (AFB) smear in view of the preoperative CXR findings. This was reported positive. The TB culture was negative, possibly due to inappropriate handling of the specimen. The anaesthetist and her assistants were referred to the infection control physician. The medical officer had received Bacillus Calmette Guerin (BCG) vaccination at birth and at school leaving age. His Mantoux test consisting of 1 Tuberculin unit of purified protein derivative (PPD) RT 23 injected intradermally revealed a non-pustular induration measuring 22 mm. According to local guidelines for interpretation of MMT, any wheal larger than 15 mm is considered positive, taking into account previous BCG vaccination. CXR showed no abnormality. He was started on post exposure prophylaxis of isoniazid 300 mg om, but developed generalised rash and pruritis suggestive of an adverse drug reaction. It was substituted with rifampicin 600 mg om for 4 months.

The anaesthetic nurse who assisted in the intubation was also administered with the Mantoux test, which revealed a non-pustular induration measuring 13 mm. She was also asymptomatic with a normal chest X-ray. She was subsequently referred to the tuberculosis control unit where a second Mantoux test was done 1 month later. The results were similar to the first. She was started on isoniazid 300 mg om for 6 months following the history of significant exposure. She was subsequently followed up at monthly intervals. In her background history, she received the BCG vaccination at birth, but did not require subsequent boosters. She had no family history of tuberculosis; and in her nursing career, had only encountered one other known case of tuberculosis 3 years ago, for which she had taken adequate precautions.

The news caused considerable anxiety to the rest of the operating theatre staff. Alerted by the surgeons, the parents of the young boy who had the appendectomy were also concerned. Because of the use of the HMEF, the anaesthetist was confident that the circuit was not contaminated. The operating theatre workflow also prevented the boy from coming in close contact with the index patient. The infectious disease physician was consulted and the young boy was administered the Mantoux test, which proved to be negative with a wheal size of 10 mm. The rest of the staff who did not come in direct contact with the patient were reassured.

The sputum of the index case was subsequently tested

negative 6 months later. Both the medical officer and anaesthetic nurses completed their prophylactic course of antibiotics with no further complications.

Discussion

Tuberculosis is an airborne communicable disease caused by *Mycobacterium tuberculosis*. It is spread via airborne particles measuring 1-5 microns, and can be suspended in air for several hours.¹ The infectivity of a TB patient is directly related to the number of tubercle bacilli expelled. Patients are more likely to be infectious if they have pulmonary or laryngeal TB; have a cavity in the lung; are coughing or undergoing cough-inducing procedures; are not covering their mouth when coughing; have AFB on the sputum smear; or are not receiving adequate treatment.²

Infectivity appears to decline very rapidly after adequate treatment is started. Patients who have had adequate treatment for 2 to 3 weeks, whose symptoms have improved and who have 3 consecutive negative sputum smears from sputum collected on different days can be considered non-infectious.² Patients who are infected but who do not have TB disease are asymptomatic and not infectious; such patients usually have a positive reaction to the tuberculin skin test. About 10% of infected persons will develop TB at some point in their lives, but the risk is higher in the immunocompromised.¹

It is established practice in many countries to initiate therapy in patients with radiological features suggestive of active PTB from areas with high prevalence of disease regardless of bacteriology findings. A single negative sputum smear for AFB is not sufficient to exclude an active PTB. Pek et al³ suggested that the presence of symptoms, especially cough at presentation, a history of contact with tuberculosis and cavitation on chest radiograph, were associated with an increase risk of active disease.

This unfortunate incidence in the operating theatre brought about a few questions. Were the precaution taken in the operating theatre adequate? Is the Mantoux test diagnostic for recent infection? When is post exposure prophylaxis justified? A review of the subject is required.

In 1994, because of the increasing rates of TB in hospitalised patients, the Center for Disease Control (CDC) in the United States published Guidelines for Preventing the Transmission of *Mycobacterium tuberculosis* in Health Care Facilities,² which specifically addresses the operating room environment. The CDC guidelines require institutions that treat patients with TB to follow a hierarchy of controls for prevention of TB transmission, including early identification, isolation and treatment of patients with active TB. Engineering controls are required to prevent the spread and reduce the concentration of the infectious droplets, including the availability of rooms for respiratory isolation using adequate ventilation, filters and ultraviolet light.

During Surgery

When operative procedures must be performed on patients

with or suspected of having active pulmonary TB, the doors of the operating room should be closed, and traffic into and out of the room should be minimised. Attempts should be made to perform the procedure at a time when other patients are not present in the operating room suite and when a minimal number of personnel are present (e.g., at the end of the day). Patients with TB who need to be out of their respiratory isolation room to go to the operating theatre for non-elective surgery should be transported to the operating theatre wearing surgical masks to prevent respiratory secretions from entering the air.²

An ideal operating theatre designed to prevent suspended infectious droplets from leaving it would have an anteroom that is negative pressure to the corridor and the operating theatre. It should ensure that the exhausted air does not return to other parts of the hospital.

The Anaesthetic Circuit

Although there have been no documented cases of TB transmission via a ventilator or anaesthesia machine, technology exists to prevent infectious droplets from contaminating anaesthesia equipment.^{2,4} High-efficiency particulate air filters remove 99.97 percent of all particles greater than or equal to 0.3 μm . These filters can be placed between the Y-connector and the mask or the endotracheal tube and serve to keep infectious particles from getting into the operating room air, the breathing circuit, the anaesthesia machine and the scavenging system. It is prudent to use these filters when there is any suspicion of a patient having pulmonary TB.^{5,6}

The Sterivent mini heat and moisture exchanging bacterial/viral filters used in our operating theatres consists of a pleated hydrophobic membrane which provide high levels of bacterial and viral filtration in terms of removal of micro-organisms, with experimental values above 99.99999% being achievable. It is able to withstand micro-organism challenge of sizes as small as 0.02 μm .⁷ This includes bacteria and viruses, for example HIV, which is 0.1 μm in diameter, and *Mycobacterium tuberculosis*, which measures 1 to 4 μm . The hydrophobic barrier is an absolute barrier to liquid water and will protect the patient and/or the breathing system from contamination even when there is a large quantity of condensate or mucus present.⁸

Respiratory Devices

The respiratory devices used in the operating theatre should be able to protect the surgical field from the respiratory secretions of the HCWs and vice versa. The National Institute for Occupational Safety and Health (NIOSH) in the United States has come up with a set of guidelines for respirators used in the healthcare setting. Respirators approved for use in the operating theatres are the particulate respirators. These respirators remove small particles from the air you breathe. There are several types of particulate respirators (HEPA, N, P or R series) that are available for use against TB. The disposable surgical masks provide inadequate protection in cases with PTB.⁹

In our operating theatres, the disposable surgical masks are the most common masks used. This is attributed to user comfort and lower cost of these masks compared to the disposable particulate respirator (more than 2 times the cost of the normal surgical masks). The disposable particulate respirators are reserved for use by HCWs who are attending to suspected or known cases of PTB.

Recovery

During recovery from anaesthesia, the patient should be monitored and should be placed in a private room or the operating theatre in which they had their surgical procedure done.

Tuberculin Skin Test for HCW

CDC recommended yearly screening for HCW with low risk of exposure (less than 6 patients in past year). Those at intermediate risk (greater than 6 patients per year) should be screened every 6 to 12 months. High-risk HCWs should be screened every 3 months.² However, in the local context, the tuberculin skin test is only administered to HCW with significant exposure to patients with PTB. During the pre-employment check, only a CXR is required. The rationale behind this is the high number of false positives due to the mass vaccination programme in the local context.

There is still a lack of a gold standard to determine who is truly infected with TB when interpreting a tuberculin skin test result. In a study by Horowitz et al,¹⁰ the authors concluded that a large proportion of tuberculin skin test conversions of HCWs who had received BCG vaccination may not represent recently acquired tuberculosis. Rather, these conversions may be effects of previous BCG vaccination.

In our literature review, we also noted that the dose of tuberculin administered can affect the size of the induration. Stuart et al¹¹ reported that a slightly larger tuberculin skin test reading was seen with 10 tuberculin units (TU) than with 5 TU of PPD-S (which is the bioequivalent of 2 TU of PPD RT 23 used in Singapore). The mean difference was 1.5 mm between the 2 doses. The different doses of tuberculin used in different countries translate to different thresholds for diagnosis of infection.

The cut-off points for defining a positive tuberculin reaction are chosen based on the sensitivity, specificity and the prevalence of tuberculosis in the group of patients tested. In Singapore, mass BCG vaccination is given at birth and, until recently, re-vaccination was given at age 12 for tuberculin negative school leavers.¹ Our local guidelines (unpublished data) stipulate a higher cut-off reading (15 mm) than that of a non-BCG vaccinated population, and even higher than what is recommended by the American CDC.¹²

Former patients with TB may have negative skin test reaction when tested many years after infection, as delayed type hypersensitivity to tuberculin may wane over the years. The initial skin test may stimulate their ability to react to tuberculin. Thus, reaction to subsequent tests may be misinterpreted as a

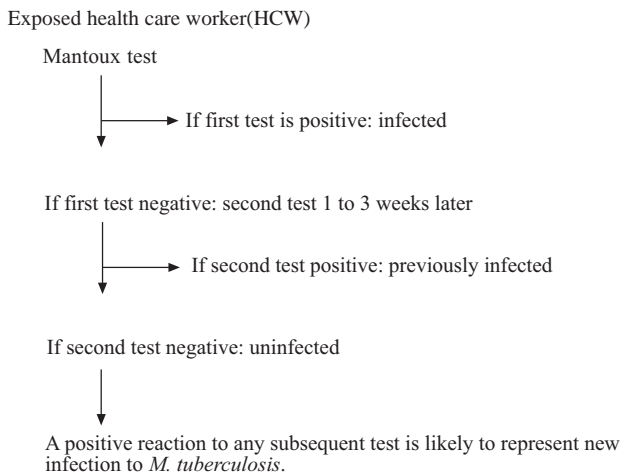


Fig. 1. Interpretation of the 2-step tuberculin test.

new infection. As such, understanding the 2-step tuberculin skin test helps to solve this problem (Fig. 1).

The guidelines as recommended by the tuberculosis control unit in Singapore for post exposure chemoprophylaxis were followed in our 2 contact cases.

Legislations Against Tuberculosis

Tuberculosis is a very real and recognised problem among HCWs. As such, many countries have implemented occupational health legislation that includes HCWs in their coverage.

In October 1997, the Occupational Safety and Health Administration (OSHA) of the United States published its proposed Tuberculosis Standard. The proposal covers hospitals, long-term care facilities for the elderly, corrections facilities, hospices, shelters for the homeless, drug abuse treatment facilities, labs that handle TB specimens, and emergency treatment during medical care, home healthcare and home-based hospice care. The proposal included an exposure control plan, including exposure determination, respiratory protection in certain situations, and medical surveillance. It also included baseline skin test and medical history; medical management and follow-up, including medical removal protection, if necessary; employee training and record keeping. Pertaining to respiratory protection, employers were required to implement OSHA's respiratory protection standard (29 CFR 1910.134) by 5 October 1998. It provides guidance on selecting, using, and testing a respirator. The new standard requires fit testing to ensure the respirator fits the employee. The employer is required to offer a variety of respirators and to teach workers how to use them properly. The standard also requires user seal checks every time the employee puts on a respirator. This is a negative-pressure check or a positive-pressure check to make sure the respirator is sealed closely to the worker's face. Workers must get training on these tasks.¹³

In Canada, similar legislations have been implemented. It

addresses issues on identification, isolation, and management of patients with infectious TB, engineering controls, follow-up of exposed patients and HCWs, and education and surveillance programmes for HCWs. Also, reporting of affected HCWs is mandated by provincial and territorial reporting legislation.¹⁴

In Singapore, there are impending changes in the occupational health legislation to include the coverage of HCWs. The current 'Factories Act' will be revised to include hospitals and other healthcare facilities. This would mean that these institutions would be required to provide a series of facilities, protection devices and engineering controls, among other things, in the protection of HCWs. Although tuberculosis is listed as a compensable occupational disease in the Workmen's Compensation Act, the definition of 'workman' includes only manual workers or workers earning less than S\$1600. Thus, most nurses and doctors are not included. Tuberculosis is currently not under the list of notifiable industrial disease. However, any reported case of occupational acquired tuberculosis will be reviewed on a case-to-case basis. Thus far, where the use of filters in breathing circuit is concerned, although it is not required by law, it is recommended by various colleges, for example the Australian and New Zealand College of Anaesthetists.¹⁵ This practice is, however, not uniformly adopted by all hospitals.

Conclusion

Although our patient had a history and radiological findings suggestive of TB, precautions were not undertaken as a result of a lack of awareness by the physicians. Thus, there should be a high index of suspicion for all patients. If there are any clinical or radiological signs suggestive of tuberculosis infection, full precautions should be taken. These include personnel protection with efficient face masks and shields, use of effective bacterial/viral filters and proper isolation of patient postoperatively. For the lack of a better screening test, the interpretation of the Mantoux test still remains an issue and the guidelines issued by the local health authority should be consulted. Post exposure chemoprophylaxis should be started in asymptomatic HCWs with high risk exposure and a significant Mantoux reading.

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