

# TRANSMISSION AND PATHOGENESIS

## Brief history of tuberculosis transmission

We have only known how the tuberculosis bacterium spreads for about 130 years. In 1868, it was found that these germs could pass between humans and animals. In 1884, Robert Koch described a bacteria-causing TB that could be spread by air, and that human sputum was the most important vehicle for the spread of this bacillus. In 1957, a group of scientists demonstrated that transmission of TB could take place by exposure to infected air without direct contact with the contagious patient.

### I. Transmission

#### A. What is tuberculosis?

1. Tuberculosis (TB) is an infection caused by a type of bacteria or germ called *Mycobacterium tuberculosis* (*M.tb*). *M.tb* is a tiny living organism like the bacterium that causes “strep throat” or bladder infections. It is different from these other bacteria in that *M.tb* grows very slowly.

#### B. How is tuberculosis spread?

1. **TB infection is spread** from person to person by **inhaling** the **droplets** of infected material produced when the “source case” (a person with contagious active TB disease in the upper respiratory tract) **exhales** forcefully. Coughing, sneezing, singing, and laughing all allow microscopic drops to be forced out into the air around the source case. If a person breathes in these droplets, some of droplets may stay inside the lungs to cause infection. Transmission of *M.tb* from one person’s lung (pulmonary TB) to another person’s lung is the main way that almost all TB infection is spread.

C. Does everyone get TB after being exposed?

Not everyone who is exposed to a person with contagious TB becomes infected with *M.tb*. The likelihood that TB infection will be spread depends on three factors:

1. The source case or person with active TB disease
2. The environment
3. The contact or person who is exposed to the infection

**II. The source case or person with active tuberculosis disease**

- A. Location – *M.tb* can grow in almost any organ of the body. The person with pulmonary (lung or upper airway) TB has the most common and contagious type of TB. People who have TB somewhere else in the body do not transmit disease. Children generally do not produce sputum as they cough and, therefore, do not transmit disease
- B. Presence of a cavity in the lung – If a chest x-ray reveals that the patient has a cavity, which is an area sheltering millions of bacilli, those people are expelling large numbers of TB germs
- C. Amount of *M.tb* – The more *M. tb* in the lung, the greater number of infected droplets comes out when the person coughs. One measure of the amount of infection is to check a sample of sputum under a microscope. If this sputum smear is “positive” (meaning the TB bacilli are so numerous that they are visible), the person (the source case) is considered to be highly infectious
- D. Symptoms – Coughing. The more a person coughs, the more particles are expelled into the air. Some people with TB have very few symptoms, and they are less likely to expose others. Laughing and singing also produce droplets. One forceful cough produces as many infectious particles as five minutes of loud talking. More frequent coughing means that person is more likely to infect others. Also, some medical procedures can cause coughing, which increases the risk of TB transmission
- \* The value of patients covering their mouths when coughing cannot be emphasized enough!
- E. Medications – Anti-TB treatment rapidly kills *M.tb*. The sooner we begin appropriate medication in an infectious patient, the faster he or she will become noninfectious. It generally takes about two weeks on medicine before an infectious person becomes less able to transmit the TB germ

### III. The Environment

- A. Volume of air – The greater the volume of air, the lower the concentration of bacilli in the air. Thus, transmission is more likely to occur in a small, poorly ventilated room than in a large room. Transmission inside is more likely than outdoors.
- B. Re-circulation of air – When air is re-circulated in a room, the bacilli are re-introduced into the room. However, cross ventilation of air through a room, such as an open door and an open window, decreases the number of infectious droplets present. Ideally there should be 12 or more room air changes per hour to reduce the risk of infectious droplets hanging in the air
  - 1. Viability of TB organisms. It has been found that in standard conditions at indoor temperature and humidity, at least 60% of TB germs were alive after three hours, 48% alive for six hours, and 28% for nine hours
  - 2. Filtration of the air. It is possible to filter the TB germ from the air using high efficiency particulate air (HEPA) filters. When a HEPA filter is placed in a room it will continually “clean” the air of any particles, including *M.tb*
  - 3. HEPA filters are expensive and are used in TB clinics, hospital isolation rooms, and other high-risk areas. Ordinary air filters will not trap out TB germs
- C. Ultraviolet light – UV light rapidly kills mycobacteria. UV lights can be placed in some rooms to help “clear” the air of mycobacteria. UV lighting is expensive and can cause eye damage if not properly installed and maintained. UV lights are useful in the highest-risk areas, such as in TB clinics

### IV. The contact to infected droplets

- A. Closeness and duration of exposure – The closer one is physically to the person with contagious TB and the longer the time they spend together, the more likely transmission will occur. For example, when looking for people who may have been infected by a new source case, the people living in the same room or apartment, or those people who spend the most time with the TB case, are at the highest risk. People who only have contact outdoors with the person with TB are at much lower risk. In general, 25-50% of household contacts of a source case of pulmonary TB are expected to be infected. Some of these people will go on to develop active TB disease

- B. Susceptibility of the contact – Some people are more vulnerable to getting infected with TB than others. People with impaired immune systems are more vulnerable. For example, it has now been found that people with HIV infection who become TB infected are 100 times more likely to progress to TB disease, than those without HIV.
- C. Prior TB infection – Someone who has been previously infected with *M.tb* is less likely to become ill from a new exposure. There is some weak protection conferred by fighting off a previous TB infection. However, this is not true in AIDS patients since they can get TB again if they are re-exposed to an infectious case of TB

### TB Infection vs. TB Disease

TB Infection	TB Disease (in the lungs)
Tubercle bacilli in the body	
Tuberculin skin test reaction usually positive	
Chest x-ray usually <b>normal</b>	Chest x-ray usually <b>abnormal</b>
Sputum smears and cultures <b>negative</b>	Sputum smears and cultures <b>positive</b>
<b>No symptoms</b>	<b>Symptoms</b> such as cough, fever, weight loss
<b>Not infectious</b>	<b>Often infectious</b> before treatment
<b>Not a case</b> of TB	<b>A case</b> of TB

#### V. Development of tuberculosis

- A. *Pathogenesis* means the way TB infection and disease develop in the body
- B. TB invades
  1. TB germs are inhaled on small droplet nuclei and reach the tiny air sacs (the alveoli) of the lungs
  2. Larger droplets are stopped by the defenses of the nose and throat, so only the smallest droplets reach the lungs
- C. TB grows unchecked
  1. Early days and weeks: the TB bacilli multiply in the lungs; a small number enters the blood stream, reaching other sites of the body

2. Areas of the body which the TB mycobacteria favor are those with good oxygen concentration: the upper lung lobes, the brain, kidneys, and bone
3. The body's defenses have not yet recognized or mobilized to fight the TB infection at this point

D. Body defenses mobilize

1. Within 2 to 10 weeks, the immune system responds. Large macrophages begin to engulf and stop or kill the bacilli. Other cells of the immune system join the battle. Over weeks, the macrophages surround the infecting TB germs and build a hard wall around them, keeping the TB bacilli from multiplying or spreading further
2. Macrophage cells die and can become liquid within the tubercle, the name of the walled-off TB germs. Inside the tubercle, growth of the TB germs is slowed or stopped partially by the development of an acid environment with low oxygen

E. TB growth stops

1. At the time the body's defense system becomes effective in stopping the growth of the germs, the tuberculin skin test shows a positive reaction
2. About 90% of adults with normal immune systems will stop the TB germs at this point and will not develop active TB disease. This is called *TB infection*

F. A delicate balance

1. Any time in the infected person's life, TB germs could begin again to multiply in great numbers and "break out" of the tubercle, causing destruction of the lung tissue and giving germs the chance to invade new tissue or other body parts, leading to active TB disease
2. About 10% of infected people will go on to develop active TB after the infection is initially stopped. It is not easy to tell if a person with active TB is a new infection that has not been contained or a reactivation of previous infection that had been dormant for some time

## VI. Tuberculosis infection

A. *TB infection* means that the tubercle bacilli are in the body but the immune system is keeping them under control

1. The TB germs are not growing and the patient has no signs or symptoms of disease (NOT SICK)
2. The chest x-ray is NORMAL

3. The tuberculin skin test may be POSITIVE, if it is 10 weeks after TB germs entered the body
4. The person is NOT INFECTIOUS to others

## **VII. Tuberculosis disease**

- A. *TB disease*, or active TB, develops when the immune system cannot keep the TB germs under control and the bacilli multiply rapidly
  1. The person develops symptoms of disease and feels sick (cough, fever, weight loss)
  2. The tuberculin skin test is usually positive
  3. Chest x-ray is usually abnormal,
  4. Sputum cultures are positive (TB germs can be grown in the lab); sputum smears may be negative or positive
  5. The person IS INFECTIOUS AND CAN SPREAD TB infection (before treatment started)
  6. This is a case of TB