Mycobacterium Tuberculosis Characteristics

Mycobacterium tuberculosis is the bacterium that causes tuberculosis. These bacteria have mycolic acid in their cell walls, so they don't stain well with Gram stain. Special acid-fast stains such as carbol fuchsin can be used, which will stain the bacteria red. Lowenstein-Jensen agar is a selective medium used to grow these bacteria in the lab. Serpentine cord factor is a virulence factor expressed by bacteria that causes them to grow in cord-like arrangements. Primary TB occurs upon first exposure to the bacteria and can lead to the formation of pulmonary caseating granulomas. When seen on X-ray, a granuloma can be termed a Ghon focus. Bacteria draining into the mediastinal lymph nodes can cause perihilar lymphadenopathy, and this finding with a Ghon focus is termed a Ghon complex. After initial infection, TB often becomes quiescent and can remain undetected in the host for a long time, termed latent TB. Reactivation TB occurs after reactivation of latent disease and often localizes to the apices of the lungs.



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Characteristics

Mycolic Acid Cell Wall
Mic Acidic-lemon Wall
Mycobacteria are noted for having a cell wall composed of predominantly mycolic acid. This cell wall gives the organisms a waxy coating, making them impervious to gram-staining. Thus, these bacteria are better identified via acid-fast staining, such as techniques using carbol fuchsin.

Acid-Fast
Acidic-lemon Running Fast
A commonly used acid-fast stain to identify Mycobacterium tuberculosis is the Ziehl-Neelsen stain, a acid-fast stain. This stain utilizes carbol fuchsin to penetrate the mycolic acid-rich cell wall, staining the bacteria bright red. A counterstain, such as methylene blue or malachite green, provides contrast, resulting in a blue or green background. Due to their lipid-rich, waxy cell walls, M. tuberculosis bacteria are acid-fast, meaning they retain the red stain despite decolorization with acid alcohol.

Carbol Fuchsin Stain Red
Car-bomb-fuse Stained Red
This stain is a component of the Ziehl-Neelsen stain and has a high affinity for mycolic acid, working to stain M. tuberculosis. Carbol fuchsin is more soluble in the cell wall lipids of Mycobacteria than in the acid alcohol. Therefore, if the bacteria is acid-fast, it will retain the initial red color of the dye because they are able to resist the destaining by acid alcohol.

Lowenstein-Jensen Agar
Low-stein-Jetson
This agar is a special selective medium that allows for the growth of Mycobacteria species in the lab while preventing the growth of unwanted pathogens.

Serpentine Cord Factor
Serpent Cord
The cord factor is a glycolipid found in the cell wall of Mycobacterium. The term "serpentine" refers to its characteristic appearance under a microscope, where it causes Mycobacterium to grow in distinctive chains of cells. As a virulence factor, the cord factor induces the release of TNF-alpha, which activates macrophages and leads to granuloma formation. Granulomas contain and prevent the growth and spread of Mycobacterium.

Primary TB

Primary TB
(1) Wand and TB-TV
Primary tuberculosis develops in a previously unexposed person. In most cases, the infection is contained by the immune system and remains asymptomatic. Of those exposed to TB, only about 30% develop infection, and among them, 90% develop latent tuberculosis, while 10% progress to active primary disease. Over several weeks (typically 2-4 weeks), the immune system mounts a response, forming granulomas that help contain the bacteria. Some patients may experience constitutional symptoms, such as fever and weight loss. In rare cases, disseminated tuberculosis (miliary TB) can occur, leading to multisystemic infections affecting the liver, spleen, meninges, and adrenal glands. After the initial infection, mycobacteria often remain dormant for years, a state referred to as latent tuberculosis.

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Caseating Granuloma

Cheese-eating Granny-llama

Histologically, sites of inflammation caused by Mycobacterium, particularly in tuberculosis, are characterized by granulomatous inflammation, often with caseation. A caseating granuloma is a type of granuloma with central necrosis, surrounded by Langhans giant cells, which are multinucleated cells formed by the fusion of epithelioid macrophages. Grossly, this type of granuloma has a cheese-like appearance, termed "caseous necrosis," which gives rise to the description of caseating granulomas associated with this disease.

Ghon Focus

Gong with Focusing-magnifying-glass

In primary tuberculosis, the inhaled bacilli typically implant in the lower part of the upper lobe or upper part of the lower lobe, often subpleural, where they cause a focus of inflammation. This leads to granuloma formation, which may caseate and, over time, can undergo fibrosis and calcification. This granuloma is termed a Ghon focus, and when associated with perihilar lymph node involvement, it is called a Ghon complex. These findings may be seen on X-rays.

Hilar Lymph Nodes

Hilary-Duff with Lymph-limes

Typically, with both inactive and active TB, there is enlargement of lymph nodes in one or both hila or within the mediastinum, with or without associated atelectasis or consolidation. This is often reported as bilateral hilar adenopathy on chest X-rays.

Ghon Complex

Complex Gong

Typically, in primary tuberculosis, the inhaled bacilli implant in the upper lung lobes and cause a focus of inflammation, which becomes a granuloma (Ghon focus) that can be seen on X-ray. Over time, bacteria drain via the lymphatic system into the hilar lymph nodes of the lung and cause enlargement of these nodes. The combination of a granuloma and an enlarged associated lymph node is referred to as a Ghon complex.

Reactivation TB

Reactivation TB

Reactivation Button on TB-TV

Reactivation of previously latent disease is a common presentation of tuberculosis. For otherwise healthy patients with latent TB, the risk of reactivation can be up to 10% over their lifetime. It occurs more often when the host immune system is weakened, such as by HIV/AIDS, malignancy, or immunosuppressive diseases and medications. In reactivated TB, the disease is typically confined to the lungs. There is a lower risk of dissemination as compared to the risk in primary disease.

Reactivation in Apex

Reactivation Button on Mountain-apex

TB classically reactivates in the apices of the upper lobes, as these organisms are obligate aerobes, and the apices of the lungs are well oxygenated.

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