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PATHOGENIC FACTORS OF THE TUBERCULOSIS AGENT – MYCOBACTERIUM TUBERCULOSIS

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Abstract. Tuberculosis is one of the most widespread infectious diseases in human history and remains a major global public health problem. The main etiological agent of this disease is *Mycobacterium tuberculosis*. This article analyzes the biological characteristics of the tuberculosis pathogen, the structure of its cell wall, and its pathogenicity factors. Particular attention is also given to the interaction of the bacterium with the immune system, the mechanisms of disease development in the human body, diagnostic methods, treatment principles, and preventive measures.

Approximately 8 million new cases of tuberculosis are reported worldwide each year. Over the past decade, a deterioration in the epidemiological situation of tuberculosis has been observed. Due to the reduction in preventive fluorographic examinations among the population, more than 50% of tuberculosis cases are now detected in general medical institutions based on patient referrals.

Mycobacteria are more resistant than many other microorganisms. They can survive for a long time under various environmental conditions: up to 10 days in street dust, up to 150 days in running water, and even in a frozen or dried state. The cell wall of mycobacteria is rich in lipids and wax-like substances, which makes them resistant to disinfectants and many drugs. These bacteria can remain in a latent ("dormant") state in the human body for years and become active when the immune system weakens.

Keywords: Mycobacterium tuberculosis, tuberculosis, pathogenicity factors, virulence, mycobacteria, granuloma, diagnosis, treatment, prevention.

Introduction.

Tuberculosis has long been one of the most serious epidemiological challenges for humanity. The causative agent of the disease, *Mycobacterium tuberculosis*, was identified in the 19th century by the German scientist Robert Koch. Since then, the etiology and pathogenesis of tuberculosis have been extensively studied.

Tuberculosis infection is primarily transmitted through airborne droplets. When an infected person coughs or sneezes, aerosol particles containing bacteria are released into the air and can

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enter the respiratory tract of a healthy individual. The infection most commonly affects the lungs; however, in some cases, it can also involve bones, lymph nodes, kidneys, or the central nervous system.

Pathogenicity factors of the causative agent play a crucial role in the development of tuberculosis. These factors enable the bacterium to survive in the host, resist immune responses, and induce inflammatory processes in tissues.

Biological characteristics of *Mycobacterium tuberculosis*. *Mycobacterium tuberculosis* belongs to the group of mycobacteria and has a slender rod-shaped structure. These bacteria are non-motile and do not form spores. Although they resemble Gram-positive bacteria, their complex lipid-rich cell wall prevents them from being fully identified using the standard Gram staining method. Therefore, acid-fast staining techniques are used for their detection.

Another important feature of mycobacteria is their slow growth rate. Under laboratory conditions, the formation of bacterial colonies may take several weeks, which complicates the laboratory diagnosis of tuberculosis.

The bacterial cell wall contains a large number of lipids, glycolipids, and mycolic acids. These components increase the bacterium's resistance to environmental factors and play a key role in determining its pathogenic properties.

Main Part

Pathogenic Factors of *Mycobacterium tuberculosis*.

The pathogenicity of the tuberculosis agent is associated with a number of biological components that enable the bacterium to survive in the human body and contribute to disease progression. One of the most important pathogenic factors of mycobacteria is mycolic acids. These substances are key structural components of the bacterial cell wall and provide acid-fastness. Mycolic acids make it difficult for the bacterium to be destroyed during phagocytosis and help it adapt to environmental conditions.

Another substance that increases the virulence of the tuberculosis agent is the cord factor, also known as trehalose dimycolate. This compound causes bacteria to arrange in cord-like structures and may negatively affect macrophage activity. The cord factor also plays an important role in the formation of granulomas.

Sulfolipids are also important components contributing to bacterial pathogenicity. These substances inhibit the fusion of phagosomes and lysosomes, allowing the bacterium to survive within macrophages. As a result, the bacterium is not completely eliminated by the immune system.

Another key component of the bacterial cell wall is lipoarabinomannan. This molecule affects the activity of the immune system and modulates cytokine production, enabling the bacterium to persist in a latent state within the host for long periods.

Pathogenesis of Tuberculosis.

Tuberculosis begins when the bacterium enters the body through the respiratory tract. After reaching the alveoli of the lungs, the bacteria are phagocytosed by macrophages. However, due to the ability of *Mycobacterium tuberculosis* to survive within macrophages, it is not destroyed after phagocytosis.

The bacterium continues to multiply inside the cells and activates various components of the immune system. In response, the body forms granulomas to contain the infection. A granuloma is a structured formation composed of macrophages, epithelioid cells, giant cells, and lymphocytes, which helps limit the spread of infection.

If the immune system becomes weakened, the bacteria within the granuloma may reactivate, leading to the recurrence of the disease.

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Diagnosis of Tuberculosis.

The diagnosis of tuberculosis involves clinical, laboratory, and instrumental methods. One of the most important diagnostic techniques is the microscopic examination of sputum samples, which allows the detection of acid-fast mycobacteria.

Bacteriological methods are also significant, involving the cultivation of bacteria on special nutrient media. Although this method requires more time, it enables precise identification of the pathogen.

Molecular biological methods, including polymerase chain reaction (PCR), are widely used for rapid detection of tuberculosis. In addition, radiographic examinations and computed tomography (CT) scans are important for identifying changes in lung tissues.

Treatment of Tuberculosis.

The treatment of tuberculosis requires a long-term and комплекс approach. A combination of several anti-tuberculosis drugs is used during therapy. The most commonly used medications include isoniazid, rifampicin, pyrazinamide, and ethambutol. Treatment usually lasts for several months, and patients must take medications regularly. Improper or incomplete treatment may lead to the development of drug-resistant forms of the bacteria.

Prevention of Tuberculosis.

Preventive measures play a crucial role in controlling tuberculosis. One of the most effective methods of prevention is the BCG vaccine, which reduces the risk of severe forms of tuberculosis in children. Preventive strategies also include adherence to санитарно-hygienic rules, early detection of infection sources, and timely treatment of infected individuals. Regular medical screenings and early diagnosis among the population help reduce the spread of tuberculosis.

Conclusion.

Mycobacterium tuberculosis is a microorganism with complex pathogenic mechanisms. Its pathogenicity is mainly associated with components such as cell wall lipids, mycolic acids, cord factor, sulfolipids, and lipoarabinomannan. These factors enable the bacterium to partially evade the immune system and survive within macrophages.

A deep understanding of the pathogenesis of tuberculosis is essential for early diagnosis, effective treatment, and the development of preventive measures.

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