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LABORATORY DIAGNOSTICS OF TUBERCULOSIS

Abstract: Tuberculosis (TB) remains one of the most pressing health problems due to the high morbidity and mortality from this infectious disease caused by Mycobacterium tuberculosis . The article discusses the main methods of laboratory diagnostics of tuberculosis: microscopy, culture methods, molecular methods and immunological tests. Each of the methods has unique advantages and disadvantages. The emphasis is on the need for a comprehensive approach to diagnostics, which will improve the quality of treatment and control the spread of the disease. Particular attention is paid to the prospects for the development of molecular diagnostics as an effective tool in the fight against tuberculosis.

Introduction. Tuberculosis (TB) remains one of the greatest public health threats despite the development of vaccines, drugs, and modern diagnostic methods. According to the World Health Organization, approximately 10 million new cases of TB are registered worldwide each year, making it one of the leading infectious diseases. Effective early diagnosis of TB is critical to reducing its spread and improving the effectiveness of treatment.

Epidemiology and importance of diagnostics .

People of any age can get tuberculosis, but those at greatest risk are:

• Individuals with weakened immune systems (e.g. HIV-positive patients).

• Persons who are often in crowded conditions (prisons, shelters).

• People with pre-existing lung diseases.

According to WHO, TB is one of the three leading causes of death among women of reproductive age in poor countries. This highlights the importance of developing effective early diagnosis and treatment programmes.

Laboratory diagnostic methods

1. Microscopy

Microscopy remains the first and most accessible method for diagnosing tuberculosis. Samples can be taken from sputum, cerebrospinal fluid, lung tissue biopsies , or lymph nodes. Classification by the number of bacteria detected allows doctors to assess the burden of infection:

• Positive result (various degrees): Indicates the presence of infection.

• Negative result: Does not exclude the diagnosis, since mycobacteria may be present in insufficient quantities.

However, the method requires additional confirmation, as it can give false positive and false negative results. Microscopy can be improved by using fluorescent dyes that increase the detection of mycobacteria.

2. Cultural methods

Bacterial culture is the gold standard for diagnosing tuberculosis. Depending on the environment, such a culture can take from several weeks to several months. Evaluation of susceptibility to various anti-TB drugs allows the development of a personalized treatment plan. Culture methods are also useful for the study of multidrug-resistant tuberculosis.

In addition, culture methods allow us to study the biological properties of bacteria, which helps in the development of new therapeutic strategies.

3. Molecular methods

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Using PCR methods, results can be provided within a few hours. Modern molecular tests, such as Xpert MTB/RIF, can simultaneously detect Mycobacterium tuberculosis and determine its sensitivity to rifampicin , one of the main drugs used to treat tuberculosis. This allows for rapid decisions on patient treatment.

The GenExpert (or GeneXpert) method is a modern molecular genetic technology used to diagnose tuberculosis. Here are the main aspects associated with this method:

• Operating principle: GenExpert is based on polymerase chain reaction (PCR) technology, which allows the detection of Mycobacterium DNA tuberculosis in samples such as sputum, tissue or other biological fluids. The method includes automated analysis, which makes the diagnostic process faster and easier.

• Speed of results: One of the key advantages of GenExpert is its speed. Results can be obtained in as little as 2 hours, significantly reducing the time from sample collection to diagnosis.

• Sensitivity and specificity: The GenExpert assay demonstrates high sensitivity and specificity, allowing it to accurately detect active TB as well as determine resistance to rifampicin , one of the main anti-TB drugs.

Advantages

1. Speed of diagnosis: Allows for the rapid detection of active forms of tuberculosis, which is especially important in epidemic conditions.

2. Resistance monitoring: GenExpert is able to detect drug resistance, which allows the doctor to immediately prescribe the most effective treatment.

3. Continuity of the process: This allows the method to be used locally, even in remote regions and resource-poor settings.

Flaws

1. Cost: Although the method is accessible and produces results quickly, it can be expensive to use due to the cost of equipment and supplies.

2. Limited sensitivity to latent forms: GenExpert is primarily intended for the diagnosis of active TB and is not suitable for the detection of latent infection.

GenExpert method represents a significant advance in TB diagnostics, providing rapid and accurate identification of the disease, which in turn facilitates more effective treatment and reduces the spread of infection. Given its advantages in speed and accuracy, the method is increasingly being used in clinical practice and in the fight against TB globally.

The speed of results also helps prevent further spread of infection, which is especially important in an epidemic.

4. Immunological tests

Interferon-based tests, such as IGRA, are highly specific for detecting latent TB. These tests cannot differentiate between active and latent TB, but they are useful for identifying people at high risk, such as those working in health care settings. It is important to remember, however, that results may be skewed in people with weakened immune systems.

Moreover, the use of IGRA may help in the investigation of tuberculosis outbreaks in closed communities and monitoring of latent infection.

Approaches to interpreting results

It is important to consider the clinical context when interpreting all tests. Each laboratory diagnostic method has its limitations, and a combination of methods may be needed to accurately diagnose. For example, negative microscopy and culture results in the presence of severe clinical features require additional attention and may require repeat testing.

Problems and challenges

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Among the main problems associated with laboratory diagnostics of tuberculosis, the following can be highlighted:

• False positive and false negative results: This may occur due to technical deficiencies, improper storage of samples or individual patient characteristics.

• Multidrug resistance : The increase in cases of multidrug-resistant tuberculosis requires improved diagnostic and monitoring methods. About 500,000 cases of tuberculosis worldwide are multidrug-resistant .

• Availability and resources: In low-resource areas, access to modern diagnostic technologies may be limited.

The Future of Laboratory Diagnostics of Tuberculosis

• Innovative technologies: The development of new diagnostic methods such as nanotechnology and biosensors can lead to faster and more accurate diagnoses.

• Genetic studies: Using next-generation sequencing to identify genetic mutations associated with resistance to TB drugs.

• Integration into health systems: It is important that new diagnostic methods are integrated into existing health systems to ensure equal access to testing and treatment.

Conclusion. Laboratory diagnostics of tuberculosis is a multi-level process that requires a combination of various tests and in-depth clinical analysis. Modern technologies provide significant progress in diagnostics, but the main focus should still be on the availability and quality of diagnostics for all segments of the population. To successfully combat tuberculosis, it is necessary to continue scientific research, develop new diagnostic methods and increase access to existing technologies worldwide.

Effective and early diagnosis is a fundamental step towards eliminating tuberculosis as a public health threat.

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