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MODERN DIAGNOSTIC METHODS OF PULMONARY TUBERCULOSIS: FROM CLASSICS TO INNOVATIONS

Tuberculosis remains one of the most serious infectious diseases worldwide, particularly in low- and middle-income countries. According to the “Global Tuberculosis Report 2024”, 10.8 million new cases of tuberculosis were registered globally in 2023, with an incidence rate of 134 per 100,000 of population, the highest one since the global monitoring began in 1995.

The largest number of tuberculosis patients is recorded in India, Indonesia, China, the Philippines, and Pakistan. These five countries account for 56% of all tuberculosis cases worldwide [6].

Regarding the situation in Ukraine, only in February 2025, 1319 individuals were registered with tuberculosis: 1009 new cases of the disease; 250 patients with relapse; 60 other cases (among them: individuals who resumed treatment; patients after unsuccessful treatment courses; patients with an unknown history of prior treatment). 254 individuals from the total number had a drug-resistant form of tuberculosis. Pulmonary tuberculosis was detected in 1225 people with tuberculosis, and extrapulmonary tuberculosis in 94. Out of the total number of tuberculosis cases in February 2025, 1013 were men and 306 were women. 214 patients were HIV-positive. The figures for tuberculosis cases are regrettably increasing monthly, which underscores the relevance of this disease and indicates the necessity of prevention, timely diagnosis, and treatment of this condition [4].

Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis* (MTB). The primary route of transmission is airborne droplet and airborne dust. Mycobacteria are present in tiny droplets released during talking, coughing, and sneezing by an infected person.

Key risk factors for developing tuberculosis include: contact with a person with active tuberculosis; weakened immune system (HIV infection, immunosuppressive therapy); chronic diseases (diabetes mellitus, autoimmune diseases); oncological diseases; advanced age; malnutrition and poor socio-economic conditions; smoking and alcohol abuse; prolonged stress.

Special attention is warranted for children, whose immune systems are not yet fully formed, and individuals in adverse conditions due to military actions, forced displacement, and limited access to adequate nutrition and medical care [3].

Tuberculosis is a disease that can affect various organs and systems. Specifically, it can involve different organs and systems, including: the respiratory system, the meninges and nervous system, the intestines, the peritoneum, the mesenteric lymph nodes, bones and joints, the kidneys, the urinary tract, the genital organs, the skin, the subcutaneous tissue, the eyes, and other organs.

The current classification of pulmonary tuberculosis includes the following forms:

1. Clinical-radiological manifestations: primary tuberculosis complex; tuberculosis of intrathoracic lymph nodes; disseminated pulmonary tuberculosis; focal pulmonary tuberculosis; infiltrative pulmonary tuberculosis; caseous pneumonia;

pulmonary tuberculoma; cavernous pulmonary tuberculosis; fibrocavernous pulmonary tuberculosis; cirrhotic pulmonary tuberculosis; tuberculous pleurisy; tuberculosis of the bronchi, trachea, and upper respiratory tract

2. Bacterial excretion: with *Mycobacterium tuberculosis* excretion (MTB+); without *Mycobacterium tuberculosis* excretion (MTB-).
3. Drug resistance: drug-susceptible tuberculosis; monoresistant tuberculosis; polyresistant tuberculosis; multidrug-resistant tuberculosis (MDR-TB); extensively drug-resistant tuberculosis (XDR-TB) [2, c.178].

Symptoms of tuberculosis can vary significantly from minimal to pronounced, depending on the form of the disease, the extent of the process, and the patient's immune status.

Primary tuberculosis is characterized by a gradual or acute onset and course, paraspecific reactions, positive tuberculin skin tests, and involvement of the lymph nodes in the pathological process. The following forms of primary tuberculosis are distinguished: early and chronic tuberculous intoxication in children and adolescents, primary tuberculous complex, bronchoadenitis (tuberculosis of the lymph nodes), and disseminated pulmonary tuberculosis.

Tuberculous intoxication manifests as an increase in body temperature to subfebrile levels, increased sweating, headache, dizziness, general weakness, pallor of the skin, impaired appetite, emotional lability, and enlargement of peripheral lymph nodes.

The primary tuberculous complex begins acutely, with an increase in body temperature to 38-39°C, the appearance of symptoms of tuberculous intoxication (weakness, loss of appetite, sweating), severe cough, chest pain, and shortness of breath [2, p.178; 4].

It should be noted that tuberculosis can be asymptomatic, especially in the early stages, which complicates timely diagnosis and underscores the importance of preventive screenings in risk groups.

Early and accurate diagnosis of tuberculosis is critical for effective treatment, prevention of infection spread, and reduction of mortality. Modern diagnostic methods for tuberculosis are constantly improving, allowing for better detection of the disease at early stages and ensuring more effective treatment.

According to current recommendations, tuberculosis diagnosis should be comprehensive and include the following methods:

1. Screening methods:

- a) clinical screening – involves the identification of symptoms that may be indicative of tuberculosis, such as a persistent cough (lasting over 2-3 weeks), fever, night sweats, weight loss, fatigue, chest pain, hemoptysis, etc;

- b) chest X-ray (radiography) – allows to detect changes in the lungs characteristic of tuberculosis, such as infiltrates, cavities, foci, and pleural effusion;

- c) tuberculin skin test (TST or Mantoux test) for children – involves the intradermal injection of tuberculin and the assessment of the reaction after 72 hours. An indicator of infection is the size of the the papule (induration) at the injection site. It is important to consider that results may be false-positive due to BCG vaccination or other factors;

- d) immunological tests (interferon-gamma release assays or IGRAs) – QuantiFERON-TB Gold test or T-SPOT.TB test – measure the immune system's response to specific *Mycobacterium tuberculosis* antigens. An indicator of infection is a positive test

result. These tests are more specific than the TST and do not give false-positive results due to BCG vaccination.

2. Diagnostic confirmation methods:

a) microscopic examination of sputum for acid-fast bacilli (AFB smear) – allows to detect *Mycobacterium tuberculosis* under a microscope. An indicator of the disease is the identification of acid-fast bacilli in the sputum;

b) culture studies – involve growing *Mycobacterium tuberculosis* on a specialized culture medium. This method is more sensitive than microscopy and allows to define an accurate diagnosis;

c) molecular genetic methods (Xpert MTB/RIF, Line Probe Assay) – allow the rapid detection of *Mycobacterium tuberculosis* DNA and determination of resistance to rifampicin (Xpert MTB/RIF) or other anti-tuberculosis drugs (Line Probe Assay). An indicator of the disease is the detection of *Mycobacterium tuberculosis* DNA;

d) drug susceptibility testing (DST) of mycobacteria – allows to determine which anti-tuberculosis drugs the mycobacteria are susceptible to and which they are resistant to. This is necessary for prescribing effective treatment.

3. Additional investigations:

a) computed tomography (CT) of the chest – allows to obtain more detailed images of the lungs than a chest X-ray and can reveal changes not visible on a standard radiograph;

b) complete blood count (CBC) with erythrocyte sedimentation rate (ESR) – helps to assess the overall condition of the body and the presence of an inflammatory process. An elevated ESR may indicate the presence of inflammation but is not specific to tuberculosis;

c) biochemical blood tests (C-Reactive Protein (CRP), Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST), Lactate Dehydrogenase (LDH), Electrolytes) – help to assess the function of the liver, kidneys, and other organs, as well as detect signs of inflammation;

d) bronchoscopy with biopsy, if necessary – allows to visualize the internal surface of the bronchi and the collection of tissue samples for examination. It is used in complex cases when other methods do not allow to establish a diagnosis [1].

It is important to note that modern molecular diagnostic methods (Xpert MTB/RIF) allow for simultaneous detection of *Mycobacterium tuberculosis* and determination of its resistance to rifampicin within a few hours, which significantly accelerates the initiation of adequate therapy.

Modern methods for diagnosing pulmonary tuberculosis improve disease detection at early stages, determine antibiotic resistance, and ensure more effective treatment. The implementation of innovative technologies, such as molecular genetics methods, is the key to combating tuberculosis and reducing its spread.

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