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MODERN CLINICAL AND LABORATORY APPROACHES TO THE DIAGNOSIS OF PNEUMONIA

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Abstract. Pneumonia is one of the most common and clinically significant diseases of the respiratory system, associated with high morbidity and a substantial risk of complications. Timely and accurate diagnosis of pneumonia is crucial for selecting appropriate treatment strategies and improving disease outcomes. In recent years, modern laboratory diagnostic methods have been widely implemented in clinical practice, enabling the detection of inflammatory processes, identification of the etiological agent, and assessment of disease severity. This paper reviews current approaches to the clinical and laboratory diagnosis of pneumonia, including general clinical, biochemical, immunological, and molecular genetic methods. Special attention is paid to the role of inflammatory laboratory markers, such as C-reactive protein, procalcitonin, complete blood count parameters, and microbiological studies, in the diagnosis of pneumonia and in monitoring the effectiveness of therapy.

Keywords: pneumonia, clinical diagnosis, laboratory diagnostics, inflammatory markers, C-reactive protein, procalcitonin, complete blood count, microbiological examination, molecular diagnostics, disease severity assessment, treatment monitoring

Relevance. Pneumonia remains one of the leading causes of morbidity and mortality among infectious diseases of the respiratory system worldwide. Despite significant advances in modern medicine, this pathology continues to represent a serious medical and social problem, which is associated with an increasing number of patients with chronic diseases, population aging, a growing prevalence of immunodeficiency conditions, and the emergence of antibiotic-resistant strains of microorganisms. The problem of pneumonia becomes especially relevant during epidemiological outbreaks of respiratory infections, including viral pneumonias, which require timely and highly accurate diagnosis. [9,14,15].

Modern clinical and laboratory diagnostics play a key role in the early detection of pneumonia, determination of its etiology, and assessment of disease severity. The clinical presentation of pneumonia is often atypical, especially in children, elderly patients, and individuals with comorbid conditions, which complicates diagnosis based solely on clinical findings and instrumental methods. In this context, laboratory methods become an integral part of the diagnostic algorithm, allowing objective assessment of the presence and activity of the inflammatory process. [6,7,10].

The introduction of modern laboratory technologies, including the determination of specific inflammatory markers (C-reactive protein, procalcitonin), extended parameters of complete blood count and biochemical tests, as well as microbiological and molecular-genetic methods, significantly increases the accuracy of pneumonia diagnosis. These approaches make it possible not only to identify the causative agent but also to differentiate between bacterial and viral etiologies, which is critically important for the rational use of antibacterial therapy and the prevention of its unjustified prescription. [7,15].

Pneumonia is an acute infectious and inflammatory disease of the lung tissue characterized by involvement of the alveoli and interstitial structures, leading to impaired gas exchange. Etiological factors of pneumonia may include bacterial, viral, fungal, and atypical microorganisms. Due to the diversity of pathogens and clinical forms, modern clinical and laboratory diagnostics occupy a central place in confirming the diagnosis and selecting appropriate treatment strategies. [7,14,15].

Clinical and laboratory diagnosis of pneumonia begins with the assessment of general clinical parameters. The complete blood count is one of the most accessible and informative diagnostic methods. Bacterial pneumonia is typically characterized by leukocytosis with a neutrophilic left shift and an increased erythrocyte sedimentation rate, whereas viral pneumonia more often presents with leukopenia or normal leukocyte counts with relative lymphocytosis. Dynamic monitoring of complete blood count parameters allows evaluation of the severity of the inflammatory process and the effectiveness of therapy. Biochemical tests play an important role in detecting and monitoring the inflammatory response. The most significant markers are C-reactive protein and procalcitonin, the levels of which correlate with the activity of inflammation and the severity of pneumonia. Elevated serum procalcitonin has high diagnostic value in bacterial etiology and is used for differential diagnosis between bacterial and viral pneumonia, as well as for justification of antibacterial therapy. [3,8,11].

Microbiological diagnostics are aimed at identifying the causative agent of pneumonia and determining its sensitivity to antibacterial drugs. For this purpose, bacteriological examination of sputum, bronchoalveolar lavage, and blood cultures in severe cases are used. Despite certain limitations related to sample contamination and prior antibiotic use, microbiological methods remain the “gold standard” of etiological diagnosis of pneumonia. Modern molecular-genetic methods, including polymerase chain reaction (PCR), have significantly expanded the diagnostic capabilities of clinical laboratories. PCR diagnostics allow rapid and highly sensitive detection of DNA or RNA of pathogens, including viruses and atypical microorganisms, which is

especially important in severe and complicated cases of pneumonia. The use of these methods contributes to early initiation of etiotropic therapy and reduces the risk of complications. [3,12,15].

Immunological methods are also widely used in the diagnosis of pneumonia. Detection of specific antibodies and antigens of pathogens helps clarify the etiology of the disease, particularly in atypical cases and when isolation of the microorganism by conventional methods is not possible. In combination with other laboratory and clinical data, immunological parameters increase diagnostic reliability. Thus, modern clinical and laboratory diagnostics of pneumonia are based on a comprehensive approach that includes general clinical, biochemical, microbiological, immunological, and molecular-genetic methods. Rational use of these approaches allows timely diagnosis, determination of disease etiology, assessment of severity, and monitoring of treatment effectiveness. [2].

Pneumonia is a polyetiological disease, the development of which may be caused by various infectious and, less frequently, non-infectious factors. Depending on the nature of the causative agent, bacterial, viral, fungal, and atypical pneumonia are distinguished, each having its own clinical and diagnostic characteristics. Bacterial microorganisms are the most common cause of pneumonia. Among them, Streptococcus pneumoniae plays a leading role and remains the principal pathogen of community-acquired pneumonia. Other important pathogens include Haemophilus influenzae, Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli, and other Gram-negative bacteria, especially in elderly patients and individuals with concomitant chronic diseases. In hospital settings and intensive care units, the role of nosocomial pathogens increases, including Pseudomonas aeruginosa and Acinetobacter spp., which are often characterized by multidrug resistance. [1,4,6].

Viral pneumonia most often develops against the background of acute respiratory viral infections. The main viral agents include influenza viruses, parainfluenza viruses, respiratory syncytial virus, adenoviruses, as well as coronaviruses. Viral infection may

act as an independent cause of pneumonia or facilitate the development of secondary bacterial infection, thereby aggravating the course of the disease. [3,15].

Atypical pathogens of pneumonia include Mycoplasma pneumoniae, Chlamydophila pneumoniae, and Legionella pneumophila. These microorganisms are characterized by intracellular parasitism and often cause pneumonia with a mild or atypical clinical presentation, which complicates timely diagnosis and requires the use of special laboratory methods, including serological and molecular-genetic tests. Fungal pneumonia occurs predominantly in patients with immunodeficiency states, oncohematological diseases, HIV infection, and those receiving prolonged immunosuppressive therapy. The most clinically significant fungal pathogens include Candida spp., Aspergillus spp., and Pneumocystis jirovecii. [1,7,15].

The clinical presentation of pneumonia is highly variable and depends on the etiological factor, disease form, patient age, immune status, and the presence of comorbidities. In most cases, pneumonia has an acute onset and manifests with signs of infectious and inflammatory involvement of lung tissue accompanied by an intoxication syndrome. The main clinical symptoms include fever, chills, general weakness, malaise, headache, and decreased working capacity. Fever is usually febrile and may be associated with pronounced intoxication, particularly in bacterial pneumonia. In elderly patients and immunocompromised individuals, body temperature may remain subfebrile or normal, which complicates early diagnosis. Respiratory symptoms include cough, which may initially be dry and later become productive with mucous or mucopurulent sputum. In severe cases, sputum mixed with blood may be observed. Dyspnea, tachypnea, and a sensation of air hunger are signs of respiratory failure and are more commonly seen in extensive lung involvement. [5,10,13].

Pain syndrome in pneumonia is associated with pleural involvement and manifests as chest pain that intensifies during deep inspiration and coughing. Physical examination reveals dullness on percussion over the affected lung area, diminished or bronchial breath sounds, as well as fine moist rales and crepitation. The clinical course

of pneumonia varies according to its etiology. Bacterial pneumonia is typically characterized by an acute onset, high fever, and pronounced intoxication symptoms. Viral pneumonia is more often associated with moderate intoxication, dry cough, and signs of upper respiratory tract involvement. Atypical pneumonia may present with blurred symptomatology, predominance of general malaise, and minimal physical findings. [6,10].

Modern laboratory diagnostics of pneumonia is an integral part of the clinical diagnostic process and is aimed at confirming the presence of inflammation, determining disease etiology, assessing severity, and monitoring treatment effectiveness. A comprehensive approach using various laboratory methods significantly increases diagnostic accuracy and timeliness. The complete blood count remains a basic and widely accessible laboratory test. Bacterial pneumonia is characterized by leukocytosis with a left neutrophilic shift, increased erythrocyte sedimentation rate, and elevated band neutrophils. In viral pneumonia, leukopenia or normal leukocyte counts with relative lymphocytosis are more commonly observed. Dynamic evaluation of hematological parameters allows assessment of inflammatory activity and treatment response. [4,11,13].

Biochemical blood tests have important diagnostic and prognostic value. Key inflammatory markers include C-reactive protein and procalcitonin. Elevated C-reactive protein reflects the intensity of the inflammatory response, while procalcitonin levels help differentiate between bacterial and viral pneumonia and assess the necessity and duration of antibacterial therapy. Additional parameters such as enzyme activity, electrolyte balance, and renal function may be evaluated to assess the patient's general condition. Microbiological diagnostics are aimed at identifying the causative agent of pneumonia and determining its susceptibility to antimicrobial agents. Bacteriological cultures of sputum, tracheobronchial aspirate, bronchoalveolar lavage, and, in severe cases, blood cultures are performed. Despite certain limitations related to the duration of testing and the impact of prior antibacterial therapy, microbiological methods remain an important stage of etiological diagnosis. [3,9].

Molecular-genetic methods, particularly polymerase chain reaction (PCR), are widely used in modern practice for rapid and highly sensitive detection of bacterial and viral pathogens of pneumonia. PCR diagnostics allow identification of microbial genetic material even at low pathogen concentrations and are especially valuable in the diagnosis of atypical and viral pneumonias. Immunological methods include the detection of specific antibodies and antigens of pathogens. Serological tests are used to confirm atypical etiology of pneumonia and in retrospective diagnosis. When combined with other laboratory indicators, immunological methods enhance the reliability of diagnostic conclusions. [13,15].

Conclusion. Pneumonia remains a relevant problem in modern clinical medicine due to its high prevalence, the diversity of etiological factors, and the risk of developing severe complications. In the context of a variable and often atypical clinical presentation, modern laboratory diagnostics plays a particularly important role, as it allows objective confirmation of the inflammatory process and clarification of the nature of the disease. The comprehensive use of general clinical, biochemical, microbiological, immunological, and molecular-genetic research methods significantly increases the accuracy and timeliness of pneumonia diagnosis.

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