MODERN LABORATORY METHODS OF DIAGNOSING SEPSIS

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Sepsis is a complex clinical and pathophysiological syndrome that occurs due to a dysregulated systemic response of the body to an infectious process and is accompanied by the development of organ dysfunction. In modern conditions, laboratory diagnosis of sepsis is considered one of the key components for early disease detection, risk stratification, prognostic assessment, and monitoring of therapy effectiveness [22,23,24].

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First and foremost, etiological diagnostics aimed at identifying the infectious agent are of paramount importance. The "gold standard" remains the microbiological examination of blood-hemoculture. It is recommended to conduct at least two to three blood samples from various veins before starting antibacterial therapy, adhering to strict aseptic rules [1,2,3].

This method allows not only for the identification of the pathogen but also for determining its antibiotic sensitivity. However, its limitations include the duration of results (48-72 hours), dependence on previous antibiotic therapy, and the risk of false negative results. Additionally, other biological media (urine, sputum, liquor, wound secretions) may be examined depending on the suspected infection site.

The second important direction is the determination of laboratory markers of the systemic inflammatory response. Among them, procalcitonin and C-reactive protein are of the greatest clinical significance. Procalcitonin is a highly specific marker of bacterial infection; its concentration increases in the first hours of sepsis development and correlates with the severity of the condition, making it useful both for diagnosis and for monitoring the effectiveness of antibacterial therapy.

C-reactive protein synthesized in the liver is a more sensitive but less specific indicator, as its level increases in various inflammatory conditions, including non-infectious ones [10,11,12].

Additionally, pro-inflammatory cytokines such as interleukin-6, tumor necrosis factor-α, and other inflammatory mediators are evaluated. Their increase reflects the

activation of the immune response, but in routine practice, their use is limited due to high costs and insufficient standardization.

General blood analysis is of significant diagnostic and prognostic importance. In sepsis, both leukocytosis and leukopenia may be observed; it is not uncommon to observe a leftward shift of neutrophils with an increase in the number of immature forms. Thrombocytopenia is considered an unfavorable prognostic sign and may indicate the development of coagulopathy.

Assessment of metabolic disorders includes determining the level of lactate in the blood, which is an important marker of tissue hypoxia and hypoperfusion. An increase in lactate concentration is associated with a worsening prognosis and is used to evaluate the effectiveness of infusion therapy and resuscitation measures [7,8,9].

An integral part of laboratory diagnostics is the study of the hemostasis system. In sepsis, disseminated intravascular coagulation (DIVS syndrome) often develops, characterized by an increase in prothrombin time, activated partial thromboplastin time, a decrease in fibrinogen levels, and an increase in fibrin degradation products, including D-dimer [4,5,6].

Biochemical blood indicators reflect the degree of organ dysfunction. An increase in creatinine and urea indicates kidney damage, while an increase in bilirubin and transaminases indicates impaired liver function. Hyperglycemia and disorders of the acid-base state also often accompany the septic process.

Modern approaches to laboratory diagnosis of sepsis include the implementation of molecular genetic methods, such as polymerase chain reaction (PCR), which significantly reduces the time required to identify the pathogen. The use of multiplex panels allows for the simultaneous detection of a wide range of pathogens and resistance genes, which is especially important under conditions of intensive therapy.

The development of multiplex PCR technologies has made it possible to simultaneously detect a wide range of pathogens (bacteria, viruses, fungi) in a single sample. This is especially important for polymicrobial infections and in cases where the source of infection is unclear. Furthermore, modern test systems are capable of detecting antibiotic resistance genes (e.g., mecA, vanA/vanB, KPC), allowing for the rapid adjustment of antimicrobial therapy [17,18,19].

One of the promising areas is the use of next-generation sequencing (NGS) methods. Metagenomic analysis allows for the identification of the entire spectrum of microorganisms present in the sample without a preliminary assumption regarding the type of pathogen. This is especially relevant for atypical or rare infections, as well as for patients with immunodeficiency. However, the high cost, complexity of data interpretation, and the need for specialized infrastructure limit the wide application of this technology.

An additional direction of molecular diagnostics is assessing the expression of the patient's immune response genes. Transcriptome analysis (RNA profiling) allows for the identification of specific gene expression patterns associated with sepsis and the differentiation of bacterial and viral infections. Such approaches open up opportunities for personalized medicine and predicting disease outcomes [19,20,21].

Promising areas include the development of new biomarkers (precepsin, procalcitonin derivatives), as well as the application of integrative diagnostic models that combine laboratory indicators with clinical scales (e.g., SOFA, qSOFA).

Thus, laboratory diagnosis of sepsis is a multi-level system that includes etiological verification, assessment of systemic inflammatory response, identification of organ dysfunction, and monitoring of patient condition dynamics. A comprehensive and timely approach to interpreting laboratory data significantly increases diagnostic efficiency and improves disease outcomes [22,23,24].

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