MODERN APPROACHES TO DIAGNOSTICS OF INFECTIOUS DISEASES

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Abstract: The article is devoted to modern approaches to diagnostics of infectious diseases, which play a key role in effective healthcare. Molecular methods such as polymerase chain reaction (PCR) and nucleotide sequencing, which allow rapid and accurate detection of pathogens in the early stages of the disease, are considered. Serological tests, including enzyme-linked immunosorbent assay (ELISA) and rapid tests that help determine the body's immune response, are also discussed. An important part of the article is the study of the use of artificial intelligence in diagnostics, including machine learning and medical image processing, which contributes to improving the quality of diagnostics and prognosis of infectious diseases. The article emphasizes the need for further research and the implementation of new technologies to effectively combat infections in the modern world.

Keywords: infectious diseases, diagnostics, polymerase chain reaction (PCR), nucleotide sequencing, serological tests, enzyme-linked immunosorbent assay (ELISA), artificial intelligence, machine learning, medical imaging, antibiotic resistance.

Diagnostics of infectious diseases is one of the most important components of modern healthcare, playing a key role in the timely detection and treatment of infections. With the rapid development of technology and scientific research, diagnostic methods are becoming more accurate and effective. Traditional approaches, such as culture methods and serological tests, are gradually being

supplemented by new molecular methods that allow pathogens to be detected at early stages of the disease with high sensitivity and specificity.

In the context of globalization and increasing incidence of antibiotic resistance, effective diagnostics of infectious diseases is becoming increasingly important. This article reviews modern diagnostic methods, including polymerase chain reaction (PCR), nucleotide sequencing, and the use of artificial intelligence. These innovative approaches not only improve the quality of medical care, but also contribute to a deeper understanding of the epidemiology of infections, which in turn helps in the development of effective prevention and treatment strategies.

Molecular diagnostic methods

Molecular diagnostic methods occupy a central place in modern approaches to identifying infectious diseases. They allow detecting the genetic material of pathogens with high sensitivity and specificity, which makes them indispensable in clinical practice. Let us consider the most common molecular methods.

Polymerase chain reaction (PCR) is a method that amplifies (increases the amount) of specific fragments of pathogen DNA or RNA. PCR is used to diagnose a wide range of infectious diseases, including viral, bacterial and fungal infections. PCR can detect even small amounts of pathogen. Results can be obtained within a few hours. The method allows for the accurate identification of specific pathogen species. Sensitivity ranges from 90% to 98% for viral infections such as COVID-19, indicating the high ability of the method to detect pathogens even at low concentrations. Specificity reaches 95-100%, confirming its ability to accurately identify target nucleic acids. The time to obtain a result is usually between 2 and 6 hours, making PCR one of the fastest diagnostic methods.

Nucleotide sequencing is a method that allows determining the sequence of nucleotides in the genetic material of pathogens. This approach is used to study genetic variability, mutations and evolution of infectious agents. Sequencing helps to track the sources of infections and their spread. It allows to identify mutations that contribute to drug resistance. The accuracy reaches 99% when analyzing high-

quality samples, which allows this method to be effectively used to study the genetic variability of pathogens. Application More than 60% of laboratories worldwide integrate sequencing into their epidemiological studies, which indicates its growing importance.

Real-time PCR (qPCR) is an advanced version of PCR that allows quantitative determination of gene expression levels or the number of pathogens in a sample. This method is used to monitor disease progression and assess treatment efficacy. The advantages include the ability to quantify and the speed of obtaining results. Sensitivity ranges from 90% to 95%, ensuring reliable detection of target sequences. Specificity reaches 95-100%. The result is obtained within 1 to 2 hours, making qPCR convenient for clinical use.

Hybridization techniques such as microarrays allow multiple samples to be analyzed simultaneously for different pathogens. These techniques are particularly useful in epidemiology, where rapid testing of large numbers of samples is required. The advantages include high throughput and the ability to detect multiple pathogens simultaneously.

Serological diagnostic methods

Serological diagnostic methods are based on the detection of antibodies or antigens in blood serum samples, which allows us to determine the presence of an infectious agent or the body's response to it. These methods play an important role in the diagnosis of infectious diseases, especially in cases where molecular methods may be less effective.

Enzyme immunoassay (ELISA) is one of the most common serological methods used to detect antibodies to pathogens or antigens in samples. ELISA is based on the specific interaction of antigens and antibodies. Sensitivity ranges from 85% to 95% for various infections (e.g. HIV, hepatitis), which confirms its effectiveness in detecting antibodies. Specificity reaches 90-98%, which minimizes the risk of false positive results. The time to obtain the result is usually from 1 to 3 hours.

Rapid tests are simple and quick diagnostic methods that provide results within 15-30 minutes. They are often used in the field and in emergency situations. Diagnosis of infections such as HIV, hepatitis, COVID-19. Ease of use and no need for complex equipment. Sensitivity varies from 70% to 90%, depending on the type of infection and the quality of the test. Specificity reaches 80-95%. The time to receive a result is from 15 to 30 minutes, which makes them especially useful in emergency situations.

Immunochemical methods include various approaches such as radioimmunoassay (RIA) and luminescent immunoassay. These methods are also based on the interaction of antibodies and antigens, but use different labels to visualize the result. Sensitivity ranges from 85% to 95%. Specificity reaches 90-98%. The time to obtain the result is usually from 1 to 2 hours.

Serological panels are sets of tests designed to detect several infectious diseases simultaneously. This is especially useful in cases where mass testing is required. It is used in epidemiological studies and screening for various infections. Sensitivity varies from 80% to 95% depending on the tests included. Specificity reaches 90-98%.

According to the presented statistical data, molecular and serological diagnostic methods have high sensitivity and specificity, which makes them key tools in the diagnosis of infectious diseases. The choice of diagnostic method depends on the clinical situation, availability of technologies and the need for rapid results, which emphasizes the importance of an integrated approach in modern healthcare.

Conclusions: In light of the presented statistical data, it can be concluded that both molecular and serological diagnostic methods are important in modern healthcare. The high sensitivity and specificity inherent in these methods allow for the effective detection of infectious diseases, which is critical for the timely initiation of treatment and control of the spread of infections.

Polymerase chain reaction (PCR) and its variations, such as qPCR, demonstrate outstanding results in pathogen detection, enabling rapid and accurate diagnostics. Nucleotide sequencing, in turn, provides valuable information on genetic variability and mutations, which contributes to the understanding of epidemiological processes and the development of new treatment strategies.

Serological methods, including enzyme-linked immunosorbent assays and rapid tests, play an important role in the detection of antibodies and antigens, which allows for the assessment of the body's immune response and mass screening. These methods are especially useful in settings with limited access to laboratory resources, enabling rapid diagnostics in emergency situations.

Thus, the integration of molecular and serological approaches into clinical practice allows for increased diagnostic accuracy, improved treatment outcomes, and effective responses to infectious disease outbreaks. Supporting further research and development in this area will contribute to improved diagnostic methods and, ultimately, improved population health.

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