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TRANSMISSIBLE INFECTIOUS DISEASES

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ABSTRACT

This article analyzes modern diagnostic methods for infectious diseases transmitted through vectors. The aim of the study is to evaluate the effectiveness of laboratory, serological, and molecular biological diagnostic approaches used for detecting these infections. The paper reviews microscopy, culture methods, enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR), and rapid diagnostic tests. The results indicate that molecular methods provide high sensitivity and specificity, while serological techniques are essential for determining disease stages. The combined use of multiple diagnostic approaches significantly improves diagnostic accuracy. In conclusion, the integration of modern diagnostic methods is crucial for the early detection and effective management of vector-borne infectious diseases.

Keywords: Vector-borne diseases, vectors, infectious diseases, diagnostics, molecular diagnostics, PCR, ELISA, serological methods, microscopy, rapid tests, epidemiology, pathogens.

INTRODUCTION

Transmissible infectious diseases (vector-borne diseases) are considered one of the most pressing issues in the global healthcare system. These diseases are characterized by the transmission of pathogenic microorganisms (bacteria, viruses, protozoa, and helminths) to the human body through biological carriers—vectors (mainly mosquitoes, ticks, lice, and flies). According to the World Health Organization (WHO), vector-borne diseases cause millions of cases of illness and deaths each year. In particular, infections such as malaria, dengue fever, leishmaniasis, Lyme disease, and yellow fever are widespread in tropical and subtropical regions. In recent years, climate change, urbanization, and global migration have contributed to the expansion of the geographical distribution of vector-borne diseases. This, in turn, complicates their early detection and effective control. Therefore, the development and implementation of modern diagnostic methods with high sensitivity and specificity are of great importance. Alongside traditional diagnostic methods (microscopy and culture techniques), molecular-biological and immunological methods are widely used today. The aim of this article is to conduct a comprehensive analysis of diagnostic methods used in the detection of vector-borne diseases, to evaluate their advantages and disadvantages, and to determine their role in clinical practice.

MATERIALS AND METHODS

In this study, an analysis of scientific literature on diagnostic methods for vector-borne infectious diseases was carried out. The main sources included modern textbooks and manuals such as Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases and Jawetz, Melnick & Adelberg's Medical Microbiology, as well as WHO and CDC guidelines.

Diagnostic methods were classified into the following groups:

Microscopic methods

Cultural methods, Serological methods, Molecular-biological methods, Rapid diagnostic tests

The sensitivity, specificity, speed, and practical applicability of each method were evaluated.

Microscopic diagnostic methods

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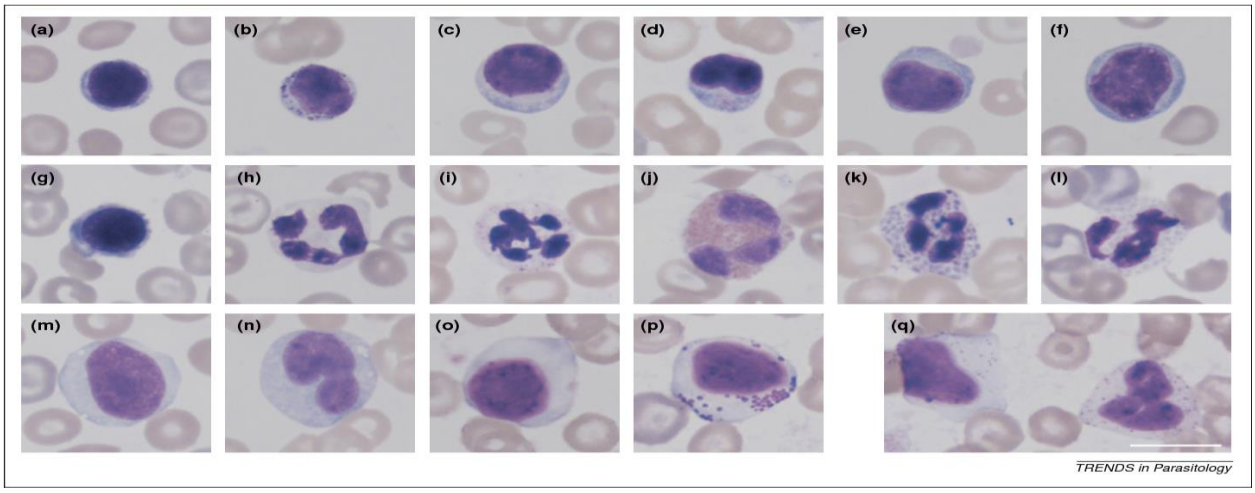
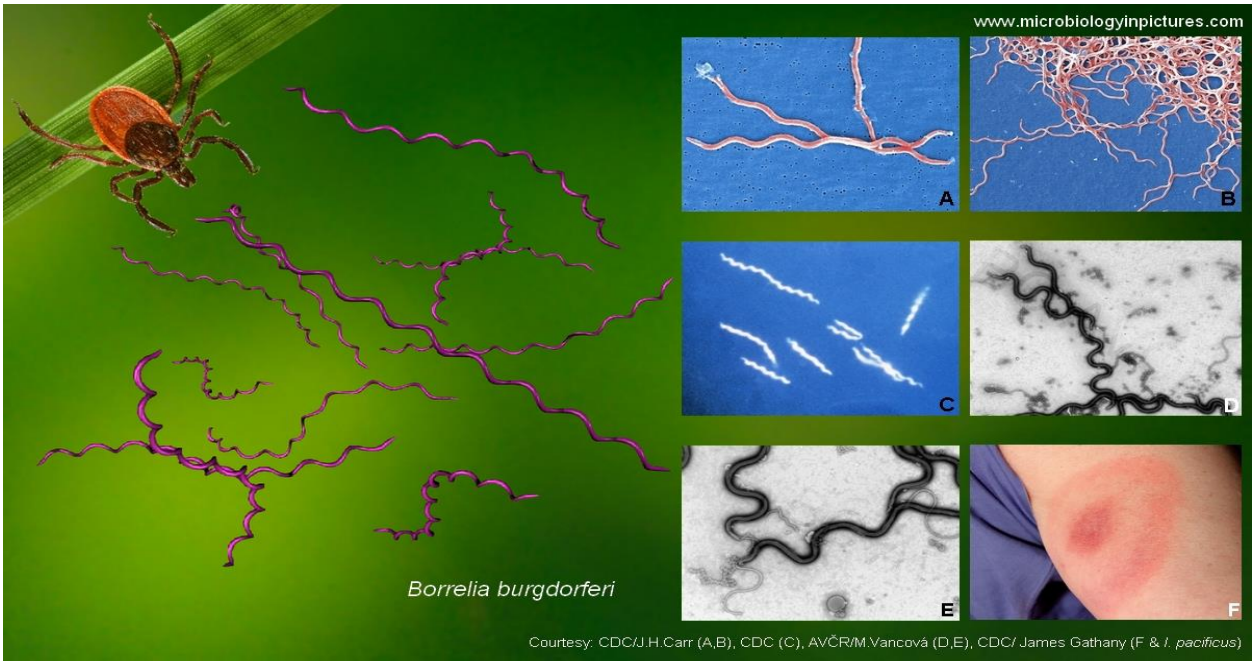


Microscopic examination is one of the oldest and most widely used methods for the detection of vector-borne diseases. For example, in the diagnosis of malaria, the preparation of thick and thin blood smears followed by the identification of Plasmodium species under a microscope is considered the "gold standard." The advantage of this method lies in its low cost and the ability to directly visualize the pathogen. However, microscopic diagnostics require highly qualified specialists, and its sensitivity decreases at low levels of parasitemia. In addition, this method is ineffective for certain diseases, particularly viral infections. Cultural methods are important in the diagnosis of bacterial vector-borne diseases. For instance, Borrelia burgdorferi (the causative agent of Lyme disease) can be cultivated in specialized nutrient media. This method allows for an in-depth study of the biological characteristics of the pathogen. Nevertheless, cultural methods are time-consuming, and some pathogens (such as viruses and certain protozoa) do not grow easily in artificial media.



Serological methods are based on antigen–antibody reactions and are widely used in the diagnosis of vector-borne diseases. The ELISA (enzyme-linked immunosorbent assay) method is effective in detecting many infections, including dengue, leishmaniasis, and Lyme disease.

Serological methods allow the identification of both acute and chronic stages of the disease. However, they may produce false-negative results during the "window period," and there is also a possibility of cross-reactivity.

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Molecular diagnostics, particularly the polymerase chain reaction (PCR), is one of the most accurate and sensitive methods for detecting vector-borne diseases. This method is based on the detection of the pathogen's DNA or RNA and is capable of identifying even very small amounts of microorganisms.

PCR enables early detection of diseases such as malaria, dengue, Zika virus infection, and many others. However, this method requires expensive equipment and highly qualified laboratory conditions.

In recent years, rapid diagnostic tests (RDTs) have become increasingly widespread. They are distinguished by their ability to provide results within a short time (15–30 minutes). For example, there are specific RDTs available for malaria and dengue.

These tests are particularly convenient in field conditions and in resource-limited settings. However, their sensitivity and specificity may be lower compared to laboratory-based methods.

In modern medicine, it is recommended to use a combination of diagnostic methods for the detection of vector-borne diseases. For instance, an initial rapid test may be followed by confirmation using PCR or ELISA. Such a comprehensive approach increases diagnostic accuracy and reduces the likelihood of erroneous results.

RESULTS

The conducted analysis showed that diagnostic methods used for the detection of vector-borne infectious diseases differ significantly in terms of sensitivity, specificity, and field of application. Although microscopic methods are important due to their ability to directly detect pathogens, their sensitivity is often relatively low, especially in the early stages of the disease. Serological methods, particularly ELISA, are effective in detecting the immune response to infection and allow differentiation between acute and chronic stages. However, they may not provide sufficient accuracy during the "window period." Molecular-biological methods, especially PCR, demonstrate the highest sensitivity and specificity and play a crucial role in early detection of pathogens. Rapid diagnostic tests (RDTs) are distinguished by their ability to provide results in a short time and are particularly valuable in epidemiological surveillance and field conditions. Nevertheless, their accuracy is somewhat lower compared to laboratory-based methods. Overall, it was found that the combined use of diagnostic methods (e.g., RDT + PCR or ELISA) significantly improves diagnostic accuracy.

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Table 1. Comparative characteristics of diagnostic methods

Diagnostic method	Sensitivity	Specificity	Advantages	Disadvantages
Microscopy	Moderate	High	Low cost, rapid, direct visualization of pathogen	Low accuracy in low parasitemia
Culture method	High	High	Allows full study of pathogen	Time-consuming, not all pathogens grow
ELISA (serological)	High	Moderate	Suitable for массов screening	Possible false results in window period
PCR (molecular)	Very high	Very high	Early detection, highly accurate	Expensive, requires special equipment
Rapid tests (RDT)	Moderate	Moderate	Fast, suitable for field conditions	Lower accuracy than laboratory methods

Table 2. Vector-borne diseases and corresponding diagnostic methods

Disease	Causative agent	Main vector	Diagnostic methods
Malaria	Plasmodium spp.	Anopheles mosquito	Microscopy, RDT, PCR
Dengue fever	Dengue virus	Aedes mosquito	ELISA, PCR, RDT
Lyme disease	Borrelia burgdorferi	Tick (Ixodes)	ELISA, Western blot, PCR
Leishmaniasis	Leishmania spp.	Sandfly	Microscopy, culture, PCR
Yellow fever	Yellow fever virus	Aedes mosquito	Serological tests (ELISA), PCR

DISCUSSION

The analysis showed that each diagnostic method for vector-borne diseases has its own advantages and limitations. Microscopic and culture methods are considered classical “gold standards” because they allow direct detection of pathogens and enable the study of their biological characteristics. However, their sensitivity is low in the early stages of disease and they require highly qualified specialists. Therefore, relying solely on microscopic examination limits diagnostic accuracy. Serological methods, particularly ELISA, allow detection of the immune response and are useful in distinguishing between acute and chronic stages of infection. However, they may yield false-negative results during the “window period,” and cross-reactivity may occur, necessitating confirmation by molecular methods. Molecular-biological diagnostics, especially PCR, provide high sensitivity and specificity and enable early detection of vector-borne diseases. At the same time, PCR requires expensive equipment and well-equipped laboratory conditions, which complicates its use in resource-limited settings. Rapid diagnostic tests (RDTs) are important in field conditions and epidemiological surveillance. Their main advantage is the rapid availability of results, while their limitation is slightly lower accuracy compared to laboratory methods. Therefore, RDT results should be confirmed using molecular or serological techniques. The results indicate that a comprehensive approach is the most effective strategy for diagnosing vector-borne diseases. For example, initial screening with RDT followed by confirmation using PCR or ELISA significantly improves diagnostic

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accuracy. Furthermore, integrating different diagnostic methods is crucial for early detection, timely treatment, and effective epidemiological control. In addition, factors such as climate change, global migration, and urbanization are increasing the spread of vector-borne diseases, making diagnosis and control strategies more complex. Therefore, continuous improvement and integration of modern diagnostic methods, as well as the development of rapid tests suitable for field conditions, remain highly relevant.

CONCLUSION

The integration of various diagnostic methods significantly increases the effectiveness of detecting vector-borne infectious diseases. Microscopic and culture methods allow direct identification of pathogens, serological methods are useful in determining disease stages, while molecular-biological methods provide the highest sensitivity and specificity. Rapid diagnostic tests serve as fast and convenient tools in field conditions and epidemiological surveillance. Therefore, the use of a comprehensive diagnostic approach enables early detection, effective treatment, and improved epidemiological control. In the future, the wider implementation of modern molecular methods and the improvement of rapid diagnostic tests are expected to enhance the management of vector-borne diseases.

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