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Biomarkers for Early Diagnosis of Alzheimer's Disease: Current Status and Future Directions

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Abstract: Alzheimer's disease (AD) is a progressive neurological disease that leads to loss of cognitive function and a significant deterioration in the quality of life. Early diagnosis plays a critical role in providing timely treatment and managing symptoms, which underscores the need to develop accurate and sensitive biomarkers to detect disease at an early stage.

Major key biomarkers, such as beta-amyloid and tau protein, have been the subject of intense research in recent decades. They reflect the pathological processes occurring in the brain of patients with AD, and can be used to assess the risk of developing and progressing the disease. However, the exact mechanisms of formation and accumulation of these biomarkers require further investigation.

This article provides an overview of the current state and future research directions on biomarkers for the early diagnosis of AD. Various research methods are considered, including neuroimaging, biochemical analyses, and genetic approaches aimed at identifying new and improving existing biomarkers.

Recent studies have shown that the combination of several biomarkers can significantly improve the accuracy of AD diagnosis and predict the likelihood of developing the disease in the early stages. The use of modern analytical technologies, such as mass spectrometry and genome sequencing, contributes to the expansion of the arsenal of tools for the study and use of biomarkers in clinical practice.

However, to fully integrate biomarkers into diagnostic and therapeutic algorithms, a number of challenges must be overcome, including standardizing methods, improving the availability of testing, and evaluating the ethical and legal aspects of using biomarkers.

In conclusion, further research on biomarkers for the early diagnosis of AD represents a promising direction that has the potential to significantly change the practice of clinical neurology. It is expected that the development and validation of new biomarkers will improve the diagnosis, prediction and monitoring of AD, which will affect the improvement of treatment outcomes and patient care.

Key words: Alzheimer's disease, biomarkers, diagnostics, neurology, medical biochemistry.

Relevance

Alzheimer's disease (AD) is one of the most common and serious neurological diseases, leading to a gradual degradation of cognitive functions and a significant deterioration in the quality of life in older people. With an increase in the average life expectancy of the world's population, the problem of socio-economic burden associated with an increase in the number of patients with dementia, including AD, is sharply increasing. In this context, the development of effective methods for early diagnosis and disease management is becoming a key area of medical research and practical medicine.

Existing methods of AD diagnosis based on clinical symptoms and neuropsychological tests have limited sensitivity and specificity in the early stages of the disease. In this regard, there is a need to develop and implement biomarkersthat can diagnose AD long before the first clinical manifestations appear, which will allow starting therapy at the earliest stages of the pathological process and, thereby, slow down the progression of the disease.

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Current research is actively investigating various biomarkers, including beta-amyloid and tau protein, as potential indicators of AD risk. However, if these biomarkers are to be successfully implemented биомаркеровin clinical practice, further research is needed to validate them, standardize them, and improve the availability of testing. One of the key challenges is to develop analysis methods that are sensitive and specific with minimal invasive procedures. This includes not only biochemical and neuroeducational methods, but also innovative technologies such as mass spectrometry and genome sequencing, which can provide new insights into the mechanisms of AD pathogenesis.

In addition, it is important to consider the ethical and legal aspects of using biomarkers, such as data confidentiality and patient consent to testing. These aspects require attention and the development of an appropriate regulatory framework.

Thus, the development and implementation of biomarkers for the early diagnosis of AD is an important and urgent task of modern medicine aimed at improving diagnostic capabilities, optimizing therapeutic strategies, and reducing the socio-economic burden associated with this neurological disease.

Purpose, Materials and Methods

The aim of this study is to review the current state of research on biomarkers for early diagnosis of Alzheimer's disease (AD), as well as to assess the prospects for the development of new methods and approaches in this area.

To achieve this goal, we analyzed the current scientific literature, including recent studies, reviews, meta-analyses, and clinical trials on the topic of biomarkers for the diagnosis of AD. The study includes works published in peer-reviewed scientific journals available to the PubMed, Scopus, and Web of Science databases.

For data collection and analysis, a systematic approach to literature review was used, including the following methods: keywords related to biomarkers, diagnosis of AD, and modern research methods were used.

A critical review of studies on various biomarkers, their sensitivity and specificity, as well as methods for their determination was conducted.

The results of the analysis were systematized and evaluated in terms of their clinical significance and potential for practical use.

Conclusion

This review highlights the importance of further research in the field of biomarkers for the early diagnosis of AD and the need to develop new methods and approaches to improve diagnostic capabilities and therapeutic strategies. This will reduce time and cost resources for diagnosis, start treatment at an early stage of the disease, and improve the prognosis of patients with asthma.

Results

The literature review identified the following key findings:

Biomarkers of beta-amyloid and tau protein: Studies have shown that elevated levels of beta-amyloid and tau protein in cerebrospinal fluid (CSF) and plasma are potential indicators of the risk of developing Alzheimer's disease. Analysis of current data has confirmed that these biomarkers can predict the likelihood of transition from normal cognitive status to mild cognitive impairment and further development of dementia.

Neuroforming factors: Evaluation of neuroforming factors, such as нейрофиламентыlight chain neurofilaments (NFL), has shown their high sensitivity and specificity in the diagnosis and monitoring

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of disease progression. Studies indicate a significant increase in NFL levels in the CSF of patients with AD, which makes them promising candidates for inclusion in diagnostic algorithms.

Genetic markers: The development of genetic markers associated with the risk of AD, such as apolipoprotein E (APOE), has shown that genetic factors play an important role in the pathogenesis of the disease. The inclusion of genetic data in a comprehensive risk assessment allows you to personalize the approach to diagnosis and treatment of patients.

Technological innovations: The use of modern technologies, such as positron emission tomography (PET) using tracers to detect beta-amyloid, and mass spectrometry for quantification of plasma proteins, has shown significant progress in improving the sensitivity and specificity of diagnostics.

Challenges and prospects: Despite significant advances, the use of biomarkers in clinical practice faces challenges, such as standardization of methods and validation of results in large population groups. However, with the development of technologies and a deeper understanding of the biological mechanisms associated with AD, the prospects for using biomarkers for early diagnosis and monitoring of the disease remain high.

Conclusion

The study confirmed the importance of biomarkers in the diagnosis of Alzheimer's disease and their potential to improve clinical practice. Further development and implementation of these biomarkers in routine clinical practice requires improvement of analysis methods and scaling of their application at the healthcare level. This area of research remains a priority to improve diagnostic accuracy, optimize treatment, and improve outcomes in patients with Alzheimer's disease.

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