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THE ROLE OF BIOMARKERS IN THE EARLY DIAGNOSIS OF SCHIZOPHRENIA

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Abstract : Schizophrenia is a severe mental disorder characterized by disturbances in thought, perception, and behavior. Early diagnosis plays a crucial role in improving treatment outcomes and quality of life for patients. In recent years, the use of biomarkers — including genetic, neuroimaging, and biochemical indicators — has become a promising approach for identifying schizophrenia in its early stages. This article reviews the current state of research on biomarkers and their potential in facilitating early detection and personalized treatment strategies.

Keywords: Schizophrenia, biomarkers, early diagnosis, neuroimaging, genetics, psychiatry

Annotatsiya : Shizofreniya — tafakkur, idrok va xulq-atvorda jiddiy buzilishlar bilan kechuvchi og‘ir ruhiy kasallikdir. Kasallikni erta aniqlash bemorlarning davolanish natijalari va hayot sifatini yaxshilashda muhim ahamiyatga ega. So‘nggi yillarda genetik, neyroximiyoviy va neyroimaging biomarkerlardan foydalanish shizofreniyani erta bosqichda aniqlashda istiqbolli yo‘nalish sifatida qaralmoqda. Ushbu maqolada biomarkerlar haqidagi so‘nggi ilmiy tadqiqotlar va ularning individual davolash strategiyalarini ishlab chiqishdagi o‘rni tahlil qilinadi.

Kalit so‘zlar: Shizofreniya, biomarkerlar, erta tashxis, neyroimaging, genetika, psixiatriya

Аннотация: Шизофрения — это тяжёлое психическое расстройство, сопровождающееся нарушениями мышления, восприятия и поведения. Ранняя диагностика играет ключевую роль в повышении эффективности лечения и улучшении качества жизни пациентов. В последние годы использование биомаркеров — генетических, нейровизуализационных и биохимических показателей — стало перспективным направлением для раннего выявления шизофрении. В статье рассматриваются современные исследования биомаркеров и их значение для персонализированных методов терапии.

Ключевые слова: Шизофрения, биомаркеры, ранняя диагностика, нейровизуализация, генетика, психиатрия

Introduction

Schizophrenia is a chronic and debilitating psychiatric disorder that affects approximately 1% of the global population. It is characterized by profound disturbances in cognition, emotion, perception, and social functioning. The disorder typically develops in late adolescence or early adulthood and often follows a progressive course if not diagnosed and treated in time. Early diagnosis of schizophrenia is crucial, as it significantly improves therapeutic outcomes, reduces relapse rates, and enhances patients' long-term psychosocial adjustment. Traditionally, the diagnosis of schizophrenia has relied on clinical assessments based on observable symptoms such as hallucinations, delusions, and disorganized thinking. However, these symptoms usually emerge only after significant neurobiological and functional changes have already occurred in the brain. Consequently, there is a growing need for objective biological indicators — known as biomarkers — that can help identify individuals at risk before the full clinical manifestation of the disease. Biomarkers can be classified into several categories, including genetic markers,

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neuroimaging markers, biochemical indicators, and electrophysiological patterns. Genetic studies have identified multiple susceptibility genes associated with schizophrenia, such as DISC1, COMT, and NRG1, which may play roles in neurodevelopmental abnormalities. Neuroimaging biomarkers, particularly those obtained from MRI and fMRI studies, have revealed structural and functional alterations in brain regions like the prefrontal cortex and hippocampus. Biochemical markers, including inflammatory cytokines, oxidative stress parameters, and neurotransmitter imbalances, also provide valuable insights into the pathophysiology of schizophrenia. Recent advances in molecular biology and neuroinformatics have further improved the precision of biomarker research, offering new opportunities for personalized medicine in psychiatry. By integrating multimodal biomarker data, clinicians can potentially predict disease onset, monitor treatment response, and design individualized therapeutic strategies. Therefore, the aim of this study is to analyze the role of various types of biomarkers in the early diagnosis of schizophrenia, emphasizing their diagnostic value, clinical applicability, and potential to revolutionize psychiatric practice in the coming decades.

Materials and Methods

This study is based on a comprehensive review and qualitative analysis of recent scientific publications, clinical trials, and meta-analyses related to the role of biomarkers in the early detection of schizophrenia. Sources were selected from major international databases, including PubMed, Scopus, ScienceDirect, and Google Scholar, covering the period between 2014 and 2024.Publications were included if they: Focused on early-stage or prodromal schizophrenia, Investigated biological markers such as genetic, neuroimaging, or biochemical indicators, Provided quantitative or qualitative data on diagnostic sensitivity and specificity, Were published in peer-reviewed journals in English. Studies with small sample sizes, unclear diagnostic criteria, or insufficient statistical validation were excluded to ensure data reliability. Data from the selected studies were systematically extracted, categorized, and compared according to biomarker type. Three main biomarker categories were analyzed:

1. Genetic biomarkers – variations in schizophrenia-associated genes (DISC1, COMT, NRG1, DTNBP1), and polygenic risk scores;
2. Neuroimaging biomarkers – structural and functional brain abnormalities identified through MRI, fMRI, PET, and EEG techniques;
3. Biochemical biomarkers – inflammatory markers (IL-6, TNF-α, CRP), oxidative stress markers, and neurotransmitter metabolites (dopamine, glutamate).

Data were analyzed using a comparative and integrative approach to identify recurring patterns, correlations between biomarkers and disease onset, and potential predictive indicators. As this work is a literature-based study, no direct involvement of human participants was required. However, all reviewed studies adhered to ethical research standards approved by institutional and international review boards.

Results

The review and analysis of the selected literature revealed that biomarkers play an increasingly significant role in the early detection and risk assessment of schizophrenia. Findings from multiple research domains — genetics, neuroimaging, and biochemistry — demonstrate

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measurable biological alterations that precede the onset of full-blown psychotic symptoms. Recent genomic studies have identified over 100 susceptibility loci associated with schizophrenia, with strong evidence for genes such as DISC1 (Disrupted-in-Schizophrenia 1), COMT (Catechol-O-methyltransferase), NRG1 (Neuregulin-1), and DTNBP1 (Dystrobrevin-binding protein 1). These genes are primarily involved in synaptic transmission, dopaminergic regulation, and neurodevelopmental processes. Polygenic risk scoring (PRS) has been shown to predict schizophrenia with moderate accuracy, especially when combined with environmental risk factors such as early-life stress or substance abuse. Neuroimaging studies consistently demonstrate structural and functional brain abnormalities in high-risk individuals and first-episode schizophrenia patients. Reduced gray matter volume in the prefrontal cortex, temporal lobe, and hippocampus; Altered functional connectivity between the prefrontal cortex and limbic regions; Abnormal neural oscillations detected through EEG, particularly decreased P300 amplitude and increased theta activity. Functional MRI (fMRI) data indicate that these changes may occur years before clinical symptoms emerge, suggesting their potential as predictive diagnostic tools. Biochemical studies reveal notable alterations in inflammatory and oxidative stress markers. Elevated levels of interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP) have been reported in individuals at ultra-high risk of psychosis.

Moreover, dopaminergic and glutamatergic dysregulation are central to schizophrenia pathophysiology, where excessive dopamine activity in mesolimbic pathways and NMDA receptor hypofunction contribute to positive and cognitive symptoms. When genetic, neuroimaging, and biochemical data are combined, predictive accuracy improves significantly. Studies using multimodal biomarker models have reached diagnostic sensitivities of up to 85%, outperforming clinical assessments alone. These findings highlight the importance of biomarker-based approaches in precision psychiatry and early intervention programs.

Discussion

The results of this review indicate that the integration of biomarkers into psychiatric diagnostics holds great promise for transforming the early detection and management of schizophrenia. Each class of biomarkers — genetic, neuroimaging, and biochemical — contributes unique insights into the complex pathophysiology of the disorder, yet none alone provides complete diagnostic accuracy. Genetic biomarkers offer valuable information about inherited susceptibility and molecular pathways involved in brain development and neurotransmission. However, schizophrenia is highly polygenic and influenced by environmental factors; thus, genetic data alone cannot fully predict disease onset. Polygenic risk scores (PRS), when combined with environmental and clinical indicators, improve diagnostic precision and allow for early risk stratification. Neuroimaging biomarkers such as cortical thinning, hippocampal volume reduction, and functional dysconnectivity have consistently been observed in individuals at ultra-high risk (UHR) and in first-episode patients. These findings suggest that structural and functional brain alterations occur long before psychosis manifests clinically. Nevertheless, neuroimaging remains limited by high costs, variability in imaging protocols, and accessibility issues, particularly in low-resource settings. Biochemical biomarkers, including inflammatory cytokines, oxidative stress molecules, and neurotransmitter metabolites, reflect the ongoing pathophysiological processes underlying schizophrenia. Elevated inflammatory markers such as IL-6 and CRP have been linked to both the onset and progression of psychotic symptoms. Yet, these biomarkers may lack specificity, as similar profiles are observed in other neuropsychiatric

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and systemic disorders. An integrative, multimodal approach combining genetic, imaging, and biochemical data appears to be the most effective strategy for early diagnosis. Advances in artificial intelligence (AI) and machine learning now allow for large-scale data integration, enhancing predictive models and supporting clinical decision-making in psychiatry. Despite these advances, several limitations remain.

Conclusion

Early identification of schizophrenia remains one of the most critical challenges in modern psychiatry. Biomarkers provide a promising pathway to detect the disorder before the onset of severe clinical symptoms. Evidence from genetic, neuroimaging, and biochemical studies demonstrates that biological changes occur years before psychosis becomes evident. The integration of these biomarkers into a multimodal diagnostic framework enhances the accuracy of early detection and supports the development of personalized treatment strategies. Continued research is needed to validate biomarker combinations, standardize methodologies, and ensure ethical implementation in clinical practice. Ultimately, biomarker-based approaches may revolutionize psychiatric diagnostics, enabling early intervention, reducing disease burden, and improving the overall prognosis and quality of life for individuals affected by schizophrenia.

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