

METABOLIK SINDROMNI ERTA ANIQLASHNING ZAMONAVIY DIAGNOSTIK USULLARI

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Annotatsiya. Metabolik sindrom yurak-qon tomir kasalliklari, 2-tip qandli diabet va boshqa surunkali kasalliklarning rivojlanish xavfini oshiruvchi metabolik buzilishlar majmuasidir. Ushbu maqolada metabolik sindromni erta aniqlashning zamonaviy diagnostik usullari, jumladan antropometrik ko'rsatkichlar, laborator biomarkerlar, insulin rezistentligini baholash usullari, molekulyar-genetik tekshiruvlar hamda sun'iy intellekt va raqamli tibbiyot texnologiyalarining diagnostikadagi o'rni yoritilgan. Kasallikni erta aniqlash xavf omillarini o'z vaqtida bartaraf etish, individual profilaktika choralari ishlab chiqish hamda og'ir asoratlarning oldini olish imkonini beradi.[3,4]

Kalit so'zlar: metabolik sindrom, erta diagnostika, insulin rezistentligi, biomarkerlar, HOMA-IR, semizlik, dislipidemiya, qandli diabet, sun'iy intellekt, skrining.

MODERN DIAGNOSTIC METHODS FOR THE EARLY DETECTION OF METABOLIC SYNDROME

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Abstract. Metabolic syndrome is a cluster of metabolic disorders that significantly increases the risk of cardiovascular diseases, type 2 diabetes mellitus, and other chronic conditions. This article reviews modern approaches to the early diagnosis of metabolic syndrome, including anthropometric assessment, laboratory biomarkers, evaluation of insulin resistance, molecular genetic testing, and the application of artificial intelligence and digital healthcare technologies in clinical practice. Early detection enables timely risk assessment, personalized preventive interventions, and reduction of long-term complications, thereby improving patient outcomes and quality of life.[3,4]

Keywords: metabolic syndrome, early diagnosis, insulin resistance, biomarkers, HOMA-IR, obesity, dyslipidemia, type 2 diabetes mellitus, artificial intelligence, screening.

СОВРЕМЕННЫЕ МЕТОДЫ РАННЕЙ ДИАГНОСТИКИ МЕТАБОЛИЧЕСКОГО СИНДРОМА

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Аннотация. Метаболический синдром представляет собой комплекс метаболических нарушений, значительно повышающих риск развития сердечно-сосудистых заболеваний, сахарного диабета 2 типа и других хронических патологий. В статье рассмотрены современные методы ранней диагностики метаболического синдрома, включая антропометрические показатели, лабораторные биомаркеры, оценку инсулинорезистентности, молекулярно-генетические исследования, а также применение технологий искусственного интеллекта и цифровой медицины. Ранняя диагностика позволяет своевременно выявлять факторы риска, разрабатывать индивидуальные профилактические мероприятия и предупреждать развитие тяжелых осложнений.[3,4]

Ключевые слова: метаболический синдром, ранняя диагностика, инсулинорезистентность, биомаркеры, HOMA-IR, ожирение, дислипидемия, сахарный диабет 2 типа, искусственный интеллект, скрининг.

Relevance of the Topic. Metabolic syndrome has become one of the most significant global public health challenges due to its rapidly increasing prevalence and its strong association with cardiovascular diseases, type 2 diabetes mellitus, chronic kidney disease, and premature mortality. According to international epidemiological studies, the incidence of metabolic syndrome continues to rise worldwide, driven by sedentary lifestyles, unhealthy dietary habits, obesity, and population aging. Consequently, early identification of individuals at high risk has become a priority in preventive medicine. Recent advances in diagnostic

technologies, including novel biochemical biomarkers, molecular and genetic testing, advanced imaging techniques, and artificial intelligence-based clinical decision support systems, have significantly improved the accuracy and timeliness of metabolic syndrome detection. These modern diagnostic approaches facilitate personalized risk assessment, early therapeutic intervention, and effective disease prevention before irreversible metabolic and cardiovascular complications develop. Therefore, investigating contemporary diagnostic methods for the early detection of metabolic syndrome is highly relevant from both scientific and clinical perspectives. Improving early diagnosis can contribute to reducing healthcare costs, enhancing patient quality of life, and decreasing the global burden of chronic non-communicable diseases.[1,2]

Main Part. Metabolic syndrome (MetS) is a multifactorial disorder characterized by the coexistence of central obesity, insulin resistance, hypertension, dyslipidemia, and impaired glucose metabolism. The syndrome substantially increases the risk of cardiovascular diseases, type 2 diabetes mellitus, and other metabolic complications. Since the progression of metabolic syndrome is often asymptomatic in its early stages, timely diagnosis is essential for preventing irreversible health consequences.

The diagnosis of metabolic syndrome is commonly based on internationally accepted criteria established by organizations such as the International Diabetes Federation (IDF), the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), and the World Health Organization (WHO). These criteria include measurements of waist circumference, blood pressure, fasting plasma glucose, triglyceride levels, and high-density lipoprotein (HDL) cholesterol.

Modern diagnostic approaches extend beyond conventional clinical assessments. Anthropometric measurements, including body mass index (BMI), waist-to-hip ratio, and body composition analysis, provide valuable information about obesity-related risks. Laboratory investigations involve fasting glucose, glycated

hemoglobin (HbA1c), lipid profile, fasting insulin levels, inflammatory biomarkers such as C-reactive protein (CRP), adipokines, and liver function tests. The Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) is widely used to evaluate insulin resistance, one of the key mechanisms underlying metabolic syndrome.[3,5]

Recent research has highlighted the role of novel biomarkers, including adiponectin, leptin, interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF- α), and circulating microRNAs, in improving the early detection and risk stratification of metabolic syndrome. Molecular and genetic analyses have also contributed to identifying individuals with increased genetic susceptibility to metabolic disorders. Advances in imaging technologies, such as abdominal ultrasonography, magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DEXA), and computed tomography (CT), enable accurate assessment of visceral fat accumulation, which is closely associated with metabolic syndrome severity. Artificial intelligence, machine learning algorithms, and digital health technologies are increasingly being integrated into clinical practice. These systems analyze large clinical datasets, identify hidden risk patterns, and support physicians in making accurate and timely diagnostic decisions. Wearable devices and remote patient monitoring systems further facilitate continuous evaluation of metabolic health and improve early intervention strategies.

A comprehensive diagnostic approach that combines clinical examination, laboratory testing, imaging methods, molecular diagnostics, and digital technologies provides the highest diagnostic accuracy. Early identification of metabolic syndrome enables personalized treatment, lifestyle modification, and prevention of long-term cardiovascular and metabolic complications.[7]

Materials and Methods. This study was conducted using a comprehensive review and analysis of contemporary scientific literature on the early diagnosis of metabolic syndrome. Relevant publications indexed in international scientific

databases, including PubMed, Scopus, Web of Science, and Google Scholar, published between 2020 and 2026, were systematically examined.

The study focused on evaluating current diagnostic methods for metabolic syndrome, including anthropometric measurements, biochemical laboratory tests, imaging techniques, molecular and genetic biomarkers, and artificial intelligence–based diagnostic technologies. International clinical guidelines developed by the International Diabetes Federation (IDF), the American Diabetes Association (ADA), the World Health Organization (WHO), and the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) were also reviewed to compare diagnostic criteria and recommendations.

The collected data were analyzed using comparative and descriptive methods. Information regarding diagnostic accuracy, sensitivity, specificity, clinical applicability, and predictive value of various diagnostic approaches was critically assessed. The findings were synthesized to identify the most effective modern strategies for the early detection of metabolic syndrome and their potential role in improving preventive healthcare and patient outcomes.[6,7]

Conclusion. Early detection of metabolic syndrome is a crucial component of modern preventive medicine, as timely identification of metabolic disorders allows effective prevention of cardiovascular diseases, type 2 diabetes mellitus, and other chronic complications. Traditional diagnostic approaches based on anthropometric parameters and biochemical indicators remain important; however, the integration of advanced biomarkers, molecular genetic methods, imaging technologies, and artificial intelligence significantly improves diagnostic accuracy and risk prediction.

A comprehensive approach combining clinical assessment, laboratory investigations, and innovative digital technologies provides opportunities for personalized prevention and management strategies. The implementation of modern diagnostic methods in routine clinical practice can contribute to early intervention, reduction of disease progression, improvement of patients' quality of

life, and decreasing the global burden of metabolic disorders. Further research is required to standardize novel diagnostic markers and develop accessible, cost-effective technologies for widespread screening and early identification of individuals at high risk of metabolic syndrome.

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