Personalized medicine and artificial intelligence in neurology: an individual approach to diagnosis and treatment

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Abstract
The article considers an individual approach to the diagnosis and treatment of neurological diseases within the framework of personalized medicine and the use of artificial intelligence capabilities. The main focus is on an individual approach to the diagnosis and treatment of neurological diseases. Modern methods of data analysis and technologies allowing to adapt treatment to a specific patient are considered. Examples of successful applications of machine learning and artificial intelligence algorithms for the prediction, diagnosis and treatment of neurological disorders are also being investigated. The authors also emphasize the importance of collecting and analyzing big data in the development of personalized medicine in neurology and identify prospects for further research and application of this methodology.

In addition, the advantages of personalized medicine and the use of artificial intelligence in neurology, such as improving diagnostic accuracy, optimizing treatment and improving the effectiveness of results, were analyzed. The challenges and limitations faced by researchers and doctors when implementing personalized approaches in neurological practice are studied, as well as ethical issues related to the use of patient data and decision-making based on machine learning algorithms are analyzed.

Keywords
Personalized medicine, Neurology, Diagnosis, Treatment, Individual approach

INTRODUCTION
Personalized medicine is necessary for effective prevention and treatment of diseases among various population groups[1]. Many progressive neurological diseases are associated with dysfunction of many body systems. Nervous, endocrine, immune, cardiac and digestive functions can contribute to the progression of the disease, and the factors affecting each of these systems throughout life are extremely diverse [2]. Therefore, it is extremely important to move away from a universal approach to healthcare and lean towards developing a more accurate diagnosis and individual treatment regimen in order to better approach an inclusive healthcare system.

In recent years, artificial intelligence (AI) models have demonstrated tremendous transformative potential in various fields of clinical medicine. Advanced natural language processing (NLP) tools such as ChatGPT-3.5 and ChatGPT-4 can understand complex concepts, solve problems logically, summarize long text and generate meaningful results [3]. AI tools allow you to use advanced deep learning techniques with self-control to accumulate huge reserves of knowledge in a variety of fields. Healthcare applications include automated diagnostics, optimized image interpretation, personalized treatment plans, and improved clinical workflows.

Recent advances in machine learning and AI algorithms have provided a much-needed foundation for data mining that will lead to the development of the most accurate diagnostic and therapeutic approaches [5]. Predictive analysis based on artificial intelligence,
based on neurodegenerative diagnostic measures together with health conditions (comorbidities), genetics, environmental influences and lifestyle factors, will provide healthcare providers with an adaptive and harmonized set of tools for the most effective treatment of complex multifactorial diseases. These algorithms can also analyze huge datasets to predict the response to treatment, as well as the risk of disease progression. Major obstacles that need to be overcome include data harmonization and sharing, as well as the inclusiveness of clinical trials.

The purpose of the study is to consider an individual approach to the diagnosis and treatment of neurological diseases within the framework of personalized medicine and the use of artificial intelligence capabilities.

MATERIALS AND METHODS

In this paper, an array of data has been studied within the framework of the topic under study. The methods of machine learning used in the practice of medical professionals, such as neural networks, classification algorithms, clustering, regression, etc., as well as their application for data analysis and identification of patterns, are considered. Diagnostic and treatment protocols used in neurology and the peculiarities of their adaptation to a personalized approach have also been studied. The metrics and criteria used to evaluate the effectiveness of diagnostic and treatment methods, such as accuracy, sensitivity, specificity, survival rates, etc., have been studied. Comparative and analytical research methods have been used in writing the work.

RESULTS

Advances in personalized medicine based on AI resources mean a paradigm shift in the provision of medical care [5]. Through the use of AI technologies, including machine learning algorithms, deep learning frameworks and natural language processing systems, they are making a real revolution in the medical field. By combining extensive data sets including genetic profiles, medical histories and clinical outcomes, artificial intelligence facilitates the precise adaptation of interventions to individual patient characteristics. By recognizing complex patterns in these datasets, artificial intelligence algorithms can predict disease susceptibility, determine optimal treatment regimes, and even predict patient responses to specific treatments.

The integration of AI into personalized medicine goes beyond traditional medical approaches, using the capabilities of big data analysis and computer modeling [6]. These technologies enable clinicians to decode the complex interactions between genetic predisposition, environmental factors, and disease manifestations with unprecedented precision. Also, predictive models based on artificial intelligence allow healthcare providers to anticipate potential health risks and take preventive measures, thereby mitigating the occurrence or progression of diseases. These proactive interventions not only improve patient treatment outcomes, but also optimize the allocation of resources within health systems, giving priority to preventive measures over reactive treatment [7].

It should also be said that the emergence of artificial intelligence-based genome sequencing platforms has made it easier to identify rare genetic variants associated with hereditary disorders. By analyzing genomic data at scale, artificial intelligence algorithms can recognize subtle genetic abnormalities indicating susceptibility to diseases, allowing for early detection and intervention. This possibility is extremely important for oncologists who use artificial intelligence-based approaches to precision oncology to determine targeted therapies adapted to the molecular profile of individual tumors. Thus, there is a benefit for patients from the use of personalized treatment strategies that maximize effectiveness while minimizing side effects, thereby improving overall treatment outcomes and quality of life.

However, the integration of artificial intelligence into personalized medicine also raises ethical, regulatory, and privacy issues that require careful consideration. The use of confidential patient data requires a reliable regulatory framework to protect their rights in the area under consideration. Addressing these ethical and regulatory issues is essential to build trust in personalized medicine based on artificial intelligence and promote equal access to transformative healthcare technologies.

The synthesis of artificial intelligence and personalized medicine heralds a new era of precision healthcare, in which treatment methods are developed taking into account the unique characteristics of each patient. Using artificial intelligence-based analytics, clinicians can leverage the power of big data to optimize treatment outcomes, improve patient care, and revolutionize healthcare delivery. Through continuous innovation and collaboration, personalized AI-based medicine promises to transform healthcare delivery and improve patient outcomes globally [8].
Artificial intelligence algorithms can analyze complex medical data, leading to more accurate diagnoses. For example, AI can interpret X-ray images or genetic information more efficiently than traditional methods.

AI accelerates drug discovery by predicting how different drugs can interact with targets in the body, allowing for more effective drugs with fewer side effects [9]. Artificial intelligence can tailor treatment plans to individual patients based on their unique genetic makeup, lifestyle, and medical history, potentially improving the effectiveness of treatment.

Artificial intelligence can predict disease risks based on genetic and health data, which allows for early interventions and prevention strategies. By automating routine tasks and improving diagnostic accuracy, artificial intelligence can help reduce healthcare costs.

The ability of artificial intelligence to decode genetic information accelerates diagnostic processes, allowing clinicians to identify genetic predisposition to diseases and adapt treatment strategies accordingly. Moreover, artificial intelligence plays a key role in accelerating drug development processes, thereby accelerating the translation of scientific discoveries into clinically viable treatments. By predicting how various drugs interact with molecular targets in the body, artificial intelligence facilitates the identification of promising candidate drugs with increased efficacy and reduced side effects [10]. This transformative approach not only simplifies the drug development process, but also facilitates the creation of personalized medicines tailored to the individual characteristics of patients, thereby optimizing therapeutic results and minimizing adverse reactions.

In addition, personalized medicine based on artificial intelligence provides patients with customized treatment plans tailored to their unique genetic makeup, lifestyle factors, and medical history [11]. By integrating various sources of patient data, including genetic profiles, medical records, and lifestyle data, artificial intelligence algorithms generate personalized treatment recommendations that optimize therapeutic effectiveness while minimizing side effects. This individual approach to treatment planning represents a paradigm shift in the provision of medical care, a transition from a universal approach to precision medicine adapted to the specific needs of each patient.

In addition, the capabilities of predictive analytics of artificial intelligence allow healthcare providers to anticipate disease risks based on a comprehensive analysis of genetic and health data [12]. By identifying individuals at increased risk of developing certain conditions, artificial intelligence enables early interventions and the development of preventive strategies that mitigate disease progression and improve long-term health outcomes. Such a proactive approach to healthcare not only improves the well-being of patients, but also reduces the burden on healthcare systems by reducing the incidence of expensive and debilitating diseases.

Finally, the integration of artificial intelligence technologies into healthcare promises to reduce costs by automating and improving diagnostic accuracy. By automating routine administrative tasks and increasing the efficiency of diagnostic processes, artificial intelligence optimizes work processes in the healthcare sector, thereby optimizing the use of resources and reducing operating costs. Moreover, the increased accuracy and efficiency of AI-controlled diagnostic tools minimizes the need for unnecessary tests and procedures, further contributing to cost savings in the healthcare ecosystem. In fact, the practical results of personalized medicine based on artificial intelligence include improved diagnosis and treatment, accelerated drug development, personalized treatment planning, predictive analytics and cost reduction [13].

AI has many applications in the field of healthcare, including protocol development, disease prevention, patient monitoring, medical history management, and even helping researchers and doctors extract important information from the data stream. The tools used in clinical fields are equipped with updated versions of intelligent machine learning capabilities that can be used to avoid errors in forecasts and decision-making processes.

Neurological diseases are the main cause of disability and mortality, requiring innovative, scalable and sustainable solutions. Brain health has become a global priority with the adoption of the World Health Organization’s Intersectoral Global Action Plan in 2023. At the same time, rapid progress in AI is revolutionizing neurological research and practice. At the present stage, specialists are widely researching the importance of AI in neurology and brain health, systematizing new clinical opportunities and future trends at all stages of medical care: prevention, risk stratification, early detection, diagnosis, management and rehabilitation. The potential of AI to advance personalized
precision neurology and global brain health guidelines depends on the coordinated implementation of targeted recommendations. Priority actions include the rapid, ethical and equality-oriented integration of new technologies into clinical workflows, mitigation of data-related problems, closing gaps in digital inequality, and the creation of reliable management systems balancing security and innovation [14].

Neurological disorders are diseases associated with the peripheral and central nervous system. Common symptoms include muscle weakness, paralysis, seizures, pain, poor coordination, and loss of consciousness. There are more than 600 diseases related to the nervous system, such as brain tumors, Parkinson’s disease (PD), Alzheimer’s disease (AD), multiple sclerosis (MS), epilepsy, dementia, headaches, neuroinfections, stroke and traumatic brain injuries and others [15].

Hundreds of millions of people worldwide suffer from neurological disorders. Abnormal or abnormal neurological conditions are usually detected by neuropathological examination. So, dementia is usually progressive. Dementia syndromes disrupt many cortical functions, namely memory, orientation, thinking, calculation, speech, understanding, judgment, and learning ability. The prevalence of dementia doubles with age every 5 years. Genetic polymorphism increases the risk for 25% of the total population [16].

Epilepsy, a chronic neurological disease, affects both men and women and people of all ages. Diagnosis of epileptic seizures is carried out by first determining the case of epilepsy, and then differentiating conditions called provoked or chronic epileptic seizures. The total incidence of epilepsy is 23-190 per 100,000 population. The prevalence gradually increases with age. Today, experts use AI techniques to analyze electroencephalograms (EEG), detect seizures, and diagnose epilepsy. There are also studies in the literature on the dynamics of epileptiform discharges induced by transcranial magnetic stimulation in epilepsy, and methods for predicting epileptic seizures using diffusion distance and Bayesian linear discriminant analysis on intracranial EEG are proposed.

In modern developed countries, 75-80% of strokes are caused by cerebral ischemia, and 10-15% by intracerebral hemorrhages. The diagnosis of stroke is made accurately and completely based on clinical data only by a specialist [17].

At the present stage, leading experts hold the following opinion: computer diagnostic systems trained using a large amount of patient data, physiological signals and images based on the integration of advanced signal processing and artificial intelligence methods into an automated approach can help neurologists, neurosurgeons, radiologists and other medical professionals make more informed clinical decisions. In the last decade, research in this area has been developing at an accelerated pace.

**DISCUSSION**

Identification of new biomarkers, including using AI tools, is of paramount importance for the early detection of neurological diseases. Although many age-related diseases in the field of neurology are not inherited, many genetic risk factors have been identified [18]. Polygenic risk assessments (PRS) obtained as a result of genome-wide association studies (GWAS) have shown promising results in stratifying individuals at risk by disease stages and have successfully identified new genes that can be used as new biomarkers and treatment targets [19]. This made it possible to start treatment of diseases at an early stage, prevent vision loss and slow down the decline in cognitive functions [20]. The integration of PRS testing into clinical practice for the screening of neurodegenerative diseases is seen as a cost-effective approach to reducing the economic burden associated with this disease.

For Alzheimer’s disease, the most powerful risk factor is the APOE4 mutation, which leads to a violation of cholesterol regulation, but the risk varies depending on hereditary origin and disease [21]. Currently, there are several diagnostic tests available that determine the amyloid ratio and APOE status. Related studies are examining other biomarkers, including phospho-tau species, neurofilament proteins, and markers of inflammation, to name just a few. The ultimate goal should be a multianalytical panel that allows you to distinguish between dementias of different etiologies, determine the stage of the disease and predict the effectiveness of treatment [22].

In-depth algorithms can include vital signs, genome sequencing, and longitudinal biomarkers combined with neuroimaging scans and neuropsychological tests to provide a wealth of information that will eventually be needed to create inclusive, comprehensive, and diagnostic algorithms [23]. Without these in-depth diagnostic measures, the precision medicine approach will be missing. The lack of historically collected data from people of different backgrounds, as
well as from people resistant to disease, immediately derailed these efforts. Accordingly, in order to increase the accuracy of forecasting, it is necessary to apply a holistic approach to data collection [24].

Since the development of neurological diseases occurs slowly over time, it is important to develop new biomarkers that can detect diseases at the earliest stages. The design of clinical trials can have a profound impact on how we determine the onset of a disease (and therefore the set of participants), and biomarkers can provide personalized targets for future treatment development [25].

One of the central aspects of achieving personalized medicine is data sharing. Initiatives aimed at standardizing data collection in institutions and centers, as well as the development and implementation of electronic medical records, are a prerequisite for improving the effectiveness of personalized medicine. Standardization of medical documentation will provide the necessary basic information about the general state of health and factors contributing to the longevity of patients [26].

Personalized medicine will play a key role in developing the personalized approach needed to treat complex neurodegenerative diseases. It has received the most dynamic development with the advent of artificial intelligence, new generation genetics and multi-genome screenings. Specialized departments specializing in precision medicine are being established in academic, government, non-profit, and commercial institutions around the world. The most important success factor will be a collective, collaborative approach – not only within scientific disciplines, but also in relation to diseases [27].

When developing effective treatment methods and applying knowledge in clinical practice, it is necessary to understand how one organ system can respond to treatment directed at another organ system. For example, some isoforms of risk proteins in the brain (APOE) cause resistance in the eyes, and any treatment aimed at APOE should take this into account. This problem is further highlighted by recent clinical trials of disease-modifying treatments for Alzheimer’s disease. It is becoming increasingly obvious that the state of the vascular system plays an important role in determining the effectiveness of amyloid immunotherapy. APOE status and vascular integrity strongly influence side effects and can make people more or less amenable to specific treatment strategies. These challenges demonstrate that the mutual enrichment of ideas and research/industry results will accelerate the discovery of more effective methods of diagnosis, prevention and treatment.

Neurological diseases require a holistic medical approach. A multi-pronged approach aimed at many aspects of the etiology of diseases, including inflammation and excitotoxicity, is extremely important. Personalized therapies will eventually become the definitive treatments for neurodegenerative diseases of consciousness and vision. Thanks to personalized medicine, a person will receive the right combination of treatment at the right dose at the right time with constant monitoring and adaptation throughout life [28].

Understanding the pathogenesis of Alzheimer’s disease (AD) and developing suitable preclinical models are vital for research. One group of specialists has developed a behavioral observation method to study gait and research activity during the progression of Alzheimer’s disease and aging, adding motor symptoms to the classical cognitive perspective.

It is extremely important to develop new therapeutic strategies for the treatment of neurological and cardiovascular diseases, which are the leading causes of morbidity and mortality worldwide. In addition, non-invasive brain stimulation techniques have become an integral aspect of clinical research on neurological and mental diseases. Methods such as transcranial magnetic stimulation and transcranial direct current stimulation have been used in preclinical models to investigate their potential therapeutic alternatives. These methods offer a unique opportunity to modulate neural activity in certain areas of the brain by simulating neuromodulating effects. Noninvasive brain stimulation in preclinical studies allows scientists to explore the neural circuits involved in neuropsychiatric conditions, which provides valuable information about the underlying pathology. It also facilitates the assessment of the safety and effectiveness of these methods before their introduction into clinical use.

Another group of scientists explored the potential of stem cell-based therapies, tissue engineering, and regenerative medicine in enhancing effective treatments for these diseases, emphasizing the importance of interdisciplinary collaboration and the need for a deeper understanding of the underlying pathomechanisms of these conditions [29].

Another group of researchers analyzed the therapeutic potential of mesenchymal stem cells (MSCs)
neurological disorders. Thus, they demonstrated that xenografts of human umbilical cord MSCs contribute to recovery after chronic ischemic stroke, which provides valuable information about the therapeutic potential of MSCs in the treatment of neurological diseases and regenerative medicine, which can help in the development of new therapeutic strategies for these conditions [30].

In the preclinical model of multiple sclerosis, experts studied the use of a combined approach to therapy using tolerant dendritic cells of vitamin D3 and interferon-β. The results show that in a preclinical model, such combined treatment can effectively reduce the severity of multiple sclerosis symptoms and improve overall outcomes, potentially leading to the development of new therapeutic strategies.

CONCLUSIONS

The integration of artificial intelligence (AI) into personalized medicine predetermines the emergence of an era of transformation in healthcare, promising improved patient outcomes and more effective medical care. However, realizing this potential requires a conscientious approach that carefully considers ethical implications and regulatory considerations. A balance between using artificial intelligence to optimize patient care and the need to address ethical issues such as data privacy, bias mitigation, and accountability is paramount to the successful implementation of artificial intelligence in personalized medicine.

When integrating artificial intelligence into personalized medicine, ethical considerations are of great importance, especially regarding the responsible handling of confidential patient data. Ensuring the confidentiality and security of data is essential to maintaining patient trust and ethical standards. Moreover, the elimination of biases inherent in artificial intelligence algorithms is necessary to prevent differences in treatment outcomes among different patient groups.

Research in the field of personalized medicine and artificial intelligence allows specialists to simulate painful neurological conditions and explore the complex connections between genetics, the environment, pharmacology and concomitant diseases. The considered developments give an idea of the pathomechanisms underlying neurological disorders, facilitate testing of potential treatment methods and allow evaluating therapeutic effectiveness.

Preclinical models also play a crucial role in the study of neurological conditions. In addition, this approach contributes to the development of personalized medicine, allowing the use of customized treatments for neurological disorders. These models also provide an opportunity to explore structural changes in the brain and improve imaging techniques for clinical use. Preclinical research plays an important role in uncovering the complexities of brain diseases by offering valuable information and testing treatments, as well as paving the way for innovative treatments and personalized medicine.

Despite a number of existing problems, the integration of artificial intelligence into personalized medicine promises to revolutionize the provision of medical care. By leveraging the power of artificial intelligence to analyze vast datasets and create personalized treatment plans, healthcare providers can optimize treatment outcomes and increase patient satisfaction. Moreover, predictive analytics based on AI allows for early interventions and prevention strategies, thereby reducing the burden of disease and improving public health. The integration of artificial intelligence into personalized medicine represents a paradigm shift in medical care, offering unprecedented opportunities to improve patient care and improve health outcomes.

LIST OF LITERATURE

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