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Artificial intelligence in neurological diagnosis and prognosis.

Li Zhang*

Department of Neurogenetics, Beijing Central Hospital, China.

*Correspondence to: Li Zhang, Department of Neurogenetics, Beijing Central Hospital, China, E-mail: liwei.zhang@bch.cn

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Introduction

Artificial intelligence has emerged as a transformative force in medicine, offering advanced tools for data analysis, pattern recognition, and decision-making support. In neurology, where diagnosis often relies on interpreting complex and heterogeneous data from clinical examinations, neuroimaging, electrophysiology, genetics, and patient history, AI presents a remarkable opportunity to enhance diagnostic accuracy and improve prognostic predictions. Neurological disorders are diverse and often progressive, including conditions such as Alzheimer's disease, Parkinson's disease, multiple sclerosis, stroke, epilepsy, and brain tumors. These diseases can present with overlapping symptoms and subtle early signs, making timely and precise diagnosis challenging. AI algorithms, particularly those leveraging machine learning and deep learning, are capable of integrating large, multidimensional datasets, identifying patterns imperceptible to the human eye, and providing real-time insights that support clinical decision-making [1].

AI in neurological diagnosis primarily functions through the analysis of medical imaging, including magnetic resonance imaging, computed tomography, positron emission tomography, and functional neuroimaging techniques. Deep learning algorithms, such as convolutional neural networks, have demonstrated exceptional performance in segmenting brain structures, detecting lesions, and identifying subtle morphological changes associated with neurological diseases. In Alzheimer's disease, AI models can detect early structural and functional brain changes years before symptoms manifest, aiding in preclinical diagnosis. Similarly, in Parkinson's disease, AI-based analysis of MRI and dopamine transporter imaging can improve differentiation from other parkinsonian syndromes. In stroke care, AI-powered tools can rapidly process CT scans to detect early ischemic changes, quantify infarct core volume, and assess vessel occlusions, enabling faster treatment decisions and improving patient outcomes [2].

Electrophysiological data analysis is another area where AI is making significant contributions. Electroencephalography and magnetoencephalography produce high-dimensional time-series data that require complex interpretation. Machine learning algorithms can detect seizure patterns in EEG recordings with high sensitivity, aiding in the diagnosis and monitoring of epilepsy. Automated EEG analysis systems can also help distinguish between epileptic and non-epileptic events, classify seizure types, and even localize seizure onset zones, guiding surgical planning for drug-resistant epilepsy. In sleep medicine, AI has been applied to polysomnographic data to automate the scoring of sleep stages and detect sleep-related neurological disorders such as REM sleep behavior disorder, which can be an early marker for neurodegenerative diseases [3].

The integration of multimodal data is a defining strength of AI in neurology. Many neurological conditions cannot be fully characterized by a single diagnostic modality. AI can combine neuroimaging data with genetic information, biochemical biomarkers, neuropsychological test results, and clinical history to create comprehensive predictive models. For example, combining structural MRI, cerebrospinal fluid biomarker levels, and APOE genotype data, AI models can predict conversion from mild cognitive impairment to Alzheimer's disease with high accuracy. In multiple sclerosis, AI can integrate MRI lesion load, serum biomarkers, and clinical relapse history to predict disease activity and guide treatment strategies. Such integrative approaches move diagnosis and prognosis closer to personalized medicine, tailoring care to the specific characteristics of each patient [4].

Prognostication is an equally critical domain where AI offers substantial benefits. Neurological diseases often have variable trajectories, and accurately predicting outcomes is essential for treatment planning, patient counseling, and resource allocation. In stroke patients, AI can analyze imaging features, clinical parameters, and treatment variables to predict functional recovery, risk of hemorrhagic transformation, and long-term disability. In traumatic brain injury, AI-based models can use early imaging and clinical data to estimate survival probability, cognitive recovery potential, and rehabilitation needs. In progressive diseases such as amyotrophic lateral sclerosis, AI can forecast the rate of functional decline, helping clinicians and patients make informed decisions about care and interventions [5].

Conclusion

In conclusion, artificial intelligence is poised to transform the field of neurology by improving diagnostic accuracy, enabling earlier detection of disease, and providing more precise prognostic predictions. From advanced neuroimaging analysis and multimodal data integration to continuous monitoring via wearable devices and natural language processing of clinical records, AI offers powerful tools for enhancing neurological care. While challenges remain in terms of data quality, interpretability, clinical integration, and ethical oversight, the benefits of AI-driven insights have the potential to significantly improve outcomes for patients with neurological disorders.

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