

## REVIEW

### Artificial Intelligence in Neurology

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**Abstract:** The purpose of this paper is to provide a concise analysis of the role of artificial intelligence (AI) in the diagnosis of two major neurological disorders: stroke and multiple sclerosis. In the case of stroke, AI plays a pivotal role in enabling rapid diagnosis, which can significantly impact patient outcomes. Convolutional neural networks (CNNs) are employed to detect large vessel occlusions, calculate the ASPECT score, and assess prognosis. Other AI models contribute by enhancing image quality, reducing both patient exposure time and radiation dose. In multiple sclerosis, one of the main purposes of AI is the analysis of various serum or cerebrospinal fluid biomarkers to help differentiate it from other neurological diseases. Additionally, in the imaging field, AI allows the establishment of correlations between specific lesion patterns and clinical outcomes, including disease progression and response to treatment.

**Keywords:** artificial intelligence, stroke, multiple sclerosis.

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#### INTRODUCTION

This article presents a narrative review of recent literature regarding the application of artificial intelligence (AI) in the diagnosis of neurological disorders. The aim is to synthesize key developments and highlight the clinical relevance of AI tools, with a particular focus on two major conditions: stroke and multiple sclerosis (MS).

Stroke remains one of the leading causes of mortality and long-term disability worldwide. According to recent estimates, approximately 15 million people are affected each year; among them, 5 million die, and another 5 million are left with permanent impairments [1–3]. Pathophysiologically, stroke can be divided into two major categories: ischemic, accounting for 80–90% of cases, and hemorrhagic, responsible for 10–20% [3]. Ischemic stroke results from the

occlusion of a cerebral vessel due to embolism, thrombosis, or progressive atherosclerosis [3–5], while hemorrhagic stroke involves vessel rupture and bleeding into the subarachnoid space or brain parenchyma [3].

Rapid clinical assessment and imaging are essential to improve patient outcomes. The first and most critical investigation to differentiate stroke types and guide therapeutic decisions is computed tomography (CT). CT imaging can identify acute hemorrhage and reveal early signs of ischemic stroke, such as the loss of gray-white matter differentiation [6,7].

Multiple sclerosis (MS) is a chronic autoimmune demyelinating disease of the central nervous system, characterized by inflammation, gliosis, and neurodegeneration. It affects approximately

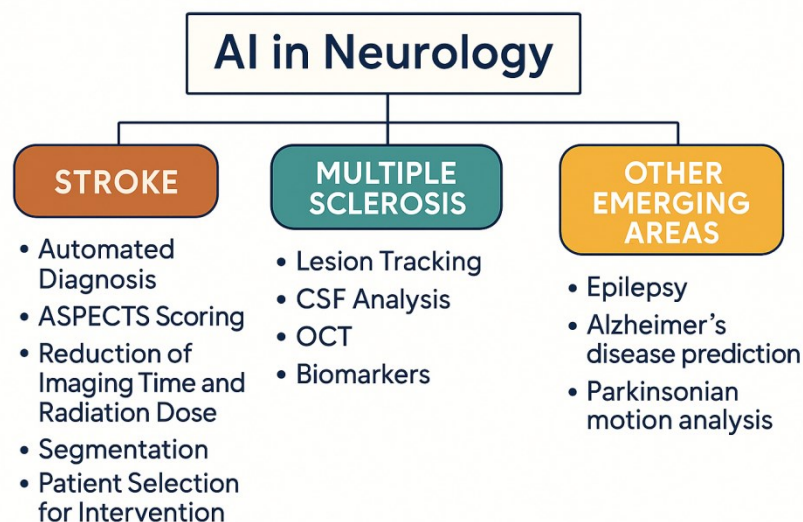
2.3 million people globally, with a higher prevalence among women aged 20 to 50 [8,9]. An acute episode is defined as the onset of a neurological deficit lasting more than 24 hours, in the absence of an alternative explanation such as infection or other disease, followed by at least 30 days of clinical stability or improvement [8].

The diagnosis of multiple sclerosis relies on a combination of clinical and paraclinical criteria, including cerebrospinal fluid analysis, visual evoked potentials, and, most importantly, magnetic resonance imaging (MRI) [8].

Artificial intelligence in medicine refers to the development and application of systems and algorithms capable of analyzing and learning from medical data—including clinical, imaging, and laboratory information—to identify patterns and

perform tasks that typically require human intelligence. The ultimate goal is to support clinicians in making more accurate and timely diagnoses. Multiple studies have demonstrated that AI can achieve diagnostic performance comparable to, or even exceeding, that of experienced medical professionals [9,10].

While AI applications in neurology are rapidly expanding - ranging from epilepsy monitoring and Alzheimer's disease prediction to parkinsonian motion analysis - this review focuses on stroke and multiple sclerosis due to their high prevalence, diagnostic complexity, and the volume of existing literature supporting AI implementation in these domains. An overview of the main neurological domains where AI proves useful is summarized in Figure 1.



**Figure 1.** Key Domains of AI Integration in Neurological Disorders.

## ARTIFICIAL INTELLIGENCE IN STROKE DIAGNOSIS

AI encompasses multiple branches, among which machine learning (ML) holds particular clinical relevance. ML includes various subtypes, such as artificial neural networks (ANNs), which mimic biological neural structures. Within this category, convolutional neural networks (CNNs) are especially notable for their application in

medical image classification using large datasets [7,11].

### 1. Automated Diagnosis

To facilitate rapid stroke diagnosis—particularly in settings with limited access to specialized personnel - AI platforms have been developed to detect large vessel occlusions on CT angiography and to differentiate healthy, ischemic, and

infarcted tissue on CT perfusion and MRI sequences [7]. For instance, detecting a large vessel occlusion is essential in identifying candidates for mechanical thrombectomy. A machine learning algorithm known as Support Vector Machine (SVM) demonstrated approximately 97% sensitivity in identifying the "dot sign" on non-contrast CT (NCCT) in patients with acute stroke. Another CNN-based software achieved ~90% sensitivity and 82% specificity in detecting proximal occlusions, with performance reaching 83% sensitivity and 94% specificity in a separate study involving 650 patients. Nonetheless, limitations such as artifacts, patient movement, pre-existing lesions, and vascular tortuosity can affect accuracy [7,18,20].

## **2. ASPECTS scoring**

The Alberta Stroke Program Early CT Score (ASPECTS) is a 10-point system used on non-contrast CT to evaluate infarction in the middle cerebral artery (MCA) territory. One point is deducted for each region showing hypodensity [7,12,13]. AI enables automated ASPECTS scoring, with several validated software tools in current use. The e-ASPECTS software, for instance, showed comparable performance to stroke experts in studies involving 34 and 132 patients, respectively [7,14,15]. However, the algorithm may be less reliable in cases with leukoencephalopathy, prior infarctions, or parenchymal abnormalities [13,16].

## **3. Segmentation**

Accurate segmentation of imaging data is crucial in distinguishing irreversibly damaged tissue from the potentially salvageable ischemic penumbra, which guides therapeutic decisions. Segmentation is typically performed on CT perfusion (evaluating cerebral blood flow) or MRI diffusion-weighted imaging (DWI) using the "time to maximum" parameter [7,13,17]. CNN-based segmentation models

are often evaluated using the Dice Similarity Coefficient, where values closer to 1 reflect higher accuracy. In a 2017 study involving 741 patients, two CNN models achieved a mean Dice score of 0.67 on DWI scans. However, these models tend to overestimate small lesions and underestimate large ones, necessitating human radiologist oversight. Moreover, they are limited in distinguishing acute from chronic infarcts based on age [7,18,19].

## **4. Reduction of Imaging Time and Radiation Dose**

The fastest imaging techniques for stroke remain non-contrast CT and CT angiography, although MRI with DWI remains superior in identifying infarct core. CNN-based reconstruction algorithms are now being applied to reduce scan time and radiation exposure while maintaining image quality. For example, CNNs have been used to denoise ASL perfusion MRI images and to lower radiation doses in CT perfusion scans [18,21,22].

## **5. Patient Selection for Intervention**

Therapeutic decisions in stroke depend on factors such as clinical symptoms, lesion volume and location, and risk of complications like haemorrhagic transformation post-thrombolysis or thrombectomy. Estimating the infarct core volume is instrumental in anticipating such risks. In one study of 165 patients, ML algorithms like SVM and spectral kernel regression analyzed perfusion and DWI MRI to predict hemorrhagic transformation, with kernel regression reaching an accuracy of ~83% [7,23].

## **ARTIFICIAL INTELLIGENCE IN MULTIPLE SCLEROSIS DIAGNOSIS**

AI has also shown promise in enhancing the diagnostic process for MS, aiming to improve both accuracy and efficiency across several modalities.

### 1. Imaging

AI-based segmentation of MRI images is used to track the spatial and temporal progression of MS lesions, assessing lesion load and activity. Architectures like nnU-Net v2 and 3D-CNNs have improved the precision of identifying new and evolving lesions. Moreover, CNNs have been employed to detect imaging biomarkers, such as the central vein sign (CVS), which supports MS diagnosis [9,24–26].

### 2. Optical Coherence Tomography (OCT)

OCT is frequently used to evaluate optic neuritis, a common manifestation in MS, and to monitor retinal thinning over time. Several ML algorithms, including SVM, have shown effectiveness in distinguishing MS patients from healthy individuals based on OCT findings [24,27,28].

### 3. Biomarker Analysis

A Brazilian study explored the role of serum antioxidants in differentiating MS patients from healthy controls using ML techniques. The most significant biomarkers identified were zinc, adiponectin, total radical-trapping antioxidant parameter (TRAP), and sulfhydryl groups. Both SVM and neural networks confirmed correlations between lower antioxidant levels and MS, suggesting a potential pathophysiological role [24,29].

### 4. Cerebrospinal Fluid (CSF)

In a more recent analysis of 92 CSF biomarkers, an unsupervised ML model was used to detect patterns and classify protein interactions. A LASSO regression model (Least Absolute Shrinkage and Selection Operator) further identified specific biomarkers capable of distinguishing MS from other neurological diseases [24,30].

## CLINICAL IMPLEMENTATION AND INVESTMENT LANDSCAPE

As artificial intelligence transitions from experimental innovation to practical application, its integration into clinical neurology is accelerating across healthcare systems. In high-income countries such as the United States, Canada, Germany, and the United Kingdom, AI technologies are increasingly embedded in stroke units and multiple sclerosis centers. Platforms such as Viz.ai and RapidAI, which are FDA-approved, are now used in more than 1,000 stroke-ready hospitals, enabling faster triage, improved detection of large vessel occlusions, and shorter door-to-needle times. According to *The Lancet Digital Health* (2022), such systems may reduce disability-adjusted life years (DALYs) by up to 20% in acute ischemic stroke when implemented systematically [31].

Investments in AI infrastructure vary considerably—from \$250,000 to over \$1 million per hospital—depending on the extent of implementation, such as software licenses, imaging hardware upgrades, staff training, and integration with existing systems. Despite these initial costs, implementation has shown a favorable return on investment within a few years, driven by gains in diagnostic accuracy, fewer misdiagnoses, and reduced long-term care needs [32, 33].

In Central and Eastern Europe, efforts are underway to align with these global trends. In Romania, for instance, academic and research institutions have begun exploring the applications of AI in neurology through collaborative initiatives. Recent contributions presented at the 2024 National Autumn Scientific Conference of the Romanian Academy of Scientists (AOSR) addressed the intersection of neuroscience, medical ethics, and artificial intelligence. While still in early stages of clinical implementation, these discussions reflect an increasing interest in AI as a future pillar of

neurological innovation in the region [34, 35].

## CHALLENGES AND ETHICAL CONSIDERATIONS

While this review has already highlighted specific technical limitations encountered in stroke imaging applications, broader systemic and disease-specific challenges continue to shape the responsible implementation of AI in neurology.

In multiple sclerosis, AI has shown utility in lesion detection, segmentation, and biomarker interpretation. However, its performance remains limited in atypical presentations, and variability in MRI acquisition protocols across centers can reduce diagnostic reliability. Distinguishing MS from other demyelinating diseases - particularly early in the disease course - remains a significant hurdle [36]. Furthermore, longitudinal assessment of disease progression using AI requires standardized imaging and consistent follow-up, which is often difficult to ensure [25].

More generally, many AI models in neurology have limited generalizability, being trained on narrowly selected datasets that may not reflect clinical complexity. The interpretability of results is another major concern. Many models function as “black boxes,” offering little transparency into how diagnostic outputs are generated [37, 38]. Integrating these tools into clinical workflows also requires substantial infrastructure and training, often unavailable in routine healthcare settings [39].

The adoption of AI in neurology is not only a technological milestone but also a moment of profound ethical reflection. Key concerns include transparency, accountability, and the potential erosion of clinical autonomy in decision-making. These dilemmas take on particular importance in neurology, where diagnoses are often uncertain and the therapeutic

consequences long-lasting. As aptly phrased in the title of a recent Romanian academic presentation, “*From Religion, through Science and Ethics, to Artificial Intelligence. Quo vadis, Domine?*”, this journey urges us to reflect not only on what AI can do, but also on what it should do [40].

## CONCLUSION

Artificial intelligence is rapidly reshaping the diagnostic landscape in neurology, offering tangible advancements in both stroke and multiple sclerosis. In stroke care, AI assists with time-sensitive decisions through automated detection of large vessel occlusions, ASPECTS scoring, and image segmentation - ultimately improving patient triage and treatment outcomes. In multiple sclerosis, AI contributes to enhanced lesion tracking, cerebrospinal fluid and biomarker analysis, and retinal imaging, paving the way for more individualized and timely diagnoses.

Yet beyond the metrics and models, the integration of AI into our daily clinical work brings a growing sense of both opportunity and responsibility. As neurologists, we are witnessing not just a technological shift but a transformation in how we see, interpret, and support the complexity of the human brain.

While challenges remain—ranging from limited generalizability to ethical and infrastructural hurdles—AI is no longer a distant concept. It is becoming a trusted partner in our effort to offer precision, clarity, and hope to those living with neurological disease. In this evolving landscape, we find ourselves both learners and contributors—curious, cautious, but ultimately optimistic.

## Author Contributions

*M.T.T. and E.A.I. conducted the research, selected the relevant articles, and drafted the initial version of the manuscript. D.M. and V.S. revised and refined the draft,*

*contributing additional content to strengthen and finalize the review. C.A.S. originated the concept, designed the review structure, and supervised both the editorial process and the preparation of the final manuscript. All authors contributed equally to data interpretation, final editing, and approved the final version.*

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*The authors declare no conflict of interest regarding this article.*

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