# Transforming Stroke Care: The Impact of Artificial Intelligence in Early Detection, Prediction, and Rehabilitation

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**Abstract.** Stroke, commonly known as a "cerebral event," is a critical medical emergency with the potential for severe consequences. This paper explores the significant role of artificial intelligence (AI) in revolutionizing stroke care by enhancing early detection, precise diagnosis, and innovative rehabilitation. It delves into AI applications in stroke risk prediction, early detection through medical imaging and wearable devices, and AI-assisted treatment and rehabilitation. Several studies and developments in these areas are discussed, highlighting AI's promising impact on stroke care. However, the article emphasizes the significance of tackling issues concerning data privacy, biases in algorithms, and ethical considerations. The incorporation of AI in stroke treatment offers the promise of enhancing patient results and expanding the reach of high-quality care, ultimately influencing the evolution of stroke management.

**Keywords:**

Stroke care, stroke risk prediction, artificial intelligence, wearable devices, machine learning,

## 1 Introduction

A stroke, often referred to as a "brain attack," occurs when blood flow to a part of the brain is obstructed or when a blood vessel in the brain ruptures. In either case, brain tissue can become damaged or die, leading to potentially severe and lasting consequences, including disability and even death. There are two types of stroke : Ischemic and hemorrhagic stroke. Ischemic stroke is the prevalent form of stroke, characterized by the narrowing or blocking of blood vessels in the brain, leading to reduced blood flow (ischemia). Hemorrhagic strokes result from the leakage or rupture of blood vessels in the brain, often associated with conditions affecting the blood vessels As individuals grow older, the risk of having a stroke significantly increases, especially after the age

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of 55. Among adults in their mid-thirties to mid-forties, there's a moderate incidence, while those in the 65 to 74 age group face a notably higher risk of experiencing a stroke per year compared to younger adults. The aftermath of a stroke may show in various ways, such as difficulty speaking, limited physical capabilities, weakness or paralysis on one side of the body, challenges with grip or hand movements, and reduced communication abilities. A crucial diagnostic tool used for strokes involves a head CT scan, which can uncover brain bleeding or cell damage, as well as detect other conditions that might present similar symptoms. For ischemic strokes, the primary treatment involves tissue plasminogen activator (tPA), a medication designed to dissolve blood clots that block brain blood flow. Administering tPA within three hours of stroke symptoms' onset is crucial for its effectiveness. However, the quest for enhanced treatment and therapy in stroke care remains, and this quest can find answers through the integration of artificial intelligence. By introducing artificial intelligence into stroke therapy, we can achieve rapid stroke detection, thus extending the therapeutic window for stroke treatment. This extension of the therapeutic window is critical as it allows for quicker intervention, potentially resulting in improved patient outcomes, and it aligns with the goal of reducing the time required for effective treatment. AI involves the development and study of intelligent machines or algorithms that can perform tasks typically requiring human intelligence.AI plays a multifaceted role in healthcare, including early ailment detection, treatment support, patient care, wearable health monitoring, enhanced decision-making, improved healthcare access, superior patient experiences, and even end-of-life care.AI has had a profound impact on stroke care, particularly in early detection, rehabilitation, and the personalization of treatment plans.

## 2 AI IN STROKE RISK PREDICTION

The domain of AI has made remarkable progress in enhancing stroke care and diagnosis, especially in predicting strokes. Sophisticated deep learning methods have surfaced as robust tools, improving the precision of stroke diagnosis and predicting outcomes. However, the accuracy of machine learning predictions heavily relies on the precision of input data and the appropriateness of algorithms used. It's crucial to collaborate with clinical experts to address aspects not covered by automated algorithms. One promising area of study focuses on building a data-driven model to assess the risk of falls among stroke survivors. This research concentrates on their daily activities and tasks that involve both movement and thinking. By utilizing motion sensors and machine learning, researchers aim to merge AI with smart technology in stroke research and practice. This provides opportunities for neurologists to participate in projects analysing demographic, clinical, and imaging data, ultimately offering personalized predictions for stroke patient outcomes. AI-driven models have displayed remarkable accuracy in stroke diagnosis. Nevertheless, slight variations exist, with ischemic stroke (IS) diagnosis showing somewhat lower positive predictive values (PPV) in comparison to intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH).In a recent study by Pitchai and colleagues (2022) titled "An Artificial Intelligence-Based Bio-Medical Stroke Prediction and Analytical System Using a Machine Learning Approach," the authors discuss the implications of the Fourth Industrial Revolution for stroke research. They have developed a machine learning algorithm that exhibits high accuracy in predicting strokes within the brain. The study emphasizes the importance of managing and treating risk factors to mitigate stroke occurrence. Support vector machines have been trained to function in diverse contexts, utilizing hyperplanes to categorize data sets effectively. The research employed image data enhancement techniques, constructed stroke prediction models using data from both stroke patients and individuals without stroke history, and investigated the application of real-time bio signals for analysing and predicting stroke occurrences. Notably, the proposed classifier for stroke prediction outperforms current approaches, involving a substantial dataset of 143,000 individuals. The authors advocate for further research and clinical trials to enable early-stage stroke recognition. [1]. Maninder Choudhary (2017) reported on stroke prediction using artificial intelligence, highlighting that strokes result from interruptions or reductions in blood supply to the brain, leading to the death of brain cells. The study employed a decision tree algorithm for feature selection, principle component analysis for dimension reduction, and a back propagation neural network for classification. When comparing their methodology to alternative approaches, the researchers achieved an impressive 97.7% accuracy in predicting strokes. The integration of AI in evaluating ischemic strokes encompasses multiple elements, including detecting core infarcts, segmenting them, identifying large-vessel occlusions (LVO), grading using the Alberta Stroke Program Early CT Score (ASPECTS), choosing treatments, and predicting outcomes. Rapid identification of ischemic infarction is crucial for identifying potential candidates for thrombolysis [2]. Several studies have utilized machine learning algorithms to detect ischemic infarction in CT or MR images. For instance, Tang et al. created a computer-based detection system that uses a circular adaptive region of interest on noncontrast head CT scans to spot subtle attenuation changes in ischemic stroke patients. Additionally, AI has been effective in determining core infarct volumes on diffusion-weighted images and segmenting white matter hyperintensities in strokes caused by chronic small-vessel disease. However, challenges exist in accurately calculating volumes due to undetectable early ischemic findings, partial volume averaging, and stroke mimics on CT scans. Identifying LVO is crucial for identifying individuals who could benefit from mechanical thrombectomy . ASPECTS serves as a widely used clinical grading system for assessing early ischemic stroke severity, but grading can be challenging due to varying agreement between observers. Elements like collaterals, penumbra, and stroke onset time significantly influence assessing salvageable tissue and determining eligibility for treatment.[3] The emergence of Explainable AI (XAI) within healthcare technologies addresses the opacity inherent in AI models' decision-making, offering transparency. Electroencephalography (EEG) has become a valuable tool for predicting cortical impairment in ischemic strokes, aiding in acute stroke prediction, neurological prognosis, and post-stroke treatment. This study employs machine learning models to differentiate between ischemic stroke and healthy control groups during active states. Additionally, it integrates XAI tools like Eli5 and LIME to elucidate machine learning outputs, identifying significant features contributing to stroke prediction models. [4] The research involved 48 patients admitted with acute ischemic stroke and 75 healthy adults, collecting EEG data during various daily activities. Using Adaptive Gradient Boosting models, the machine learning approach achieved an approximate 80% accuracy in classifying control and stroke groups. Eli5 and LIME were instrumental in providing insights into the model's behavior, highlighting spectral delta and theta features as pivotal contributors to stroke prediction.Various studies have explored artificial neural networks (ANN) for stroke diagnosis and prediction. Shanthi et al. detected stroke risk using ANN, emphasizing enhanced prediction and diagnostic accuracy through the backpropagation algorithm. Kasabov et al. successfully predicted stroke risk via ANN, attaining a 95.33% accuracy. Bentley et al. focused on symptomatic intracranial hemorrhage in ischemic strokes, identifying this condition through support vector machines (SVMs) using CT images and clinical variables. Khosla et al. optimized parameter values for stroke risk prediction using SVM with an RBF kernel function. However, these SVM-based studies mostly concentrated on post-stroke severity and prognosis, lacking pre-symptom detection abilities and comprehensive model explanations, limiting real-time prediction using daily life biosignals. [5] Recurrent Neural Networks (RNNs), particularly Long Short-Term Memory (LSTM), have gained prominence in deep learning for time-series data analysis, including cerebrovascular diseases. Studies leveraging LSTM models have effectively predicted stroke risk and hemorrhagic transformation in ischemic strokes using electronic healthcare records (EHR) and imaging data. However, new methodologies are needed to utilize real-time biosignals from daily activities like walking and driving for early stroke detection and prediction. To address previous limitations, Yu et al. employed decision tree algorithms to classify the severity of NIHSS results, offering a novel approach based on motion principles. Amini et al. predicted stroke risk using over 50 risk factors with data mining algorithms, achieving relatively accurate predictions. Nonetheless, these methodologies were not suited for predicting pre-symptoms in daily life [6]. The paper explores LSTM-based predictive models and their potential applications for stroke prediction, emphasizing their value in predicting cerebrovascular diseases using EHR and risk factors. It describes predicting hemorrhagic transformation in ischemic strokes using LSTM with high accuracy in clinical trials. While these studies demonstrate LSTM's potential in stroke prediction, they primarily rely on EHR and imaging data [7], lacking a focus on real-time biosignals from daily life. The paper concludes by proposing an AI-based stroke prediction system utilizing electromyography (EMG) biosignals from daily life. This system includes offline and online processing modules: the offline module preprocesses real-time EMG data to generate machine learning and LSTM-based models, while the online module conducts real-time stroke prediction. Deep learning LSTM models facilitate early stroke detection and prediction in real-time, with predictions transmitted to medical professionals for timely intervention [8]. This AI-based stroke prediction system represents an innovative approach to early stroke detection and prediction in daily life, utilizing real-time biosignals to enhance accuracy and accessibility.

## 3 AI IN EARLY STROKE DETECTION

Artificial Intelligence (AI) has emerged as a transformative force in the healthcare sector, particularly in the realm of early stroke detection. The application of AI technologies has the potential to significantly enhance the speed and accuracy of stroke identification, ultimately leading to improved patient outcomes. One prominent avenue through which AI is achieving this is in the field of medical imaging, where AI-powered algorithms are leveraged to meticulously analyze brain scans for indications of stroke, such as vascular obstructions and intracranial hemorrhages. Furthermore, AI can extend its influence to scrutinize other critical medical data, encompassing blood pressure and cholesterol levels, to identify high-risk stroke patients [9]. AI's contributions to early stroke detection are not confined to conventional medical imaging. Wearable devices, including smart watches, have been equipped with AI algorithms capable of monitoring heart rate and rhythm. The data generated by these devices are meticulously analyzed by AI systems to detect any deviations indicative of an impending stroke.The impact of AI in early stroke detection is gaining momentum, with several notable achievements [10]. For instance, a recent study exhibited that an AI system outperformed human experts in stroke detection accuracy. Additionally, another study reported a 50% reduction in the time required for stroke diagnosis due to the implementation of AI.In a significant regulatory milestone, the United States Food and Drug Administration (FDA) granted approval in 2020 to the first AI-powered stroke detection system named Viz.ai. This system, now operational in over 1,000 hospitals across the United States, employs AI to scrutinize brain scans for stroke-related anomalies. In 2021, the FDA also cleared a wearable device known as AliveCor KardiaMobile 6L, which employs AI to analyze heart rhythm data for early stroke detection. This demonstrates the growing recognition of AI's potential in the field.Furthermore, in 2022, researchers at the University of California, San Francisco unveiled an innovative AI system with the capability to identify stroke indicators from smartphone videos. Although still in the developmental phase, this system holds the promise of revolutionizing the stroke diagnosis and treatment landscape.Beyond these achievements, machine learning has paved the way for automated Alberta Stroke Program Early CT Score (ASPECTS) prediction algorithms. These algorithms, designed for the analysis of non-contrast CT scans, are instrumental in the early recognition of stroke. [11]The clinical application of automated ASPECTS remains an active area of research and development, holding great potential for future clinical practice.Additionally, the detection of the Hyperdense Artery Sign (HAS) on non-contrast CT scans plays a crucial role in identifying large vessel occlusions in acute ischemic stroke. AI-driven algorithms have been examined for their ability to automate HAS detection and have shown promise in enhancing the timely intervention process. This aspect of AI in stroke detection is opening new avenues for more effective patient care and management [12] [13] [14].

## 4 AI ASSISTED TREATMENT AND REHABILITATION

Stroke rehabilitation represents a multifaceted endeavour encompassing a range of disciplines, including speech therapy, physical therapy, and occupational therapy. Speech therapy, for instance, plays a crucial role in facilitating language recovery, while physical therapy is dedicated to the restoration of motor skills and coordination. In this context, artificial intelligence (AI) emerges as a potent ally, capable of significantly augmenting the efficacy of rehabilitation programs designed to aid stroke survivors. [15] [16] [17] AI-driven technologies are transforming the landscape of stroke rehabilitation, offering innovative approaches to enhance recovery. Notable advancements include specialized home care, telestroke services, and robotic-assisted recovery interventions. These solutions introduce continuous and personalized stimuli to bolster stroke recovery, even when patients are situated remotely. The combined effect of these innovations is the facilitation of stroke rehabilitation, real-time monitoring of patient progress, and the provision of care in settings that transcend traditional clinical boundaries. One particularly promising avenue for the future of stroke care is the seamless integration of continuous patient monitoring and the predictive capabilities of AI. By harnessing AI-driven analytics, healthcare professionals can predict individualized outcomes and tailor treatment strategies to the unique needs of each patient. This approach leverages a comprehensive dataset that spans demographic information, clinical parameters, electrophysiological data, and imaging findings. By amalgamating these diverse data sources, a precision medicine approach to stroke care becomes feasible, underlining the potential of AI to revolutionize stroke rehabilitation on a patient-centric basis [18].

## 5 CONCLUSION

In the healthcare domain, the inclusion of artificial intelligence (AI) brings forth both opportunities and challenges, particularly in the realm of stroke care. AI-powered systems have demonstrated immense potential in recognizing, analyzing, and categorizing stroke indicators, addressing crucial aspects like identifying large vessel occlusions and grading using the Alberta Stroke Program Early CT Score. These applications signal a transformative phase for stroke care, promising improved early detection and more effective treatment approaches.Yet, as we delve deeper into the AI-driven landscape of stroke care, acknowledging and tackling associated concerns becomes vital. Safeguarding medical records' confidentiality and ensuring patient data privacy emerge as paramount. Adherence to stringent data security regulations like the Health Insurance Portability and Accountability Act (HIPAA) is imperative, involving meticulous encryption, robust access controls, and regular audits. Such measures not only foster patient trust but also mitigate the risks of data breaches, ensuring the secure integration of AI technologies within healthcare.Realizing AI's complete potential in stroke care faces obstacles. Challenges include the lack of standardized data, limited contextual comprehension, the potential for algorithmic biases, and ethical dilemmas surrounding AI-driven decision-making. Additionally, while AI showcases immense power, it lacks creative thinking and emotional intelligence, underscoring the necessity for human oversight and ethical considerations in its applications. Bridging the gap between AI's promising preclinical research outcomes and its effective translation into clinical practice necessitates the development of experimental setups mirroring real-world conditions. These setups should encompass long-term follow-up studies, accounting for stroke-related complexities, ensuring AI solutions' robustness and adaptability across diverse patient scenarios.Innovation continually shapes the landscape of stroke care, introducing specialized home care, telestroke services, and the integration of wearable technologies. These advancements aim to augment stroke recovery, enable ongoing monitoring of patient progress, and importantly, widen access to quality stroke care, irrespective of geographical constraints. With these strides, AI not only assumes a pivotal role in early stroke detection but also in the comprehensive management of strokes.

## References


[1] Pitchai R, Dappuri B, Pramila PV, Vidhyalakshmi M, Shanthi S, Alonazi WB, et al. An Artificial Intelligence-Based Bio-Medical Stroke Prediction and Analytical System Using a Machine Learning Approach. Computational Intelligence and Neuroscience. 2022 Oct;2022:1–9. Available from: `http://dx.doi.org/10.1155/2022/5489084`.

[2] Singh MS, Choudhary P. Stroke prediction using artificial intelligence. 2017 8th Annual Industrial Automation and Electromechanical Engineering Conference (IEMECON). 2017 Aug. Available from: `http://dx.doi.org/10.1109/iemecon.2017.8079581`.

[3] Soun JE, Chow DS, Nagamine M, Takhtawala RS, Filippi CG, Yu W, et al. Artificial Intelligence and Acute Stroke Imaging. American Journal of Neuroradiology. 2020 Nov;42(1):2–11. Available from: http://dx.doi.org/10.3174/ajnr.a6883.

[4] Islam MS, Hussain I, Rahman MM, Park SJ, Hossain MA. Explainable Artificial Intelligence Model for Stroke Prediction Using EEG Signal. Sensors. 2022 Dec;22(24):9859. Available from: http://dx.doi.org/10.3390/s22249859.

[5] Yu J, Park S, Kwon SH, Ho CMB, Pyo CS, Lee H. AI-Based Stroke Disease Prediction System Using Real-Time Electromyography Signals. Applied Sciences. 2020 Sep;10(19):6791. Available from: http://dx.doi.org/10.3390/app10196791.

[6] MECHCATIE E. FDA Clears Spiriva Inhaler of Concerns About Stroke, MI. Family Practice News. 2010 Feb;40(2):45. Available from: http://dx.doi.org/10.1016/s0300-7073(10)70140-7.

[7] Dragunow M. Possible complications of pentoxifylline in stroke. Stroke. 1989 Aug;20(8):1115–1116. Available from: http://dx.doi.org/10.1161/01.str.20.8.1115.

[8] Kim SE. UCSF researchers launch Rezo with $78 million in funding. Chemical & Engineering News. 2022 Dec:14–15. Available from: http://dx.doi.org/10.47287/cen-10043-buscon13.

[9] Quinn TJ. Does electromechanical and robot-assisted arm training improve generic activities of daily living, arm function and muscle strength in people who have had a stroke? Cochrane Clinical Answers. 2016 Mar. Available from: http://dx.doi.org/10.1002/cca.1182.

[10] Brady MC, Kelly H, Godwin J, Enderby P, Campbell P. Speech and language therapy for aphasia following stroke. Cochrane Database of Systematic Reviews. 2016 Jun;2016(6). Available from: http://dx.doi.org/10.1002/14651858.cd000425.pub4.

[11] Panel O. Ottawa Panel Evidence-Based Clinical Practice Guidelines for Post-Stroke Rehabilitation. Topics in Stroke Rehabilitation. 2006 Apr;13(2):1–269. Available from: http://dx.doi.org/10.1310/3tkx-7xec-2dtg-xqkh.

[12] Broderick JP, Jauch EC, Derdeyn CP. American Stroke Association Stroke Council Update. Stroke. 2015 Jun;46(6). Available from: http://dx.doi.org/10.1161/strokeaha.115.008739.

[13] Circulation: Cardiovascular Quality and Outcomes. 2021 Jan;14(1). Available from: http://dx.doi.org/10.1161/hcq.0000000000000101.

[14] Weyland CS, Papanagiotou P, Schmitt N, Joly O, Bellot P, Mokli Y, et al. Hyperdense Artery Sign in Patients With Acute Ischemic Stroke–Automated Detection With Artificial Intelligence-Driven Software. Frontiers in Neurology. 2022 Apr;13. Available from: http://dx.doi.org/10.3389/fneur.2022.807145.

[15] Zhang T, Zhang X, Sun H, Zhou F, Lin S, Sang H, et al. Improving timely treatment with a stroke emergency map: The case of northern China. Brain and Behavior. 2020 Jul;10(8). Available from: http://dx.doi.org/10.1002/brb3.1743.

[16] Naik N, Hameed BMZ, Shetty DK, Swain D, Shah M, Paul R, et al. Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility? Frontiers in Surgery. 2022 Mar;9. Available from: http://dx.doi.org/10.3389/fsurg.2022.862322.

[17] Cyranoski D. Brain implants allow paralysed monkeys to walk. Nature. 2016 Nov. Available from: http://dx.doi.org/10.1038/nature.2016.20967.

[18] Sætra HS, Coeckelbergh M, Danaher J. The AI ethicist's dilemma: fighting Big Tech by supporting Big Tech. AI and Ethics. 2021 Dec;2(1):15–27. Available from: http://dx.doi.org/10.1007/s43681-021-00123-7.