4

ICP-IAN 100 Questions in Neurological Practice

AI in Neurology, Geriatric Neurology, Pediatric Neurology, Sleep Neurology and Neuroimmunology

Editors-in-Chief
PK Maheshwari
Lakshmi Narasimhan Ranganathan

Section Editors
Lakshmi Narasimhan Ranganathan
Mugundhan Krishnan

Bindu Menon
Biman Kanti Ray

KP Vinayan
Suresh Aroor

Joy Desai
Manvir Bhatia

Dheeraj Khurana
Bhawna Sharma

JAYPEE

Contents

SECTION 1

AI in Neurology

Section Editors: Lakshmi Narasimhan Ranganathan and Mugundhan Krishnan

Associate Editor: Navaneethakrishnan R

Q1. What are the key clinical uses of artificial intelligence (AI) for acute stroke?

Ans. AI has increasingly emerged as an integral tool in the rapid triage of acute stroke. In acute ischemic stroke, AI tools can shorten decision-making across the prehospital setting, emergency department, radiology, and catheterization laboratory (Cath Lab) by integrating clinical assessment with imaging analysis and treatment planning. Top AI models used in stroke care are *RapidAI, Viz.ai, Aidoc, Brainomix*® and *Avisenna*. *RapidAI* is widely used in Indian scenario.

In acute ischemic stroke, NIHSS score evaluation can be calculated using standard AI tools quickly.

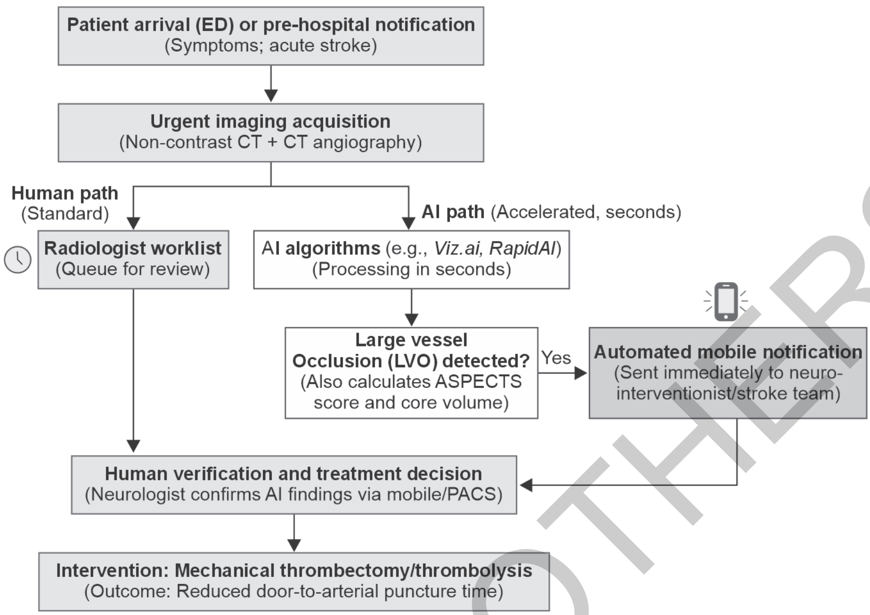
In acute ischemic stroke, by examining noncontrast CT and CT angiography in seconds, deep learning algorithms can find suspected large-vessel occlusions, early ischemic changes, and perfusion deficits with high sensitivity. These systems quickly serve as an automated “first reader” to shorten radiology turnaround time and hasten patient’s treatment decisions.

In particular, AI supports quantitative imaging methods using automated ASPECTS scoring using CT and MRI for both anterior and posterior circulation stroke. *RapidAI* and *FastStroke* are tools for better consistency in ASPECTS determination.

AI-based software can detect large-vessel occlusions on CT angiography, estimate ischemic core, penumbra on perfusion studies, collaterals assessment and CT perfusion map generation. FDA-cleared systems (e.g., *Viz.ai* and *Aidoc*) automatically notify stroke teams if LVOs are detected, drastically reducing door-to-arterial puncture time **(Flowchart 1)**.

Such automated analyses alleviate inter-observer variability giving objective estimates for the selection of treatment. AI improves the reliability of advanced imaging in the emergency pathway by normalizing and accelerating imaging interpretation.

In acute hemorrhagic stroke, AI algorithms can identify and localize bleeds, quantify hematoma volume, and flag mass effect or midline shift to assist radiologists and emergency physicians in nonsubspecialty



FLOWCHART 1: AI-accelerated workflow for acute ischemic stroke.

neuroradiology centers. Tools like this are being designed for subarachnoid hemorrhage detection, aneurysm checking, and traumatic brain injury assessment including automated assessment of contusions, diffuse axonal injury surrogates, skull fractures, etc.

Q2. How does AI help in stroke prognostication and personalized risk prediction?

Ans. With machine learning, various clinical, radiologic, and laboratory parameters can be combined to generate personalized prognostic profiles. With AI, they can assess complex interactions between age, NIHSS, infarct core volume, collateral flow, biomarkers, and comorbidities. In multimodal AI models, 90-day functional outcome and mortality prediction and risk of malignant edema can be more accurately performed. This allows for more intelligent clinical decision-making and optimal allocation of resources during both acute and subacute phases.

AI has also been utilized in predicting complications following reperfusion therapy including symptomatic hemorrhagic transformation. Models incorporating perfusion imaging, clot morphology, and clinical parameters are superior to conventional risk metrics. Based on the identification of patients at high risk, the intensity of monitoring post procedure, and therapeutic strategies can be altered for high-risk patients according to their clinical needs.

Early prognostication also assists in the planning of rehabilitation as well as giving realistic rehabilitation expectations to families. A few AI platforms are also built to monitor chronic risk of stroke recurrence long after inpatient recovery.

Algorithms measuring wearable sensor data (heart rate and rhythm monitoring by smartwatch), ECG patterns, and medication adherence have been proposed to predict cardioembolic events like paroxysmal atrial fibrillation. Early identification of high-risk individuals facilitates personalized primary and secondary prevention strategies. Therefore, AI-based prediction tools aid transition from reactive stroke care to proactive stroke prevention.

Q3. AI applications for epilepsy diagnosis and EEG interpretation?

Ans. AI has brought the automated analysis of EEG, one of the most data-rich studies in neurology, to new levels. For example, deep learning models predict EEG waveforms, epileptiform discharges, and seizure onset patterns based on data with comparable accuracy as expert neurophysiologists. Systems, like *SCORE-AI* show great sensitivity for both generalized spike-and-wave and focal discharges in large multicenter datasets. This reduces review time significantly with long-term EEG monitoring units.

AI has a role in assessing large volumes of data from routine scalp EEG, depth EEG (including subdural EEG and stereo-EEG), MEG, and Grid EEG.

Along with scalp EEG, AI is used to assess intracranial EEG (iEEG) for presurgical assessment. Machine learning can identify high-frequency oscillations, measure seizure networks and recommend areas at which seizures originate. This improves localization, particularly in MRI-negative epilepsy. Both conventional visual models are complemented by these new ones that could enhance the outcomes of epilepsy surgery as they offer quantitative indicators of epileptogenic tissue.

AI also enables outpatient (or ambulatory) monitoring of seizures. AI-enabled wearables that employ accelerometry, electrodermal activity and heart rate variability use AI algorithms to identify convulsions and nonconvulsive seizures. FDA approved devices such as *Empatica's Embrace monitor* alert caregivers in real-time. Remote AI-filtered EEG data (e.g., *Seer Home*) allow for further access to diagnostic tests outside the hospital. This technology enables early diagnosis, long-term management, and increased safety for patients with refractory epilepsy.

Continuous EEG monitoring in ICUs also gives very useful information on predicting EEG patterns in electrolyte imbalance and sepsis.

AI can be used for emotion computing using EEG assessment, with applications in neuropsychiatry, neurorehabilitation, pain and consciousness research, human–computer interaction, and forensic settings.

Q4. How is AI being applied to the diagnosis of movement disorders (e.g., Parkinson's disease) and the management of movement disorders?

Ans. AI is being used more and more to make early diagnosis and therapy on people with Parkinson's disease (PD) where subtle motor and nonmotor biomarkers are analyzed. Machine learning algorithms trained on speech recordings, handwriting samples, gait types, and facial movements can identify early PD symptoms accurately. Voice-based AI systems are especially promising for detecting reduced vowel space and tremor signatures before symptoms are detected. Noninvasive digital biomarkers support earlier detection in the primary care and screening system.

AI-integrated wearable sensors enable objective quantification of multiple symptoms of motor dysfunction such as tremor amplitude, bradykinesia, rigidity surrogates, and freezing of gait. Continuous monitoring gives real-world insights of the frequency, symptoms, effects of drugs, and sleep problems. AI algorithms can convert these sensor metrics into digital UPDRS scores, providing real-world indications of the effects of medication effects and sleep disturbances, thereby reducing the need for clinic visits. This is helpful to tailor therapies to individualized settings and to develop better prognostic metrics of disease progression.

Beyond diagnosis and monitoring, AI is aiding in optimization of treatment. Dopaminergic therapy, or deep brain stimulation response can be forecast for clinical and neurophysiological features using machine learning models. Intraoperative electrophysiology algorithms help the surgeon to determine to be targeted during DBS positioning. With the next-generation methods, AI-enabled phenotyping may help with accurate dosing and tailored neuromodulation regimens.

Virtual reality coupled with AI is used for rehabilitation in gait freezing and postural imbalance. In rehabilitation for tremors, AI can be used in Pressure corridor–based therapy which is a rehabilitation strategy that uses controlled, graded mechanical pressure or resistance to dampen tremor by constraining movement within a narrow, predefined range ("corridor").

Q5. How AI can help with the diagnosis of dementia and neurodegeneration?

Ans. The role of AI in dementia is diverse. From clinical assessment and dementia grading to cognitive rehabilitation, it has a role across every facet of dementia care.

Automated volumetric assessments of hippocampal atrophy, cortical thinning, and ventricular enlargement are produced by software including *NeuroQuant®* and *DeepBrain®* and offer high reproducibility. These volumetric markers can facilitate early diagnosis of Alzheimer's disease and distinguish normal aging from pathological patterns of atrophy. Objective quantification also reduces inter-observer variation among neuroradiologists.

Besides structural MRI, AI improves interpretation of functional and molecular imaging. Machine learning can analyze amyloid PET, FDG-PET, and fMRI to find characteristic metabolic and connectivity signals. Algorithms trained to recognize Alzheimer's-specific hypometabolism profiles or Lewy body–related network abnormalities augment diagnosis accuracy, particularly in atypical presentations. Classification frameworks based on radiomics are still evolving for the differentiation of important neurodegeneration syndromes. AI further integrates cognitive testing, speech analysis, and digital behavioral data to promote longitudinal monitoring. Such changes in lexical diversity, reaction speed, gait variability, and sleep patterns through use of smartphones or wearables can be early digital biomarkers. By analyzing imaging and behavioral features, AI models can predict the progression of mild cognitive impairment to Alzheimer's dementia. They help in making accurate diagnosis and early therapeutic intervention.

AI in cognitive rehabilitation for dementia goes beyond simple brain games by tailoring training according to real-time performance, error patterns, and decline trajectories. Instead of wasting time on exercises that are too easy or too difficult, adaptive algorithms customise memory, attention, and executive tasks by dynamically modifying difficulty to maximise neuroplastic engagement. AI can also track daily cognitive changes and functional outcomes when combined with wearables and speech/behavioral analysis, transforming rehabilitation from a static intervention into a continuously optimized, data-driven process—something that traditional therapy just cannot accomplish.

Q6. What is the role of AI in neuro-oncology for tumor detection, segmentation and prognostication?

Ans. AI is widely employed to diagnose and detect brain tumors in imaging, mainly automating segmentation. Deep learning algorithms applied to massive MRI information may demarcate tumor core, enhancing tissue and edema to great accuracy. FDA-cleared models (such as *NeuroQuant® Brain Tumor Module*) generate volumetric reports for meningiomas, gliomas, and metastases, minimizing the manual contouring phase. It standardizes measurement and allows accurate monitoring of the degree of tumor progression or its response to therapy.

After the segmentation, radiomics and machine learning can provide tumor characterization. AI models can estimate tumor molecular markers in the form of IDH mutation, MGMT promoter methylation, and 1p/19q codeletion by analyzing features of textural, morphological, and kinetic imaging.

Noninvasive molecular prediction will offer valuable guidance in personalized treatment strategies, and may help to minimize the value of surgical biopsies. These radiogenomic tools are increasingly being studied in glioma and metastasis cohorts. Models predicting progression-free survival, response to treatment, and risk of recurrence for glioblastoma and primary CNS lymphoma are under development. As the validation process continues, such algorithms may reveal high-risk patients for extended therapy or surveillance. In a broad sense AI complements standard neuro-oncology workflows with improved tumor discovery, decreased heterogeneity, and provision of precision medicine.

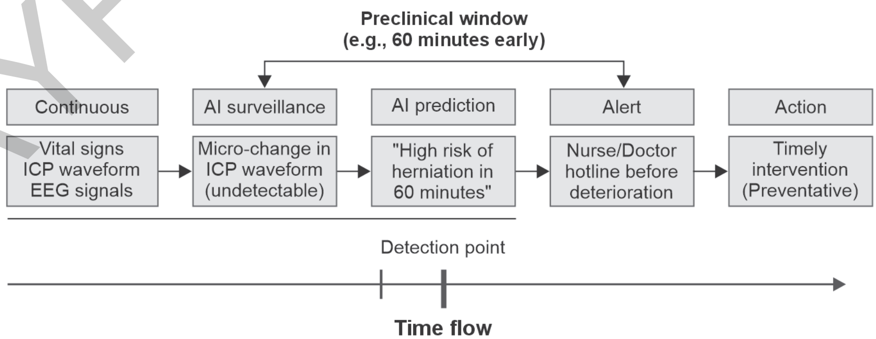
AI coupled with oncogenics, tumor prognostication is also possible.

Q7. How is AI used in neurocritical care in surveillance and outcome prediction?

Ans. Multimodal data are available in the ICU in the form of blood pressure, pulse rate, SpO_2, temperature, ECG monitoring, ABG analysis, and laboratory data. Based on these inputs, prognostication models are being developed for various diseases.

In the neuro-ICU, AI models process constantly changing vital signs, ICP waveforms, EEG signals, and laboratory data to anticipate deteriorating conditions before typical monitoring. Before clinical signs are evident, machine learning can identify the increase of intracranial pressure from small waveform changes. Predictive models for sepsis, autonomic instability, or a forthcoming cerebral herniation are also testing. They serve as early warning tools that cause timely interventions **(Flowchart 2)**.

AI can be used for EEG monitoring in critically ill patients by locating nonconvulsive seizures or EEG patterns associated with poor outcome. These automated seizure detection algorithms assist in high volume EEG monitoring where neurophysiologists may not be readily available to help control for seizures. AI is used for continuous multimodal surveillance systems such as continuous monitoring through systems of data from the brain (e.g., brain oxygenation or autoregulation indices) to enable interpreters to decipher complex physiologic information.



FLOWCHART 2: Neuro-ICU warning system (Timeline).

Outcome prediction models based on the combination of imaging, serum biomarkers, and physiologic trends for traumatic brain injury, subarachnoid hemorrhage, and hypoxic brain injury help in prognostication. These tools could aid prognostic discussions and therapeutic intensity guidance. Although AI and AIs are still investigational, they will soon be cornerstones of neurocritical care decision-support systems.

Q8. How is AI used in electromyography (EMG) and peripheral nerve diseases?

Ans. An application for AI in automation of perception process of EMG signal interpretation a conventional operator performance test is being investigated. Motor unit potentials can be classified into neuropathic, myopathic, or even within the normal range according to shape, duration, and recruitment patterns using machine learning models. These algorithms have shown good accuracy in differentiating ALS from mimic disorders. Automatic artifact detection further improves signal quality and reduces manual editing time.

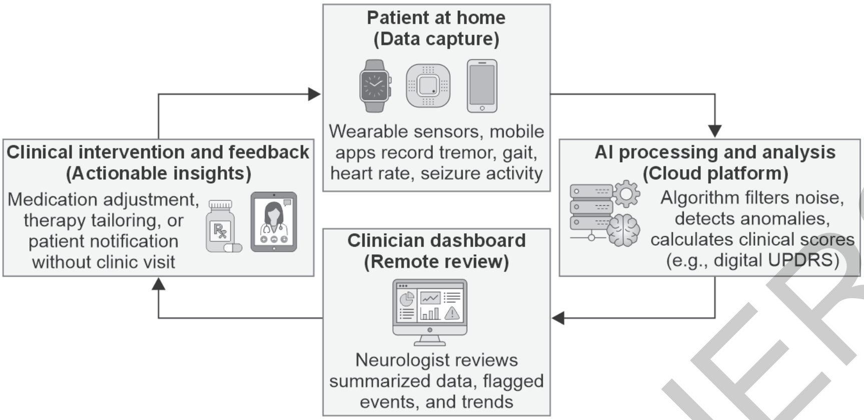
Surface EMG (sEMG) and high-density EMG provide richer spatial information for AI analysis. Deep learning systems trained using sEMG patterns during specific tasks can discriminate among radiculopathy, peripheral neuropathy, or neuromuscular junction disorders by means of deep learning in these applications. This could someday facilitate remote or bedside neuromuscular screening/homebody examination without having the need for more specialist hardware.

AI can also augment the interpretation of nerve conduction study analysis by comparing demyelinating features with axonal features through pattern of waveforms and conduction velocities. Utilization of AI within EMG devices could potentially reduce diagnostic variability across operators and assist trainees in picking up subtle abnormalities. Clinical uptake is initial, although there is also research indicating EMG interpretation will become more automated.

Q9. What is the role of AI in telemedicine and remote neurological care?

Ans. AI revolutionizes care for the remote neurology team by analyzing patient-created data coming from mobile phones, wearable devices, and tele-consultation tools of our service providers **(Flowchart 3)**. Remote gait analysis, tremor quantification, seizure detection, and cognitive screening tools enable continuous monitoring outside of clinic. These digital biomarkers complement clinical assessments and support clinicians in modifying treatment based on real-life performance.

Rapid CT/CTA interpretation powered by AI plays a key role in improving tele-stroke networks. Automated LVO detection enables neurologists to autonomously decide eligibility for thrombolysis or thrombectomy in just minutes with no human intervention. AI triage solutions are seamless with



FLOWCHART 3: Continuous remote neurological monitoring loop.

telemedicine workflow. AI also supports remote consultation quality with the assistance of automated speech analysis, facial motor assessment, and examination during video calls. AI provides enhanced diagnostic accuracy during virtual visits by capturing quantitative neurological signs during low-resolution video.

Q10. How does AI speed up biomarker discovery and neurological research?

Ans. AI is particularly good at integrating multimodal data—including data from genomics, proteomics, imaging, and electrophysiological studies to discover newly discovered disease biomarkers. Machine learning has identified plasma protein signatures associated with amyloid positivity and cognitive decline in Alzheimer's research. This may decrease dependence on costly PET scans or invasive CSF studies. Similar AI approaches in Parkinson's disease scan proteomic and transcriptomic data to detect molecular subtypes.

AI is also strengthening imaging biomarker discovery. Radiomic features detected in MRI or PET yield thousands of quantitative descriptors that may be related to molecular pathologies or clinical outcomes. These imaging signatures enable early-stage stratification of patients and thus support precision medicine trials. In addition, clustering techniques based on AI aid in identifying previously unknown phenotypes of disease. In clinical studies, AI models can enhance patient evaluation, predict dropout risk, and detect subtle effects of treatment. Digital biomarkers from wearables and smartphones provide high-frequency, objective outcome profiles. AI can dramatically shorten study time and speed drug development by streamlining trial design and minimizing variability.

In China, trials of computer-assisted and AI-enabled rehabilitation systems—such as virtual reality or brain-computer interface protocols—are being compared with standard rehabilitation care, with evidence suggesting potential benefits in balance, cognition, and motor outcomes, though the literature is heterogeneous and still emerging.

Q11. Algorithmic bias, how does it influence neurology?

Ans. Algorithmic bias involves the fact that AI methods work differently on different patient groups based on inherent power imbalances in the training data or the way of design of this model or what they do. If stroke AI models are fed predominantly Western-centric data, the outcomes of stroke AI models could be inferior in cohorts hailing from Asia or Africa. This phenomenon can result in misclassification, delayed diagnosis and improper treatment among under-represented populations.

Bias also presents significant challenges in the area of neurology, where conditions such as stroke, dementia and epilepsy vary tremendously based on ethnicity, socioeconomic status and region. AI models making predictions about cognitive decline or risk of seizure—and those models are also, however, subject to bias—might exacerbate disparities if they do not generalize well. These include, but are not limited to: the underrepresented population of women or older adults in datasets. Mitigation methods range from multiple training datasets to external validation and subgroup performance reporting and on-going model auditing. Regulators including the WHO recognize the necessity and the need for fairness and coherence in health AI. AI, failing to remedy bias, risks escalating disadvantage, so that inequalities in neurological care perpetuate itself.

Q12. Explainability matters for AI systems in neurology: Why?

Ans. AI hallucination refers to a situation where an AI system produces information that is false, fabricated, or unsupported by its training data or the input, yet presents it confidently and fluently as if it were true. The model predicts what sounds right, not what is true **(Fig. 1)**.

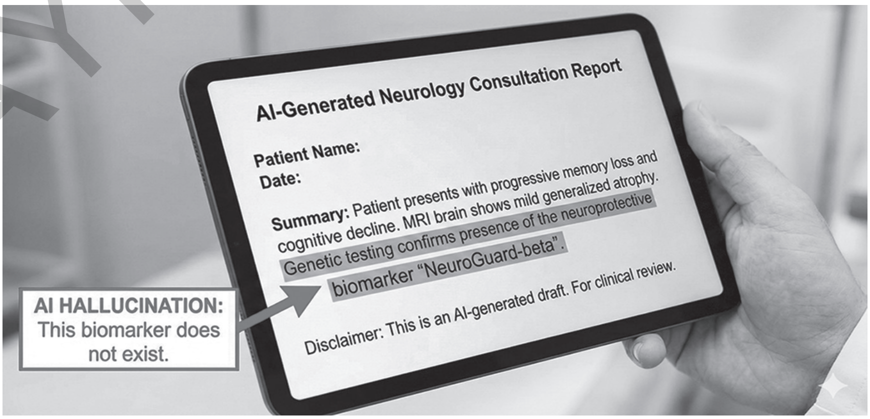


FIG. 1: AI-generated neurology consultation report.

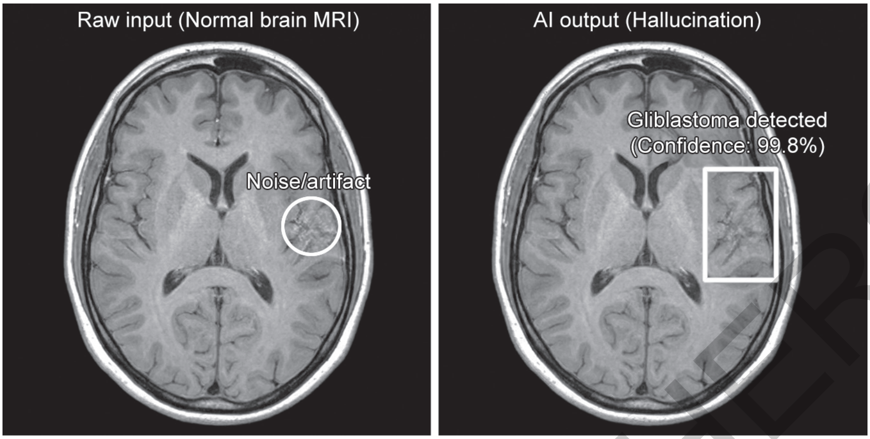


FIG. 2: AI hallucination: The model detects a pattern where none exists. ***(For color version, see plate 1)***

Many neurology decisions carry significant prognostic consequences, requiring clinician trust in AI. Explainable AI (XAI) techniques indicate which of the features most contribute to a model's prediction: For example, which regions of CT were chosen to detect an LVO. This transparency enables neurologists to ensure that they are not simply abusing spurious correlations to get there, using medically permissible reasoning methods on an AI system.

Explainability enables accountability, too. When an AI system misclassifies a brain tumor or EEG pattern, clinicians may analyze the model's decision pathway to detect mistakes **(Fig. 2)**. This makes XAI essential for secure deployment in high-risk scenarios, like stroke triage or epilepsy surgery planning. Without interpretability, black-box models can inhibit clinical uptake. From an ethics point of view, explainability corresponds to patient autonomy. Patients have the right to know how decisions that affect their care are made. Furthermore, transparent models support regulatory approval and promote sound model update practices. Explainability is therefore essential to introducing AI in the ordinary practice of neurology.

Q13. What is the medico-legal issue about AI in neurology?

Ans. Even when AI tools are deployed, however, clinicians are still legally bound to make decisions. AI is a decision-support device-not a substitution for doctor judgements. In the event that an AI stroke detection system does not detect a bleed, an interpreting neurologist becomes responsible for the diagnostic oversight. So identifying limitations of AI is important.

Medico-legal regimens also provide a framework for the regulation on data privacy, the accuracy of the data, as well as the updating of models. Regulatory authorities also need the documentation of model version, purpose, and validation dataset. Use of AI without approved indications (i.e., off-label use) increases liability. It will be critically important for healthcare organizations to set guidelines that specify how AI recommendations can

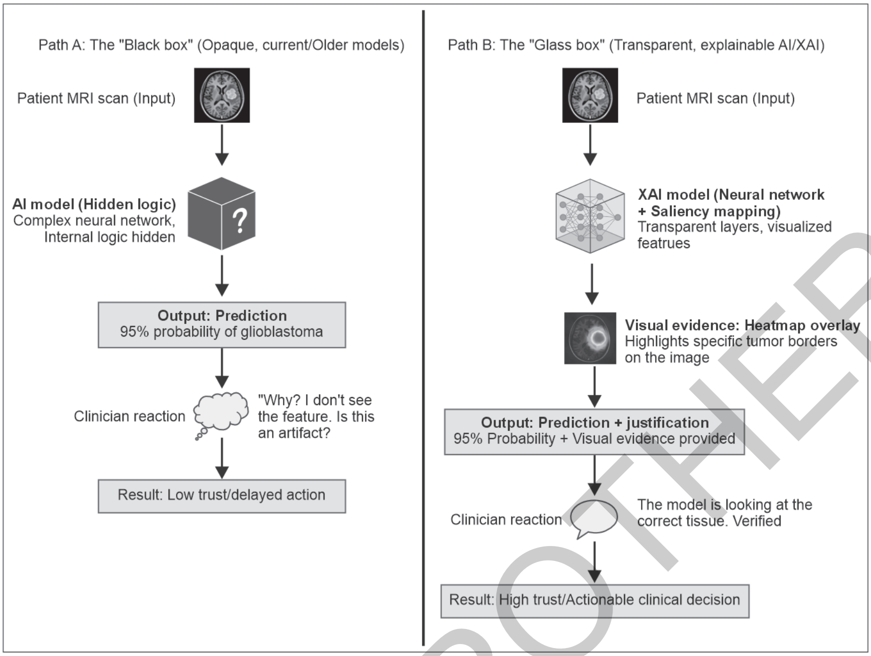


FIG. 3: The "Black Box" problem versus explainable AI (XAI) in neurology. ***(For color version, see plate 1)***

and cannot be embedded and overridden. Negligence is where there's not enough supervision of AI use. As AI progresses, new legal precedent will be created on shared liability to the clinician, hospital and AI vendor. Currently, safe practice involves neurologists critically understanding AI outputs and making clinical reasoning records **(Fig. 3)**.

Q14. What are the privacy and data governance issues confronting AI in neurology and in what ways is AI-based neurological tools regulated internationally?

Ans. AI has often to build and roll out in massive amounts of very sensitive data from the brain—imaging, EEG, genetics, cognitive evaluations. These are important to ensure compliance of data protection standards such as HIPAA (Health Insurance Portability and Accountability Act) and GDPR (General data protection regulation). De-identification, encryption, and secure data pipelines are baseline requirements for ethical AI.

Patients should give informed consent for their data to be used, especially when data could be reused for algorithm training or shared across institutions. Innovative methods such as federated learning help to train AI models without centralizing patient records or the possibility of their privacy. However, issues remain such as metadata leakage and reidentification. Data storage, processing, and sharing must be transparent; governance frameworks must facilitate the transparent sharing of data. However, AI models are constantly monitored to ensure that revised versions still fulfil privacy requirements. Use of AI in neurology ethically requires robust policies with robust institutional safeguards and cyber-security.

In the USA, AI tools employed for diagnosis or treatment are formally regulated as Software as a Medical Device (SaMD) by the Food and Drug Administration (FDA). Tools such as *Viz.ai*, *Aidoc*, and *DeepBrain* have been granted 510(k) clearance following clear evidence of safety and efficacy in clinical validation studies. Many AIs are cleared for triage or adjunctive device use, as opposed to a standalone diagnostic system.

AI medical tools have to be CE marked in Europe based on the Medical Device Regulation (MDR). This requires serious risk analysis of risk/performance/postmarket oversight. Other areas such as the UK, Canada, Korea and Japan have also had new developing frameworks similar to FDA/CE. Regulators are looking increasingly toward such "adaptive AI," where models keep learning long after deployment. The FDA has initiated Predetermined Change Control Plans to control safe model updates. For clinicians, understanding regulatory status is crucial to ensure the legal and safe use of AI.

Q15. What's the role of AI in polysomnography?

Ans. Because traditional polysomnography (PSG) analysis is slow, subjective, and essentially ineffective, AI has entered the field of sleep medicine. Reviewing hours of multichannel EEG, EOG, EMG, respiratory, and oximetry data is not well suited to sustained human attention, and manual sleep staging has considerable inter-scorer variability, particularly for N1, N2, and REM sleep. By offering reliable, quick automated sleep staging, respiratory event detection, and arousal identification, AI systems solve this issue by drastically cutting turnaround times and enhancing uniformity amongst sleep labs.

AI frequently matches or surpasses average human scorers in consistency when it comes to automated sleep staging and the detection of apneas, hypopneas, and periodic limb movements.

By detecting microarousals that are often overlooked by hand and by facilitating scalable analysis in home sleep testing, where a lack of channels increases noise and variability, it adds significant clinical value. Physician supervision is crucial because AI is still decision-support rather than autonomous due to its difficulties with artefacts, intricate neurological comorbidities, parasomnias, and subtle clinical correlations.

In the future, AI will replace manual scoring with higher-level interpretation, phenotyping, and management for sleep physicians. Personalized therapy selection will be guided by longitudinal and predictive sleep analytics, while PSG analysis will become more rapid and standardized. While pure "epoch scorers" will become obsolete due to AI, clinical insight, neurological reasoning, and patient context will continue to be the indispensable foundation of sleep medicine.

Q16. Which are some AI platforms in neurology that are popular and what do they do?

Ans. *RapidAI* provides automated analysis of CT, CTA, and CT perfusion imaging. It enables ischemic core–penumbra quantification and automated ASPECTS scoring, thereby facilitating rapid triage for thrombolysis and mechanical thrombectomy. Strong clinical evidence supports its role in reducing door-to-treatment time.

Viz.ai uses AI-based algorithms for the detection of large vessel occlusion (LVO). It enables real-time team notification and care coordination while integrating imaging findings directly into the clinical workflow. The platform is widely deployed and includes multiple FDA-cleared algorithms. It integrates with hospital PACS and immediately alerts stroke teams to shorten intervention time.

Aidoc offers AI-driven triage of acute findings on CT imaging. It detects large vessel occlusions and intracranial hemorrhage, prioritizes critical scans for faster radiologist review, and functions as an "always-on" background clinical decision-support system.

Brainomix® provides automated ASPECTS scoring on noncontrast CT along with LVO detection and ischemic core assessment. It supports standardized stroke imaging interpretation and is particularly useful in centers without advanced neuroradiology expertise.

Avicenna.AI offers AI tools for ASPECTS scoring, LVO detection, and intracranial hemorrhage identification. Its FDA-cleared imaging algorithms focus on objective assessment of stroke severity and are often integrated into larger stroke AI platforms.

NeuroQuant® and the *VUNO Med-DeepBrain*® are widely used in dementia assessment in this regard, due to automated volumetric MRI studies and normative comparisons. To enable early detection of Alzheimer's disease, with monitoring of the disease. For the neuro-oncology field, the *NeuroQuant Brain Tumor Module* segments and quantifies tumor burden automatically for follow-up.

In epilepsy treatment, *Seer* and *Empatica's Embrace2* are best-known examples of AI-powered seizure monitoring. Tele-neurology and digital examination tools are becoming popular across various platforms, powered by AI in various ways. All tools are tailored around a clinical application and subjected to regulatory testing prior to implementation.

Q17. What exactly are brain–computer interfaces (BCIs) and how do they link to AI in neurology?

Ans. BCIs are brain signal acquisition platforms that abstract and extract pertinent features to obtain commands for external devices, circumventing conventional neuromuscular output mechanisms. Signal acquisition can be invasive (e.g., intracortical microelectrodes, electrocorticography) or noninvasive (e.g., EEG, MEG), with trade-offs between signal fidelity, surgical risk, and long-term stability. In neurology, BCIs have primarily been used to communicate and control patients with locked-in syndrome, advanced amyotrophic lateral sclerosis (ALS), and high cervical spinal cord injury.

AI, particularly deep learning, is critical here. Using large amounts of neural data and their high spatial-temporal patterns can be used to encode an action or word. In contrast to earlier rule-based methods or linear methods, advanced decoders can accept nonstationary signals in the environment and use human learning to fine-tune the target. Multimodal AI algorithms combining neural and eye-tracking data, EMG, or context information (e.g., language models) will also increase accessibility.

With recent demonstrations including: High-rate intracortical BCIs capable of text or speech synthesis at conversational speeds, control of robotic limbs and exoskeletons. Ethical and regulatory frameworks have emphasized the implications for autonomy, agency and responsible decisions driven by BCIs, long-term safety, and access, encouraging stakeholders to consider global standards to guide the governance of neurotechnology, such as UNESCO. As such, clinical neurologists participating in BCI programs should be versed in both technical principles and the wider ethical framework.

Q18. How can AI enhance global health equity in neurology?

Ans. For under-resourced areas, applications of AI in the neuro field are provided in imaging interpretation, seizure detection, and cognitive screening automation. As an example, AI stroke triage tools can aid hospitals that do not have on-site neuroradiologists, facilitating timely thrombolysis decisions. Cost-effective smartphone-based AI apps can assess gait, tremor, or speech, leading to the early diagnosis of PD or dementia in rural areas.

Utilizing AI-enabled tele-neurology platforms, patients can be linked with experts over a distance through digital and mobile methods with AI-defined processes helping with routine assessment on automation and enhancing accuracy. Patients experiencing low resource settings benefit from ongoing monitoring and early indication by using multi-modal data from wearables and mobile devices. This has the potential to decrease time to diagnosis and improve outcomes. But equity gains are contingent on diverse training datasets and convenient deployment. Without validation of tools across populations on the global level, WHO warns, AI could exacerbate health inequalities.

Q19. What are the key constraints and challenges in using AI in neurology?

Ans. Another limitation is the absence of a robust prospective multicenter validation. Most AI models work well for retrospective studies, but do poorly with the real clinical settings. Performance can also be degraded because of variability in MRI protocols and EEG configurations and in the characteristics of the population. External validation rigour and regulatory scrutiny must occur before clinical implementation is required.

Integration in the clinical workflow is also a challenge. The outputs of AI systems should be understandable and explainable, well-programmed and should be easily incorporated into the system or to be integrated into PACS or electronic medical record systems. Too few clinicians are trained in AI interpretation—and therefore are overly or unduly used. Bias, transparency, and responsibility are other ethical considerations that add complexity to adoption. Resource issues cost for the implementation, need of IT infrastructure, security vulnerability, etc., become more challenges. AI in neurology is promising, yet continued thorough and rigorous development and guidance to facilitate safe and ethical integration are necessary.

Q20. What should the future-proofing of neurologists do to prepare for AI in clinical practice?

Ans. We have entered the era of AI, more appropriately termed augmented intelligence. It is not going to replace physicians; rather, it will serve as a powerful auxiliary tool in medical practice.

Within the medical curriculum, many mandatory and repetitive tasks can be supported by AI. These include maintaining electronic medical records, generating discharge summaries using voice recordings, and integrating information from patient records.

Neurologists have to gain proficiency in interpreting AI output, understanding model strengths and limitations and linking AI to clinical reasoning. Digital neurology, data literacy and simple machine learning are becoming more present in training. Healthcare providers need to remember that AI is a tool and not a substitute for expert opinion.

Practitioners (and other experts) ought to help assess and validate AI tools in their jurisdictions. Compliance with current regulations, approved indications, and the ethics and data governance standards ensures safe implementation. New AI uses need to be appraised by neurologists with sceptical eyes, focusing their judgment on evidence quality, not on marketing claims. Responsible AI development will be formed via active collaboration among neurologists, data scientists and policy-makers. But, as AI grows, it will be the responsibility of clinicians to maintain transparency, fairness, and support for patient well-being. Ongoing education and reasonable optimism will support a neurology that looks to an AI-fuelled future.

SUGGESTED READINGS

1. Bösel J, Mathur R, Cheng L, et al. AI and Neurology. Neurol Res Pract. 2025;7(1):11.
2. Boriesosdick J, Shahzadi I, Xie L, et al. Deep Learning Based Detection of Large Vessel Occlusions in Acute Ischemic Stroke Using High-Resolution Photon Counting Computed Tomography and Conventional Multidetector Computed Tomography. Clin Neuroradiol. 2025;35(1):185-95.
3. Soun JE, Chow DS, Nagamine M, et al. Artificial Intelligence and Acute Stroke Imaging. AJNR Am J Neuroradiol. 2021;42(1):2-11.

4. Heit JJ, Coelho H, Lima FO, et al. Automated Cerebral Hemorrhage Detection Using RAPID. AJNR Am J Neuroradiol. 2021;42(2):273-8.
5. Xingchen Dong, Landi He, Haotian Li, et al. Deep learning based automatic seizure prediction with EEG time-frequency representation. Biomedical Signal Processing and Control. 2024;95(352):106447.
6. Bai L, Litscher G, Li X. Epileptic Seizure Detection Using Machine Learning: A Systematic Review and Meta-Analysis. Brain Sci. 2025;15(6):634.
7. Nhu D, Janmohamed M, Antonic-Baker A, et al. Deep learning for automated epileptiform discharge detection from scalp EEG: A systematic review. J Neural Eng. 2022;19(5):10.
8. Di Cesare MG, Perpetuini D, Cardone D, et al. Machine Learning-Assisted Speech Analysis for Early Detection of Parkinson's Disease: A Study on Speaker Diarization and Classification Techniques. Sensors (Basel). 2024;24(5):1499.
9. Sun YM, Wang ZY, Liang YY,et al. Digital biomarkers for precision diagnosis and monitoring in Parkinson's disease. NPJ Digit Med. 2024;7(1):218.
10. Su D, Liu Z, Jiang X, et al. Simple Smartphone-Based Assessment of Gait Characteristics in Parkinson Disease: Validation Study. JMIR Mhealth Uhealth. 2021;9(2):e25451.
11. Shahid SB, Kaikaus M, Kabir MH, et al. Novel deep learning for multi-class classification of Alzheimer's in disability using MRI datasets. Front Bioinform. 2025;5:1567219.
12. Shafiq Ul Rehman, Noha Tarek, et al. Mahmoud, Ibrahim Sadek, AI-based tool for early detection of Alzheimer's disease. Heliyon. 2024;10(8):e29375.
13. Javeed A, Dallora AL, Berglund JS, et al. Machine Learning for Dementia Prediction: A Systematic Review and Future Research Directions. J Med Syst. 2023;47(1):17.
14. Mostafa AM, Zakariah M, Aldakheel EA. Brain Tumor Segmentation Using Deep Learning on MRI Images. Diagnostics (Basel). 2023;13(9):1562.
15. Wang Z, Wang L, Wang Y. Radiomics in glioma: emerging trends and challenges. Ann Clin Transl Neurol. 2025;12(3):460-77.
16. Huang Y, Bert C, Sommer P, et al. Deep learning for brain metastasis detection and segmentation in longitudinal MRI data. Med Phys. 2022;49(9):5773-86.
17. Fong N, Feng J, Hubbard A, et al. IntraCranial pressure prediction AlgoRithm using machinE learning (I-CARE): Training and Validation Study. Crit Care Explor. 2023;6(1):e1024.
18. Srichawla BS. Future of neurocritical care: Integrating neurophysics, multimodal monitoring, and machine learning. World J Crit Care Med. 2024;13(2):91397.
19. Gorenshtein A, Weisblat Y, Khateb M, et al. AI-Based EMG Reporting: A Randomized Controlled Trial. J Neurol. 2025;272(9):586.
20. Mohamed AY, Said A, Siham E. Automated detection and removal of artifacts from sEMG signals based on fuzzy inference system and signal decomposition methods. Biomedical Signal Processing and Control. 2024;94.
21. Farhud DD, Zokaei S. Ethical Issues of Artificial Intelligence in Medicine and Healthcare. Iran J Public Health. 2021;50(11):i-v.
22. Smith MJ, Axler R, Bean S, et al. Four equity considerations for the use of artificial intelligence in public health. Bull World Health Organ. 2020;98(4):290-2.
23. Hildt E. What Is the Role of Explainability in Medical Artificial Intelligence? A Case-Based Approach. Bioengineering (Basel). 2025;12(4):375.
24. Cestonaro C, Delicati A, Marcante B, et al. Defining medical liability when artificial intelligence is applied on diagnostic algorithms: a systematic review. Front Med (Lausanne). 2023:10:1305756.
25. Urs J Muehlematter, Christian Bluethgen, Kerstin N Vokinger. FDA-cleared artificial intelligence and machine learning-based medical devices and their 510(k) predicate networks. Lancet Digit Health. 2023;5(9):e618-e626.
26. Habehh H, Gohel S. Machine Learning in Healthcare. Curr Genomics. 2021;22(4):291-300.
27. Topol EJ. High-performance medicine: the convergence of AI and healthcare. Nat Med. 2019;25:44-56.
28. World Health Organization. Ethics and Governance of Artificial Intelligence for Health. Geneva: WHO; 2021. [online] Available from https://www.who.int/publications/i/item/9789240029200

29. McLouth CJ, Sebastian Elstrott, Yasmina Chaibi, et al. Deep learning for detection of LVO stroke on CTA. Radiology. 2022;304(1):167-74.
30. Koska İÖ, Selver A. Artificial Intelligence in Stroke Imaging: A Comprehensive Review. Eurasian J Med. 2023;55(1):91-7.
31. Abed S, Hergan K, Pfaff J, et al. Artificial intelligence for detecting traumatic intracranial haemorrhage with CT: A workflow-oriented implementation. Neuroradiol J. 2025: 19714009251346477.
32. Abdelhameed A, Bayoumi M. A Deep Learning Approach for Automatic Seizure Detection in Children With Epilepsy. Front Comput Neurosci. 2021:15:650050.
33. Qamar WUR, Lee MH, Abibullaev B. Deep learning in intracranial EEG for seizure detection: advances, challenges, and clinical applications. Front Neurosci. 2025:19:1677898.
34. Prasanth T, Thomas J, Yuvaraj R, et al., Deep Learning for Interictal Epileptiform Spike Detection from scalp EEG frequency sub bands. Annu Int Conf IEEE Eng Med Biol Soc. 2020:2020:3703-6.
35. Rana A, Dumka A, Singh R, et al. Imperative Role of Machine Learning Algorithm for Detection of Parkinson's Disease: Review, Challenges and Recommendations. Diagnostics (Basel). 2022;12(8):2003.
36. Arora S, Venkataraman V, Zhan A, et al. Detecting and monitoring the symptoms of Parkinson's disease using smartphones: A pilot study. Parkinsonism Relat Disord. 2015;21(6):650-3.
37. Coupé P, Fonov VS, Bernard C, et al. Detection of Alzheimer's disease signature in MR images seven years before conversion to dementia: Toward an early individual prognosis. Hum Brain Mapp. 2015;36(12):4758-70.
38. Yeafi A, Islam M, Yusuf MSU. A deep learning framework for 3D brain tumor segmentation and survival prediction. Healthcare Analytics. 2025;8:100418.
39. Ozkara BB, Chen MM, Federau C, et al. Deep Learning for Detecting Brain Metastases on MRI: A Systematic Review and Meta-Analysis. Cancers (Basel). 2023;15(2):334.
40. Kumar A, Taneja A, Singh YP, et al. Artificial Intelligence in Critical Care: Promise, Peril, and the Path Forward. Cureus. 2025;17(6):e85323.
41. Li Y, Wang PT, Vaidya MP et al., Electromyogram (EMG) Removal by Adding Sources of EMG (ERASE)-A Novel ICA-Based Algorithm for Removing Myoelectric Artifacts From EEG. Front Neurosci. 2021:14:597941.
42. Char DS, Shah NH, Magnus D. Implementing Machine Learning in Health Care - Addressing Ethical Challenges. N Engl J Med. 2018;378(11):981-3.
43. Amann J, Blasimme A, Vayena E, et al. Explainability for artificial intelligence in healthcare: a multidisciplinary perspective. BMC Med Inform Decis Mak. 2020;20(1):310.
44. U.S. FDA. Artificial Intelligence/Machine Learning-Based Medical Devices: 2024 Update. [online] Available from: https://www.fda.gov/medical-devices
45. Topol EJ. High-performance medicine: the convergence of AI and healthcare. Nat Med. 2019;25:44-56.
46. World Health Organization. Ethics and Governance of Artificial Intelligence for Health. Geneva: WHO; 2021. [online] Available at: https://www.who.int/publications/i/item/9789240029200

ICP-IAN 100 Questions in Neurological Practice

AI in Neurology, Geriatric Neurology, Pediatric Neurology, Sleep Neurology and Neuroimmunology

Salient Features

- A comprehensive book in a question-and-answer format with Five Sections on Artificial Intelligence (AI) in Neurology, Geriatric Neurology, Pediatric Neurology, Sleep Neurology, and Neuroimmunology
- Contains specific neurology topics with clinical implications pertaining to the Indian context
- Each section contributed by accomplished neurologists
- Useful to postgraduates, general physicians, and neurologists in their day-to-day clinical work

PK Maheshwari MD DM(Neurology) MAMS FFIACM FRCP(Edinburgh) FICP FIAN is Professor and Head, Department of Neurology, and former Director–Professor and Head, PG Department of Medicine, Sarojini Naidu Medical College, Agra, Uttar Pradesh, India. He is currently the President of the Agra Academy of Neurology and the Honorary Secretary of the Agra Branch of the Association of Physicians of India. He has presented 12 prominent guest lectures and contributed over 22 chapters to various medical books and updates, authored or co-authored more than 64 research papers in renowned international and national scientific journals, and delivered 3 orations at prestigious scientific conferences. He has played a significant role as Organizing Secretary for the 23rd Annual National Conference of the Indian Academy of Neurology, Agra (IANCON 2015), and the 75th Annual Conference of the Association of Physicians of India (APICON 2020), Agra. During his tenure as Secretary of the API Agra Branch, the branch received the Best Branch Award from national API. He was also honored with the Membership Development Award by the national API. As a committed educator and mentor, he has nourished many physicians and neurologists through concise and updated knowledge in ICP-IAN 100 Questions in Neurological Practice (Stroke, Epilepsy, and CNS Infections), ICP-IAN 100 Questions in Neurological Practice 2 (Headache, Movement Disorders, and Vertigo), and ICP-IAN 100 Questions in Neurological Practice 3 (Office Neurology, Neuromuscular and Functional Neurology). His contributions to the medical field have earned him Lifetime Achievement Award.

Lakshmi Narasimhan Ranganathan MD(General Medicine) DNB(Medicine) DM(Neurology) DrNB(Neurology) PhD(Neurology) FRCP(Glasgow) FRCP(London) FAAN FEBN FIAN FACP MNAMS is presently the Professor and Head, Department of Neurology, SRIHER, Chennai, Tamil Nadu. He is currently the President of Indian Academy Neurology and the President of World Headache Society. He was former Director of Neurology of Institute of Neurology at Madras Medical College. He is the Editor of Journal of Stroke Medicine, International Journal of Epilepsy, and Cochrane Epilepsy group. He is also the recipient of the prestigious AB Baker Award and Palatucci Award from the American Academy of Neurology and Dronacharya Award and Gifted Teacher Award from the Association of Physicians of India. He has edited DeJong's The Neurologic Examination and Paul Brazis and Biller Textbooks in Neurology. He has also been the Editor for seven titles of reviews in neurology. He has about 100 national and international publications to his credit. He is the founder member of the Tamil Nadu Association of Neurology, Advocacy Subsection of Indian Academy of Neurology, and South Asian Cochrane Network.

Shelving Recommendation
NEUROLOGY

ISBN 978-93-7545-350-5

9 789375 453505

JAYPEE BROTHERS