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Narrative Review

AI in Acute Stroke Care: Current Evidence, Challenges and Future Directions

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ABSTRACT

Background: Acute stroke requires rapid and accurate clinical decision-making, and artificial intelligence (AI) is increasingly being integrated into diagnostic and treatment workflows.

Methods: A narrative review of peer-reviewed literature and relevant professional and public-health guidance was undertaken, focusing on AI applications in neuroimaging, large-vessel-occlusion detection, treatment selection, prognosis, triage, and workflow optimization.

Results: AI can facilitate rapid analysis of non-contrast CT, CT angiography, and perfusion imaging; detection of intracranial hemorrhage and large-vessel occlusion; infarct-core estimation; outcome prediction; and automated communication of time-critical findings. These applications may improve diagnostic consistency and workflow efficiency. However, challenges include dataset bias, limited generalizability, explainability, interoperability, cybersecurity, automation bias, and limited prospective validation.

Conclusion: AI has considerable potential to enhance acute stroke care but should complement rather than replace clinical expertise. Future research should emphasize multicenter validation, equity, usability, cost-effectiveness, and patient-centered outcomes.

Keywords: Artificial intelligence; Acute stroke; Clinical decision support; Machine learning; Neuroimaging.

INTRODUCTION

Stroke remains a major cause of mortality and long-term disability worldwide. The clinical outcome of acute ischemic stroke is strongly influenced by the time taken to recognize symptoms, transport the patient, perform brain and vascular imaging, establish eligibility for reperfusion therapy and deliver treatment. Modern stroke systems therefore depend not only on pharmacological and endovascular advances but also on efficient clinical workflows [1]. Clinical decision making in stroke is complex because clinicians must integrate symptom onset or last-known-well time, neurological examination, comorbidities, medication history, laboratory information and multiple imaging findings. In high-volume emergency settings, interpretation may also be affected by workload, specialist availability and variation in experience [2,3]. These factors have encouraged interest in AI-based decision-support tools.

AI encompasses machine-learning and deep-learning approaches that can identify patterns within large datasets. In stroke care, these approaches are particularly suited to medical imaging because they can rapidly analyze large numbers of pixels and derive quantitative features that may be difficult to assess consistently by visual inspection alone. AI is also being investigated for clinical prediction, speech analysis, prehospital triage, rehabilitation and outcome prediction. The growing availability of AI does not mean that algorithmic prediction is equivalent to clinical diagnosis [4,5]. An AI system is trained on particular data distributions and may behave differently when exposed to patients, scanners, protocols or populations that differ from its development dataset [6]. Consequently, clinical implementation requires careful validation, governance and human oversight. This review examines AI-driven clinical decision support in acute stroke care from a multidisciplinary perspective, focusing on the transition from algorithm development to clinically meaningful implementation.

REVIEW METHODOLOGY

This manuscript was prepared as a narrative review. Peer-reviewed literature concerning artificial intelligence and machine learning in acute stroke diagnosis, neuroimaging, large-vessel-occlusion detection, prognosis, workflow and digital health was considered.

Guidance and evidence from recognized professional and public-health organizations were also considered. Priority was given to recent literature, while landmark studies and guidelines were retained where they provide essential clinical context. The evidence was organized into the following domains: diagnostic imaging, triage and treatment selection, workflow integration, multidisciplinary practice, implementation barriers, ethics and future research.

CONCEPTUAL FRAMEWORK OF AI-DRIVEN DECISION SUPPORT

Artificial intelligence and machine learning

AI refers broadly to computational methods capable of performing tasks that normally require aspects of human intelligence. Machine learning enables systems to learn patterns from data, while deep learning uses multilayer neural networks to model complex relationships. In medical imaging, convolutional neural networks and related architectures have been widely investigated for image classification, segmentation and detection.

Clinical decision support

Clinical decision support refers to tools that provide clinicians with patient-specific information or recommendations intended to support decision making. AI-driven decision support may produce an alert, probability score, segmentation map, quantitative measurement or prioritized notification. Its value depends not only on algorithmic accuracy but also on whether the information reaches the correct professional at the correct time and leads to an appropriate clinical action.

Human–AI partnership

The appropriate clinical model is human–AI collaboration. The algorithm can perform repetitive and computationally intensive tasks rapidly, while clinicians contribute contextual reasoning, communication with patients and families, recognition of atypical presentations and ethical judgment. A well-designed system should therefore support rather than displace professional responsibility.

APPLICATIONS IN ACUTE STROKE CARE

Automated detection of intracranial hemorrhage: AI systems can analyze non-contrast CT scans for patterns suggestive of intracranial hemorrhage and can prioritize potentially abnormal studies. In emergency settings, such alerts may shorten the time to specialist review and support rapid escalation. The technology is particularly relevant when specialist radiology services are not continuously available.

Large-vessel-occlusion detection: Large-vessel occlusion is clinically important because selected patients may benefit from mechanical thrombectomy. AI-based analysis of CT angiography can support detection of proximal arterial occlusion and may facilitate notification of stroke teams. Prehospital and emergency clinicians can combine this information with neurological findings, onset time and local transfer protocols when determining the most appropriate destination.

Automated perfusion and infarct-core estimation: Perfusion imaging can provide information about cerebral blood flow and tissue at risk. AI-assisted software can automate segmentation and estimation of perfusion abnormalities, potentially reducing interpretation time and improving consistency. However, automated thresholds depend on acquisition parameters, software characteristics and clinical context, and should not be interpreted independently of the complete imaging study.

Treatment selection and prognostic prediction: Machine-learning models are being investigated for predicting functional outcome, hemorrhagic transformation, treatment response and mortality. These applications may eventually support individualized care pathways. At present, prediction should be considered complementary information because clinical outcomes are influenced by many variables that may not be captured by the model.

Prehospital and emergency triage: AI may support stroke recognition through analysis of speech, facial movement, motor performance and structured clinical information.

Integration with emergency medical services could potentially improve identification of suspected stroke and large-vessel occlusion before hospital arrival. The greatest benefit would be achieved when digital alerts are integrated into established stroke pathways rather than operating as isolated applications.

AI AND STROKE WORKFLOW OPTIMIZATION

The potential benefit of AI extends beyond diagnosis. Automated notifications can connect emergency departments, radiology services, neurologists, neurointerventional teams and receiving hospitals. In transfer-dependent systems, faster communication may reduce avoidable delays. Workflow systems can also provide timestamps for major events and facilitate audit of door-to-imaging, door-to-needle and door-to-transfer intervals. However, excessive alerts may create alert fatigue. A system that generates frequent false-positive notifications may reduce clinician trust and eventually decrease responsiveness to genuine alerts. Workflow design should therefore consider alert thresholds, escalation rules, responsibility for responding and documentation of actions.

ROLE OF ALLIED HEALTH PROFESSIONALS

AI implementation is inherently multidisciplinary. Nurses and emergency-care professionals may be among the first to respond to AI-supported stroke alerts and must understand the clinical significance and limitations of algorithmic outputs. Radiographers and radiology personnel contribute to imaging quality, acquisition protocols and verification of automated findings. Physiotherapists, occupational therapists and speech and language professionals may participate in AI-supported assessment and rehabilitation technologies. Health-information and digital-health professionals have important responsibilities related to interoperability, data quality, access control, cybersecurity and system monitoring. Educators and clinical leaders must ensure that staff receive training in both the capabilities and limitations of AI. Assistant professors and other academic clinicians can contribute by incorporating AI literacy, critical appraisal and ethical reasoning into undergraduate and postgraduate health-science education.

Domain	Potential advantage	Clinical relevance
Speed	Rapid analysis of imaging and structured data	Supports time-critical stroke pathways
Standardization	Consistent quantitative assessment	May reduce variability in selected tasks
Triage	Automated LVO or hemorrhage alerts	Supports prioritization and referral
Communication	Automated notification across teams	Can reduce avoidable workflow delays
Quantification	Automated segmentation and measurements	Provides objective imaging information
Education	Case-based AI outputs for teaching	Supports critical appraisal and digital-health literacy

Table:1 Advantages of AI-Driven Clinical Decision Support

LIMITATIONS AND IMPLEMENTATION CHALLENGES

Dataset bias and generalizability: An algorithm trained on a limited population may not perform equally well in other populations. Differences in age, sex, ethnicity, disease spectrum, scanner type, imaging protocol and healthcare setting can influence performance. External validation is therefore essential before clinical adoption.

Explainability and transparency: Many advanced AI models are difficult to interpret. Clinicians may need to know why an alert was generated, particularly when the result could influence transfer or treatment. Explainability should be balanced with the need for high-performing models, and uncertainty should be communicated clearly.

Automation bias: Automation bias occurs when clinicians place excessive confidence in an automated recommendation. Both false-positive and false-negative outputs can cause harm. Training should emphasize that AI output is decision support, not a substitute for clinical reasoning.

Interoperability and infrastructure: AI systems must communicate reliably with picture archiving and communication systems, electronic health records, EMS platforms and hospital communication systems. Poor interoperability can create duplicate work and may negate the intended time savings.

Privacy and cybersecurity: Stroke AI applications may process highly sensitive imaging and clinical information. Secure data transmission, role-based access, audit trails, appropriate consent and institutional governance are necessary components of responsible deployment.

ETHICAL AND PROFESSIONAL CONSIDERATIONS

AI implementation raises questions of accountability. When an algorithm produces an incorrect result, responsibility should be defined within institutional governance rather than assumed to belong to a single user. Healthcare organizations should establish policies for validation, procurement, monitoring, incident reporting and periodic reassessment of model performance. Equity is another important issue. Advanced AI should not widen the gap between well-resourced tertiary centers and rural or resource-limited settings. Implementation planning should consider connectivity, workforce capacity, technical support and affordability. Technology should strengthen, rather than replace, essential clinical services. Patients and professionals should also understand that AI performance can change over time as populations, imaging protocols and clinical practices change. Continuous monitoring and recalibration may therefore be required.

IMPLICATIONS FOR HEALTH-SCIENCE EDUCATION

AI literacy should become part of contemporary health-science education. Students and practicing professionals should be able to distinguish diagnostic accuracy from clinical effectiveness, recognize common forms of bias, interpret sensitivity and specificity, understand predictive values, and critically appraise validation studies. For faculty members, AI also creates opportunities for case-based teaching. A stroke case can be used to compare conventional clinical assessment with algorithmic output and to discuss situations in which the two disagree. Such teaching can develop clinical reasoning rather than encourage passive reliance on technology. Continuing professional development should address practical system use, interpretation of alerts, documentation, data privacy and escalation when AI is unavailable or inconsistent with clinical findings.

FUTURE RESEARCH DIRECTIONS: Future research should prioritize prospective multicenter validation and evaluation in real-world stroke networks. Studies should report performance across diverse populations and should compare AI-supported care with existing clinical pathways using patient-centered outcomes. Important outcomes include onset-to-treatment time, door-to-imaging time, door-to-needle time, transfer efficiency, thrombectomy eligibility, functional independence, mortality, cost-effectiveness and patient safety. Human-factors research should also assess usability, alert burden, clinician trust and the consequences of automation bias. Future systems may combine imaging, clinical examination, speech, wearable sensor data and electronic health records to create multimodal decision support. Such systems will require rigorous governance because increasing data integration also increases privacy and cybersecurity demands.

CONCLUSION: Artificial intelligence-driven clinical decision support represents an important development in acute stroke care. Its strongest current applications are in rapid imaging analysis, large-vessel-occlusion detection, automated notification and workflow support. AI can improve the speed and consistency of selected clinical tasks, but algorithmic performance alone does not establish clinical effectiveness. A safe implementation strategy requires prospective validation, multidisciplinary training, transparent governance, continuous performance monitoring and clear human accountability. For allied health professionals and educators, the emerging priority is not simply learning how to operate AI systems but developing the ability to critically evaluate, appropriately interpret and ethically integrate AI into patient-centered stroke care.

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