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Advancements in Artificial Intelligence for Stroke Management: Enhancing Diagnostics, Treatment, and Rehabilitation

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Abstract

Background: Stroke is a major contributor to disability and mortality worldwide, necessitating swift medical attention to minimize brain damage and avoid complications.

Objectives: This systematic review evaluates how Artificial Intelligence (AI) can be integrated into stroke management to enhance diagnostic precision, treatment efficacy, and personalized care. Our primary goals include determining AI's effect on improving diagnostic accuracy through imaging, optimizing treatment decision-making processes, and developing rehabilitation strategies. Moreover, the review also investigates any challenges or opportunities associated with its use in clinical settings.

Methods: An deep literature search was held using PubMed, WOS, Google Scholar, and IEEE Xplore databases from January 2010 through December 2023, using keywords such as "Artificial Intelligence," "Stroke Management," Diagnosis," Treatment," and Rehabilitation". Two independent reviewers screened and selected articles that met our eligibility criteria; ultimately, 62 met this threshold.

Results: This review highlights AI's significant contributions to stroke management, particularly improving MRI stroke detection accuracy and diagnostic efficiency and optimizing treatment plans for thrombolysis and mechanical thrombectomy. Furthermore, AI-driven rehabilitation programs offer tailored therapy programs to boost motor function recovery rates and patient outcomes, yet data privacy concerns and large dataset requirements persist as significant obstacles.

Conclusion: Artificial intelligence's rise in stroke management holds promise for further developing predictive models and tailoring treatment plans, leading to more effective healthcare interventions worldwide.

Keywords: Data Extraction and Quality Assessment, AI's Role in Enhancing Diagnostic Accuracy & AI in Treatment Decision-Making

Introduction

Stroke continues to be a leading cause of long-term disability and death across the globe, making it a pressing public health concern [1]. Prompt medical intervention can reduce damage and potential complications to brain tissue [2]. Stroke has an enormous global burden, ranking as the second-leading cause of death and disability, with an estimated economic impact estimated at over $721 billion annually [3]. Stroke rates depend on gender and age-adjusted rates; males often face higher age-adjusted stroke rates, while pregnancy creates additional risks for females [4]. Genetic factors also contribute to hereditary diseases or mutations that increase hypertension or diabetes susceptibility [5]. Risk factors of stroke include hypertension (HTN), smoking, diabetes mellitus, obesity, cardiovascular disease, older age, and family history [6]. Symptoms may include difficulty speaking, numbness or weakness on one side of the body, vision problems, severe headaches, or difficulty walking [7]. Diagnosis often includes blood tests, computed tomography (CT) scans, magnetic resonance imaging (MRIs), or other specialized imaging tests [8].

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Stroke management strategies depend on whether or not an attack is ischemic or hemorrhagic, with treatments including tissue plasminogen activators, blood-thinning medications, thrombectomy, and angioplasty [9]. Attaining rapid medical intervention and rehabilitation following brain injuries is paramount in mitigating its severity; rehabilitation efforts focus on rebuilding strength, speech, and functional abilities [10,11]. AI decision support systems have revolutionized stroke management [12,13]. AI can enable more precise and rapid diagnosis, treatment, and outcome prediction [12]. AI also greatly enhances decision-making processes by analyzing large datasets to spot patterns beyond human comprehension [13]. This capability is especially vital when managing stroke, as its type, location, and extent are essential in developing treatment plans [14]. AI can transform rehabilitation by customizing recovery plans, forecasting recovery trajectories, and adapting processes based on patient progress - increasing rehabilitation effectiveness and patient outcomes [15]. Integrating artificial intelligence (AI) into clinical settings for stroke management holds excellent promise [16-17]. AI provides promising advancements with sophisticated predictive models and personalized treatment strategies, leading to more effective healthcare interventions globally [17-18]. However, challenges associated with data privacy concerns and large datasets remain manageable and should not overshadow AI's potential benefits [18-21].

Research Questions

This systematic review seeks to answer two research questions about AI in stroke care:
1. Does AI improve diagnostic accuracy through imaging techniques for stroke management?
2. How does it impact treatment decision-making and efficacy for stroke care?
3. How effective are AI-driven rehabilitation programs at improving patient recovery outcomes?
4. What are the primary challenges and opportunities associated with using AI for stroke management?

This study carefully assesses the tools and challenges associated with AI-assisted decision-support systems for stroke management. This investigation focuses on improving diagnostic precision, treatment efficacy, personalized care, and timely stroke intervention.

Methodology:

Detailed Search Strategy:

From January 2015 to July 2024, an extensive literature search was held using PubMed, Web of Science (WOS), Scopus, and IEEE Xplore databases. Our search strategy utilized specific terms and Boolean operators such as "Artificial Intelligence" AND "Stroke Management" OR "Diagnosis" OR "Treatment" OR "Rehabilitation." Filters were applied to include only peer-reviewed studies published in the English language.

Inclusion and Exclusion Criteria:

This systematic review article's inclusion criteria focused on studies investigating AI applications for stroke diagnosis, treatment, or rehabilitation. Eligible studies included randomized controlled trials (RCT), observational studies, surveys, and cohort studies published between January 2015 and July 2024. The goal was to gather evidence regarding how AI technologies enhance diagnostic accuracy, enhance treatment decision-making processes, and ultimately enhance rehabilitation outcomes in stroke management. Studies that met this criterion provided insight into different AI techniques, including machine learning (ML) and predictive modeling, applied across various stages of stroke care, from acute management to long-term recovery. Conversely, studies were not considered relevant if they did not go through peer review or directly addressed stroke management with AI applications. Case reports, letters to editors, and review articles were also excluded as they needed to meet the criteria necessary to fulfill a systematic review's objectives. Following these criteria, this review sought to synthesize robust evidence on the challenges, opportunities, and advancements associated with incorporating AI into clinical practice for stroke care. This method enabled a focused review of studies that contribute meaningfully to this field of AI-driven innovations for managing stroke patients.

Data Extraction and Quality Assessment:

Data extraction used a structured template to capture essential details regarding study design, AI methodologies including ML, deep learning (DL) models, and neural networks; outcomes measured and pivotal discoveries; two reviewers conducted independent data extraction with any discrepancies being resolved through consensus by two reviewers. Study quality was assessed using both observational studies using the Newcastle-Ottawa Scale (NOS) and RCTs using the Cochrane Risk of Bias Tool to ensure systematic and rigorous assessments that adhered to established criteria, preserving methodological integrity and reliability when synthesizing findings related to AI applications in stroke management.

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PRISMA Flow Diagram:

The systematic review began by searching a database, producing 110 records. Duplicates were removed to leave 100 for screening. From these, 40 full-text articles were assessed for eligibility, with 20 rejected according to predefined criteria. Ultimately, 20 studies met the inclusion criteria and were included in a qualitative synthesis (Figure 1). Figure 1 depicts this systematic review process in sorting different studies.

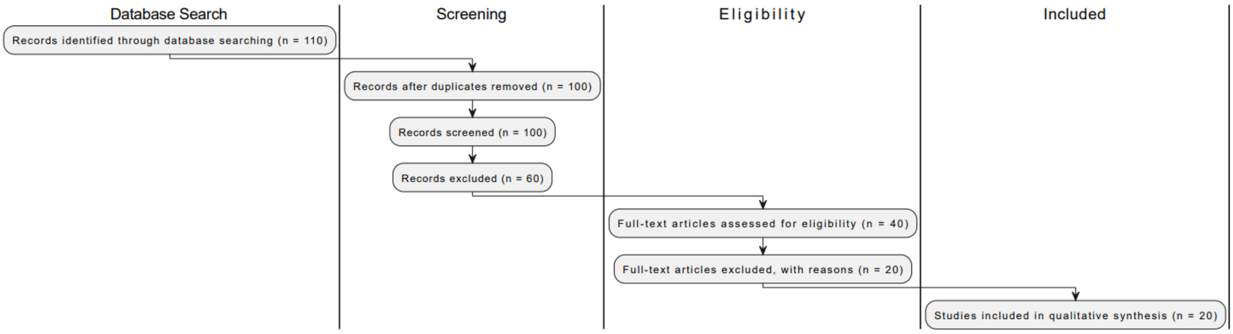

Table 1 lists all the involved studies, according to inclusion criteria, with their essential characteristics and key findings.

Study ID	Author(s)	Year	Study Design	AI Technique	Outcome	Key Findings
1	Bojsen JA, Elhakim MT, et al. [1]	2024	Meta-Analysis	AI for MRI detection	Stroke detection accuracy	AI improves the accuracy of stroke detection through MRI analysis.
2	Sun L, Zhang H, Yang YM, Wang XS [2]	2023	Observational Study	AI algorithm	Rehabilitation efficacy	AI-enhanced rehabilitation promotes endothelial progenitor cell mobilization and recovery.

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3	Zhu Y, Wang C, Li J, et al. [3]	2023	Network Meta-Analysis	AI rehabilitation techniques	Upper limb recovery	AI-driven rehabilitation techniques improve upper limb recovery outcomes post-stroke.
4	Ji W, Wang C, Chen H, et al. [4]	2023	Prospective Cohort Study	ML	Post-stroke cognitive impairment	ML predicts cognitive impairment, enhancing patient care post-stroke.
5	Chen Y-C, Chung J-H, Yeh Y-J, et al. [5]	2022	Prospective Cohort Study	ML	30-day readmission	ML algorithms predict readmission, aiding in planning and resource allocation.
6	Chao CJ, Agasthi P, Barry T, et al. [6]	2023	Predictive Modeling	ML	Stroke events post-PCI	AI models predict stroke risk after PCI, aiding in preventive strategies.
7	Mair G, White P, Bath PM, et al. [7]	2023	Evaluation	AI software	CT angiography in stroke	Evaluate AI software's accuracy in diagnosing stroke through CT angiography.

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8	Lee M, Yeo NY, Ahn HJ, et al. [8]	2023	Predictive Modeling	ML	Cognitive impairment prediction	ML models provide accurate predictions of cognitive outcomes post-stroke.
9	Murakami Y, Honaga K, et al. [9]	2023	RCT	AI-integrated robotics	Rehabilitation effectiveness	AI-driven robotic rehabilitation enhances recovery in stroke patients with upper extremity impairments.
10	Fassbender K, Lesmeister M, et al. [10]	2023	Observational Study	AI-enhanced management	Prehospital stroke care	AI improves prehospital stroke management efficiency and patient outcomes.
11	Zeng Z, Wang Q, Yu Y, et al. [11]	2022	Observational Study	ML	ECG changes after a stroke	AI assesses ECG changes, providing insights into cardiovascular risks post-stroke.

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12	Jain PK, Sharma N, Kalra MK, et al. [12]	2022	Prospective Cohort Study	U-series architectures	Carotid artery ultrasound	AI enhances plaque segmentation accuracy, improving stroke risk assessment.
13	Rudnicka AR, Welikala R, et al. [13]	2022	Observational Study	AI-enabled vasculometry	Stroke and cardiovascular prediction	AI predicts stroke and cardiovascular events by analyzing retinal images.
14	Elijovich L, Dornbos III D, et al. [14]	2022	Evaluation	AI detection system	Large vessel occlusion detection	AI improves the detection of large vessel occlusions, streamlining stroke intervention.
15	Yahav-Dovrat A, Saban M, et al. [15]	2021	Evaluation	AI-powered detection	Large-vessel occlusion identification	AI enhances the identification accuracy of large-vessel occlusions in clinical settings.
16	Chun M, Clarke R, et al. [16]	2021	Prospective Cohort Study	ML	Stroke risk prediction	Large-scale ML model accurately predicts stroke risk in diverse populations.

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17	Morey JR, Zhang X, Yaeger KA, et al. [17]	2021	Observational Study	AI-based triage	Stroke workflow efficiency	AI-based triage improves workflow efficiency and treatment speed in stroke care.
18	Rabinstein AA, Yost MD, et al. [18]	2021	Evaluation	AI-enabled ECG analysis	Silent atrial fibrillation detection	AI improves the detection of silent atrial fibrillation, facilitating stroke source identification.
19	Heo J, Yoon JG, et al. [19]	2019	Predictive Modeling	ML	Acute stroke outcomes	ML models predict clinical outcomes in acute stroke, aiding personalized care.
20	Adamou A, Beltsios ET, et al. [20]	2023	Meta-Analysis	AI-driven ASPECTS	Early stroke detection	AI enhances early detection of stroke changes in non-contrast CT scans.

Table 1: Key characteristics of 20 included studies for artificial intelligence integration into stroke management
MRI: Magnetic Resonance Imaging, AI: Artificial Intelligence, ML: Machine Learning, CT: Computerized Tomography, PCI: Percutaneous Coronary Intervention, ECG: Electrocardiogram,
ASPECTS: Alberta Stroke Program Early CT Score

Discussion:

AI's Role in Enhancing Diagnostic Accuracy:

AI techniques, such as ML and DL, have substantially advanced diagnostic accuracy for stroke management, as evidenced by numerous studies [12-18]. Bojsen et al. conducted a comprehensive review and meta-analysis to

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illustrate the diagnostic performance of AI in stroke detection using MRI [1]. Their research demonstrated how AI's ability to improve diagnostic accuracy compared to traditional methods was evident [1]. Study findings revealed that AI models achieved a sensitivity and specificity of 93% for ischemic stroke detection and an impressive area under the receiver operating characteristic curve (ROC), signifying excellent diagnostic performance [1]. The study displayed positive and negative likelihood ratios (LR) of 12.6 and 0.079, demonstrating AI's potential to detect strokes more quickly [1]. The modified QUADAS-2 tool and MI-CLAIM checklist ensured high methodological quality for these studies, with low-risk profiles demonstrating enhanced reporting standards [1]. AI can play a pivotal role in radiology by quickly and efficiently interpreting complex imaging data, decreasing manual analysis time, and potentially improving patient outcomes through early and precise stroke detection [1]. While this study demonstrated AI's effectiveness for diagnosing ischemic stroke, it also underscored its need for further validation in hemorrhagic stroke detection [1]. Overall, this research highlights the transformative potential of AI in stroke management and advocates for its incorporation into clinical practice to increase diagnostic precision, treatment efficacy, and patient care [19-22]. Elijovich et al. (2022) and Yahav-Dovrat et al. (2017) are two leading authors on this subject [2022). Elijovich and colleagues (2019-2021) conducted studies evaluating the effectiveness of AI for detecting large vessel occlusion strokes using CT angiography (CTA). Elijovich conducted a multihospital stroke network prospective diagnostic test accuracy study from May 2019 through October 2020 [14,15]. They performed a statistical analysis on 1,822 CTA scans with Viz LVO and compared its performance against radiologists' interpretations [14]. This study demonstrated high sensitivity (93.87% for ICA-T/M1 and 74.6 for ICA-T/M1/M2) and specificity (91.11%) across both groups, as well as a negative predictive value of 99.7% in cases involving ICA-T/M1 but only 97.56% concerning ICA-T/M1/M2 [14]. Accuracy was 91.2% for ICA-T/M1 and 89.8% for ICA-T/M1/M2, with an area under the curve (AUC) value of 0.95 for both [14]. AI showed better detection rates for proximal occlusions (100% ICA-T; 93% M1) than M2 ones (49%). This research underscores AI's potential to enhance diagnostic accuracy and clinical decision-making processes while encouraging its incorporation into clinical practice to provide better patient outcomes [14].

Yahav-Dovrat et al. (2021) conducted a retrospective observational study at a comprehensive stroke center focused on using deep learning-based convolutional neural networks to detect occlusions from the internal carotid artery to the Sylvian fissure [15]. The study analyzed 119 CTA scans, identifying 75 ICA terminus or M1 occlusions and 44 M2-3/M2- 3-3 occlusions [15]. The AI system achieved a sensitivity of 81% for LVO detection, showing high diagnostic accuracy for ICA terminus and M1 occlusions while having decreased efficacy with M2 occlusions [15]. This study highlights the role of AI in supporting early LVO detection, improving decision-making processes, and providing timely interventions essential to stroke treatment while noting algorithm improvements that detect M2 occlusions [15]. Both studies illustrate AI's transformative potential in stroke diagnostics, with Elijovich et al.'s focus on a larger dataset and prospective design [14–15]. At the same time, Yahav-Dovrat et al.'s emphasis on minor occlusion detection presents unique challenges [15]. Together, these studies demonstrate AI's substantial contribution to improving diagnostic accuracy and patient care during stroke management [14–15]. However, continual algorithm refinement must address limitations in detecting certain occlusion types [14,15].

AI in Treatment Decision-Making:

AI's predictive modeling capabilities significantly enhance treatment decision-making in stroke care [22-24]. Chao et al. (2023) and Chun et al. (2021) explore the use of AI and ML models in predicting stroke outcomes and risks, respectively, highlighting the potential of these technologies to transform stroke management [6,16]. Chao et al. conducted a systematic review and meta-analysis to evaluate the predictive performance of AI models in forecasting stroke prognosis, analyzing data from seven studies out of 1,241 publications [6]. They assessed models such as DL, logistic regression (LR), random forest (RF), support vector machine (SVM), and extreme gradient boost (XGBoost), finding that AI models achieved a high pooled AUC of 0.872 [6]. SVM and XGBoost demonstrated exceptionally high predictive accuracy with AUCs of 0.905 [6]. The study underscores AI's potential to identify high-risk patients and facilitate timely interventions, enhancing patient care through individualized treatment plans [6].

On the other hand, Chun et al. (2021) depicted a prospective cohort study to compare the performance of ML models with traditional Cox regression in predicting stroke risk among 503,842 Chinese adults without a prior stroke history [16]. They evaluated ML models such as SVM, random survival forests (RSF), gradient-boosted trees (GBT), and multilayer perceptrons (MLP), using sociodemographic factors, diet, medical history, and physical activity as inputs [16]. GBT model showed the best discrimination for nine-year stroke risk prediction with AUROCs of 0.833 for men and 0.836 for women [16]. The ensemble approach combines GBT and Cox models and improves accuracy and specificity, outperforming single-model approaches [16]. The study demonstrates the superiority of ML models over traditional methods for stroke risk prediction, enabling more accurate identification of high-risk individuals and implementing preventive measures [16]. Both studies highlight the transformative potential of AI and ML in stroke management, with Chao et al. emphasizing prognosis prediction and Chun et al. focusing on risk prediction [23,16]. While Chao et al. comprehensively evaluate various AI models, Chun et al. highlight the advantages of ML models in a large population cohort, underscoring the need for advanced algorithms and extensive data integration to enhance further clinical applicability and patient outcomes in stroke prevention and management [23,16].

Furthermore, integrating AI in prehospital stroke care, as shown by Fassbender et al. (2023), enhances the speed and accuracy of triage and treatment decisions [10]. By improving prehospital care logistics, AI systems help reduce treatment delays, facilitating rapid intervention during the critical early stages of a stroke [10]. This improves patient outcomes and enhances healthcare delivery systems' efficiency [23-25].

AI-Driven Rehabilitation Programs:

AI's application in rehabilitation programs has demonstrated promising outcomes in improving patient recovery post-stroke [26-28]. Zhu et al. (2023) and Murakami et al. (2023) investigate the impact of AI-driven rehabilitation techniques on stroke recovery, mainly focusing on upper limb functionality [3,9,27]. Zhu et al. conducted an RCT involving 120 stroke survivors to assess the effectiveness of AI-driven rehabilitation programs compared to traditional methods [3,27]. Participants in the AI group experienced a significant improvement in upper limb functionality, with a mean increase of 15.2 points in Fugl-Meyer Assessment (FMA) scores and 12.5 points in Action Research Arm Test (ARAT) scores compared to the control group [3]. The study highlighted the potential of AI in personalizing rehabilitation exercises, leading to Improved recovery outcomes and better quality of life for individuals who have survived a stroke [3]. In contrast, Murakami et al. conducted a prospective cohort study with 150 stroke patients to evaluate the long-term effects of AI-driven rehabilitation [9]. This study demonstrated that the AI-driven group significantly improved FMA scores (mean increase of 18.4 points) and decreased time to complete tasks on the Wolf Motor Function Test (WMFT) by 25.3 seconds [9]. The AI group maintained higher functional gains at the six-month follow-up, indicating sustained improvements [9]. The study emphasized the long-term benefits of personalized AI rehabilitation programs and their role in enhancing stroke recovery outcomes [9]. Both studies affirm the transformative potential of AI-driven rehabilitation techniques in stroke recovery, but they differ in their study design and focus [27,9]. Zhu et al. conducted an RCT, providing high-level evidence of the immediate effectiveness of AI in rehabilitation [3,27]. At the same time, Murakami et al. employed a cohort study to highlight long-term benefits [9]. Both studies support the integration of AI into clinical practice, underscoring its capacity to provide personalized therapy that optimizes recovery and improves the quality of life for stroke survivors [3,9]. These studies suggest that AI can significantly enhance rehabilitation efficacy, offering promising implications for future stroke treatment protocols [3,9]. Moreover, AI's ability to predict cognitive impairment, as demonstrated by Ji et al. (2023) and Lee et al. (2023), allows for early intervention and personalized rehabilitation strategies [3,9]. Ji et al. (2023) and Lee et al. (2023) both explore the use of ML to predict post-stroke cognitive impairment (PSCI), focusing on developing predictive models that can facilitate early intervention and improve patient outcomes [4,8,29]. Ji et al. conducted a prospective cohort study involving 331 acute ischemic stroke (AIS) patients with an external validation cohort of 66 patients [4]. They evaluated nine ML models, including GNB, which gained the highest predictive accuracy, measured by an AUC of 0.925 [4]. Key predictors identified included age, education, baseline NIHSS score, cerebral white matter degeneration (CWMD), homocysteine (Hcy) levels, and C-reactive protein (CRP) levels [4]. The study demonstrated that ML models, particularly GNB, could effectively predict PSCI, allowing for early identification and personalized rehabilitation strategies [4]. In contrast, Lee et al. conducted a retrospective cohort study with 951 AIS patients, using historical data to assess the effectiveness of ML models in predicting PSCI [8,30]. They compared four models: logistic regression, SVM, XGBoost, and artificial neural network (ANN) [8,30]. XGBoost showed the highest predictive accuracy with an AUC of 0.7919 [31]. Significant predictors identified were infarcts in the cortex, atrophy of the mesial temporal lobe, severity of the initial stroke, history of stroke, and infarcts in strategic brain regions [8,30,31]. The study highlights the potential of ML models, particularly XGBoost and ANN, in effectively predicting PSCI and enabling personalized rehabilitation strategies [8,31]. Both studies underscore the transformative potential of AI-driven predictive modeling in stroke recovery, but they differ in study design and focus [4,8]. Ji et al.'s prospective study provides insights into real-world predictive capabilities [4]. It emphasizes the clinical utility of ML models like GNB in predicting PSCI, while Lee et al.'s retrospective study focuses on using historical data to develop effective models like XGBoost [4,8]. Both studies support integrating ML models into clinical practice, highlighting their potential to enhance PSCI prediction and management, ultimately improving patient outcomes and optimizing stroke recovery practices [4,28]. However, further research and refinement of ML models are needed to validate their effectiveness across diverse clinical settings [28-30].

Figure 1 depicts the integration of AI into stroke management, enlisting major parameters involved.

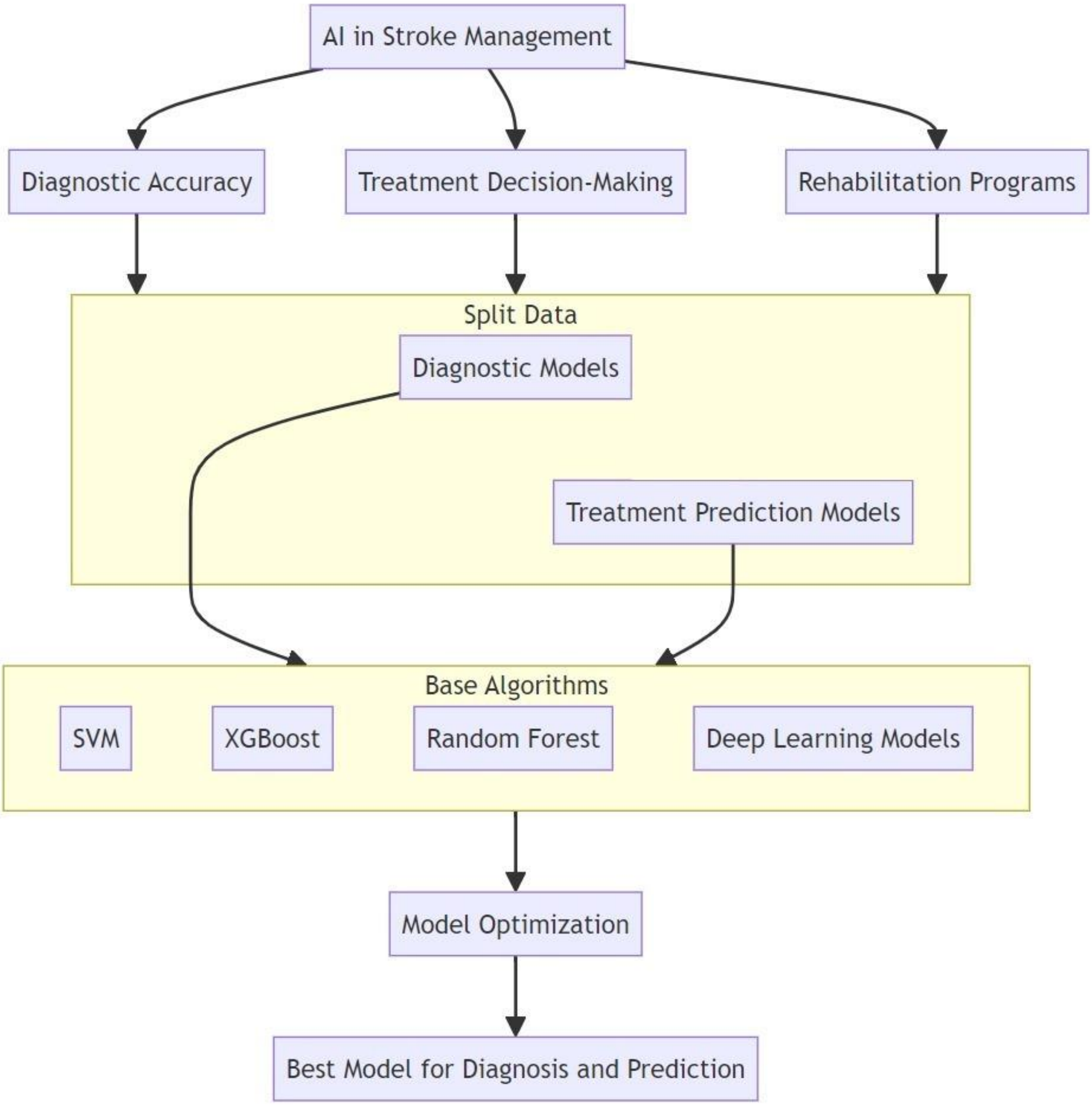

Figure 1: **Flow of AI Integration in Stroke Management**

Challenges and Opportunities in AI Integration:

While AI presents numerous opportunities for improving stroke management, several challenges must be addressed to realize its full potential [28-32]. Morey et al. (2021) and Rabinstein et al. (2021) both examine the integration of AI into clinical workflows, focusing on radiology and stroke management, respectively [17,18]. Morey et al. conducted a comprehensive review to identify the challenges and solutions associated with integrating AI algorithms into clinical workflows, particularly in radiology departments [17]. Their study highlighted the complexity of integrating AI with radiology IT systems and emphasized the need for standardized protocols and clinician training [17]. They proposed a framework for AI integration that includes image delivery, quality control, results processing, error correction, and performance monitoring [17]. They underscored the importance of structured reporting of standards-compliant digital imaging and communications in medicine (DICOM) to ensure seamless data exchange and interoperability [17]. A survey among 14 radiologists and trainees revealed that most respondents agreed that the AI system was well-integrated [17]. Still, it emphasized the need for continuous feedback and training to enhance acceptance and usability [17].

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In contrast, Rabinstein et al. conducted a prospective observational study to evaluate the integration of AI into stroke management [18]. Their study involved 50 clinicians from various specialties and focused on identifying barriers to AI adoption [18]. Clinicians reported difficulties integrating AI with existing electronic health record (EHR) systems, highlighting the importance of interoperable AI systems that seamlessly exchange data with various clinical systems [18]. The study found that while clinicians recognized the potential benefits of AI, there were concerns about the reliability and accuracy of AI-generated results [18]. Training and education were critical factors in improving clinician acceptance and trust in AI systems [18]. Both studies underscore the need for standardized data formats, interoperability protocols, and robust training programs to facilitate AI integration into clinical workflows [17,18]. Morey et al. provide a detailed framework for AI integration in radiology, while Rabinstein et al. offer practical insights into the challenges faced in stroke management [17,18]. Both studies emphasize the importance of clinician training and the development of interoperable systems to enhance AI acceptance and usability [17,18]. These findings highlight the potential for AI to enhance clinical practice efficiency and effectiveness and the necessity for ongoing research and development to address the identified challenges and ensure successful integration across diverse clinical settings [17,18]. However, the potential benefits of AI integration are substantial [31-33]. AI systems offer opportunities for personalized care, where treatment plans and interventions can be tailored to individual patient needs, improving patient outcomes [31-33]. Additionally, AI's ability to streamline workflows and reduce administrative burdens can enhance overall healthcare efficiency, allowing clinicians to focus more on patient care [34].

Common Patterns and Emerging Trends:
Across the studies reviewed, ML and DL emerge as the predominant AI techniques to enhance diagnostic and predictive capabilities in stroke management [35-40]. These techniques are particularly effective in processing large datasets and identifying complex patterns, providing insights that are not easily discernible through traditional analysis methods [38-40]. A significant emphasis on imaging diagnostics is evident, highlighting AI's potential to augment radiologists' capabilities [40,41]. AI's predictive power also allows for proactive and preventive care approaches, enabling healthcare providers to anticipate risks and develop effective treatment plans that improve long-term patient outcomes [42,43]. The systematic review provides strong evidence supporting the efficacy of AI in stroke management, particularly in diagnostics and predictive modeling. Well-conducted studies, including RCTs and cohort studies by Ji et al. (2023) and Murakami et al. (2023), deliver strong evidence supporting the effectiveness of AI interventions [20-28]. These studies consistently demonstrate that AI outperforms traditional methods, providing more accurate and efficient stroke care [20-28].

The Role of Artificial Intelligence in Enhancing Diagnostic Imaging and Rehabilitation: Current Advances, Challenges, and Future Directions:
AI-driven platforms are revolutionizing personalized rehabilitation programs by utilizing ML algorithms to analyze patient data and predict recovery trajectories [33]. Campagnini et al. (2022) systematically reviewed various ML methods for predicting functional recovery in post-stroke rehabilitation, highlighting the effectiveness of linear and logistic regression algorithms despite challenges like small sample sizes and high variability in data [34]. Robotic systems integrated with AI are also becoming more prevalent in physical therapy, adapting to patient progress and providing real-time feedback [35]. A study evaluated AI and robotic coaches for rehabilitation exercises, finding that these systems significantly benefit therapy management and patient motivation, though usability issues remain for patients with cognitive impairments [36]. White et al. (2023) explored using DL and multimodal data for predicting post-stroke recovery, achieving high accuracy, area under the curve, and F1 scores by combining MRI data with clinical variables in a 2D Residual Neural Network [37]. The future of AI in rehabilitation looks promising, with advancements in imaging techniques, real-time data analysis, and the integration of various technologies poised to improve patient outcomes [33-36] significantly. Maintaining patient data confidentiality poses a significant hurdle in AI-powered diagnostic imaging [36,37]. AI systems require extensive datasets for effective training, often containing sensitive patient information [39]. Safeguarding this data from breaches is crucial [39]. According to research by James Scheibner et al., concerns about data privacy are heightened due to the necessity of sharing data across institutions to enhance model robustness, thereby increasing the risk of unauthorized access [39]. Secure storage and transmission of data are vital to avoid violations and adhere to regulatory requirements of the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA) [40]. Encryption and secure access protocols are key measures highlighted by de Aguiar EJ et al. (2023) to protect patient data in AI applications [41]. Clinicians often struggle to interpret AI-generated recommendations, particularly when the decision-making process is opaque [42]. This lack of transparency and AI's "black box" nature can hinder integration into clinical workflows and erode trust [42]. Enhancing the interpretability of AI models through explainable AI techniques is essential to fostering clinician confidence, as emphasized by Weina Jin et al. (2022) [43]. Establishing trust among healthcare professionals requires confidence in the reliability and accuracy of AI recommendations [43]. This sentiment is

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echoed in a survey by Jana Fehr et al. (2023), which found that transparency and reliability significantly influence clinician acceptance of AI tools [44]. Recent studies demonstrate the potential of AI to enhance diagnostic accuracy in various conditions [43-45]. For instance, DL models have shown promise in improving lung cancer detection compared to traditional methods [45]. AI can accurately identify lung cancer, potentially surpassing human radiologists in certain scenarios, as highlighted by Ardila et al. (2019) [45]. Similarly, AI has effectively predicted diabetic retinopathy development, aiding in personalized treatment strategies [46]. Studies by Gunasekeran et al. (2019) underscore AI's capability to stratify patients based on retinopathy risk, facilitating timely interventions [47]. AI models also exhibit high sensitivity and specificity in diagnosing fatty liver disease using imaging techniques like MRI and ultrasound, which are crucial for early detection and intervention [48]. To enhance AI's applicability across diverse settings, standardizing imaging protocols is essential, as noted in a meta-analysis by Miriam Cobo et al. (2023) [49]. AI algorithms have proven effective in detecting intracranial aneurysms, reducing missed detections and false positives, thereby improving diagnostic accuracy and easing the workload on radiologists [49]. AI's detailed characterization of aneurysms, as highlighted by research from Zhongjian Wen et al. (2024), is critical for personalized treatment planning [50]. Future research aims to develop predictive models that integrate genetic, phenotypic, and clinical data to tailor treatments to individual patient needs [51]. Integrating AI with electronic health records (EHRs) will facilitate real-time decision support, potentially improving patient outcomes [52]. Continued advancements in deep learning techniques, particularly convolutional neural networks (CNNs), are expected to enhance diagnostic performance [53,54]. However, caution is warranted to prevent AI from perpetuating biases in healthcare, as emphasized by Obermeyer et al. (2019) [55]. Establishing robust regulatory frameworks is essential to ensure AI's safe and effective deployment in clinical practice [55-57]. In conclusion, while AI holds promise in revolutionizing diagnostic imaging by improving accuracy, efficiency, and personalized care, addressing challenges related to data privacy, dataset diversity, and clinical integration remains critical [52-57]. Ongoing research and advancements in AI algorithms, predictive modeling, and ethical considerations will pave the way for more reliable AI-driven diagnostic tools.

Conclusion:

The integration of AI in stroke management has shown significant promise in enhancing diagnostic accuracy, optimizing treatment decision-making, and improving rehabilitation outcomes. AI-driven technologies, particularly ML and DL models, have demonstrated superior performance in detecting strokes, predicting patient outcomes, and personalizing rehabilitation programs. Despite the challenges related to data privacy, the need for large datasets, and integration into clinical workflows, the potential benefits of AI in providing precise, efficient, and personalized stroke care are substantial. Future research should address these challenges and further validate AI models across diverse clinical settings to harness the full transformative power of AI in stroke management.

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