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RESEARCH ARTICLE

MRI in the Diagnosis of Ischemic Stroke: A systematic review

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ABSTRACT

It is recognized that ischemic stroke is a major cause of mortality and disability. Over the last several decades, many efforts have been made to improve acute ischemic stroke therapy's efficacy. MRI with multimodality may be used to choose treatment plans for acute-phase ischemic stroke diagnosis. To explore the clinical efficacy, sensitivity, and outcomes of MRI in diagnosing patients with ischemic stroke. This study is a systematic review of research published between 2014 and 2023 that examined the clinical effectiveness, sensitivity, and results of MRI in the diagnosis of ischemic stroke patients. We looked for research on our topic using the PubMed, Cochrane, Web of Science, and Google Scholar databases. The terms were utilized in different combinations and included "clinical, efficacious, sensitivity, outcomes, MRI, diagnosis, ischemic, stroke." Furthermore, original studies that reported the use of MRI in the diagnosis of ischemic stroke were assessed. Publications in full text were used as the inclusion criteria. Fifteen studies met our eligibility criteria. The studies were published between 2014 and 2023. five of the included studies were retrospective. Five were prospective, One single-center study, One systematic review, and three were literature review studies. The studies were conducted on patients suffering from acute ischemic stroke. Imaging of the brain and blood vessels is crucial to the emergency assessment of stroke suspect patients. The principal imaging test might be an MRI or CT scan. When it comes to identifying lesions related to both acute and chronic ischemia, as well as persistent microbleeds, MRI is quite sensitive. Nonetheless, CT continues to be the most practical and widely used first brain imaging method. It is recommended to perform a non-invasive intracranial vascular study during the initial imaging assessment of a patient who has experienced an acute stroke, particularly if mechanical thrombectomy is being considered. This is because a non-enhanced CT or T2* MRI sequence that does not reveal any bleeding is sufficient to determine whether intravenous treatment is appropriate within the first 4.5 hours following a stroke. Utilizing multimodal MRI for advanced imaging can enhance the precision of diagnosing and characterizing ischemic strokes. It should be regarded as a viable alternative to CT, particularly for identifying patients who are eligible for acute reperfusion therapy within extended time frames, as well as for patients with unknown stroke onset times. Nevertheless, MRI should only be taken into account in the acute stroke process if medical facilities can attain a comparable level of rapidity and efficiency in prioritizing patients, as is now achievable with CT-based imaging.

INTRODUCTION

With over 6 million fatalities reported each year across all socioeconomic levels, cardiovascular illnesses rank as the second most common cause of death globally, with ischemic heart disease being the primary cause (Nowbar et al., 2019). One of the main causes of mortality and a major source of morbidity is cerebral vascular disease. Up to 50% of stroke sufferers do not achieve functional independence within three months after the stroke, and 20% need institutional assistance. Aphasia, hemianopia, and hemiparesis are often the first neurological symptoms of a stroke, also known as a cerebrovascular accident. (Paraparesis is uncommon in stroke cases and suggests a non-ischemic etiology or an ischemic lesion in the spinal cord). The beginning may come on suddenly or be felt after arousal, accompanied by a headache, nausea, vomiting, dizziness, or loss of consciousness. There are two primary forms of stroke: hemorrhagic stroke and ischemic stroke. Since the therapeutic modalities for these two subtypes differ substantially, managing stroke starts with an early diagnosis and subtype identification (Donkor, 2018).

Hemorrhagic or intracerebral hemorrhages cause ten to fifteen percent of stroke cases. This type of stroke is rare, yet it has a high risk of morbidity and death. After a hemorrhagic stroke, up to 38% of patients may pass away in less than 30 days, and about 50% of survivors require help with everyday tasks (Lo et al., 2021). 85% of all stroke episodes are ischemic strokes, which are more prevalent and have a significantly lower 30-day death rate of 12% (Zhakhina et al., 2022). The morbidity from an ischemic stroke can also be relatively high; thus, early detection and treatment are necessary to minimize it. It's also feasible for an ischemic lesion to transform hemorrhagically. This is especially prevalent in myocardial infarction caused by venous blockage. The examination of a venous (sinus) system obstruction should be performed upon the discovery of a hemorrhagic infarction. It's also possible to have a transient ischemic attack (TIA), which would cause a 24-hour-long localized neurological impairment. Even though TIA is self-limiting, it might complicate the diagnosis of an ischemic stroke. TIAs are a significant short-term predictor of stroke, with up to 20% of patients experiencing a stroke within 90 days (Gonçalves et al., 2023).

LITERATURE REVIEW

Over time, a variety of clinical diagnostic tools have been created to assist in the identification of stroke cases. These examinations may support the first neurological patient triage. Still, their sensitivity and specificity are inferior to imaging studies, and no clinical test can accurately differentiate between hemorrhagic and ischemic stroke (Athar et al., 2023). Consequently, the initial course of treatment for a patient suspected of having had a stroke is an imaging evaluation.

Since CT scans are usually accessible around the clock in large hospitals, they are the most commonly used imaging test clinicians use to screen for strokes. Early stages of minor abnormalities may not always be detected by C.T. scans, which also carry the danger of ionizing radiation exposure and the possibility of adverse responses to the intravenous contrast agent (Murphy and Werring, 2020). Nonetheless, there are several advantages to diagnosing ischemic stroke with MRI. Because MRI is more sensitive to early changes associated with ischemic stroke, it is an excellent diagnosis technique. Furthermore, MRI can produce sharper, more accurate brain images, improving the visibility of damaged areas. Moreover, MRI can differentiate between different types of stroke, including ischemic and hemorrhagic strokes, which helps choose the best course of treatment (Zirpe and Tilak, 2020; Veterini et al., 2024).

Magnetic resonance imaging (MRI) can typically distinguish between stroke mimics and later ischemic lesions with high specificity and sensitivity. Lesions observed on DWI scans have historically been interpreted as indicators of irreversible ischemia in the context of acute ischemic stroke. Reperfusion therapy has been demonstrated to be reversible in certain situations with these lesions. This makes assessing the risks and benefits of mechanical thrombectomy in acute stroke situations and determining the infarct core's irreversibility difficult. M.R. imaging techniques have been employed to find patients with salvageable regions that may benefit from reperfusion treatments. These methods have viewed DWI lesions as the central region of the infarction.

On the other hand, the ADC measures the diffusion of water molecules in tissues, serving as an indicator. The ADC is lowered in ischemic tissues when cytotoxic edema is present. A notable drop in the ADC points to a metabolic energy breakdown that causes tissue infarction (Nagaraja, 2021).

DWI collects data on the ischemic tissue's structure using the water's diffusivity. Because these areas look brighter on DWI, it can reveal acute focal regions with restricted diffusion and cytotoxic edema. After the first four days after an ischemia incident, the appearance, sub-acute, and chronic stages usually seem normal or darker on DWI. On the other hand, the T2 shine-through effect may cause chronic stroke lesions that seem brighter on fluid-attenuated inversion recovery (FLAIR) and T2 sequences to also appear brighter on DWI. Getting ADC maps is essential to address this problem since they can account for the T2 shine-through effect and differentiate between acute ischemia and deceptively brighter chronic lesions. ADC maps are helpful because they preserve the brightness of chronic lesions while emphasizing the areas of acute ischemia that are brighter than usual. There is ongoing debate over the usefulness of DWI and ADC maps in distinguishing irreversibly damaged tissue from permanently damaged tissue (Albano et al., 2022).

The best magnetic resonance imaging (MRI) sequence for identifying an ischemic stroke is diffusion-weighted imaging (DWI); minutes after artery blockage, symptoms of a severe brain infarction manifest. Appearing diffusion coefficient (ADC) maps indicate that strong signal on DWI and accompanying low signal area are indicative of locations with limited tissue diffusion. Computed tomography (CT) is now the imaging modality of choice for patients with suspected stroke because of its widespread availability and quick image recording, even though magnetic resonance imaging (MRI) has a better sensitivity in identifying infarctions. If a patient has acute stroke symptoms and initial CTA and CT angiography (CT) findings are negative, they may be referred for MRI as a follow-up diagnostic imaging technique. An MRI may confirm the diagnosis of ischemic stroke in this non-acute stroke work-up (Ryu et al., 2020). This suggests that MRI can reliably recognize and diagnose people with ischemic stroke. Therefore, in the present study, we aim to perform a literature review to investigate the clinical efficacy, sensitivity, and outcomes of MRI in diagnosing patients with ischemic stroke.

Aim of work:

The purpose of this study is to investigate the clinical efficacy, sensitivity, and outcomes of MRI in diagnosing patients with ischemic stroke.

METHOD AND SEARCH STRATEGY

This systematic review complies with the PRISMA checklist standards for meta-analyses and systematic reviews (Liberati et al., 2009). The databases examined were PubMed, Cochrane, Web of Science, and Google Scholar. We searched the two databases for research on "clinical, efficacy, sensitivity, outcomes, MRI, diagnosis, ischemic, stroke," which was our primary subject. The research was released in publications from 2014 to 2023.

"Clinical, efficacy, sensitivity, outcomes, MRI, diagnosis, ischemic stroke" were the keywords utilized in the search procedure. Additionally, all relevant articles were gathered using the related keywords. All of the titles were revised as a consequence of this preliminary investigation.

Eligibility criteria

After examining the titles of studies on the clinical effectiveness, sensitivity, and outcomes of MRI in identifying patients with ischemic stroke before 2014, only those that focused on these aspects of the research were eliminated. After assessing the abstracts of the remaining papers, the second step comprised choosing only original, English-language studies that reported the clinical effectiveness, sensitivity, and outcomes of MRI in identifying patients with ischemic stroke. However, case reports and editor's letters were left out. Original English-language papers analyzing and assessing the clinical effectiveness, sensitivity, and results of MRI in the diagnosis of ischemic stroke patients were included in the last phase. These articles underwent further scrutiny to eliminate duplicates, articles without full text, and articles with inadequate material, such as data that overlapped or was partial. A comprehensive description of the search strategy is shown in Figure 1.

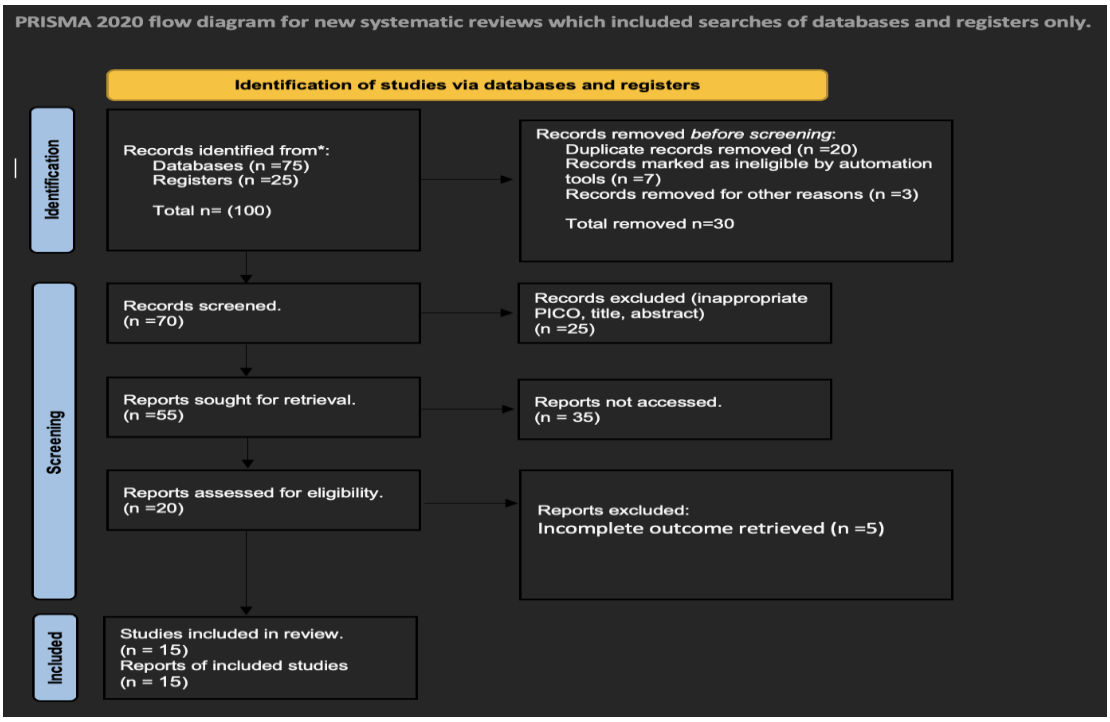

Figure 1: Planning of eligible criteria

DATA REVIEWING AND ANALYSIS

To extract the relevant information and move it to a pre-made Excel sheet, the complete texts and abstracts of the publications were assessed. After that, the selected data were modified in the Excel sheet and concatenated to create a summary that would make data analysis easier.

RESULTS

Author	Study type	Study design and population	Study focus	Key findings
1. Mitomi et al., (2014)	Prospective study	The study group comprised 130 patients (71 men; median age, 75 years) with an anterior territory stroke who underwent CT and DWI within 3 hours of onset.	To compare diffusion-weighted magnetic resonance imaging (DWI) and computed tomography (CT) for the detection rate of ischemic lesions within three hours after start.	• • The CT-Alberta Stroke Program Early CT Score (ASPECTS) and DWI-ASPECTS were used to evaluate the lesions seen on CT and DWI, and detection rates were compared for each ASPECTS area. Compared to CT, the DWI had a greater detection rate of ischemic lesions (76.9% vs. 30.0%). There was no correlation (r = 0.51) between the DWI-ASPECTS and CT-ASPECTS scores. The lentiform nucleus (43.8% vs 20.0%), insula (59.2% for

				DWI vs 15.4% for CT), and the M1 (30.8% vs 6.9%), M2 (50.8% vs 6.2%), M3 (28.5% vs 3.1%), M4 (32.3% vs 6.9%), M5 (48.5% vs 10.8%), and M6 (31.5% vs 4.6%) regions of the middle cerebral artery were all shown to have ischemic lesions. Except the internal capsule and caudate head, DWI found ischemia lesions much more often than CT did in all ASPECTS locations.
2. Nael et al., (2014)	Prospective, single institutional study	The National Institutes of Health Stroke Scale of ≥3, the lack of MRI contraindications, and the beginning of symptoms of acute ischemic stroke within 24 hours were the inclusion criteria.	We outline the technical details and provide a firsthand account of our clinical experience with this approach.	• Sixty-two patients in all fulfilled the requirements for inclusion • Twenty-two individuals underwent repeat MRI scans, yielding 84 MRIs for the study. • 90% of neck M.R. angiography, 96% of brain M.R. angiography, 100% of diffusion-weighted imaging, 98% of EPI-gradient remembered echo, and 94% of dynamic susceptibility contrast perfusion scans achieved diagnostic picture quality with interobserver agreements (k) ranging from 0.64 to 0.84. Ninety-nine people, or 95% of the total, had an acute infarction. • There was high interobserver agreement in the dynamic susceptibility contrast-Tmax mismatch classification detection and the EPI-fluid attenuation inversion recovery imaging findings. • On the EPI-gradient remembered echo, 13 acute cerebral hemorrhages were discovered by both observers.

				•A useful 6-minute multimodal M.R. approach with adequate diagnostic quality may be used to assess patients with acute ischemic stroke. Significantly shorter scan durations than those of the multimodal computed tomographic technique may result from it.
3. Manwani et al. (2019)	Retrospective study	Enrolled in the trial were 432 individuals who had a localized neurological impairment and were hospitalized to Hartford Hospital in 2014. They had brain MRI and CPT scans. The research excluded patients who were less than 18 years old or who had bleeding issues. Individuals were classified as having had an early MRI (within 12 hours) or a late MRI (beyond 12 hours).	To investigate the correlation between time to MRI and length of hospital stay.	• When comparing patients who had an MRI within 12 hours of admission to those who had one more than 12 hours later, there was a statistically significant difference in the length of hospital stay (early MRI group: 3 days (1.8, 4.9) versus four days (2.6, 7.0). • According to the research, a brain MRI completed within 12 hours of arrival shortens hospital stays and makes stroke assessment easier. It offers proof of the MRI's cost-effectiveness in treating ischemic stroke.
4. Ko, Y., Lee,. (2014).	Prospective study	Patients suffering from acute ischemic stroke had pertinent lesions on MR-diffusion weighted imaging (DWI) and were admitted to one of the 14 participating centers within seven days of the stroke's beginning were included in our enrollment. MAGIC was created with the latest developments in thrombolytic therapy and stroke imaging in mind.	The researchers developed and implemented the MAGIC method, which classifies acute ischemic stroke subtypes using magnetic resonance imaging (MRI).	• For MAGIC and TOAST, the total intra-class correlation coefficient (ICC) values were 0.43 and 0.28, respectively. The most frequent cause of acute ischemic stroke (38.3%) was extensive artery atherosclerosis (LAA), which was followed by cardioembolism (22.8%), unknown cause (22.2%), and small-vessel occlusion (SVO, 14.6%). • For patients with two or more U.D.s, the one-year stroke recurrence rate was greatest (11.8%), followed by LAA (7.30%), C.E. (5.60%), and SVO (2.50%). • This study demonstrates that the

				MAGIC method is viable and may aid in classifying stroke subtypes in the clinic despite several drawbacks.
5. Simonsen et al., (2015)	single-center study	Researchers gathered demographic, imaging, and outcome data on all stroke patients receiving intravenous tissue-type plasminogen activator treatment based on magnetic resonance imaging (MRI) in this single-center study. We determined the sensitivity and specificity of DWI and extra PWI for the diagnosis of acute ischemic stroke after identifying the patients who tested negative for the test. To find traits linked to DWI negativity, we compared patients with positive and negative DWI results.	To calculate the percentage of DWI positive and DWI negative strokes and to pinpoint the variables that contribute to DWI negativity. It was also assessed how helpful PWI was in validating the diagnosis of ischemic stroke	• Based on acute magnetic resonance imaging, 569 consecutive patients received intravenous tissue-type plasminogen activator treatment. In 518 cases, a DWI lesion was visible. • Thirty-three of the forty-seven patients who tested negative for DWI had a meaningful PWI lesion. • Intravenous tissue-type plasminogen activator was used to treat four-stroke mimics; one of the patients had a DWI lesion. Thus, DWI negative status was present in 8% of all stroke patients. A sensitivity of 97.5% was achieved in diagnosing ischemic stroke using the combination of DWI and PWI. • Less severe strokes, placement in the posterior circulation, a more extended period between onset and scan, and better 90-day outcomes were all linked to DWI negative. • DWI-negative causes were more likely to be the etiology of small-vessel disease. When DWI and PWI are combined with intravenous tissue-type plasminogen activator, the diagnosis of 97.5% of ischemic strokes is confirmed.
6. Luo et al., (2015)	Retrospective study.	Within three days of the beginning of symptoms, 18 stroke patients with acute infarction underwent diffusion-weighted imaging (DWI), SWI, PWI, and	To examine susceptibility-weighted imaging (SWI) against perfusion-weighted imaging (PWI) in identifying ischemic penumbra in	• When assessing ischemic penumbra, there was no discernible difference between the DWI-mean transit time (MTT) mismatch and the DWI-SWI mismatch.

		magnetic resonance angiography (MRA) .	stroke patients with acute cerebral infarction	• Out of the eighteen patients with cerebral infarction, eleven (61%) had the susceptibility vessel sign (SVS) in suspected stroke. • Ten (91%) of the eleven SVS-positive patients had MRA results that indicated stenosis or blockage of the impacted arteries. • The occurrence of damaged vessels or thrombus in the afflicted vessels • was substantially correlated with the SVS on SWI. • When assessing ischemic penumbra in stroke patients with cerebral infarction • , DWI-SWI mismatch is a valuable sign. • Intra-arterial thrombolytic therapy may be guided by SWI, which can identify thrombus in the impacted vessels.
7. Khalil et al., (2016)	Retrospective analysis	A total of fifty-seven patients who presented with infratentorial stroke clinical characteristics received low-resolution EPI-DWI, high-resolution EPI-DWI, and STEAM-DWI.	In the infratentorial compartment, to evaluate the sensitivity of echo-planar imaging diffusion-weighted imaging (EPI-DWI) vs stimulated echo acquisition mode diffusion-weighted imaging (STEAM-DWI) to ischemic stroke.	There was a 24-hour interval between the beginning of symptoms and imaging. In 89.5% of instances, STEAM-DWI and LR-DWI agreed, as did HR-DWI. • LR-DWI (41/57) and HR-DWI (44/57) both had more intraparenchymal artifacts (1/57) than did STEAM-DWI. In 87% of LR-DWI instances, 93% of HR-DWI cases, and 89% of STEAM-DWI cases, ischemia was evident. • For STEAM-DWI, interobserver agreement was excellent. In contrast to HR-DWI, the finest M.R. sequence available at the moment for diagnosing ischemia, STEAM-DWI has a comparable sensitivity to infratentorial stroke and less artifacts.

8.	Meng et al., (2023)	Retrospective study	In this study, participants with ischemic stroke at the acute (24 h–7d, n = 33) or hyperacute (0–24 h, n = 23) phases were enrolled. The length of the patient's symptoms was connected with lesion N-acetyl aspartate (NAA), lactate, choline, creatine, and T2 signals, which were compared between groups	The goal is to create a multispectral imaging method that may predict the stroke onset time by combining quick quantitative T 2 mapping with high-resolution 3D magnetic resonance spectroscopic imaging (MRSI) to capture the multifactorial biochemical changes within stroke lesions	• Within the lesion, there were detectable quantities of T2 and lactate in both groups and choline and NAA in fewer amounts. • For every patient, variations in the T2, NAA, choline, and creatine signals were associated with the length of their symptoms. • The greatest results were obtained by merging information from MRSI and T 2 mapping into predictive models of stroke start time. • The suggested multispectral imaging method enhances the evaluation of the length of cerebral infarction and offers a mix of biomarkers that indicate early pathological alterations after stroke in a clinically realistic amount of time.
9.	Nagaraja et al., (2020)	A systematic review	Studies were included if the first DWI MRI was performed within 24 hours of stroke onset and follow-up DWI or fluid-attenuated inversion recovery (FLAIR)/T2 was performed within 7 or 90 days, respectively, to measure DWIR. We abstracted clinical, imaging, and outcomes data.	To systematically review the literature for reversible diffusion-weighted imaging (DWIR) lesions and to describe its prevalence, predictors, and clinical significance.	• The prevalence of DWIR was 26.5% in DWI-based studies and 6% in FLAIR/T2-based studies. Tissue plasminogen activator (t-PA) or endovascular therapy used alone or in combination, earlier t-PA treatment, a shorter time to endovascular therapy following MRI, and no or less severe perfusion deficit within the DWI lesion were all associated with DWIR. In six out of seven studies, DWIR was linked to both long-term outcome (defined as NIHSS score ≤1, improvement in the NIHSS score ≥8 points, or modified Rankin Scale score up to ≤2 at 30 or 90 days), likely as a result of

				reperfusion, and early neurologic improvement (defined as improvement in the NIH Stroke Scale (NIHSS) score by 4 or 8 points from baseline or NIHSS score 0 to 2 at 24 hours after treatment or at discharge or median NIHSS score at 7 days). • • DWIR is linked to a favorable clinical outcome after reperfusion and may be seen in up to 25% of individuals with acute ischemic stroke. Our results point up the drawbacks of using DWI to identify the ischemic core in the first stages of a stroke.
10. Shah et al., (2015)	A review study	In 2013, quality improvement methods were implemented to decrease the door-to-needle (DTN) time at the two hospitals where the NIH stroke team delivers clinical treatment. Patients with acute ischemic stroke (AIS) who were administered intravenous tissue plasminogen activator (tPA) within 4.5 hours from the time of their last known normal state were identified. An analysis was conducted on the demographic and clinical parameters, as well as the timing metrics, comparing the time periods before to, during, and following the implementation of the quality improvement activities.	To illustrate the efficacy of fast multimodal MRI screening prior to thrombolysis in patients with acute stroke.	• Between 2012 and 2013, 157 people received intravenous tissue plasminogen activator (IV tPA) therapy for acute ischemic stroke (AIS). Of these patients, 135 (86%) had magnetic resonance imaging (MRI) performed for evaluation. During this time, the DTN time was significantly reduced by 40%, from a median of 93 minutes in the first half of 2012 to 55 minutes in the final half of 2013 ($p < 0.0001$). Furthermore, the percentage of treated patients with a DTN time of 60 minutes or less increased significantly, from 13.0% to 61.5% ($p < 0.00001$), a four-fold increase. The amount of time it required to move patients from the entrance to the MRI room decreased in proportion to the DTN duration. The clinical and demographic parameters did not

				differ (p 5 0.21–0.76). • It is feasible and workable to administer intravenous tissue plasminogen activator (IV tPA) to acute ischemic stroke (AIS) patients using magnetic resonance imaging (MRI) as the routine screening technique within national benchmark timeframes.
11. Vilela et al., (2017)	A literature review		Computed tomography (CT) and magnetic resonance (MR) imaging techniques, such as CT angiography and MR angiography, are utilized to rule out conditions that resemble stroke and detect any bleeding. They are also employed to evaluate the underlying cause and mechanism of the stroke, assess the size of the brain infarct, and identify any blockage in a major artery.	• Imaging plays a crucial role in determining whether patients are suitable for therapy of acute ischemic stroke (AIS). It is essential to do imaging of the parenchyma and blood vessels using either CT or MRI, depending on the local availability. • Advanced computed tomography (CT) and magnetic resonance imaging (MRI) techniques, which include assessments of artery collateral status and core/penumbra mismatch, offer accurate insights into the specific pathophysiology of a stroke. The utilization of personalized physiological imaging should enable more accurate patient selection for therapy inside and beyond the therapeutic time frame. Having a small core and strong collateral circulation are linked to positive outcomes, while having a malignant DWI profile, no penumbra, and poor collateral circulation are associated with negative outcomes, regardless of the time since the stroke occurred and the results of revascularization.

12. Vert et al., (2017)	Literature review		Imaging of the brain and blood vessels is crucial to the emergency assessment of stroke suspect patients. The principal imaging test may be an MRI or CT scan.	• MRI is more sensitive in identifying microbleeds that are persistent as well as acute and chronic ischemia lesions. CT is still the most practical and widely used first brain imaging method, nevertheless. Even though, in the first 4.5 hours following a stroke, a non-enhanced CT or T2* MRI sequence without any bleeding signs is sufficient to determine whether intravenous treatment is appropriate, it is highly recommended that the initial imaging evaluation of the patient also include a non-invasive study of the brain's blood vessels. This is especially important if there is consideration for mechanical thrombectomy. Utilizing multimodal MRI for advanced imaging can enhance the precision of diagnosing and characterizing ischemic strokes. It should be regarded as a viable alternative to CT scans, particularly for identifying patients who may benefit from acute reperfusion therapy within extended timeframes, as well as for patients with unknown stroke onset times. Nevertheless, the inclusion of MRI in the acute stroke workflow should only be contemplated if centers can attain comparable levels of velocity and efficiency in triaging as those now achievable with CT-based imaging.
13. Yuenet al., (2022)	Prospective study	Bedside neuroimaging is obtained using portable magnetic resonance imaging (pMRI) at a very low magnetic field intensity of 0.064 T for 50 confirmed	The objective of this study is to conduct a comprehensive assessment of pMRI's effectiveness in visualizing cerebral infarction	• Low-field pMRI identified infarctions in 45 out of 50 individuals, accounting for 90% of the sample. These infarctions were

		patients with ischemic stroke, providing actionable results.	and its practical use in the treatment of ischemic stroke.		located in various areas of the brain, including the cortex, subcortex, and cerebellum. Records included lesions as small as 4 mm. On T2-weighted, fluid-attenuated inversion recovery, and diffusion-weighted imaging sequences, infarcts were seen as regions of enhanced brightness. Stroke volume data showed consistency across low-field pMRI and traditional high-field MRI studies, as well as uniformity across different pMRI sequences. At the time of discharge, there was a significant association between the functional outcome and the stroke volume as determined by low-field pMRI. These results open the door for the use of low-field pMRI in resource-constrained environments by confirming its efficacy in generating diagnostically significant stroke pictures.
14. Zhang et al., (2022)	Prospective study	A total of sixty-five consecutive patients who had either a transient ischemic attack or a recent ischemic stroke were recruited. Every patient who was registered got standard magnetic resonance imaging scans and cross-sectional scans of the narrowed middle cerebral artery vascular	This research uses high-resolution magnetic resonance imaging to evaluate the characteristics and diagnostic utility of atherosclerotic plaques in patients with acute stroke and middle cerebral artery (MCA) stenosis.	•	• The group of people with symptoms showed smaller lumen area (LA) (P=0.027), larger plaque area (P<0.001), larger remodelling index (P<0.001), more superior/posterior plaques (P=0.001), more prominently enhanced plaques (P<0.001), and more PR patterns (P<0.001) in the

		wall. The study evaluated the arterial wall characteristics and location, degree of enhancement, and patterns of plaque remodeling in the stenotic middle cerebral artery (MCA) between two groups of patients: symptomatic (n=30) and asymptomatic (n=35).		stenotic MCA than the group of people without symptoms. Logistic regression study revealed that the size of the plaque, patterns of remodeling, luminal area in the narrowed middle cerebral artery, degree of enhancement, and location of the plaque were all factors that predicted the occurrence of acute stroke. The predictive value of the stenotic MCA's plaque area and LA, together with the degree of plaque augmentation, was shown to be ideal (area under the curve = 0.927). • A greater extent of plaque deposition and reduced luminal area in the narrowed middle cerebral artery (MCA), along with prominent augmentation of the plaque, might suggest an increased susceptibility of the patient to experiencing a sudden onset of stroke.
15. de Havenon et al., (2023)	Retrospective study	In order to identify individuals with acute ischemic stroke (AIS) who presented to an emergency department (ED) within 6 hours after sustaining abrupt neurological symptoms that resulted in a "brain attack" code, researchers performed a retrospective study. Before fast MRI became available, we covered consecutive patients from January 2012 to	To assess the impact of rapid magnetic resonance imaging (MRI) scans on the expenses and duration of hospitalization for patients with acute ischemic stroke (AIS).	• They recorded a total of 408 instances of brain attack activations, with an average age of 62.1 ± 17.6 years and a male population of 47.8%. Specifically, there were 257 activations in the CTP cohort and 151 activations in the MRI cohort. The discharge diagnostic indicated that 193 out of 408 patients (47.3%) had experienced an ischemic stroke.

		September 2015. This patient group had CT perfusion (CTP), and we compared it to a different patient group that underwent fast MRI between October 2015 and May 2018. They used IPW, or inverse probability weighting, to make sure that each cohort was balanced.		Following the process of patient matching, we discovered notable decreases in overall cost (18.7% reduction, 95% confidence interval 35.0 to 2.4, p = 0.02) and hospital length of stay (17.0% reduction, 95% confidence interval 31.2 to 2.8, p = 0.02) for the MRI group, compared to the CTP group. However, there was no difference in emergency department length of stay (p = 0.74) between the two cohorts. • While these findings are early and serve to generate hypotheses, this research revealed that implementing a fast MRI strategy for patients experiencing brain attacks in the emergency department resulted in a significant 18.7% decrease in overall direct costs and a 17% decrease in hospital length of stay.

Fifteen studies met our eligibility criteria. The studies were published between 2014 and 2023. Six of the included studies were retrospective. Four were prospective, one single-center study, one systematic review study and three were literature review studies. The studies were conducted on patients suffering from acute ischemic stroke. The detection rates of ischemic lesions within three hours after start by CT and DWI were studied by Mitomi et al. (2014). Thirty-one patients with an anterior area stroke who had CT and DWI within three hours of the stroke's start made up the research group. The CT–Alberta Stroke Program Early CT Score (ASPECTS) and DWI–ASPECTS were used to evaluate the lesions seen on CT and DWI, and detection rates were compared for each ASPECTS area. Compared to CT, the DWI had a greater detection rate of ischemic lesions (76.9% vs. 30.0%). There was no correlation found between the DWI-ASPECTS and CT-ASPECTS scores. Ischemic lesions were seen in the lentiform nucleus (43.8% vs 20.0%), insula (59.2% for DWI vs 15.4% for CT), and the middle cerebral artery's M1 (30.8% vs 6.9%), M2 (50.8% vs 6.2%), M3 (28.5% vs 3.1%), M4 (32.3% vs 6.9%), M5 (48.5% vs 10.8%), and M6 (31.5% v 4.6%) sections. With the exception of the internal capsule and caudate head, DWI found ischemia lesions much more often than CT did in all ASPECTS locations.

Another study by Nael et al. (2014), described the technical specifics and provided a personal description of our clinical experience with this strategy. Sixty-two patients met the criteria for inclusion. Twenty-two people got repeat MRI scans, totaling 84 MRIs for the research. Diagnostic picture quality was obtained in 90% of neck M.R. angiography, 96% of brain M.R. angiography, 100%

of diffusion-weighted imaging, 98% EPI-gradient remembered echo, and 94% of dynamic susceptibility contrast perfusion scans, with interobserver agreements (k) ranging from 0.64 to 0.84. Ninety-nine people (95%) had an acute infarction. The EPI-fluid attenuation inversion recovery imaging findings, as well as the dynamic susceptibility contrast-Tmax mismatch classification detection, demonstrated strong interobserver agreement. Both observers discovered 13 acute cerebral hemorrhages using EPI-gradient recalled echo. Individuals with acute ischemic stroke may be assessed using a realistic 6-minute multimodal magnetic resonance approach with satisfactory diagnostic quality. It may result in much shorter scan times than the multimodal computed tomography approach.

In addition, Manwani et al. (2019) identified 432 patients admitted to Hartford Hospital with a focal neurological impairment in 2014 and obtained a CT head and an MRI brain to explore the relationship between time to MRI and duration of hospital stay. When patients who had an MRI within 12 hours of admission were compared to those who had one after 12 hours, there was a statistically significant difference in duration of hospital stay (early MRI group: 3 days (1.8, 4.9) against four days (2.6, 7.0). According to the research, having a brain MRI conducted within 12 hours of admission helps with stroke assessment and shortens hospital stays. It demonstrates the cost-effectiveness of MRI in ischemic stroke patients.

Ko et al. (2014) conducted research in which patients with acute ischemic stroke who exhibited relevant lesions on MR-diffusion weighted imaging (DWI) and were hospitalized at one of the 14 participating centers within seven days of the stroke's onset were included. Patients with two or more U.Ds had the highest one-year stroke recurrence rate (11.8%), followed by LAA (7.30%), C.E. (5.60%), and SVO (2.50%). Despite various limitations, this research demonstrated that the MAGIC technique is practical and may contribute to the clinical classification of stroke subtypes.

Furthermore, Simonsen et al. (2015) evaluated the proportion of DWI-positive and negative strokes and identified the factors that lead to DWI negativity. It was also determined how effective PWI was in verifying the diagnosis of ischemic stroke. Following acute magnetic resonance imaging, 569 consecutive patients got intravenous tissue-type plasminogen activator therapy. In 518 instances, a DWI lesion was evident. Thirty-three of forty-seven individuals who tested negative for DWI had a significant PWI lesion. Four-stroke mimics were treated with intravenous tissue-type plasminogen activator, with one patient having a DWI lesion. Thus, DWI-negative status was found in 8% of all stroke patients. The combination of DWI and PWI resulted in a sensitivity of 97.5% in identifying ischemic stroke. Less severe strokes, location in the posterior circulation, a longer interval between start and scan, and better 90-day outcomes were all associated with DWI negative. DWI-negative was a more probable cause of small-vessel disease. The combination of DWI and PWI before intravenous tissue-type plasminogen activator confirms the diagnosis in 97.5% of all ischemic strokes.

Luo et al. (2015) compared susceptibility-weighted imaging (SWI) to perfusion-weighted imaging (PWI) in detecting the ischemic penumbra in stroke patients with acute cerebral infarctions. When measuring ischemia penumbra, there was no noticeable difference between the DWI-MTT and DWI-SWI mismatches. Among the eighteen patients with cerebral infarction, eleven (61%) exhibited the susceptibility vessel sign (SVS) in suspected stroke. Ten (91%) of the eleven SVS-positive patients obtained MRA findings that showed stenosis or occlusion in the affected arteries. The presence of damaged vessels or thrombus in the affected vessels was significantly associated with the SVS on SWI. When measuring ischemic penumbra in stroke patients with cerebral infarction, DWI-SWI mismatch is a useful indicator. SWI can detect thrombus in affected arteries and guide intra-arterial thrombolytic treatment.

Khalil et al. (2016) examined fifty-seven patients with clinical symptoms of infratentorial stroke using STEAM-DWI, high-resolution EPI-DWI, and low-resolution EPI-DWI. The sensitivity of stimulated echo acquisition mode diffusion-weighted imaging (STEAM-DWI) to ischemic stroke was compared to echo-planar imaging diffusion-weighted imaging (EPI-DWI) in the infratentorial compartment. The median time between symptom onset and imaging was 24 hours. STEAM-DWI concurred with LR-DWI in 89.5% of instances and HR-DWI in 89.5%. STEAM-DWI exhibited less intraparenchymal artifacts (1/57) than HR-DWI (44/57) and LR-DWI (41/57). Ischemia was present in 87% of LR-DWI patients, 93% of HR-DWI cases, and 89% of STEAM-DWI cases. Interobserver agreement was favorable for STEAM-DWI. Compared to the best presently available M.R. sequence for identifying ischemia (HR-DWI), STEAM-DWI has fewer artifacts and is as sensitive to infratentorial stroke.

According to Nagaraja et al. (2020), there was a 26.5% prevalence of DWIR in studies based on DWI and 6% in studies based on FLAIR/T2. Tissue plasminogen activator (t-PA) or endovascular therapy used alone or in combination, earlier t-PA treatment, a shorter time to endovascular therapy following MRI, and no or less severe perfusion deficit within the DWI lesion were all associated with DWIR. In six out of seven studies, DWIR was linked to both long-term outcome (defined as NIHSS score ≤1, improvement in the NIHSS score ≥8 points, or modified Rankin Scale score up to ≤2 at 30 or 90 days), likely as a result of reperfusion, and early neurologic improvement (defined as improvement in the NIH Stroke Scale (NIHSS) score by 4 or 8 points from baseline or NIHSS score 0 to 2 at 24 hours after treatment or at discharge or median NIHSS score at 7 days).

Meng et al. (2023) developed a multispectral imaging system that may predict stroke start time by combining rapid quantitative T 2 mapping with high-resolution 3D magnetic resonance spectroscopic imaging (MRSI) to capture multifactorial biochemical changes inside stroke lesions. T2 and lactate were evident in both groups, while choline and NAA were in lower concentrations. Changes in T2, NAA, choline, and creatine signals were all associated with illness duration in all individuals. Predictive models of stroke onset time that include information from MRSI and T 2 mapping performed the best. The suggested multispectral imaging technique uses a mix of biomarkers to detect early pathological alterations following stroke in a clinically relevant time frame, improving the evaluation of cerebral infarction length.

Furthermore, Shah et al. (2015) provided evidence on the value of rapid multimodal MRI screening in patients experiencing acute stroke prior to thrombolysis. Intravenous tissue plasminogen activator (IV tPA) treatment was administered to 157 patients between 2012 and 2013 for acute ischemic stroke (AIS). 135 individuals, or 86% of the total, underwent magnetic resonance imaging (MRI). DTN time dropped by 40% throughout this time, with a median of 55 minutes in the latter half of 2013 ($p < 0.0001$) compared to 93 minutes in the first half of 2012. Furthermore, from 13.0% to 61.5% ($p < 0.00001$), the proportion of treated patients with a DTN duration of 60 minutes or fewer rose fourfold. The amount of time needed to move patients from the entrance to the MRI room decreased in proportion to the reduction in DTN time. Clinical or demographic variables did not vary (p 5 = 0.21–0.76). Giving intravenous tissue plasminogen activator (IV tPA) to patients diagnosed with acute ischemic stroke (AIS) within national benchmark timeframes is both feasible and feasible, with magnetic resonance imaging (MRI) acting as the principal screening method.

Vilela et al. (2017) conducted a literature review on the use of computed tomography (CT) and magnetic resonance (MR) imaging methods, including CT angiography and MR angiography. Imaging is critical in identifying whether patients are candidates for acute ischemic stroke treatment. Depending on what is available locally, imaging the parenchyma and blood arteries using either CT or MRI is essential. The pathophysiology of a stroke may be precisely understood with the use of sophisticated computed tomography (CT) and magnetic resonance imaging (MRI) techniques, such as assessments of artery collateral status and core/penumbra mismatch. Personalized physiological imaging ought to make it possible to pick patients more precisely for therapy both during and after the therapeutic phase. Regardless of the length of time since the stroke or the success of revascularization, smaller core sizes and robust collateral circulation are linked to better results, whereas malignant DWI profiles, the absence of a penumbra, and weak collateral circulation are linked to worse outcomes.

Furthermore, Vert et al. (2017) discovered that MRI showed a greater sensitivity for detecting microbleeds over an extended period of time as well as acute and chronic ischemia lesions. Still, CT is the most useful and often used first brain imaging technique. A non-invasive study of the brain's blood vessels should be included in the patient's initial imaging evaluation, even though a non-enhanced CT or T2* MRI sequence without bleeding signs is sufficient to decide whether intravenous treatment is appropriate within the first 4.5 hours following a stroke. This is particularly significant when mechanical thrombectomy is being considered. Using multimodal MRI for advanced imaging may improve the accuracy of identifying and describing ischemic strokes. It may be considered a feasible alternative to CT scans, especially for identifying individuals who may benefit from acute reperfusion treatment over longer periods, as well as for patients with uncertain stroke start timings. However, the use of MRI in the acute stroke process should only be considered if centers can achieve similar levels of triage velocity and efficiency as those now achieved with CT-based imaging.

Yuen et al. (2022) performed a thorough evaluation of pMRI's efficiency in imaging cerebral infarction and its practical use in the treatment of ischemic stroke. Low-field MRI detected infarctions in 45 of 50 patients, accounting for 90% of the sample. These infarctions occur in many parts of the brain, including the cortex, subcortex, and cerebellum. Lesions as small as 4 mm were reported. Regions of elevated brightness on T2-weighted, diffusion-weighted, and fluid-attenuated inversion recovery imaging sequences were used to identify infarcts. The findings of the stroke volume analysis were comparable to low-field pMRI and traditional high-field MRI investigations and held true across several pMRI sequences. The degree of the stroke and the functional outcome at discharge were highly connected with the stroke volumes assessed by low-field pMRI. These findings support low-field pMRI's ability to provide diagnostically valuable stroke images, paving the way for its use in resource-constrained scenarios.

Zhang et al. (2022) investigated the features and diagnostic significance of atherosclerotic plaques in patients with middle cerebral artery stenosis (MCA) and acute stroke using high-resolution magnetic resonance imaging. Comparing the stenotic MCA of individuals with symptoms to the control group, the symptomatic group showed smaller lumen area (P=0.027), bigger plaque area (P<0.001), higher remodeling index (P<0.001), more superior/posterior plaques (P=0.001), more markedly enhanced plaques (P<0.001), and more PR patterns (P<0.001). The chance of an acute stroke was shown to be predicted by many factors, including the location of the plaque, its degree of enhancement, luminal area in the constricted middle cerebral artery, remodeling patterns, and plaque size. These findings were confirmed by a logistic regression analysis. Plaque size, LA, and degree of plaque augmentation in the stenotic MCA were shown to have an ideal predictive value (area under the curve = 0.927). Significant plaque augmentation, together with a higher degree of plaque deposition and a decreased luminal area in the constricted middle cerebral artery (MCA), may suggest that the patient is at a higher risk of experiencing a stroke with a rapid start.

De Havenon et al. (2023) conducted a final research to analyze the influence of quick magnetic resonance imaging (MRI) scans on hospitalization costs and duration for patients with acute ischemic stroke (AIS). The study found 408 cases of brain attack activation, with an average age of 62.1 ± 17.6 years and a male population of 47.8%. Specifically, there were 257 activations in the CTP group and 151 in the MRI cohort. The discharge diagnosis revealed that 193 of 408 patients (47.3%) had suffered an ischemic stroke. Following the patient matching procedure, we observed that the MRI group had a significantly lower total cost (18.7% reduction, 95% confidence range 35.0 to 2.4, p = 0.02) and hospital length of stay (17.0% reduction, 95% confidence interval 31.2 to 2.8, p = 0.02) than the CTP group. However, there was no difference in emergency department duration of stay (p = 0.74) between the two groups. While these findings are preliminary and serve to generate hypotheses, this study found that implementing a fast MRI strategy for patients experiencing brain attacks in the emergency department resulted in a significant 18.7% reduction in overall direct costs and a 17% reduction in hospital length of stay.

DISCUSSION

The present systematic review aimed to explore the clinical efficacy, sensitivity, and outcomes of MRI in diagnosing patients with ischemic stroke. Fifteen studies met our eligibility criteria. The studies were published between 2014 and 2023. Mitomi et al., (2014) showed that the detection rate of ischemic lesions was higher on DWI than on CT. There was no correlation found between the DWI-ASPECTS and CT-ASPECTS scores. Ischemic lesions were seen in the lentiform nucleus (43.8% vs 20.0%), insula (59.2% for DWI vs 15.4% for CT), and the middle cerebral artery's M1 (30.8% v 6.9%), M2 (50.8% v 6.2%; P 5.006), M3 (28.5% v 3.1%), M4 (32.3% v 6.9%), M5 (48.5% v 10.8%), and M6 (31.5% v 4.6%) sections. With the exception of the internal capsule and caudate head, DWI found ischemia lesions much more often than CT did in all ASPECTS locations. These findings conflict with those of a prior research that looked at stroke patients that occurred within seven hours of start and found that the detection rates of ischemia (DRI) using DWI-ASPECTS and CT-ASPECTS were comparable (Barber et al., 2005). Within three hours after a stroke, a greater DRI with DWI-ASPECTS may be associated with many variables. First, in animal models, DWI may often show ischemia alterations sooner than CT; intensity changes can be seen on DWI a few seconds after an artery is occluded (Rother et al., 1996).Second, DWI provides better ischemia detection capabilities since the ASPECTS instrument concentrates on anterior circulation.Oppenheim et al. (2000) computed the number of instances in whom initial DWI results were negative and follow-up DWI results were positive. They also discovered that 2% of anterior circulation stroke patients on first DWI results were falsely negative.On the other hand, Urbach et al. (2000) discovered that patients with anterior circulation stroke who had positive follow-up CT scans had a 54% false-negative rate on first CT scans.Third, the power to identify hyperacute ischemia in CT and DWI done within three hours of stroke onset was compared in a research evaluated by Wardlaw and Mielke (2005) using procedures that differed from the current investigation.t

Furthermore, Nael et al. (2014) shown that evaluating persons with acute ischemic stroke may be achieved using a convenient 6-minute multimodal magnetic resonance (M.R.) approach that produces satisfactory diagnostic results. It may result in far reduced scan durations compared to the multimodal computed tomographic approach. The use of advanced MR scanners with improved gradient performance and fast imaging techniques, such as generalized autocalibrating partially parallel acquisition, allows for the acquisition of high-resolution CE-MRA images of the entire head and neck. These images have voxel sizes smaller than a millimeter and can be obtained in approximately 20 seconds, as demonstrated in this study and others. Although the spatial resolution of the CE-MRA approach is lower than that of time-of-flight, it seems to be adequate for accurately assessing the proximal cerebral arteries (Nael et al., 2007; Phan et al., 2001). According to Manwani et al. (2019), doing a brain MRI within 12 hours of arrival may aid in evaluating strokes and reduce the duration of hospitalization. The study offers proof of the cost-effectiveness of MRI in diagnosing ischemic stroke. The provision of immediate treatment for acute stroke continues to be a significant financial challenge, and the length of stay (LOS) in the hospital is a key factor in determining the expenses paid. Decreasing the length of stay (LOS) results in reduced medical expenses for both hospitals and patients. Moreover, stroke is a significant contributor to disability, and a considerable number of stroke patients are sent to rehabilitation institutions after their release from the hospital. Obtaining a brain MRI at an early stage enables the patient to move more quickly from the hospital to home or rehabilitation centers, facilitating a speedier start to treatment. Subsequently, research has shown that this approach increases the likelihood of successful recuperation (Arobix et al., 2012; Paolucci et al., 2000). Furthermore, Ko et al. (2014) showed that the MAGIC technique is feasible and can assist in categorizing stroke subtypes in the clinic, despite certain limitations. The use of MAGIC did not enhance the consistency among raters in categorizing subtypes, in contrast to earlier research findings. Nevertheless, we saw a little enhancement in ICC (Intraclass Correlation Coefficient) while utilizing MAGIC in the validation research population, as reported by Ay et al. (2005) and Meschia et al. (2006). The rise in ICC using MAGIC may be linked to the algorithm and decreased uncertainty due to the inclusion of three distinct categories (LAA-LC, LAA-BR, and LAA-NG), which likely allows most clinicians to assign stroke subtypes more consistently. The distribution of stroke subtypes, with the exception of UD, did not change significantly between MAGIC and other hospital-based stroke registries. However, the frequency of CE subtype was comparatively greater in MAGIC (Deleu et al., 2011; Lee et al., 2001). Nevertheless, the distribution of stroke subtypes in studies conducted within communities varied. Specifically, the subtype known as LAA was less prevalent, ranging from 9.3% to 20.9%. On the other hand, the subtypes SVO and CE were more prevalent, ranging from 20.5% to 27.0% and 25.6% to 30.2%, respectively (Grau et al., 2001; Hajat et al., 2011).

Simonsen et al., (2015) shown that using both diffusion-weighted imaging (DWI) and perfusion-weighted imaging (PWI) prior to administering intravenous tissue-type plasminogen activator (tPA) results in a diagnostic confirmation rate of 97.5% for all cases of ischemic strokes. Consistent with these results, a prior investigation discovered that DWI had a sensitivity of 90.4% in detecting strokes (Brunser et al., 2013), whereas a smaller research revealed a false-negative rate of 5.8% when imaging was conducted within 48 hours (Oppenheim et al., 2000). In their study, Luo et al. (2015) discovered that the discrepancy between DWI-SWI is a reliable indicator for assessing the ischemic penumbra in stroke patients with cerebral infarction. Susceptibility-weighted imaging (SWI) has the capability to identify thrombus in the afflicted blood arteries, making it a valuable tool for directing intra-arterial thrombolytic treatment. This discovery aligns with other studies indicating that discrepancies between DWI-SWI and DWI-PWI have comparable predictive capabilities for stroke progression (Kao et al., 2012; Viallon et al., 2010). SWI also displays large veins in cases of acute infarction, which may indicate an elevation in the ratio of deoxyhemoglobin to oxyhemoglobin due to reduced blood flow-induced rise in oxygen extraction fraction (Mittal et al., 2009). The reliability and suitability of SWI as a quantitative assessment technique for deep cerebral veins has been reported by Xia et al. (2013). Furthermore, Kahlil et al. (2016) found that STEAM-DWI had a similar sensitivity for identifying infratentorial stroke and less artifacts than HR-DWI, the best MR sequence for diagnosing ischemia. In contrast to spin-echo EPI sequences, STEAM sequences showed lower signal-to-noise ratios; yet, we found that STEAM-DWI and both HR-DWI and LR-DWI were highly concordant in detecting ischemia. The diagnostic accuracy of STEAM-DWI in a clinical setting cannot be sufficiently determined by the agreement between the DWI sequences alone. This is due to the fact that it leaves open the possibility that the patients' identities were misidentified by one of the two genomes under comparison. Thus, we evaluated and compared the true sensitivities of the various DWI sequences using a definitive diagnosis of infratentorial infarction, which had been used as a benchmark in prior comparable studies, derived from follow-up imaging and other clinical data (Oppenheim et al., 2000; Chalela et al., 2007).

Shah et al. (2015) state that using magnetic resonance imaging (MRI) as the standard screening method, it is feasible and convenient to administer intravenous tissue plasminogen activator (IV tPA) to acute ischemic stroke (AIS) patients consistently and quickly within the expected time limits set by the country. The techniques used in the SMART (Screening with MRI for Accurate and Rapid Stroke Treatment) Study to reduce DTN (Door-to-Needle) time may be generally applicable to other healthcare settings. The results of this investigation, which used screening MRI, are consistent with those published by other large medical facilities that use CT as the primary screening method. These include the time reached for DTN (Door-to-Needle) and the percentage of patients receiving intravenous tissue plasminogen activator (IV tPA) within 60 minutes (Ford et al., 2012). Comparing the results of the AHA/ASA Get With the Guidelines–Stroke participating hospitals collectively reported by Fonarow et al. (2014), it was shown that the reduction in DTN time and the increase in the proportion of patients treated within 60 minutes were more significant. Our hospitals' lean process assessments showed that the door-to-imaging time has the highest possibility for changes to minimize DTN time, even though another study suggests that the prolonged imaging-to-needle time is the primary cause causing delay in DTN time (Sauser et al., 2014).

In addition, Vielela et al. (2017) determined that enhanced stroke CT and MRI procedures, which assess artery collateral status and core/penumbra mismatch, provide accurate insights into the specific stroke pathogenesis. Utilizing personalized physiological imaging may enhance the process of selecting patients for therapy, both inside and beyond the typical timeframe for therapeutic intervention. A favorable result is linked to the existence of a small core and well-developed collateral circulation. Conversely, the existence of a malignant DWI profile, the lack of penumbra, and the absence of collateral circulation are independently linked to a negative prognosis, regardless of the period since the stroke occurred and the outcomes of revascularization. According to Schellinger et al. (2010), DWI-MRI is the most efficient method for evaluating the infarct core, with both a high sensitivity (91–100%) and specificity (86–100%). As mentioned before, DWI lesions may sometimes be reversed. with a frequency ranging from 8-44% depending on factors such as the length of the stroke, the timing of reperfusion, and the first fall in ADC magnitude (Kranz et al., 2009). Nevertheless, it is important to note that the potential reversibility mentioned may not always result in improved clinical outcomes or influence treatment decisions. The actual reversibility observed in the DEFUSE-EPITHET trial analysis was found to be residual, with only 6.7% of cases showing reversibility and a median volume of 2.3 cm3 (Campbell et al., 2012).

Vert et al. (2017) state that MRI is more sensitive in detecting microbleeds over the long term as well as acute and chronic ischemic lesions. However, CT continues to be the most useful and popular first brain imaging technique. While a non-enhanced CT or T2* MRI sequence without bleeding evidence is adequate to determine a patient's eligibility for IV treatment within the first 4.5 hours following a stroke, it is highly advised to include a non-invasive assessment of the cerebral blood vessels in the patient's initial imaging evaluation. For patients with an uncertain diagnosis and a greater risk associated with IV t-PA therapy, doing an MRI rapidly may lead to better clinical results compared to a CT scan. Although case studies have shown the safety of IV t-PA even when there is a high prevalence of stroke mimics (Chernyshev et al., 2010; Obaid et al., 2024), improved diagnosis accuracy could result in quicker and safer therapy in the appropriate direction, even individuals who do not have an acute stroke. PWI, or perfusion-weighted imaging, is not necessary for choosing between IV t-PA or endovascular treatment. However, it can be used for various purposes such as ruling out stroke mimics, identifying high-risk patients after a transient ischemic attack, determining the specific type of stroke and its hemodynamics, confirming the presence and location of a blocked blood vessel, assessing vasospasm, deciding if blood pressure management is needed, guiding decisions on whether to transfer the patient to an intensive care unit, and predicting prognosis, especially in cases of large "malignant" perfusion patterns at early stages, where the risks of treatment may outweigh the benefits (Lev, 2012; Tang et al., 2023).

The study conducted by Yuen et al. (2022) discovered a strong correlation between stroke severity and functional outcome at discharge with low-field pMRI stroke volumes. Recent research by Sheth et al. (2021) has shown that low-field pMRI is both safe and achievable. When evaluating acute stroke and acute neurological deterioration, it is crucial to identify and exclude the presence of cerebral bleeding by neuroimaging. A previous study by Mazurek et al. (2021) indicates that low-field pMRI has practical use in this context. So far, there has been little evaluation of this method for detecting ischemic stroke, which is responsible for 87% of all strokes. A bedside device's capability to confirm the existence and assess the severity of cerebral infarction may establish a clinical diagnosis, eliminating the need for supplementary procedures and speeding up the process of prioritizing and treating patients. Moreover, the availability of a portable and convenient solution that can validate diagnoses will greatly enhance the provision of medical treatment in many contexts with limited resources for stroke assessment, such as inpatient units, mobile vehicles, and low-resource environments (Ogbole et al., 2018).

In their study, Zhang et al. (2022) found that a greater plaque area and smaller luminal area (LA) in the narrowed middle cerebral artery (MCA), together with noticeable plaque enhancement, might suggest an increased susceptibility to acute stroke in patients. Arterial walls, being dynamic organs, have the ability to alter their structure via a process called remodelling in order to compensate for the narrowing of the blood vessel following the creation of plaque (Miao et al, 2009). Prior research has found two distinct types of remodeling: PR and NR. PR is seen as an insecure remodeling pattern that leads to vessel expansion, whereas NR constricts the vessel and is recognized as a rather stable kind of remodeling. Studies on coronary and carotid arteries have shown that symptomatic individuals had a higher resistance index (RI) and a greater frequency of PR patterns compared to asymptomatic patients (Hardie et al., 2007). The outcomes of this investigation were in line with the earlier studies mentioned above. The possibility exists that PR's impact on vascular dilation increases the pressure in the narrowed middle cerebral artery (MCA). Consistent with this, the group of individuals displaying symptoms in our research had a greater prevalence of PA and a reduced presence of LAMNL compared to the group of individuals without symptoms. Several researchers have shown comparable findings (Shi et al., 2012). Nevertheless, in this investigation, the group experiencing symptoms had a lower LA (lumen area) in the reference slice of the MCA (middle cerebral artery) compared to the group without symptoms. However, there was no significant difference in the NWI (normalized wall index) at the reference location. Consequently, after adjustments made according to the NWI at the reference location, the vascular wall characteristics were found to be in concurrence. The NWI, or Normalized Wall Index, enhances the capacity to compare vascular wall characteristics across various patients and vessel regions. This is achieved by mitigating the impact of variations in vessel wall thickness on the WA, or Wall Area, measurement (Jia et al., 2017).

According to de Havenon et al. (2023), the discharge diagnostic for 193 out of 408 cases (47.3%) was ischemic stroke. Following the process of matching patients, researchers discovered significant decreases in both the overall cost and length of hospital stay for the MRI group, but there was no change in the length of stay in the emergency department compared to the CTP group. Although there are some limitations that are discussed in detail below, the preliminary analysis results demonstrate that a rapid MRI protocol can be useful in quickly evaluating patients suspected of having AIS. This protocol can help reduce costs and length of stay, and therefore further research is needed to confirm these findings. Previous studies using decision-analytic and simulation models have shown comparable results, as did a particular study examining the expenses associated with CT and MRI imaging techniques for secondary stroke prevention (Liberman et al., 2021; Martinez et al., 2021).

CONCLUSION

Brain and vascular imaging are necessary for the emergency evaluation of individuals who may have had a stroke. The first imaging test might be an MRI or CT scan. Even though MRI is more sensitive to the presence of microbleeds and acute and chronic ischemia lesions, CT is still the most useful and common first brain imaging examination. Although a non-invasive intracranial vascular study is strongly advised during the initial imaging evaluation of the acute stroke patient, especially if mechanical thrombectomy is being considered, a non-enhanced CT or T2* MRI sequence showing no hemorrhage is sufficient for determining eligibility for intravenous treatment within the first 4.5 hours after stroke onset. Multimodal MRI, a form of advanced imaging, has the potential to improve the diagnosis and characterization of ischemic strokes. It is a viable alternative to CT when selecting patients for acute reperfusion therapy during prolonged time windows or when the patient's time of stroke onset is unknown. MRI should only be taken into account in the acute stroke process, however, if centers can attain the same level of speed and triaging effectiveness as CT-based imaging at this time.

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