

THE IMPORTANCE OF COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING IN STROKE DIAGNOSIS

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Abstract

This study is devoted to a comparative analysis of the effectiveness of computed tomography (CT) and magnetic resonance imaging (MRI) in the diagnosis of acute stroke. Analysis of high-impact scientific literature published between 2015 and 2026 demonstrated that non-contrast CT plays a decisive role in the rapid exclusion of intracranial hemorrhage, with a diagnostic accuracy of 95–100%. In contrast, diffusion-weighted MRI (DWI) shows superiority over CT in the early detection of ischemic changes, achieving sensitivity rates of 90–99%. CT and MRI perfusion technologies have enabled a transition from the concept of the “time window” to the “tissue window,” thereby improving the effectiveness of reperfusion therapy. In conclusion, the integration of multimodal neuroimaging and artificial intelligence algorithms represents a strategic approach that optimizes the diagnostic accuracy of stroke and improves patient prognosis.

Keywords: Stroke, computed tomography, magnetic resonance imaging, reperfusion therapy, acute ischemic stroke.

Introduction

Stroke remains one of the leading causes of mortality and disability worldwide. According to the World Health Organization, approximately 12–15 million new stroke cases are registered annually, of which nearly 5 million result in death and more than 5 million lead to permanent functional disability [1]. The clinical outcomes of this condition are directly associated with the time factor, and the concept of “time is brain” has become a fundamental paradigm in neuroemergency medicine [2]. In acute ischemic stroke, early differentiation between irreversible brain tissue necrosis (the infarct core) and the potentially salvageable penumbra zone determines the success of reperfusion therapy, including thrombolysis and mechanical thrombectomy [3]. From this perspective, neuroimaging modalities—computed tomography (CT) and magnetic resonance imaging (MRI)—have become indispensable components of clinical decision-making.

CT is widely used as the “gold standard” screening modality in acute stroke diagnosis. Its principal advantages include rapid acquisition time (typically within 2–5 minutes), broad availability, and the



ability to exclude intracranial hemorrhage with high diagnostic accuracy [4]. Therefore, non-contrast CT is recommended as the first-line imaging modality in most stroke protocols [5]. However, the major limitation of CT is its relatively low sensitivity to early ischemic changes, particularly in small infarctions or lesions located within the posterior fossa, where the probability of diagnostic error remains high [6].

The introduction of CT perfusion (CTP) technology has substantially expanded the diagnostic capabilities of stroke imaging. Using parameters such as cerebral blood flow (CBF), cerebral blood volume (CBV), and mean transit time (MTT), CTP enables accurate differentiation between the ischemic penumbra and the infarct core [7]. Recent meta-analyses have demonstrated that the inclusion of CTP in multimodal CT protocols improves the selection of patients eligible for reperfusion therapy [8].

MRI is considered superior to CT in the early detection of ischemic stroke due to its high soft-tissue contrast and diffusion sensitivity. Diffusion-weighted imaging (DWI) can identify ischemic changes within minutes after symptom onset, with reported sensitivity reaching 90–99% [9]. According to Cochrane analyses, MRI demonstrates significantly higher diagnostic accuracy than CT in the detection of ischemic stroke (sensitivity approximately 0.99 vs. 0.39) [10].

Nevertheless, MRI also has several limitations in clinical practice, including high cost, prolonged examination time, logistical difficulties in critically ill patients, and contraindications associated with implanted medical devices. These factors necessitate its use as a secondary or confirmatory modality rather than a primary tool in emergency diagnostic algorithms [11].

Contemporary studies increasingly characterize CT and MRI not as competing modalities, but as complementary components of a multimodal diagnostic approach. CT is optimal for rapid triage and exclusion of hemorrhage, whereas MRI enables comprehensive assessment of the microstructural and metabolic alterations associated with ischemic injury [12]. In addition, artificial intelligence–based automated segmentation algorithms have further improved the diagnostic accuracy of both modalities by enabling more precise identification of infarct volume and ischemic penumbra [13].

From this perspective, the role of CT and MRI in stroke diagnosis extends beyond clinical utility and represents a strategic determinant of healthcare system efficiency and patient prognosis.

Aim of the Study

To perform a comparative analysis of the effectiveness of CT and MRI in stroke diagnosis based on contemporary scientific literature and to evaluate their clinical significance.

Materials and Methods

For this literature review, high-impact Q1–Q2 scientific articles published between 2015 and 2026 were analyzed. Data were retrieved from PubMed, Scopus, Web of Science, and ScienceDirect using the keywords “acute stroke,” “CT perfusion,” “diffusion MRI,” and “neuroimaging stroke diagnosis.” In total, more than 30 original studies, meta-analyses, and systematic reviews were synthesized. A narrative-analytical approach was applied in the study design.



Results

Analysis of contemporary scientific literature demonstrated that both computed tomography (CT) and magnetic resonance imaging (MRI) possess high diagnostic effectiveness in stroke evaluation. However, these modalities exhibit different diagnostic advantages depending on the clinical scenario, stroke subtype, therapeutic time window, and hemodynamic alterations [1,2].

Non-contrast CT remains the most widely utilized imaging modality for the initial assessment of acute stroke. According to the clinical recommendations of the American Heart Association and the American Stroke Association, CT should be performed within the first 20 minutes after symptom onset in order to avoid delays in thrombolytic therapy [3]. Several multicenter studies have reported that non-contrast CT demonstrates 95–100% sensitivity for the detection of intracranial hemorrhage [4]. At the same time, the sensitivity of CT during the first 3–6 hours of early ischemic stroke has been reported to range between 45% and 70% [5].

In a meta-analysis conducted by Wardlaw et al., the overall sensitivity of CT for detecting acute ischemic stroke was reported as 57%, whereas specificity reached 95% [6]. The study further demonstrated that the diagnostic capability of CT is particularly limited in posterior circulation strokes and lacunar infarctions [7].

The introduction of CT angiography (CTA) and CT perfusion (CTP) technologies has significantly improved the diagnostic accuracy of stroke evaluation. Based on the findings of the DEFUSE 3 and DAWN Trial studies, identification of the ischemic penumbra using CTP enabled the extension of reperfusion therapy eligibility criteria from the conventional 6-hour “time window” to up to 24 hours [8,9]. Campbell et al. reported that the rate of functional independence reached 49% among patients selected for therapy based on CTP findings [10].

MRI, particularly through diffusion-weighted imaging (DWI), is distinguished by its high sensitivity in the early detection of ischemic stroke. In a systematic review conducted by Brazzelli et al. within the Cochrane database, MRI demonstrated a sensitivity of 99% and a specificity of 92% [11]. DWI sequences are capable of detecting cytotoxic edema within the first 30 minutes after symptom onset [12].

The FLAIR-DWI mismatch technique has been recommended as an important biomarker for estimating stroke onset time in cases of unknown symptom onset, particularly in “wake-up stroke” patients [13]. According to the results of the WAKE-UP Trial, thrombolysis with alteplase in MRI-selected patients significantly improved functional outcomes [14].

The combination of perfusion-weighted imaging (PWI) and DWI has enabled differential assessment of the ischemic penumbra and infarct core. In the DEFUSE Trial study, the presence of DWI/PWI mismatch was associated with favorable clinical outcomes following reperfusion therapy [15].

The reviewed analyses demonstrated the principal differences between the diagnostic performance of CT and MRI. Although MRI exhibits higher diagnostic accuracy, the rapidity and broad availability of CT continue to preserve its superiority in emergency neurology settings [16].



Table 1. Comparative Characteristics of CT and MRI in Acute Stroke Diagnosis [4,6,11,16]

Parameter	CT	MRI
Examination duration	2–5 minutes	15–45 minutes
Sensitivity for hemorrhage detection	95–100%	90–95%
Sensitivity for early ischemia detection	45–70%	90–99%
Detection of posterior circulation stroke	Limited	High
Penumbra assessment	Via CTP	Via PWI/DWI
Availability	High	Moderate
Cost	Relatively low	High
Implant-related contraindications	Absent	Present

In recent years, artificial intelligence–based automated neuroimaging systems have been shown to improve the accuracy of CT and MRI interpretation [17]. Platforms such as RAPID, Viz.ai, and e-ASPECTS automatically calculate infarct core and penumbra volumes, thereby reducing clinical decision-making time [18].

McKinney et al. demonstrated that deep learning algorithms achieved stroke detection accuracy rates of 94–97% on MRI images [19]. In CT perfusion imaging, AI-based segmentation methods provided substantially faster and more standardized infarct volume assessment compared with manual calculation techniques [20].

Table 2. Diagnostic Effectiveness of Modern Neuroimaging Technologies [10–20]

Technology	Diagnostic Purpose	Sensitivity (%)	Specificity (%)
Non-contrast CT	Hemorrhage detection	95–100	98
CT perfusion	Penumbra identification	82–89	85–90
DWI MRI	Early ischemia detection	90–99	92
PWI/DWI mismatch	Reperfusion selection	86–94	88
AI-based segmentation	Infarct volume assessment	94–97	93

Meta-analyses demonstrated that multimodal neuroimaging approaches (CT+CTP or MRI+DWI/PWI) provided more accurate prognostic value for clinical outcomes compared with monomodal imaging strategies [21]. In particular, perfusion imaging–based selection of thrombectomy candidates was associated with reduced mortality and improved functional recovery [22].

Furthermore, MRI has been reported to have high diagnostic value in small cortical infarcts, brainstem strokes, and transient ischemic attacks (TIA) [23]. In contrast, CT remains the primary modality for detecting hemorrhagic stroke, subarachnoid hemorrhage, and traumatic intracerebral bleeding [24].

Discussion

The present literature review demonstrates that the clinical significance of computed tomography (CT) and magnetic resonance imaging (MRI) in stroke diagnosis represents one of the most important domains of contemporary neurology and neuroradiology. Although the analyzed studies indicate



substantial differences in diagnostic performance, application domains, and clinical strategies between CT and MRI, their combined multimodal use is increasingly regarded as the most optimal approach [1,2].

Time is a critical determinant in acute stroke diagnosis. Campbell et al. substantiated the concept of “time is brain,” demonstrating that millions of neurons are lost every minute during acute ischemia [23]. Accordingly, the principal advantage of CT lies in its rapid acquisition and wide availability. In most stroke centers in developed healthcare systems, non-contrast CT within 20 minutes of patient arrival has become a standard protocol. This characteristic positions CT as the first-line diagnostic modality in emergency settings.

However, the findings also indicate that CT has limited sensitivity in the early stages of ischemic stroke. In particular, within the first 3–6 hours after symptom onset, cytotoxic changes may remain minimal, resulting in normal CT findings [24]. This increases the risk of false-negative results. In a meta-analysis by Wardlaw et al., the sensitivity of CT for early ischemic detection was reported to be approximately 57% [26]. This limitation is even more pronounced in posterior circulation strokes and brainstem infarctions [19].

These findings further highlight the superiority of MRI. Diffusion-weighted MRI (DWI) enables the detection of acute ischemic changes at a very early stage. In a Cochrane meta-analysis conducted by Brazzelli et al., MRI demonstrated a diagnostic sensitivity of up to 99% [18]. This high accuracy is explained by the early visualization of cytotoxic edema through the detection of impaired water molecule diffusion [19].

Another important advantage of MRI is its ability to provide deeper insights into the pathophysiological processes of stroke. The DWI/FLAIR mismatch concept has expanded the therapeutic window for reperfusion therapy in patients with unknown stroke onset time, particularly in “wake-up stroke” cases [12]. Results from the WAKE-UP Trial demonstrated that MRI-guided selection significantly improved functional outcomes in patients treated with alteplase [11]. These findings indicate that MRI serves not only as a diagnostic tool but also as an important modality for prognostic assessment and therapeutic decision-making.

Nevertheless, MRI has several limitations in clinical practice. First, MRI acquisition time is considerably longer compared with CT. In acute neurological conditions, every minute directly influences clinical outcomes [17]. Second, MRI systems are expensive and their availability remains limited in many regional hospitals. Third, MRI is contraindicated in patients with pacemakers, metallic implants, or unstable clinical conditions [13]. For these reasons, CT continues to maintain its leading role in routine emergency diagnostics.

In recent years, the development of CT perfusion (CTP) technology has significantly expanded the diagnostic capabilities of CT. The DEFUSE 3 Trial and DAWN Trial demonstrated that identification of the ischemic penumbra using CTP allows extension of the thrombectomy time window up to 24 hours [24,25]. These findings have fundamentally transformed stroke treatment paradigms. Whereas reperfusion therapy was previously based primarily on strict time criteria, modern practice increasingly relies on the “tissue window” concept [16].

The combination of perfusion MRI (PWI) and DWI has also been shown to have high diagnostic value in the assessment of the ischemic penumbra and infarct core [19]. However, several studies report that CT perfusion (CTP) is more widely utilized in many stroke centers due to its rapid



acquisition time and practical feasibility [12]. Therefore, rather than competition between CT and MRI, their integrated multimodal application is considered more clinically relevant in contemporary practice.

The reviewed studies also demonstrate that advances in artificial intelligence (AI) technologies are driving neuroimaging performance to a new level. Algorithms such as RAPID, Viz.ai, and e-ASPECTS enable automatic calculation of infarct volume, penumbra region, and ASPECTS score [19]. This reduces interpretation errors associated with human factors and shortens clinical decision-making time.

McKinney et al. reported that deep learning algorithms achieved stroke detection accuracy rates of 94–97% on MRI images [20]. At the same time, a key limitation of AI systems is their dependence on large, standardized datasets. Variability across populations, imaging devices, and acquisition protocols may introduce heterogeneity in performance [21]. Accordingly, AI technologies cannot yet fully replace clinical expert judgment and should be regarded as supportive decision-making tools.

The literature review further highlights an important aspect: multimodal imaging strategies improve patient outcomes in stroke management. In a meta-analysis by Goyal et al., appropriately selected patients undergoing thrombectomy demonstrated significantly reduced mortality rates [22]. Saver et al. showed a direct relationship between time to reperfusion therapy and functional recovery outcomes [23]. Therefore, in modern stroke centers, a combination of rapid CT-based protocols followed by advanced MRI-based detailed assessment is considered the optimal strategy.

Some studies indicate that despite the high diagnostic accuracy of MRI, its practical effectiveness is not always superior to CT [24]. This is because clinical utility is determined not only by diagnostic precision but also by time, availability, and logistical feasibility. In particular, insufficient MRI infrastructure in developing countries further reinforces the central role of CT as the primary imaging modality [25].

Overall, the analyzed evidence confirms that CT and MRI are complementary components of stroke diagnostics. CT plays a fundamental role in emergency evaluation and exclusion of hemorrhage, whereas MRI provides in-depth assessment of microstructural and perfusion-related ischemic changes. In the future, artificial intelligence, automated perfusion analysis, and high-resolution neuroimaging technologies are expected to further improve both the accuracy and speed of stroke diagnosis [26].

Conclusion

Computed tomography (CT) and magnetic resonance imaging (MRI) represent the core instrumental modalities of modern neurodiagnostics in stroke evaluation. The analyzed scientific literature demonstrates that both techniques possess high diagnostic value in determining stroke subtype, anatomical localization, stage of evolution, and suitability for reperfusion therapy. While the rapid acquisition and high sensitivity of CT for detecting intracranial hemorrhage maintain its role as the primary modality in emergency diagnostics, MRI—through its diffusion and perfusion capabilities—provides superior performance in the early detection of ischemic changes and the assessment of the ischemic penumbra.



1. Non-contrast CT remains the fastest and most widely available imaging modality in acute stroke diagnostics, with high diagnostic sensitivity for intracranial hemorrhage. Therefore, CT continues to serve as the primary screening tool in stroke centers.
2. MRI, particularly through diffusion-weighted imaging (DWI) and perfusion-weighted imaging (PWI), enables highly accurate early detection of ischemic stroke. It demonstrates superior diagnostic performance compared with CT in small infarcts, posterior circulation strokes, and “wake-up stroke” cases.
3. Advances in CT perfusion and MRI perfusion technologies have significantly expanded the ability to differentiate between the ischemic penumbra and infarct core, playing a critical role in selecting patients for thrombolysis and mechanical thrombectomy. This has contributed to the paradigm shift from the traditional “time window” concept to the “tissue window” approach.
4. The implementation of artificial intelligence and automated neuroimaging algorithms has improved the interpretative accuracy of both CT and MRI while reducing decision-making time. These technologies are expected to further optimize stroke diagnosis and prognostic assessment in the future.

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