Current Research in MRI

Original Article

Fast Magnetic Resonance Diffusion-Weighted Imaging Versus Computed Tomography in Diagnosis of Hyperacute Ischemic Stroke

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Cite this article as: Musalah SK. Fast magnetic resonance diffusion-weighted imaging versus computed tomography in diagnosis of hyperacute ischemic stroke. *Current Research in MRI*, 2025;4(2):35-38.

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Received: August 29, 2025 **Accepted:** September 22, 2025 **Publication Date:** October 30, 2025

DOI: 10.5152/CurrResMRI.2025.25124

Abstract

Objective: Hyperacute ischemic stroke is a time-critical emergency that requires rapid and accurate diagnosis to enable timely intervention and improve outcomes. While non-contrast computed tomography (CT) is commonly used for initial evaluation due to its availability and speed, it has limited sensitivity for early ischemic changes, particularly in posterior circulation strokes. This study aimed to compare the diagnostic performance of fast diffusion-weighted imaging (DWI) and CT in the detection of hyperacute ischemic stroke within 6 hours of symptom onset.

Methods: This prospective cross-sectional study included 72 patients presenting to Azadi Teaching Hospital, Duhok, between June and November 2024 with acute stroke symptoms. After excluding hemorrhage via non-contrast CT, eligible patients underwent DWI within 6 hours of symptom onset. Demographic, clinical, and imaging data were recorded and analyzed using SPSS.

Results: Among the 72 patients (mean age 64.7 years; 51.4% male), all underwent DWI within a mean of 3.2 hours from symptom onset. Left-sided infarctions were most common (62.8%), followed by right-sided (31.9%) and bilateral lesions (4.1%). The middle cerebral artery was the most frequently affected territory (58.3%). Hypertension was the most prevalent risk factor (63.8%), followed by diabetes (44.4%) and heart disease (37.5%). Diffusion-weighted imaging detected acute ischemic lesions in 100% of patients, whereas CT detected lesions in only 37.5%. Computed tomography was particularly limited in detecting posterior circulation strokes.

Conclusion: Diffusion-weighted imaging demonstrated superior sensitivity compared to CT in the diagnosis of hyperacute ischemic stroke, particularly for posterior fossa lesions. These findings support the adoption of magnetic resonance imaging–first imaging protocols in acute stroke settings. The establishment of a stroke management center in Duhok was recommended to facilitate rapid diagnosis and evidence-based care.

Keywords Acute ischemic stroke, CT, fast diffusion-weighted imaging, hyperacute stroke

INTRODUCTION

Stroke is one of the leading causes of mortality and long-term disability worldwide, posing a significant public health burden.[1] Clinically, stroke refers to a sudden onset of neurological deficit due to a vascular cause,[2] broadly classified into hemorrhagic (15%-25%) and ischemic types (75%-85%).[3] Among these, ischemic stroke demands particularly swift intervention, as therapeutic efficacy, especially for reperfusion strategies, is highly time-dependent.[4] Early and accurate diagnosis within the hyperacute phase, defined as the first 6 hours from symptom onset, is critical for initiating effective treatment and improving patient outcomes.[5]

Conventional imaging with non-contrast computed tomography (NCCT) remains the first-line modality in many centers due to its availability and utility in ruling out hemorrhage.[6] However, CT is known to have limited sensitivity for detecting early ischemic changes. The sensitivity of CT for infarction has been reported to be as low as 30% at 3 hours and approximately 60% at 24 hours.[7,8]

In contrast, magnetic resonance imaging (MRI), particularly diffusion-weighted imaging (DWI), has emerged as a highly sensitive tool for identifying hyperacute ischemic changes.[9] Diffusion-weighted imaging can reveal cytotoxic edema within minutes of onset as hyperintense lesions with corresponding apparent diffusion coefficient (ADC) hypointensity, allowing for early and accurate diagnosis.[10] Comparative imaging studies consistently demonstrate DWI's superiority over NCCT in sensitivity and accuracy, especially for middle cerebral artery (MCA) territory infarction.[11]

Recent developments have fueled interest in MRI-first imaging protocols, even in the hyperacute window. Evidence suggests that MRI-based pathways can be implemented in comprehensive stroke centers with minimal delay and significantly improved diagnostic yield compared to CT-first workflows.[12] Furthermore, advanced diffusion and perfusion imaging markers—such as Diffusion-Weighted Imaging–Alberta Stroke Program Early CT Score(DWI-ASPECTS), lesion volume, and perfusion metrics—have emerged as important predictors of final infarct size and functional outcomes.[13]

Despite technological advances, NCCT remains the mainstay in many healthcare settings due to its accessibility and speed, particularly in settings with limited MRI availability. Limitations include low sensitivity for posterior circulation strokes, early small infarcts, and inter-reader variability in detecting early ischemic signs.[14] Artificial intelligence (AI)–supported algorithms applied to NCCT have shown promise in improving detection of early ischemic changes, although performance remains variable, especially for small infarcts.[15]

Taken together, there is a pressing need for robust comparative assessment of NCCT versus fast DWI protocols in real-world hyperacute stroke settings. Such studies should assess not only diagnostic sensitivity and specificity but also the relationship between imaging findings (e.g., DWI lesion volume, DWIASPECTS) and clinical variables such as NIHSS and functional outcome (e.g., mRS).[16,5]

This study aims to evaluate the diagnostic performance of fast DWI compared to NCCT in the detection of hyperacute ischemic stroke within 6 hours of symptom onset. By focusing on a local clinical population, the aim was to assess the applicability of advanced imaging protocols in real-world settings, potentially contributing to optimized stroke management in the region.

MATERIAL AND METHODS

Ethics Committee Approval

This research was performed in compliance with the revised Declaration of Helsinki and received approval from the Institutional Ethics Committee of the University of Duhok on July 17, 2022 (Institutional Review Board Approval Number: DDG N. 13062022-7-17).

All participants provided informed consent before being included in the study; data was anonymized to protect donor confidentiality**.**

Study Design and Setting

A cross-sectional, prospective diagnostic accuracy study was conducted at the Emergency and Radiology Departments of Azadi Teaching Hospital, affiliated with the College of Medicine, University of Duhok, Iraq. The study period spanned from June 1 to November 1, 2024.

Study Population

A total of 72 patients with suspected hyperacute ischemic stroke were consecutively enrolled. Inclusion criteria comprised patients presenting with acute focal neurological deficits consistent with ischemic stroke within 6 hours of symptom onset. All patients underwent an initial NCCT scan to exclude intracerebral hemorrhage. Patients with confirmed hemorrhage on NCCT were excluded from the study.

MAIN POINTS

- Diffusion-weighted magnetic resonance imaging (MRI) detected hyperacute ischemic stroke lesions in 100% of patients, while computed tomography (CT) identified only 37.5%, confirming the superior sensitivity of diffusion-weighted imaging (DWI).
- Diffusion-weighted imaging proved especially effective in identifying posterior fossa infarctions, where CT sensitivity was markedly low.
- Hypertension, diabetes, and heart disease were the most common risk factors in this cohort, aligning with established stroke epidemiology.
- Findings support adopting MRI-first protocols in acute stroke management, with potential to improve early diagnosis and patient outcomes in resource-equipped centers.

Imaging Protocol

Following exclusion of hemorrhage, all patients underwent fast MRI with DWI on either a 1.5 Tesla or 3 Tesla MRI scanner, within the hyperacute window (≤6 hours post-symptom onset). Diffusion-weighted imaging images were evaluated alongside ADC maps to confirm ischemic lesions. Computed tomography scans were performed using a standard multislice CT scanner and interpreted by an experienced radiologist blinded to the MRI findings. The sensitivity of NCCT in detecting early ischemic changes was compared to DWI, which was considered the reference standard due to its established diagnostic superiority in hyperacute stroke.

Data Collection and Variables

Demographic data (age, sex), time from symptom onset to imaging, side and vascular territory of infarction (e.g., MCA, vertebrobasilar circulation), and risk factors (e.g., hypertension, diabetes mellitus, heart disease, smoking, obesity, and family history) were recorded using a standardized data collection sheet.

Imaging Analysis

Diffusion-weighted imaging positivity was defined as hyperintense signal on DWI with corresponding hypointensity on ADC maps. Computed tomography positivity was defined by the presence of visible hypodensity, loss of gray-white matter differentiation, or other early signs of ischemia. Imaging findings were categorized by side (right, left, bilateral) and vascular territory.

Stroke Classification

Ischemic strokes were categorized based on the time from symptom onset into 4 stages: hyperacute (0-6 hours), acute (6-24 hours), subacute (1-14 days), and chronic (>14 days), following previously established imaging criteria[17,18]

Each stage demonstrates characteristic changes on DWI and ADC sequences. Table 1 summarizes the expected signal changes in DWI and ADC across these time intervals.

Statistical Analysis

Data analysis was performed using SPSS version 10 (SPSS Inc.; Chicago, IL, USA). Descriptive statistics (mean, SD, percentages) were used for demographic and clinical variables. Sensitivity and detection rates for DWI and CT were calculated. A *P*-value ≤ .05 was considered statistically significant. The clinical diagnosis based on presentation was used as the reference standard for sensitivity comparison.

RESULTS

Age and Sex Distribution

A total of 72 patients with suspected hyperacute ischemic stroke were included in this study. The mean age was 64.7 years (range: 17-86 years). Of the total, 37 patients (51.4%) were male and 35 (48.6%) were female. All patients were assessed within 6 hours of symptom onset, with an average time of 3.2 hours from onset to imaging (Table 2).

Table 1. Changes in Diffusion-Weighted Imaging and Apparent Diffusion Coefficient Findings by Time

Time	<6 Hours	3 Days	7 Days	30 Days
DWI	Bright	Very bright	Bright	Isointense
ADC	Dark	Very dark	Dark	Bright

ADC, apparent diffusion coefficient; DWI, diffusion-weighted imaging.

Table 2. Gender and Lesion Side Distribution

Variable		Number	%
Gender	Male	37	51.4
	Female	35	48.6
Lesion side	Right	23	31.9
	Left	46	63.8
	Bilateral	3	4.1

Lesion Distribution

Regarding lesion laterality, infarction was more commonly observed in the left hemisphere, affecting 46 patients (62.8%), while right-sided lesions were found in 23 patients (31.9%). Only 3 patients (4.1%) exhibited bilateral involvement (Table 2).

Vascular Territory Involvement

The most frequently affected vascular territory was the MCA, observed in 42 patients (58.3%). The vertebrobasilar system was involved in 20 patients (27.8%). Combined anterior and MCA involvement was recorded in 5 patients (6.9%), middle and posterior cerebral arteries in 3 patients (4.2%), and isolated anterior cerebral artery infarction in 2 patients (2.8%) (Table 3).

Risk Factors

Hypertension was the most prevalent risk factor, affecting 46 patients (63.8%). Other common comorbidities included diabetes mellitus in 32 patients (44.4%), heart disease in 27 (37.5%), smoking in 19 (26.3%), and obesity in 15 (20.8%). A family history of stroke was reported in 13 patients (18.0%) (Table 4).

Imaging Findings

All 72 patients underwent both non-contrast CT and DWI. Diffusion-weighted imaging successfully identified acute ischemic lesions in all patients (100%), while CT detected ischemic changes in only 27 cases (37.5%). Thus, 45 patients (62.5%) had false-negative CT results despite clear evidence of infarction on DWI. The difference in lesion detection between CT and DWI was statistically significant ($P < .001$). Importantly, DWI was particularly superior in detecting posterior circulation strokes. Of the 29 patients with infarcts involving the posterior fossa, only 5 (17.2%) were identified by CT, while all were visualized on DWI.

DISCUSSION

In this diagnostic accuracy study, DWI reliably identified ischemic lesions in 100% of patients presenting within 6 hours of symptom onset, while CT detected lesions in only 37.5%, underscoring a substantial sensitivity gap in favor of DWI. These results corroborate longstanding findings demonstrating the superior diagnostic accuracy of DWI in hyperacute stroke detection.[19,20]

Recent studies reinforce this paradigm shift. A meta-analysis confirms that even CT protocols enhanced with perfusion imaging significantly underperform compared to DWI in detecting early ischemic changes.[21] Moreover, emerging evidence supports the practicality of MRI-first protocols in acute stroke workflows. A multicenter investigation demonstrates that even ultrafast MRI with concurrent Magnetic Resonance Angiography(MRA), performed in as little as 3 minutes, maintains diagnostic sensitivity comparable to standard MRI in identifying vessel occlusions and ischemic lesions.[22]

Deep-learning–accelerated MRI acquisition techniques offer further promise. One study reported that rapid MRI protocols using AI reconstruction yielded images equivalent in quality to conventional scans—while reducing scan time by up to 75%—without sacrificing lesion detection capability.[23] These findings address one of the primary concerns cited against MRI-first approaches: scan-to-treatment delay.

In addition to technical superiority, DWI provides prognostic insight. A systematic review and meta-analysis indicates that DWI-negative presentations occur in approximately 11%-16% of stroke patients, especially in mild or posterior circulation strokes, and are associated with better functional outcomes (e.g., mRS 0-1), lower recurrence rates, and reduced mortality.[12,19]

In this cohort, CT underperformed particularly in detecting posterior fossa lesions (only 5 of 29 cases), while DWI detected all, reinforcing its critical role in evaluating vertebrobasilar infarction.

Despite MRI's superior sensitivity and prognostic value, CT remains ubiquitous—particularly in resource-limited settings. However,

Table 3. Study Sample by Arterial Territory

Arterial Territory	Numbers	%
Middle cerebral artery	42	58.33
Vertebral basilar arteries	20	27.77
Anterior and middle cerebral artery	5	6.94
Middle and posterior cerebral artery	3	4.16
Anterior cerebral artery	2	2.77

Table 4. Study Sample by Risk Factors

Risk Factors	Stroke Patients with Risk Factors	%
Hypertension	46	63.8
DM	32	44.4
Heart disease	27	37.5
Smoking	19	26.3
Obesity	15	20.8
Family history	13	18

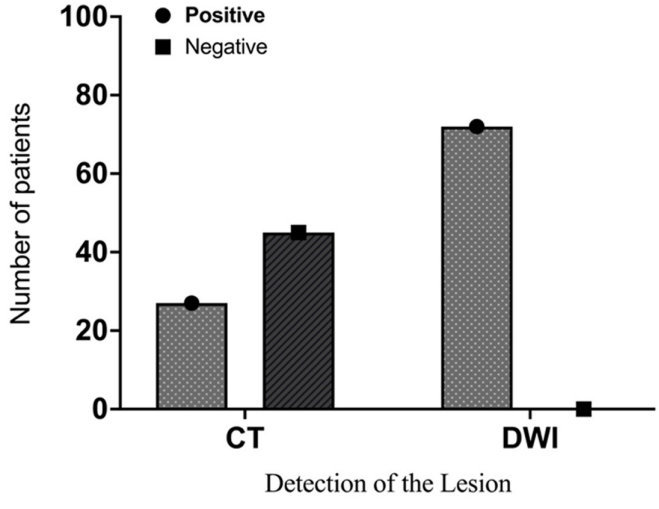

Figure 1. The bar graph illustrating lesion detection rates by computed tomography (CT) versus diffusion-weighted imaging (DWI). It clearly shows that DWI identified lesions in all 72 patients, while CT detected lesions in only 27, missing 45 cases.

recent position statements, including from the American Academy of Neurology, now recommend DWI-based imaging over CT as the preferred first-line modality in acute ischemic stroke assessment.[24]

These findings support adopting MRI-first protocols in acute stroke imaging workflows where infrastructure permits. Integration of 3-minute ultrafast MRI or 6-minute MRI code stroke protocols, paired with AI-based reconstruction and deep-learning segmentation, can significantly reduce door-to-imaging times without compromising diagnostic accuracy.[22] Tele-stroke and remote MRI interpretation systems could further expand access in underserved regions. Although this study did not observe any DWI-negative strokes, prior literature indicates that such cases, though uncommon—can occur, particularly in mild or posterior circulation strokes. In these situations, clinical management still critically depends on clinical evaluation and risk factor assessment.

Limitations include modest sample size, single-center design, and limited availability of advanced imaging such as perfusion MRI or CT perfusion. Future studies incorporating perfusion-diffusion mismatch evaluation using arterial spin labeling or dynamic susceptibility contrast MRI could refine core-penumbra assessment in early stroke management.

In conclusion, DWI-MRI offers unquestionable advantages over NCCT in the detection of hyperacute ischemic stroke, especially in lesions affecting the posterior circulation. Emerging fast MRI protocols and AI-supported workflows have the potential to eliminate previous logistical barriers to MRI-first paradigms. In settings where MRI is available and properly implemented, standard of care should increasingly favor DWI-based assessment over CT in acute stroke—aligning radiologic practice with evolving international guidelines.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of University of University of Duhok (Approval No: 13062022-7-17; Date: July 17, 2022).

Informed Consent: Written informed consent was obtained from the participants who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author has no conflict of interest to declare.

Funding: The author declared that this study has received no financial support.

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