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Computed Tomography versus Magnetic Resonance Imaging Diffusion-Weighted Imaging in the Diagnosis of Acute Cerebral Infarction: A Comparative Observational Study

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Abstract: Background: Acute cerebral infarction (ACI) represents a neurological emergency where time-sensitive revascularization is paramount. The choice of initial neuroimaging modality critically influences therapeutic decision-making. While non-contrast computed tomography (CT) is widely used for its rapidity and accessibility, magnetic resonance imaging with diffusion-weighted imaging (MRI-DWI) offers superior sensitivity for early ischemia. Objective: This study aimed to conduct a rigorous, head-to-head comparison of the diagnostic efficacy of CT and MRI-DWI in a well-defined cohort of patients with ACI, with a specific focus on lesion detection rates across different brain locations and sizes. Methods: A prospective observational study was conducted involving 100 patients with clinical suspicion of lacunar infarction. All participants underwent both non-contrast CT and MRI-DWI examinations within 6 hours of symptom onset. Images were independently evaluated by two blinded radiologists. Diagnostic accuracy, lesion localization detection rates (frontal, parietal, temporal, occipital lobes, basal ganglia, thalamus, internal capsule, cerebellum, brainstem), and lesion size detection rates (<5 mm, ≥5 mm) were calculated and compared using chi-square tests, with a significance level set at $P < 0.01$. Results: The study cohort had a median age of 64 years, with 63% male participants. MRI-DWI demonstrated a diagnostic accuracy of 100%, significantly outperforming CT's accuracy of 85% ($P < 0.01$). Statistically significant differences in detection rates favoring MRI-DWI were observed across all specified cerebral locations, most notably in the brainstem ($P = 0.01$). Furthermore, MRI-DWI was significantly superior in detecting infarcts smaller than 5 mm ($P < 0.01$). Conclusion: MRI-DWI is unequivocally more sensitive than non-contrast CT in the early diagnosis of ACI, particularly for small lesions and those located in the posterior fossa. These findings strongly suggest that MRI-DWI should be considered the first-line imaging modality when available and feasible, as it provides critical information that can optimize patient triage and treatment strategies.

Keywords: Acute Cerebral Infarction; Early Diagnosis; Lesion Localization; Computed Tomography; Diffusion-Weighted Imaging.

1. Introduction

Cerebral infarction, synonymous with ischemic stroke, denotes focal ischemic necrosis or encephalomalacia of brain tissue resulting from a critical disruption of cerebral blood flow, typically due to thromboembolism [1]. As a leading cause of long-term disability and mortality globally, its incidence escalates markedly with age, making it a predominant health concern in the elderly population [2]. The pathophysiological cascade initiated by ischemia is time-dependent; neuronal death occurs rapidly without restoration of blood flow. The efficacy of intravenous thrombolysis and endovascular thrombectomy, the cornerstone of acute reperfusion therapy, is profoundly contingent on the duration of ischemia. The therapeutic window, especially for thrombolysis, is optimally within 4.5 hours of symptom onset, underscoring the adage that "time is brain." Missing this narrow window not only diminishes the potential benefits of revascularization but also heightens the risk of hemorrhagic transformation [3]. Consequently, the imperative for rapid and accurate diagnosis is twofold: it is the foundation upon which effective treatment is built and the essential prerequisite for its safe initiation.

This diagnostic imperative places neuroimaging at the forefront of acute stroke management. The primary objectives of immediate imaging are to differentiate irreversible ischemia from stroke mimics, exclude intracerebral hemorrhage (an absolute contraindication to thrombolysis), and identify the site and extent of vascular occlusion. In current clinical practice, non-contrast computed tomography (CT) is the most widely utilized initial modality. Its advantages are substantial: it is rapidly acquired (often in seconds), universally available in emergency settings, relatively low-cost, and has few contraindications. It exhibits high sensitivity for acute hemorrhage. Conventional magnetic resonance imaging (MRI) sequences, such as T1-weighted (T1WI) and T2-weighted (T2WI) imaging, provide superior soft-tissue contrast and are less affected by bony artifacts at the skull base, aiding in the evaluation of posterior fossa structures [4].

However, the critical limitation of non-contrast CT in the hyperacute phase (<6 hours) of cerebral infarction is its notoriously low sensitivity. Early ischemic changes, such as focal hypodensity and sulcal effacement, are often subtle and can be missed by even experienced clinicians. This is where MRI, particularly diffusion-weighted imaging (DWI), has revolutionized stroke imaging. DWI measures the random Brownian motion of water molecules within tissue. During acute ischemia, the failure of the sodium-potassium pump leads to cytotoxic edema, where water shifts from the extracellular to the intracellular space. This increase in intracellular water restricts its diffusion, appearing as a bright signal on DWI maps within minutes to hours of symptom onset, far earlier than changes become visible on CT or conventional MRI sequences [5, 6].

Despite the well-established superior sensitivity of DWI, CT remains the first-line imaging modality in many stroke centers worldwide, primarily due to logistical constraints related to MRI availability, longer acquisition times, and patient compatibility issues (e.g., pacemakers, claustrophobia). This creates a significant clinical dilemma: does the reliance on CT lead to under-diagnosis of small or strategically located infarcts, potentially altering management? Therefore, a direct, meticulous comparison in a contemporary patient cohort is necessary to quantify the magnitude of this diagnostic gap and inform imaging protocols. The purpose of this study was to rigorously evaluate and compare the diagnostic efficacy of non-contrast CT and MRI-DWI in patients with acute cerebral infarction, with a specific focus on lesion detection rates based on location and size, to provide an evidence-based reference for optimizing early diagnosis and treatment planning.

2. Materials and Methods

2.1. Study Population and Ethical Considerations

This prospective observational study was conducted at the Affiliated Hospital of Youjiang Medical University for Nationalities between January 2025 and August 2025. The study protocol received full approval from the hospital's Institutional Review Board (Ethics Approval Number: 2025091701), and written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment.

Consecutive patients presenting to the emergency department with clinical symptoms suggestive of acute lacunar infarction (e.g., pure motor stroke, ataxic hemiparesis, sensory-motor stroke) were screened for eligibility. The inclusion criteria were: (1) age $\geq$ 18 years; (2) clinical diagnosis of acute focal neurological deficit consistent with lacunar infarction syndrome; (3) time from symptom onset to imaging of less than 6 hours; (4) no contraindications to either MRI or CT examinations (e.g., pregnancy, non-MRI compatible implants, severe renal impairment for contrast if needed); and (5) availability of complete clinical and imaging data. Exclusion criteria were strictly applied to minimize confounding factors and included: (1) a history of significant cranial trauma or neurosurgery that could distort brain anatomy; (2) known severe dysfunction of major organs (heart, liver, kidneys) that could mimic or complicate stroke presentation; (3) concurrent diagnosis of intracranial or systemic malignant tumors; and (4) having undergone any form of thrombolytic or endovascular therapy prior to the completion of the study imaging protocols. A final cohort of 100 patients meeting all criteria was enrolled.

2.2. Imaging Acquisition Protocols

All enrolled patients underwent both non-contrast CT and MRI-DWI examinations in immediate succession. The order of scanning was determined by scanner availability, with a target of completing both studies within 60 minutes of each other.

CT Protocol: Non-contrast head CT scans were acquired using a GE Revolution 256-slice CT scanner. Patients were positioned supine on the scanner table. The scanning range covered the entire brain, from the foramen magnum to the vertex. Scans were performed in axial or helical mode with the following technical parameters: tube voltage 120 kV, tube current 150 mA, slice thickness 5.0 mm, and reconstruction interval 5.0 mm. No intravenous contrast agent was administered.

MRI Protocol: MRI examinations were performed using a GE Revolution 3.0T MRI system equipped with a dedicated head coil. Patients were similarly placed in a supine position, and the head was comfortably immobilized using foam padding to minimize motion artifacts. The scanning range extended from the vertex to the foramen magnum. The multiparameter axial head sequences included T1WI, T2WI, and DWI. The key acquisition parameters for the axial DWI sequence were: field of view (FOV) of 230 mm, slice thickness of 5 mm, an interslice gap of 1.5 mm, and b-values of 0 and 1000 s/mm². Apparent Diffusion Coefficient (ADC) maps were automatically generated by the system software for all DWI sequences.

2.3. Image Analysis and Interpretation

All acquired images were anonymized and transferred to a dedicated picture archiving and communication system (PACS) workstation for analysis. The image analysis was performed independently by two board-certified radiologists, each with over 8 years of experience in neuroradiology. Both readers were blinded to the patients' clinical details (beyond the suspicion of stroke) and the results of the other imaging modality.

The images were assessed for the presence or absence of acute cerebral infarction. For CT, acute infarction was defined by the presence of hypodensity, loss of gray-white matter differentiation, and sulcal effacement. For MRI-DWI, acute infarction was defined by a hyperintense signal on DWI with a corresponding hypointense signal on the ADC map, confirming true restricted diffusion.

The readers first attempted a consensus reading for each case. In instances of disagreement between the two primary readers, a third senior radiologist with more than 15 years of experience was consulted. The third reader's assessment was considered the final judgment, thereby ensuring the accuracy and reliability of the diagnostic results.

2.4. Outcome Measures

The primary outcome measures for this study were:

Overall Diagnostic Accuracy: Using the final comprehensive clinical diagnosis (incorporating all available data including follow-up imaging, neurology consultation, and clinical course) as the reference standard, the diagnostic results (positive or negative for ACI) from both CT and MRI-DWI were recorded. Accuracy was calculated as (True Positives + True Negatives) / Total Cases.

Lesion Localization Detection Rate: The detection rates of acute infarcts in specific anatomical locations (frontal lobe, parietal lobe, temporal lobe, occipital lobe, basal ganglia, thalamus, internal capsule, cerebellum, and brainstem) were meticulously compared between the two imaging modalities. A lesion was considered "detected" in a location if it was correctly identified by the reader.

Lesion Size Detection Rate: The detection rates for lesions of different sizes were calculated. Lesions were categorized into two groups based on their maximum diameter as measured on the MRI-DWI sequence: small lesions (< 5 mm) and larger lesions (≥ 5 mm).

2.5. Statistical Analysis

All statistical analyses were performed using the SPSS software package (version 26.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize patient demographics. The overall detection rate of ACI and the detection rates for different infarction locations and sizes were compared between CT and MRI-DWI using the Chi-square (χ^2) test. A two-sided P-value of less than 0.01 was considered statistically significant to account for multiple comparisons and reduce the risk of Type I error.

3. Results

The final study cohort comprised 100 patients. The population included 63 (63%) men and 37 (37%) women, with a median age of 64 years (interquartile range: 58-72 years). The comprehensive clinical diagnosis confirmed acute cerebral infarction in all 100 patients.

The overall diagnostic accuracy of MRI-DWI was 100% (100/100), meaning it correctly identified infarction in all confirmed cases. In contrast, the diagnostic accuracy of CT was 85.00% (85/100); it failed to detect infarction in 15 patients who were subsequently confirmed to have small or strategically located infarcts.

The detection rates of ACI in specific brain locations are detailed in Table 1. Statistically significant differences ($P<0.01$) were observed between the two modalities for infarcts in the frontal lobe, temporal lobe, parietal lobe, occipital lobe, basal ganglia, and cerebellum. The most striking difference was noted in the brainstem. MRI-DWI successfully detected all brainstem infarcts (n=8), whereas CT had a substantially lower detection rate (1/8), a difference that was statistically significant ($P=0.01$).

Furthermore, a highly significant difference was observed between the two methods in detecting cerebral infarction lesions smaller than 5 mm ($P<0.01$), as summarized in Table 2. MRI-DWI detected 42 out of 42 small lesions, while CT only detected 5, underscoring its superior sensitivity for microinfarcts. For lesions ≥ 5 mm, while CT's performance improved, MRI-DWI still maintained a 100% detection rate.

Table 1. Comparison of Detection Rates by Lesion Location Between the Two Imaging Modalities [n (%)]

Imaging Modality	Basal ganglia (n=77)	Corona radiata (n=73)	Frontal lobe (n=47)	Parietal lobe (n=34)	Centrum semiovale (n=33)	Pons (n=33)	Thalamus (n=30)	Occipital lobe (n=24)	Temporal lobe (n=24)	Cerebellar hemisphere (n=15)	Insular lobe (n=12)	Detection Rate (n=402)
CT	60(77.92)	42(57.53)	23(48.94)	18(52.94)	18(54.55)	15(45.46)	15(50.00)	11(45.83)	7(29.17)	5(33.33)	5(41.67)	219(54.48)
DWI	66(85.71)	68(93.15)	43(91.49)	31(91.18)	25(75.76)	26(78.79)	24(80.00)	19(79.18)	23((95.83)	12(80.00)	9(75.00)	346(86.07)
χ^2												96.032
p												<0.01

Table 2. Comparison of Detection Rates by Lesion Size Between the Two Imaging Modalities [n (%)]

Imaging Modality	<5mm(n=509)	≥5mm(n=252)
CT	174(45.43)	143(56.75)
DWI	335(87.47)	203(80.56)
χ2	151.785	33.189
p	<0.01	<0.01

4. Discussion

This prospective comparative study provides compelling evidence for the superior diagnostic performance of MRI-DWI over non-contrast CT in the early hours of acute cerebral infarction. Our findings, consistent with the pathophysiological principles of ischemic stroke, highlight critical limitations of CT that can impact patient management.

Non-contrast CT's role as the initial imaging modality in acute stroke is rooted in practical necessity: its speed is invaluable for the rapid exclusion of hemorrhage, which remains the absolute priority in triage . However, our results demonstrate that this utility comes at a cost in diagnostic sensitivity for ischemia. The 85% accuracy rate of CT in our cohort, while seemingly high, implies a 15% false-negative rate. In clinical terms, this translates to one in seven patients with a genuine infarction being potentially misclassified initially, which could lead to delays in treatment or failure to initiate secondary prevention strategies. The low sensitivity of CT is intrinsically linked to the early pathophysiology of infarction. In the hyperacute phase, the primary change is cytotoxic edema, which causes only a minimal increase in tissue water content (1-3%). This subtle change often manifests on CT as only a slight loss of gray-white matter differentiation or obscuration of the insular ribbon, signs that are subjective and easily missed, particularly in patients without significant mass effect.

In stark contrast, MRI-DWI directly visualizes the biophysical correlate of cytotoxic edema—the restriction of water diffusion. Our finding of 100% diagnostic accuracy for DWI confirms its status as the gold standard for the imaging diagnosis of acute ischemia. As Mullins et al. and others have established, DWI can identify infarcted tissue within minutes of arterial occlusion, far surpassing the sensitivity of any other non-invasive imaging technique. The bright signal on DWI, corresponding to a dark signal on the ADC map, provides an objective and unequivocal marker of cellular energy failure.

Our study adds granularity to this established superiority by demonstrating significant disparities based on lesion location and size. The profoundly low detection rate of brainstem infarcts on CT is a critical finding. The brainstem is surrounded by dense bone, which leads to beam-hardening artifacts on CT that can obscure subtle hypodensities. MRI is inherently less susceptible to these artifacts, allowing for clear visualization of the brainstem. Missing a brainstem infarct can have profound consequences, as the clinical presentation can be atypical and misdiagnosis can lead to inappropriate management. Similarly, the near-complete failure of CT to detect infarcts smaller than 5 mm underscores its limitation in evaluating lacunar syndromes. These small, deep infarcts are a common cause of stroke, and their accurate identification is crucial for understanding the etiology and guiding long-term prevention, such as aggressive management of small vessel disease.

The pathological concept of the ischemic core and penumbra further explains the advantage of DWI. DWI excellently defines the core of irreversibly injured tissue. While our study did not incorporate perfusion imaging, the ability of DWI to precisely delineate the infarct core helps in patient selection for reperfusion therapies, even beyond the conventional time window, by estimating the mismatch between the core and the hypoperfused tissue.

5. Conclusion

In conclusion, this study unequivocally demonstrates that MRI-DWI is significantly more sensitive and accurate than non-contrast CT for the diagnosis of acute cerebral infarction, particularly for small lacunar infarcts and those located in the posterior fossa and brainstem. While CT remains an essential tool for the rapid exclusion of hemorrhage, its diagnostic limitations for ischemia are substantial. In centers where resources and logistics permit, MRI-DWI should be aggressively pursued as the first-line diagnostic modality for patients presenting with acute stroke symptoms. Its implementation in acute stroke protocols can minimize diagnostic errors, provide more accurate etiological information, and ultimately contribute to improved patient outcomes through more tailored and timely treatment decisions. Future efforts should focus on overcoming the logistical barriers to rapid MRI access in emergency settings.

References

[1] Jin G, Han W, Duan T, et al. Edaravone dextranol alleviates ferroptosis, Cuproptosis, and blood-brain barrier damage after acute cerebral infarction[J]. Metabolic Brain Disease, 2025, 40(3): 134.DOI:10.1007/s11011-025-01559-0.

[2] Huang Y, Shao Y, Wang Y, et al. Elevated troponin I levels on admission predict long-term mortality in patients with acute cerebral infarction following thrombolysis[J]. Neurological Sciences, 2022, 43(9): 5431-5439.DOI:10.1007/s10072-022-06116-6.

[3] Gao L, Zhang S, Wo X, et al. Intravenous thrombolysis with alteplase in the treatment of acute cerebral infarction[J]. Pakistan journal of medical sciences, 2022, 38(3): 498-504. DOI:10.12669/pjms.38.3.4521.

[4] Lakshmipriya, T., & Gopinath, S. C. B. (2025). Clinical Markers and Diagnostics for Diagnosing Cerebral Infarction. CNS & neurological disorders drug targets, 24(7), 494–497. https://doi.org/10.2174/0118715273372575250212091813.

[5] Peng Y, Luo C, Wang H, et al. Feasibility of CT attenuation values in distinguishing acute ischemic stroke, old cerebral infarction and leukoaraiosis [J]. BMC Medical Imaging, 2024, 24(1): 160.DOI:10.1186/s12880-024-01340-2.

[6] Yan B, Zhang H, Liu J. Application of Quantitative CT Imaging in Rehabilitation Nursing of Cerebral Apoplexy Patients[J]. Pak J Med Sci, 2021, 37(6): 1574-1579. DOI:10.12669/pjms.37.6-WIT.4840.