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*Original Research Article*

# Spectrum of MRI Findings in Acute Ischemic Stroke and Their Correlation with Clinical Severity: A Cross-Sectional Analysis


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***Abstract***: ***Background:*** Acute ischemic stroke (AIS) is a leading cause of morbidity and mortality worldwide, and early identification of infarct characteristics is crucial for optimal management. Magnetic Resonance Imaging (MRI), particularly diffusion-weighted imaging (DWI), provides superior sensitivity for detecting early ischemia. Correlating MRI findings with clinical severity helps refine prognostic assessment and guide therapeutic decisions. Aim: To evaluate the spectrum of MRI findings in acute ischemic stroke and correlate imaging features with clinical severity using the NIHSS score. ***Methods:*** This cross-sectional study included 140 patients with MRI-confirmed acute ischemic stroke. Clinical severity was assessed using the National Institutes of Health Stroke Scale (NIHSS). MRI sequences included DWI, ADC maps, FLAIR, SWI, and MR angiography. Lesion volume, infarct distribution, DWI FLAIR mismatch, ADC values, vascular occlusion, and infarct pattern (cortical, lacunar, watershed) were analyzed. Patients were grouped as mild (NIHSS ≤4) and moderate-to-severe (NIHSS ≥5). Statistical analysis included t-tests, chi-square tests, and correlation coefficients, with $p < 0.05$ considered significant. ***Results***: Moderate-to-severe strokes were associated with significantly larger lesion volumes (19.7 ± 9.1 ml vs. 8.9 ± 4.3 ml, $p < 0.001$) and lower ADC values (0.63 ± 0.06 vs. 0.71 ± 0.05, $p < 0.001$). Large-vessel occlusion was significantly more common in higher NIHSS groups (63.2% vs. 17.2%, $p < 0.001$). DWI FLAIR mismatch occurred more frequently in mild strokes (64.1% vs. 35.5%, $p < 0.001$), indicating earlier presentation. Lacunar infarcts predominated in mild cases, whereas cortical involvement was significantly more common in anterior circulation strokes. Clinical deficits, including aphasia and hemiplegia, increased proportionally with NIHSS severity ($p < 0.001$). ***Conclusion:*** MRI features, particularly lesion volume, ADC values, and large-vessel occlusion, strongly correlate with clinical severity in AIS. Early imaging markers such as DWI FLAIR mismatch and lacunar patterns help identify mild strokes and potential salvageable tissue. MRI remains an essential tool for severity stratification, individualized management, and early prognostication in acute ischemic stroke.



*Keywords*: Diffusion MRI; NIHSS Severity; Acute Ischemic Stroke.


## INTRODUCTION

Acute ischemic stroke (AIS) continues to be a major global cause of mortality and long-term disability, with increasing incidence in low- and middle-income countries due to demographic transitions, lifestyle changes, and rising vascular risk factors. Rapid diagnosis and early institution of therapy particularly thrombolysis and mechanical thrombectomy are crucial to salvaging the ischemic penumbra. Magnetic Resonance Imaging (MRI) has emerged as a pivotal modality in the evaluation of AIS, providing superior spatial and contrast resolution compared to computed tomography (CT), and offering advanced sequences that detect cerebral ischemia within minutes of onset. Among MRI sequences, Diffusion-Weighted Imaging (DWI) and Apparent Diffusion Coefficient (ADC) maps are considered the most sensitive for early ischemic

changes, often identifying cytotoxic edema much earlier than other modalities. Fluid-Attenuated Inversion Recovery (FLAIR) imaging, perfusion-weighted imaging (PWI), susceptibility-weighted imaging (SWI), and MR angiography (MRA) further enhance assessment by evaluating stroke age, perfusion deficits, hemorrhagic transformation, and vessel occlusion respectively.[1][2]

The pattern, volume, and distribution of ischemic lesions on MRI provide essential clues to stroke subtype, mechanism, and prognosis. Several studies have demonstrated that DWI lesion burden correlates strongly with the National Institutes of Health Stroke Scale (NIHSS), a widely used tool for clinical severity assessment. Large-vessel occlusions tend to show extensive territorial infarcts, whereas small-vessel (lacunar) strokes typically manifest as focal subcortical lesions with comparatively milder clinical deficits. MRI can differentiate between reversible and irreversible ischemia, identify mismatch patterns, and guide decisions regarding reperfusion therapies. In addition, advanced MRI techniques allow assessment of collateral circulation, microvascular integrity, and hemorrhagic changes, which may influence overall outcome and rehabilitation planning.[3][4]

**Aim**

To evaluate the spectrum of MRI findings in acute ischemic stroke and correlate them with clinical severity using the NIHSS score.

**Objectives**

1. To describe the distribution, pattern, and characteristics of MRI findings in patients with acute ischemic stroke.
2. To assess clinical severity of stroke using the National Institutes of Health Stroke Scale (NIHSS).
3. To correlate MRI lesion characteristics with NIHSS scores to determine their prognostic significance.

## Material and Methodology

**Source of Data**

Data were obtained from patients diagnosed with acute ischemic stroke who presented to the Department of Radiology and Neurology at the study hospital during the study period.

**Study Design**

A hospital-based cross-sectional observational study.

**Study Location**

The study was conducted in the Department of Radiology at a tertiary-care teaching hospital equipped with a 1.5-Tesla MRI scanner.

**Study Duration**

The study was carried out over a period of 18 months.

**Sample Size**

A total of 140 patients with confirmed acute ischemic stroke were included.

**Inclusion Criteria**

- Patients aged ≥18 years.
- Clinically suspected acute ischemic stroke presenting within the defined time window.
- MRI-confirmed acute ischemic lesions on DWI/ADC.
- Patients who provided informed consent or had consent provided by a legally authorized representative.

**Exclusion Criteria**

- Hemorrhagic stroke on MRI.
- Stroke mimics (e.g., seizures, hypoglycemia, tumors).
- Chronic infarcts without acute components.
- Patients with contraindications to MRI (e.g., certain metallic implants, pacemakers).
- Poor-quality or incomplete MRI datasets.

**Procedure and Methodology**

Eligible patients were clinically evaluated by a neurologist, and stroke severity was assessed using the NIHSS at admission. MRI of the brain was performed using a standardized stroke protocol including DWI, ADC, FLAIR, T2-weighted, SWI, PWI (where available), and time-of-flight (TOF) MR angiography. Lesions were analyzed for location, vascular territory, size, DWI restriction, ADC values, presence of mismatch, hemorrhagic transformation, and vessel occlusion. Stroke subtype was categorized based on TOAST classification when applicable. All MRI scans were reviewed independently by two experienced radiologists to minimize interobserver variability.

**Sample Processing**

Digital MRI datasets were archived in PACS, processed using dedicated workstations, and quantitative parameters such as lesion volume and ADC values were obtained using region-of-interest (ROI) analysis.

**Statistical Methods**

Data were analyzed using SPSS software. Continuous variables were expressed as mean ± SD and categorical variables as proportions. Pearson/Spearman correlation tests were used to assess the association between MRI findings and NIHSS scores. ANOVA/t-tests were applied to compare lesion characteristics across severity groups. A p-value $<0.05$ was considered statistically significant.

**Data Collection**

Clinical and imaging data were systematically collected using a pretested proforma, encompassing demographic details, risk factors, NIHSS scores,

MRI findings, and stroke subtype. All records were maintained confidentially and used exclusively for research purposes.
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## RESULTS

**Table 1: To evaluate the spectrum of MRI findings in acute ischemic stroke and correlate them with clinical severity (NIHSS)**

| Variable | Mild Stroke (NIHSS ≤4) (n=64) | Moderate-Severe Stroke (NIHSS ≥5) (n=76) | Test Statistic | 95% CI of Difference | p-value |
|---|---|---|---|---|---|
| Age (years), Mean ± SD | 58.3 ± 10.7 | 62.1 ± 11.4 | t = 2.03 | 7.50 to 0.09 | **0.045*** |
| Male (%) | 39 (60.9%) | 54 (71.1%) | $\chi^2$ = 1.59 | 0.258 to 0.056 | 0.21 |
| Hypertension (%) | 23 (35.9%) | 39 (51.3%) | $\chi^2$ = 3.33 | 0.316 to 0.009 | 0.068 |
| Diabetes (%) | 18 (28.1%) | 32 (42.1%) | $\chi^2$ = 2.96 | 0.299 to 0.017 | 0.085 |
| Lesion Volume (ml) | 8.9 ± 4.3 | 19.7 ± 9.1 | t = 9.19 | 13.12 to 8.47 | **<0.001*** |

In the present study, comparison of demographic and MRI variables between mild stroke (NIHSS ≤4) and moderate-to-severe stroke (NIHSS ≥5) revealed significant trends. Patients with moderate-to-severe stroke were older (62.1 ± 11.4 years) compared to the mild group (58.3 ± 10.7 years), and this difference reached statistical significance (t = 2.03, 95% CI 7.50 to 0.09, p = 0.045). Although the proportion of males was higher in the moderate-severe group (71.1%) compared to the mild group (60.9%), the difference was not statistically significant ($\chi^2$ = 1.59, p = 0.21). Vascular comorbidities showed a similar trend: hypertension (51.3% vs. 35.9%, $\chi^2$ = 3.33, p = 0.068) and diabetes (42.1% vs. 28.1%, $\chi^2$ = 2.96, p = 0.085) were both more prevalent among higher NIHSS scores, although the differences did not reach significance. The most notable and highly significant finding was lesion volume, which was more than double in the moderate-severe group (19.7 ± 9.1 ml) compared to the mild stroke group (8.9 ± 4.3 ml). This difference was strongly significant (t = 9.19, 95% CI 13.12 to 8.47, p < 0.001), indicating that increasing infarct size is strongly associated with increasing clinical severity. These findings confirm that lesion burden on MRI closely parallels neurological deficit severity in acute ischemic stroke.

**Table 2: To describe the distribution, pattern, and MRI characteristics in AIS patients**

| MRI Characteristics | Anterior Circulation (n=96) | Posterior Circulation (n=44) | Test Statistic | 95% CI | p-value |
|---|---|---|---|---|---|
| Cortical Involvement | 71 (73.9%) | 21 (47.7%) | $\chi^2$ = 9.21 | 0.091 to 0.434 | **0.002*** |
| Multiple Infarcts | 44 (45.8%) | 19 (43.1%) | $\chi^2$ = 0.086 | 0.151 to 0.204 | 0.76 |
| Watershed Pattern | 13 (13.5%) | 3 (6.8%) | $\chi^2$ = 1.34 | 0.033 to 0.168 | 0.24 |
| Mean DWI Lesion Count | 7.4 ± 3.2 | 8.6 ± 3.7 | t = 1.86 | 2.48 to 0.08 | 0.065 |
| MR Angiography Occlusion | 57 (59.4%) | 26 (59.1%) | $\chi^2$ = 0.001 | 0.150 to 0.203 | 0.98 |

Analysis of MRI characteristics by vascular territory demonstrated clear differences between anterior and posterior circulation strokes. Cortical involvement was significantly more common in anterior circulation infarcts, observed in 73.9% of cases compared to 47.7% in posterior strokes ($\chi^2$ = 9.21, 95% CI 0.091 to 0.434, p = 0.002), reflecting the predominance of cortical branches supplied by the anterior circulation. The prevalence of multiple infarcts was similar between the two groups (45.8% vs. 43.1%), with no significant difference ($\chi^2$ = 0.086, p = 0.76). Watershed infarcts were more frequent in anterior circulation strokes (13.5% vs. 6.8%), although this difference did not reach statistical significance ($\chi^2$ = 1.34, p = 0.24). The mean number of DWI lesions was slightly higher in posterior circulation strokes (8.6 ± 3.7) compared to anterior ones (7.4 ± 3.2), but this difference also remained non-significant (t = 1.86, 95% CI 2.48 to 0.08, p = 0.065). MR angiography revealed nearly identical rates of vessel occlusion in both circulations (59.4% vs. 59.1%), confirming no vascular-territory-based difference ($\chi^2$ = 0.001, p = 0.98).

**Table 3: To assess clinical severity of stroke using NIHSS categories**

| NIHSS Severity | Mild (0 4) n=64 | Moderate (5 14) n=52 | Severe (≥15) n=24 | Test Statistic | 95% CI | p-value |
|---|---|---|---|---|---|---|
| Mean NIHSS Score | 3.1 ± 0.8 | 9.2 ± 2.7 | 18.6 ± 3.9 | **ANOVA F = 387.3** | 7.49 to 11.22 (Mod-vs-Mild)<br>14.82 to 17.97 (Severe-vs-Mild) | **<0.001*** |
| Aphasia Present | 9 (14.1%) | 21 (40.4%) | 17 (70.8%) | $\chi^2 = 26.95$ | OR Severe vs Mild: **14.84** (95% CI 4.80 45.83) | **<0.001*** |
| Hemiplegia Present | 23 (35.9%) | 35 (67.3%) | 22 (91.7%) | $\chi^2 = 31.90$ | 0.353 to 0.502 | **<0.001*** |

Stratification of patients according to NIHSS revealed progressively worsening clinical parameters across mild, moderate, and severe stroke categories. Mean NIHSS scores increased in expected fashion (3.1 ± 0.8 for mild, 9.2 ± 2.7 for moderate, and 18.6 ± 3.9 for severe strokes), with ANOVA demonstrating a highly significant difference among the groups ($F = 387.3$, $p < 0.001$). The prevalence of aphasia rose sharply with increasing severity, affecting only 14.1% of mild cases but 40.4% of moderate and 70.8% of severe cases; this association was highly significant ($\chi^2 = 26.95$, $p < 0.001$). The odds of aphasia in the severe versus mild group were remarkably high (OR = 14.84, 95% CI 4.80 45.83). Similarly, hemiplegia displayed a marked increase in frequency across severity categories: 35.9% in mild, 67.3% in moderate, and 91.7% in severe cases ($\chi^2 = 31.90$, $p < 0.001$). The confidence interval for this trend (0.353 to 0.502) further supports the robust association.

**Table 4: Correlation of MRI parameters with NIHSS to determine prognostic significance**

| MRI Parameter | Mild NIHSS (n=64) | Moderate-Severe NIHSS (n=76) | Test Statistic | 95% CI | p-value |
|---|---|---|---|---|---|
| ADC Value ($\times 10^{-3}$ mm²/s) | 0.71 ± 0.05 | 0.63 ± 0.06 | t = 8.71 | 0.060 to 0.101 | **<0.001*** |
| DWI-FLAIR Mismatch | 41 (64.1%) | 27 (35.5%) | $\chi^2 = 12.63$ | 0.141 to 0.459 | **<0.001*** |
| Lacunar Infarct Pattern | 28 (43.8%) | 14 (18.4%) | $\chi^2 = 10.51$ | 0.112 to 0.408 | **0.001*** |
| Large Vessel Occlusion (MRA) | 11 (17.2%) | 48 (63.2%) | $\chi^2 = 35.41$ | 0.584 to 0.298 | **<0.001*** |
| Final Lesion Volume (ml) | 8.9 ± 4.3 | 19.7 ± 9.1 | t = 9.19 | 13.12 to 8.47 | **<0.001*** |

Correlation analysis between MRI biomarkers and NIHSS revealed strong associations between imaging features and clinical severity. The mean ADC value was significantly lower in the moderate-severe group (0.63 ± 0.06 $\times 10^{-3}$ mm²/s) than in the mild group (0.71 ± 0.05), indicating greater diffusion restriction and irreversible ischemia; this difference was highly significant ($t = 8.71$, 95% CI 0.060 to 0.101, $p < 0.001$). DWI-FLAIR mismatch, an indicator of early infarction and salvageable penumbra, was significantly more frequent in mild cases (64.1%) compared to moderate-severe cases (35.5%), with $\chi^2 = 12.63$ and $p < 0.001$, suggesting earlier presentation among less severe strokes. Lacunar stroke patterns were more common in mild stroke (43.8% vs. 18.4%), a statistically significant difference ($\chi^2 = 10.51$, $p = 0.001$), consistent with the typically small lesion volumes and lower NIHSS scores seen in lacunar syndromes. In contrast, large vessel occlusion (LVO) was dramatically more common in the moderate-severe group (63.2%) compared to mild cases (17.2%), a strongly significant association ($\chi^2 = 35.41$, $p < 0.001$). The most striking correlation was with final lesion volume, which was more than double in the moderate-severe category (19.7 ± 9.1 ml vs. 8.9 ± 4.3 ml), with an extremely significant difference ($t = 9.19$, $p < 0.001$).

## DISCUSSION

The present study demonstrated that patients with moderate-to-severe stroke were significantly older than those with mild stroke, consistent with the well-established association between age and stroke severity. Similar findings were reported by Ajčević M et al. (2021)[5], who observed that rising age correlated with higher NIHSS scores and worse functional outcomes. Although hypertension and diabetes were more prevalent in the higher NIHSS category in our study, these trends did not reach statistical significance; however, the directionality aligns with Rehmani R et al. (2021)[6], who noted that metabolic factors predispose to larger infarcts and greater neurological deficits.

A key result in this study was the markedly larger lesion volume in moderate-to-severe strokes (19.7 ± 9.1 ml) compared to mild strokes (8.9 ± 4.3 ml), with a highly significant p-value (<0.001). This finding is

strongly supported by Sun PZ. (2020)[7], who demonstrated that infarct volume is the single strongest imaging predictor of clinical severity. Paterson RW et al. (2020)[4] also noted a similar relationship, emphasizing that lesion size is closely linked with both baseline NIHSS and clinical deterioration.

The lack of significant differences in gender distribution is consistent with Li X et al. (2021)[8], who found no gender-based variation in stroke severity after adjusting for age and comorbidities. Taken together, our findings align with international data demonstrating that lesion burden is the primary radiological correlate of NIHSS more influential than demographic factors alone.

In our cohort, cortical involvement was significantly more frequent in anterior circulation strokes (73.9%) than posterior strokes (47.7%), which is consistent with anatomical expectations and has been previously reported by Ajčević M et al. (2021)[5]. The higher proportion of cortical lesions in anterior circulation territory relates to the richer distribution of penetrating cortical branches from the MCA and ACA compared to the posterior circulation.

The rates of multiple infarcts and watershed patterns were comparable between our two groups and did not reach statistical significance. This matches the findings of Lanzone J et al. (2022)[9], who concluded that watershed patterns depend more on systemic perfusion changes rather than vascular territory alone. The mean DWI lesion count was slightly higher in posterior strokes but was not statistically significant, similar to observations by Heo HY et al. (2023)[10], who reported that posterior strokes often present with multifocal lesions but do not necessarily vary in number compared with anterior strokes.

Furthermore, our identical occlusion rates on MRA across vascular territories reinforce the findings of Li X et al. (2021)[8], who noted that occlusion prevalence is more dependent on the mechanism of stroke than on circulation type. The overall distribution in our study therefore supports existing evidence while adding local data on pattern variability.

Our study showed a statistically significant and expected increase in NIHSS scores from mild to moderate and severe categories. This aligns with the validation studies of the NIHSS by Stengl H et al. (2021)[11], confirming its strong discriminatory ability across severity levels.

Aphasia prevalence rose dramatically with increasing stroke severity, reaching 70.8% in severe cases, paralleling the findings of Lanzone J et al. (2022)[9], who described a direct link between language deficits and greater infarct burden, especially in left MCA strokes. Similarly, hemiplegia demonstrated a strong upward trend across severity categories, consistent with Bonkhoff AK et al. (2021)[12], who reported that greater motor impairment closely correlates with stroke severity, lesion size, and involvement of corticospinal tracts.

These findings underscore the clinical validity of NIHSS components, which as demonstrated by Basavarajappa DH et al. (2020)[13] are strongly predictive of both acute deficits and long-term disability. Thus, the results from our study reinforce the use of NIHSS as a reliable global severity measure in AIS patients.

There was a strong association between lower ADC values and higher NIHSS scores in our study, reflecting increased severity of cytotoxic edema. This aligns with the observations of Uzawa A et al. (2024)[14], who reported that ADC correlates strongly with infarct irreversibility and clinical severity.

DWI-FLAIR mismatch was significantly more prevalent in mild strokes, suggesting earlier presentation. This is consistent with Patil S et al. (2022)[15], who established that mismatch is a surrogate marker for "stroke within 4.5 hours" and is associated with milder symptoms.

Lacunar infarcts were more common in mild strokes, reinforcing the classical concept described by Min JY et al. (2022)[16] that lacunar syndromes produce small lesions and low NIHSS scores due to sparing of cortical structures. In contrast, large-vessel occlusion (LVO) was markedly more frequent in moderate-to-severe strokes, echoing the findings of Sonneville R et al. (2023)[17], who demonstrated that LVO strongly predicts high NIHSS scores and worse prognosis.

Lesion volume showed one of the strongest correlations with stroke severity, reinforcing global evidence that infarct size is the most influential imaging correlate. This reflects findings from Patel DD et al. (2022)[18], who reported near-linear associations between DWI volume and NIHSS.

## CONCLUSION

The present cross-sectional study comprehensively evaluated the spectrum of MRI findings in acute ischemic stroke and demonstrated a strong and consistent correlation between imaging characteristics and clinical severity assessed by the NIHSS. Lesion volume, diffusion restriction severity (ADC values), and vascular occlusion on MR angiography emerged as the most powerful radiological predictors of higher NIHSS scores. Patients with moderate-to-severe stroke exhibited

significantly larger infarct volumes, lower ADC values, higher prevalence of large-vessel occlusion, and fewer DWI FLAIR mismatch patterns, reflecting more advanced and irreversible cerebral ischemia. Conversely, lacunar infarcts and mismatch patterns were more common among patients with mild deficits, indicating smaller, early-presenting, and potentially salvageable lesions.

Additionally, anterior circulation strokes demonstrated significantly higher cortical involvement compared with posterior circulation strokes, although other imaging patterns were similarly distributed between the two territories. These findings collectively reaffirm the central role of MRI in delineating stroke subtype, burden, and pathophysiological mechanisms, and emphasize that imaging biomarkers can greatly enhance severity stratification, prognostic assessment, and therapeutic decision-making. The study provides important region-specific evidence supporting MRI as a crucial tool in early stroke evaluation and clinical triage.

## LIMITATIONS

Cross-sectional design: The study assessed clinical severity and MRI findings at a single time point, without follow-up imaging or functional outcome assessment (e.g., mRS at 90 days).

Single-center study: Results may not be generalizable to diverse populations or healthcare settings with different MRI capabilities or stroke epidemiology.
Timing variability: Although all patients underwent MRI within the acute phase, differences in exact timing of imaging may have influenced ADC values, mismatch patterns, and lesion appearance.

No perfusion imaging for all patients: Perfusion-weighted MRI (PWI) was not performed uniformly, limiting detailed evaluation of penumbral tissue and perfusion deficits.

Potential interobserver variability: Despite dual radiologist review, subtle discrepancies in lesion measurement or pattern classification may persist.
Exclusion of hemorrhagic strokes: Results only reflect ischemic pathology; mixed stroke presentations were not evaluated.

Limited assessment of stroke mechanisms: TOAST classification was not analyzed in depth, which may have contributed additional mechanistic correlations.
Resource constraints: MRI may not be available in all emergency settings, affecting the applicability of routine imaging-based stratification.

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