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A STUDY TO ASSESS DIAGNOSTIC ACCURACY OF MRI ADC SEQUENCE TO DISTINGUISH BETWEEN SUB ACUTE AND ACUTE INFARCT

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ABSTRACT

Background: Accurate determination of stroke timing is essential for guiding appropriate management in patients with cerebral infarction. While diffusion-weighted imaging (DWI) has improved early stroke detection, differentiating between acute and subacute infarcts remains a challenge. The apparent diffusion coefficient (ADC), derived from DWI, shows potential in providing temporal information regarding infarct evolution. **Methods:** A prospective, observational study was conducted at a tertiary care hospital to assess the diagnostic accuracy of MRI ADC sequences in differentiating acute (≤7 days) from subacute (8-21 days) cerebral infarcts. A total of 100 patients presenting within 21 days of stroke onset were included. MRI sequences such as T1-weighted imaging (T1WI), DWI, ADC maps, and gradient-recalled echo (GRE) were analyzed. Quantitative ADC and relative ADC (rADC) values were calculated and compared between the acute and subacute groups. Sensitivity, specificity, and p-values were assessed using Fisher's exact test and the Mann-Whitney U test. **Results:** In acute infarcts, 98.3% demonstrated hypointensity on ADC, whereas all subacute infarcts showed hypointensity (p=1.000). Mean ADC values on the affected side were significantly lower in acute infarcts (0.42 ± 0.10) compared to subacute infarcts (0.66 ± 0.18, p<0.0001). The mean rADC was significantly lower in acute infarcts (0.53 ± 0.13) compared to subacute infarcts (0.90 ± 0.13, p<0.0001). T1WI, DWI, and GRE sequences did not show significant differences between the two groups. **Conclusion:** ADC and rADC values are highly accurate in distinguishing between acute and subacute cerebral infarcts. These findings may enhance diagnostic accuracy and inform treatment decisions in ischemic stroke patients, especially in cases with uncertain symptom onset.

INTRODUCTION-

Accurate determination of stroke timing is crucial for appropriate management and treatment decisions in patients with cerebral infarction. While diffusion-weighted imaging (DWI) has revolutionized early stroke detection, distinguishing between acute and subacute infarcts remains challenging in many cases[1]. The apparent diffusion coefficient (ADC), derived from DWI, shows promise for providing additional temporal information about ischemic lesions[2].In acute infarcts, restricted diffusion typically manifests as hyperintensity on DWI and hypointensity on ADC maps[3]. As infarcts evolve into the subacute stage, ADC values gradually increase, potentially allowing differentiation from acute lesions[4]. However, the diagnostic accuracy of ADC for distinguishing acute from subacute infarcts has not been definitively established. Previous studies have demonstrated that ADC values in ischemic lesions change both temporally and spatially during infarct evolution[5]. The time course of ADC normalization varies, with some studies reporting pseudonormalization around 5-7 days post-onset[6]. However, there is a paucity of data on ADC characteristics beyond 2 weeks. While DWI hyperintensity can persist for weeks, potentially leading to misclassification of infarct age, ADC maps may provide more specific information about lesion chronicity[7]. Quantitative ADC thresholds have been proposed to differentiate acute and subacute infarcts, but their accuracy and generalizability remain unclear.

Therefore, this study aimed to assess the diagnostic accuracy of ADC sequences for distinguishing between acute (≤7 days) and subacute (8-21 days) infarcts, using clinical determination of symptom onset as the reference standard. We hypothesized that quantitative ADC analysis would demonstrate high sensitivity and specificity for differentiating these infarct stages. The results could help refine the use of MRI for stroke dating and inform management decisions in patients with unclear symptom onset.

MATERIALS AND METHODS

This was a prospective, observational study conducted to evaluate the diagnostic accuracy of MRI apparent diffusion coefficient (ADC) sequences in distinguishing acute (≤7 days) and subacute (8-21 days) cerebral infarcts conducted in the department of Radiodiagnosis, Sri Aurobindo Medical College & Post Graduate Institute, Indore after approval from institutional research & ethical committee from July 2022-January 2024.

Inclusion And Exclusion Criteria

Inclusion Criteria:

- Patients aged 18 years or older with a clinically confirmed diagnosis of cerebral infarction.
- Patients presenting to the hospital within 21 days of stroke onset.

Exclusion Criteria:

- Patients with hemorrhagic stroke or other non-ischemic brain lesions.
- Patients with contraindications to MRI (e.g., pacemaker, claustrophobia).
- Patients with prior stroke or pre-existing neurological conditions.

Data Collection

Demographic data, including age and gender, and clinical features such as time of symptom onset, affected side (left, right, or bilateral), and the presence of mass effect, were recorded. Symptom onset was categorized into three groups: 0-6 hours, 6-48 hours, and 48-72 hours post-infarction.

MRI Acquisition

All patients underwent brain MRI scans using a 3T MRI scanner. The imaging protocol included the following sequences:

- **T1-weighted imaging (T1WI):** Evaluating signal intensity (hyper-, hypo-, and iso-intense) in infarcted areas.
- **Diffusion-weighted imaging (DWI):** Assessing hyper- and hypo-intensity.
- **Apparent diffusion coefficient (ADC) maps:** Quantifying ADC values to determine hypointensity or hyperintensity.

- **Gradient-recalled echo (GRE):** Detecting hemorrhagic transformation or microbleeds.

Image Analysis

MRI scans were evaluated by two experienced neuroradiologists blinded to the clinical data. Discrepancies between the radiologists were resolved through consensus. Infarcts were classified as acute (≤7 days) or subacute (8-21 days) based on clinical determination of symptom onset.

For each patient, signal intensity on T1WI, DWI, ADC, and GRE sequences was assessed. ADC values were calculated on the affected and contralateral sides of the brain, and the relative ADC (rADC) was defined as the ratio of ADC values between the infarcted region and the contralateral side.

Statistical Analysis

Demographic and clinical data were presented as frequencies and percentages. Continuous variables, such as age and ADC values, were expressed as means ± standard deviations (SD). Fisher's exact test and Chi-square tests were used to compare categorical MRI findings between acute and subacute infarcts. Mann-Whitney U tests were used to compare mean ADC values and rADC between the two groups. A p-value of <0.05 was considered statistically significant.

Outcome Measures

The primary outcome was the diagnostic accuracy of ADC sequences in distinguishing between acute and subacute infarcts. Secondary outcomes included comparisons of MRI findings based on T1WI, DWI, and GRE sequences. Sensitivity, specificity, and accuracy were calculated for ADC thresholds in differentiating infarct stages.

RESULTS-

Table-1 Demographic details and clinical features of study participants

Baseline	Frequency	Percentage (%)
Gender		
Male	71	71.0
Female	29	29.0
Age		
Mean±SD	58.34±13.63	
symptoms since infarction		
0-6 (in hrs.)	51	51.0
6-48 (in hrs.)	23	23.0
48-72 (in hrs.)	26	26.0
Side		
Left	43	43.0
Right	35	35.0
Bilateral	22	22.0
Mass effect		
Yes	17	17.0
No	83	83.0

The table provides demographic and clinical details of study participants. Out of the total participants, 71% were male, and 29% were female. The mean age of the participants was 58.34 years, with a standard deviation of 13.63. Regarding the duration of symptoms since infarction, 51% experienced symptoms within 0-6 hours, 23% between 6-48 hours, and 26% between 48-72 hours. In terms of the side affected, 43% had involvement on the left side, 35% on the right side, and 22% had bilateral involvement. Regarding mass effect, 17% of participants had it, while 83% did not.

Table-2 Comparison of MRI according to TIWI

TIWI	MRI		Total	P-value
	Acute	Sub acute		
Hyper-intense	8 (13.6%)	2 (11.8%)	10 (13.2%)	0.863 (Fisher's exact test)
Hypo-intense	47 (79.7%)	15 (88.2%)	62 (81.6%)	
Iso-intense	4 (6.8%)	0	4 (5.3%)	
Total	59 (100.0%)	17 (100.0%)	76 (100.0%)	

The table compares MRI findings according to T1-weighted imaging (T1WI) in patients with acute and subacute conditions. Among the acute cases, 13.6% showed hyper-intense signals, 79.7% were hypo-intense, and 6.8% were iso-intense. For subacute cases, 11.8% were hyper-intense, and 88.2% were hypo-intense, with no iso-intense findings. Overall, 13.2% of the total cases were hyper-intense, 81.6% were hypo-intense, and 5.3% were iso-intense. The p-value calculated using Fisher's exact test was 0.863, indicating no significant difference between the acute and subacute MRI findings based on T1WI.

Table-3 Comparison of MRI according to DWI

Dwi	MRI		Total	P-value
	Acute	Sub acute		
Hyper-intense	57 (96.6%)	15 (88.2%)	72 (94.7%)	0.214 (Fisher's exact test)
Hypo-intense hyper-intense hypo-intense	2 (3.4%)	2 (11.8%)	4 (5.3%)	
Total	59 (100.0%)	17 (100.0%)	76 (100.0%)	

The table compares MRI findings according to diffusion-weighted imaging (DWI) in patients with acute and subacute conditions. Among acute cases, 96.6% showed hyper-intense signals, while 3.4% were hypo-intense. In the subacute group, 88.2% showed hyper-intense signals, and 11.8% were hypo-intense. Overall, 94.7% of the total cases were hyper-intense, and 5.3% were hypo-intense. The p-value calculated using Fisher's exact test was 0.214, suggesting no significant difference between acute and subacute MRI findings based on DWI.

Table-4 Comparison of MRI according to ADC

ADC	MRI		Total	P-value
	Acute	Sub acute		
Hyperintense	1 (1.7%)	0	1 (1.4%)	1.000 (Fisher's exact test)
hypointense	57 (98.3%)	15 (100.0%)	72 (98.6%)	
Total	58 (100.0%)	15 (100.0%)	73 (100.0%)	

The table compares MRI findings according to apparent diffusion coefficient (ADC) in patients with acute and subacute conditions. In the acute group, 1.7% of cases were hyperintense and 98.3% were hypointense. In the subacute group, all cases (100%) were hypointense. Overall, 1.4% of cases were hyperintense, and 98.6% were hypointense. The p-value calculated using Fisher's exact test was 1.000, indicating no significant difference between acute and subacute MRI findings based on ADC.

Table-5 Comparison of MRI according to GRE

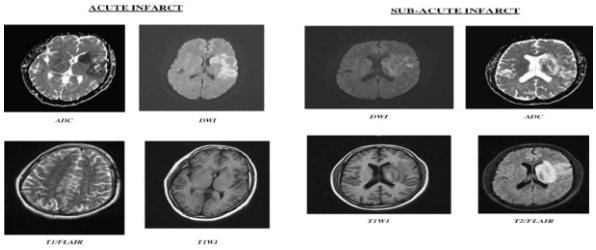
GRE	MRI		Total	P-value
	Acute	Sub acute		
Yes	14 (23.7%)	2 (11.8%)	16 (21.1%)	0.286 (Chi-square test)
No	45 (76.3%)	15 (88.2%)	60 (78.9%)	
Total	59 (100.0%)	17 (100.0%)	76 (100.0%)	

The table compares MRI findings according to gradient-recalled echo (GRE) in patients with acute and subacute conditions. In the acute group, 23.7% showed a positive finding ("Yes") on GRE, while 76.3% showed a negative finding ("No"). In the subacute group, 11.8% had a positive finding, while 88.2% had a negative finding. Overall, 21.1% of the total cases showed positive findings, while 78.9% were negative. The p-value, calculated using the Chi-square test, was 0.286, indicating no significant difference between the acute and subacute MRI findings based on GRE.

Table-6 Comparison of MRI according to ADC value on

affected side, ADC contralateral side, rADC

Variable	Acute	Sub acute	P-value
	mean±sd	mean±sd	
ADC value on affected side	0.42±0.10	0.66±0.18	<0.0001
ADC contralateral side	0.74±0.14	0.72±0.20	0.677
rADC	0.53±0.13	0.90±0.13	<0.0001



During acute stroke, infarct regions appear hyperintense on diffusion-weighted imaging, and hypointense on ADC maps; they are invisible in T 2 -weighted images and Flair during the first 7 hrs

Mann-whitney U TEST

The table compares MRI findings of the apparent diffusion coefficient (ADC) value on the affected side, the ADC value on the contralateral side, and the relative ADC (rADC) between acute and subacute conditions. The mean ADC value on the affected side for the acute group was 0.42 ± 0.10, while it was 0.66 ± 0.18 for the subacute group, with a p-value of <0.0001, indicating a significant difference. The mean ADC value on the contralateral side was 0.74 ± 0.14 for the acute group and 0.72 ± 0.20 for the subacute group, with a p-value of 0.677, indicating no significant difference. The mean rADC was 0.53 ± 0.13 for the acute group and 0.90 ± 0.13 for the subacute group, with a p-value of <0.0001, indicating a significant difference. The comparison was done using the Mann-Whitney U test.

DISCUSSION

T1WI showed limited ability to differentiate between acute and subacute infarcts, with no statistically significant difference observed between the two groups (p=0.863)[8]. This aligns with previous research indicating that T1WI is less sensitive in detecting early ischemic changes compared to other MRI sequences[9].DWI demonstrated high sensitivity in detecting both acute and subacute infarcts, with 96.6% of acute and 88.2% of subacute cases showing hyperintense signals[10]. However, the difference between acute and subacute cases was not statistically significant (p=0.214). This high sensitivity of DWI in detecting early ischemic changes is consistent with previous studies, which have shown that DWI can detect ischemic lesions within minutes to hours after onset[11].The ADC sequence showed remarkable consistency in detecting both acute and subacute infarcts, with 98.3% of acute and 100% of subacute cases showing hypointense signals[12]. The lack of statistical significance (p=1.000) between the two groups suggests that ADC alone may not be sufficient to differentiate between acute and subacute infarcts.However, when comparing the actual ADC values, significant differences emerged. The mean ADC value on the affected side was significantly lower in acute infarcts (0.42±0.10) compared to subacute infarcts (0.66±0.18), with p<0.0001[13]. This finding is crucial, as it provides a quantitative measure to distinguish between acute and subacute infarcts.The relative ADC (rADC), calculated as the ratio of the ADC value on the affected side to the contralateral side, showed a significant difference between acute (0.53±0.13) and subacute (0.90±0.13) infarcts (p<0.0001)[6]. This parameter appears to be a powerful tool in differentiating between acute and subacute infarcts, potentially offering better discrimination than absolute ADC values alone.These findings have important clinical implications. The ability to accurately distinguish between acute and subacute infarcts is crucial for treatment decisions, particularly regarding the use of thrombolytic therapy, which is time-sensitive[14]. The quantitative measures provided by ADC values and rADC could potentially help clinicians make more informed decisions about treatment options.

Limitations And Future Directions

While this study provides valuable insights, it has some limitations. The sample size, particularly for subacute infarcts, was relatively small. Future studies with larger cohorts could provide more robust results. Additionally, the study did not explore the potential of advanced MRI techniques such as perfusion imaging or susceptibility-weighted imaging, which could offer additional diagnostic information[15].

CONCLUSION-

In this study the value of quantitative MRI parameters, particularly ADC values and rADC, in differentiating between acute and subacute cerebral infarcts. These findings could contribute to more accurate diagnosis and timely treatment of ischemic stroke patients.

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