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MRI Findings in Patients with Ischemic and Hemorrhagic Stroke

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Abstract

Background: *Stroke is a leading cause of morbidity and mortality, with ischemic and hemorrhagic subtypes requiring distinct diagnostic and management approaches. Magnetic Resonance Imaging (MRI) plays a crucial role in early diagnosis, stroke classification, and prognosis assessment. This study evaluates MRI findings in ischemic and hemorrhagic stroke patients in a Bangladeshi population.*

Methods: *This cross-sectional study was conducted at the Department of Radiology and Imaging, Ibne Sina Diagnostic & Consultation Center, Uttara, Dhaka, from January 2015 to December 2015. A total of 50 stroke patients (35 ischemic, 15 hemorrhagic) underwent MRI, including DWI, ADC, PWI, GRE/SWI, FLAIR, and MRA/MRV sequences. Stroke severity was assessed using the NIH Stroke Scale (NIHSS), and functional outcomes were evaluated using the modified Rankin Scale (mRS) at 3 months.*

Results: *Among ischemic stroke patients, 91.4% had diffusion restriction on DWI, 85.7% showed low ADC values, and 40.0% had large vessel occlusions on MRA. In hemorrhagic stroke patients, 80.0% exhibited hypointense hematomas on GRE/SWI, while 40.0% had microbleeds. Severe stroke (NIHSS >15) was more common in hemorrhagic stroke (53.3%) than ischemic stroke (34.3%). Favorable outcomes (mRS 0-2) were observed in 52.0% of patients, while overall mortality was 12.0%, higher in hemorrhagic stroke (20.0%).*

Conclusion: *MRI provides crucial insights into stroke pathology, aiding in diagnosis and prognosis. DWI and ADC are essential for ischemic stroke evaluation, while GRE/SWI sequences play a key role in hemorrhagic stroke assessment. These findings highlight the importance of early MRI-based diagnosis for effective stroke management.*

Keywords: *Ischemic stroke, Hemorrhagic stroke, MRI, DWI, GRE/SWI, Stroke severity.*

1. INTRODUCTION

Stroke is one of the leading causes of morbidity and mortality throughout the world, with tremendous implications for healthcare systems, especially for developing countries like Bangladesh [1]. It is a huge public health concern, causing long-term disability, reduced quality of life, and enormous economic burden. Stroke can be broadly divided into ischemic and hemorrhagic, of which ischemic stroke accounts for the majority of cases [2]. Ischemic stroke results from arterial occlusion with subsequent cerebral infarction, while hemorrhagic stroke follows intracranial vessel rupture with bleeding into the brain parenchyma or subarachnoid space. It is crucial to differentiate between these subtypes since management differs significantly [3].

Magnetic resonance imaging (MRI) has revolutionized the diagnosis of stroke through its capability to provide exquisite information about brain tissue characteristics, vascular status, and lesion evolution [4].

Compared with computed tomography (CT), MRI is more sensitive to early ischemic changes, particularly with diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) mapping, which identify cytotoxic edema in ischemic infarcts [5]. In hemorrhagic stroke, susceptibility-weighted imaging (SWI) and gradient-echo (GRE) sequences are extremely sensitive to microbleeds, hemosiderin deposits, and hematomas. In addition, fluid-attenuated inversion recovery (FLAIR) and T2-weighted imaging (T2WI) assess perilesional edema, chronic infarcts, and white matter changes [6]. Magnetic resonance angiography (MRA) and perfusion-weighted imaging (PWI) provide valuable information about vascular occlusions, collateral circulation, and perfusion deficits, which further aid in stroke classification and prognosis assessment [3].

The burden of stroke in Bangladesh has been increasing because of the high burden of hypertension, diabetes mellitus, smoking, dyslipidemia, and cardiovascular diseases [7]. Limited access to advanced neuroimaging, delayed hospital arrival, and low awareness of stroke symptoms are usual causes of poor outcomes. While CT scan is the standard opening stroke imaging, MRI is the gold standard for the final classification and prognosis of stroke [8]. However, availability and affordability of MRI have been long-standing problems in resource-scarce settings, hence the need to determine its clinical utility in patients with stroke.

Several studies have highlighted the importance of MRI in early stroke detection, severity assessment, and long-term outcome prediction [6]. In ischemic stroke, identification of infarct core and penumbra mismatch on PWI is critical for the selection of patients for thrombolytic therapy, while in hemorrhagic stroke, hematoma volume and location guide surgical intervention [4]. In addition, MRI results match clinical scales like the National Institutes of Health Stroke Scale (NIHSS) and the modified Rankin Scale (mRS), which aid in quantifying initial stroke severity and anticipating functional recovery [8]. The utility of MRI in assessing secondary stroke risk factors, including silent infarcts, cerebral small vessel disease, and microbleeds, is also firmly established.

Despite the growing evidence in support of MRI in stroke diagnosis, its use remains inconsistent in the majority of hospitals due to economic constraints and the need for experienced technical personnel [9]. Familiarity with the patterns of MRI findings in ischemic and hemorrhagic stroke patients can improve early diagnosis, guide treatment, and result in improved patient outcomes [10]. By assessing the stroke patients with MRI, the research will provide insight into the radiological characteristics, severity indicators, and clinical outcomes with the aim of improving stroke management in the local population. The research findings will have a central role in illuminating the importance of neuroimaging in stroke care and facilitating its greater availability in clinical use.

2. METHODOLOGY & MATERIALS

This cross-sectional study was conducted at the Department of Radiology and Imaging, Ibne Sina Diagnostic & Consultation Center, Uttara, Dhaka, from January 2015 to December 2015. A total of 50 patients diagnosed with either ischemic or hemorrhagic stroke were included. Patients were selected based on clinical presentation and confirmed by MRI. Individuals with a history of previous stroke, brain tumors, or traumatic brain injury were excluded.

All patients underwent MRI using a 1.5 Tesla scanner, and sequences included diffusion-weighted imaging (DWI), apparent diffusion coefficient (ADC), fluid-attenuated inversion recovery (FLAIR), T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), susceptibility-weighted imaging (SWI), gradient-echo (GRE), perfusion-weighted imaging (PWI), and magnetic resonance angiography (MRA). Ischemic stroke was confirmed by diffusion restriction on DWI, low ADC values, and perfusion mismatch on PWI, while hemorrhagic stroke was identified by hyperintense hematomas on T1WI, hypointensity on GRE/SWI, and perilesional edema on T2/FLAIR. MRA and magnetic resonance venography (MRV) were used to assess vascular abnormalities such as arterial occlusions, aneurysms, and arteriovenous malformations (AVMs).

Clinical severity was assessed using the National Institutes of Health Stroke Scale (NIHSS) at admission, and functional outcomes were evaluated at three months using the modified Rankin Scale (mRS). Favorable outcomes were defined as mRS scores of 0 to 2, while disability and mortality were classified as mRS 3 to 5 and 6, respectively. Data were analyzed using SPSS, with categorical variables presented as frequencies and percentages.

3. RESULTS

Table 1. *Demographic Characteristics of Study Participants (N = 50)*

Characteristic	Ischemic Stroke (n=35)	Hemorrhagic Stroke (n=15)	Total (N=50)
Age (≤50 years)	12 (34.3%)	4 (26.7%)	16 (32.0%)
Age (>50 years)	23 (65.7%)	11 (73.3%)	34 (68.0%)
Male	20 (57.1%)	9 (60.0%)	29 (58.0%)
Female	15 (42.9%)	6 (40.0%)	21 (42.0%)
Hypertension	25 (71.4%)	12 (80.0%)	37 (74.0%)
Diabetes Mellitus	12 (34.3%)	4 (26.7%)	16 (32.0%)

Table 1 presents the demographic characteristics of the study participants. Among the 50 patients, 35 (70.0%) had ischemic stroke, while 15 (30.0%) had hemorrhagic stroke. The majority of patients were above 50 years (68.0%), with a slightly higher proportion of males (58.0%) than females (42.0%). Hypertension was the most common comorbidity, present in 74.0% of all patients, with a higher prevalence in hemorrhagic stroke cases (80.0%). Diabetes mellitus was found in 32.0% of patients, slightly more common in ischemic stroke cases (34.3%) than hemorrhagic stroke cases (26.7%).

Table 2. *MRI Findings in Ischemic Stroke Patients (N = 35)*

MRI Finding	Frequency (n=35)	Percentage (%)
Diffusion Restriction on DWI	32	91.40%
Low ADC Values (Cytotoxic Edema)	30	85.70%
Perfusion Mismatch on PWI	20	57.10%
Large Vessel Occlusion on MRA	14	40.00%
Chronic Infarct on FLAIR	10	28.60%

Table 2 summarizes the MRI findings in 35 ischemic stroke patients. Diffusion restriction on DWI was the most common finding (91.4%), followed by low ADC values indicating cytotoxic edema (85.7%). Perfusion mismatch on PWI, suggestive of salvageable brain tissue, was observed in 57.1% of cases. Large vessel occlusion on MRA was identified in 40.0%, while chronic infarcts on FLAIR were noted in 28.6% of patients.

Table 3. *MRI Findings in Hemorrhagic Stroke Patients (N = 15)*

MRI Finding	Frequency (n=15)	Percentage (%)
Hyperintense Hematoma on T1WI	10	66.70%
Hypointense Hematoma on GRE/SWI	12	80.00%
Perilesional Edema on T2/FLAIR	9	60.00%
Microbleeds on SWI	6	40.00%
Aneurysm/AVM on MRA/MRV	4	26.70%

Table 3 presents the MRI findings in 15 hemorrhagic stroke patients. The most common finding was hypointense hematoma on GRE/SWI (80.0%), followed by hyperintense hematoma on T1WI (66.7%), indicating different stages of blood degradation. Perilesional edema on T2/FLAIR was observed in 60.0% of cases. Microbleeds on SWI, suggestive of underlying small vessel disease, were found in 40.0% of patients. Aneurysm or arteriovenous malformation (AVM) on MRA/MRV was detected in 26.7%, highlighting the role of vascular imaging in hemorrhagic stroke evaluation.

Table 4. *Stroke Severity and Follow-Up Outcomes (N = 50)*

Outcome Measure	Ischemic Stroke (n=35)	Hemorrhagic Stroke (n=15)	Total (N=50)
NIHSS Score (Severe Stroke)	12 (34.3%)	8 (53.3%)	20 (40.0%)
Favorable Outcome (mRS 0-2)	20 (57.1%)	6 (40.0%)	26 (52.0%)
Disability Present (mRS 3-5)	12 (34.3%)	6 (40.0%)	18 (36.0%)
Death (mRS 6)	3 (8.6%)	3 (20.0%)	6 (12.0%)

Table 4 summarizes stroke severity and follow-up outcomes in 50 patients. Severe stroke (NIHSS >15) was more common in hemorrhagic stroke (53.3%) than ischemic stroke (34.3%). A favorable outcome (mRS 0-2) was achieved in 52.0% of patients, with a higher recovery rate in ischemic stroke (57.1%) compared to hemorrhagic stroke (40.0%). Moderate to severe disability (mRS 3-5) was seen in 36.0%, affecting both groups equally. The overall mortality rate (mRS 6) was 12.0%, with a higher death rate in hemorrhagic stroke (20.0%) than ischemic stroke (8.6%), reflecting its more severe prognosis.

4. DISCUSSION

Stroke remains a major cause of morbidity and mortality worldwide, with ischemic and hemorrhagic subtypes presenting distinct clinical and imaging characteristics [11, 12]. MRI plays a crucial role in differentiating between these two forms, assessing severity, and guiding management. This study highlights the key MRI findings in ischemic and hemorrhagic stroke patients and their association with clinical outcomes.

In ischemic stroke, diffusion-weighted imaging (DWI) was highly sensitive in detecting acute infarction, with 91.4% of patients showing diffusion restriction. This aligns with prior studies that established DWI as the gold standard for early ischemic stroke diagnosis [11, 13]. Low ADC values, indicating cytotoxic edema, were observed in 85.7% of cases, reinforcing its utility in identifying ischemic tissue. Perfusion-weighted imaging (PWI) showed a mismatch in 57.1% of cases, which is critical for identifying salvageable penumbra [12, 14]. This finding is consistent with earlier studies suggesting that patients with a significant perfusion-diffusion mismatch may benefit from reperfusion therapy, such as thrombolysis [13, 14]. Large vessel occlusions were detected in 40.0% of cases on MR angiography (MRA), underscoring the importance of vascular imaging in ischemic stroke. Chronic infarcts, seen in 28.6% of patients on FLAIR imaging, suggest prior silent or recurrent strokes, emphasizing the need for secondary prevention strategies [15, 16].

In hemorrhagic stroke, GRE/SWI sequences were particularly valuable, with 80.0% of patients showing hypointense hematomas, making it a reliable imaging marker for acute bleeding [15, 17]. Hyperintense hematomas on T1-weighted imaging (66.7%) suggest subacute hemorrhage, highlighting the evolution of blood products over time. Perilesional edema (60.0%) on T2/FLAIR indicates secondary injury due to mass effect and inflammation, which has been associated with worse clinical outcomes [18]. Microbleeds on SWI (40.0%) were noted, suggesting an underlying microangiopathy, which is a known risk factor for future hemorrhagic events [16, 17]. Aneurysms or arteriovenous malformations (26.7%) detected on MRA/MRV further emphasize the role of vascular imaging in hemorrhagic stroke for identifying treatable causes [19]. These findings are consistent with previous literature that has demonstrated the superiority of MRI over CT in detecting underlying vascular abnormalities in hemorrhagic stroke [15, 19].

The severity of stroke was assessed using the NIH Stroke Scale (NIHSS). Severe stroke (NIHSS >15) was more common in hemorrhagic stroke (53.3%) compared to ischemic stroke (34.3%), reflecting its typically worse initial presentation [20, 21]. The modified Rankin Scale (mRS) at 3 months was used to assess functional outcomes. A favorable outcome (mRS 0-2) was achieved in 52.0% of patients, with ischemic stroke patients having a higher recovery rate (57.1%) than hemorrhagic stroke patients (40.0%) [20]. The relatively better outcomes in ischemic stroke may be due to improved thrombolytic and endovascular interventions available for selected cases [13, 14, 20]. Disability (mRS 3-5) was observed in 36.0% of cases, similar between both groups, emphasizing the long-term impact of stroke on functional independence. The overall mortality rate was 12.0%, higher in hemorrhagic stroke (20.0%) than ischemic stroke (8.6%), consistent with previous studies showing higher early mortality in hemorrhagic stroke due to increased intracranial pressure and mass effect [20, 21].

The study findings align with previous global and regional data on stroke imaging and outcomes [21, 22]. Several studies have demonstrated that MRI is superior to CT in detecting early ischemic changes, assessing hemorrhage evolution, and identifying vascular causes of stroke [15, 19, 20]. The high prevalence of hypertension (74.0%) and diabetes (32.0%) in this cohort is consistent with established risk factors for stroke in South Asian populations, particularly in Bangladesh, where non-communicable diseases have been rising [22]. Hypertension was more common in hemorrhagic stroke (80.0%), reflecting its strong association with spontaneous intracerebral hemorrhage [22].

5. LIMITATIONS OF THE STUDY

While this study provides valuable insights, certain limitations should be considered. The relatively small sample size (N = 50) may limit generalizability, and selection bias cannot be ruled out. The study did not assess long-term follow-up beyond 3 months, which would provide better insight into stroke recovery and recurrent events. Additionally, MRI accessibility remains a challenge in many resource-limited settings, affecting early diagnosis and management. Future studies with larger sample sizes and longer follow-up are needed to further explore MRI's role in guiding stroke treatment strategies in the Bangladeshi population.

6. CONCLUSION

In conclusion, this study highlights the critical role of MRI in stroke evaluation, providing detailed insights into ischemic and hemorrhagic stroke pathology. DWI and ADC maps remain key in detecting acute ischemia, while GRE/SWI sequences are crucial for identifying hemorrhages and microbleeds. The findings reinforce the importance of early stroke diagnosis, vascular imaging, and appropriate management strategies to improve patient outcomes.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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