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Diagnosis of Acute Ischemic Stroke by CT scan and Diffusion Weighted MRI

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A B S T R A C T

Background: Acute ischemic stroke is the leading cause of death and disability. An accurate and practical understanding of imaging modalities is essential for the management of the acute stroke patients. Due to its widespread availability and speed, unenhanced Computed Tomography (CT) scan remains the initial study of choice for evaluating an acute stroke patients and Diffusion Weighted Magnetic Resonance Imaging (DWMRI) can detect abnormalities due to ischemia within 3 to 30 minutes of onset, when conventional MRI and CT images would still appear normal.**Objective:** To compare the diagnostic role of CT scan and DWMRI in acute ischemic stroke and establish the agreement between them.**Methods:** This cross-sectional study was performed on 110 patients from the Department of Radiology and Imaging, BSM Medical University Hospital, Dhaka, Bangladesh from July 2023 to August 2024. Patients were immediately transferred to the Department of Radiology and Imaging where they underwent comprehensive CT scans. Suspicion of acute ischemic stroke was present.**Results:** Total 110 patients were enrolled in this study. Almost one third (32.7%) patients belonged to age ≥70 years. The mean age was 61.11±12.49 years with range from 32 to 90 years. Almost two third patients were male (60%) followed by (40%) female. More than (38.2%) patients were retired from job, followed by house wife (34.5%). It was observed that 20 (20%) patients experienced headache, (32.7%) vertigo, (49.1%) vomiting, (70.9%) hemiparesis/hemiplegia, Majority (81.8%) had speech disturbance. The location of infarct showed that (23.6%) patients were in M1 segment (anterior circulation ASPECTS) followed by 52 (47.3%) in lentiform nucleus and 52 (47.3%) in internal capsule. Mass Effect were observed in both CT and DWMRI in 14 (12.7%) cases. More than (76.4%) patients showed parenchymal hypoattenuation (CT) and diffusion restriction (MRI) [CT, 76.4% and DWMRI, 78.2%]. Regarding ADC value, it was observed that majority (74.5%) patients were below 0.6X10-3 mm2/s. The agreement analysis of the two modalities (parenchymal hypoattenuation (CT) with diffusion restriction (MRI)) was found showing a Kappa value of 0.858 and p value <0.01. **Conclusion:** DWI-MRI is a better imaging method in detecting early ischemic lesions in acute ischemic stroke patients.

Keywords: Acute Ischemic Stroke, Unenhanced CT, Conventional MRI, DWMRI.

INTRODUCTION

Stroke was defined in 1970 by the World Health Organization as "a rapidly progressing clinical manifestation of focal (or global) impairment of cerebral function lasting more than 24 hours and with no identifiable cause other than vascular causes." [1] "Stroke is the third leading cause of death in Bangladesh. DWI is highly sensitive in detecting and localizing acute ischemic brain lesions, allowing differentiation of acute areas of ischemia from chronic infarction. Recent studies have shown a high correlation between early DWI lesion volume and clinical neurological outcome. The World Health Organization ranks Bangladesh 84th in the world for stroke mortality. No data on stroke incidence is available in Bangladesh, although stroke prevalence is reported to be 0.3%."[2] The sensitivity of standard non-contrast CT for detecting cerebral ischemia increases after 24 hours. However, a systematic review of 15 studies in which CT scans were performed within 6 hours of stroke onset found the prevalence of early CT signs of cerebral infarction to be 61%.[3]

Early ischemic changes appear on non-contrast CT as hypodensity (cytotoxic edema), loss of gray-white differentiation, swelling of the cerebral cortex, and loss of sulcal formation (loss of sulci due to tissue swelling). Diffusion-weighted imaging (DWI): DWI relies on the ability of high-speed MRI to detect signals associated with the movement of water molecules between two closely spaced radiofrequency pulses. This technique can detect ischemia-related abnormalities within 3 to 30 minutes of onset that still appear normal on conventional MRI and CT images. [4] The apparent diffusion coefficient (ADC) provides a quantitative measure of water diffusion. In acute ischemic stroke with cytotoxic edema, decreased water diffusion in the infarcted tissue causes increased DWI signal (hyperintensity) and decreased ADC, visualized as hypointense signals on brain ADC maps.[5] In a study comparing CT, DWI, and standard MRI, abnormal DWI was a sensitive and specific indicator of ischemic stroke in patients who presented to the clinic within 6 hours of symptom onset.[6] However, occasionally, patients with acute ischemic deficits show normal DWI. In these cases, infarction can be confirmed on a subsequent MRI or CT scan. A systematic review published by the American Academy of Neurology (AAN) in 2010 concluded that DWI is superior to non-contrast CT in diagnosing acute ischemic stroke in patients seen within 12 hours of symptom onset.[7]

MATERIALS AND METHODS

This cross-sectional study was performed on 110 patients from the Department of Radiology and Imaging, BSM Medical University Hospital, Dhaka, Bangladesh from July 2023 to August 2024. Patients were immediately transferred to the Department of Radiology and Imaging where they underwent comprehensive CT scans. The examinations were performed with a 0.5 mm x 80 detector, 160 slices per rotation*, 0.5 mm coverage of 4 cm, 0.35 sec rotation, SEMAR, AIDR 3D Integrated and In -field upgraded system and images were transferred to a workstation directly connected to the CT console. CT examinations of all selected subjects were performed with high resolution parameters (80 x 0.5 mm detector collimation, 1 mm slice thickness, 120 kV). CT images without contrast agents were evaluated. All patients who underwent CT scans in this study also underwent neuroimaging with diffusion weighted magnetic resonance imaging (DWMRI) using a Philips Ingenia 1.5 Tesla MR system, Netherlands. The diffusion-weighted sequence was adjusted in 50 seconds to provide high SNR and image quality, as well as fast and robust imaging.

All relevant data collected were first compiled into a master chart. Statistical analysis was then performed using Statistical Package for Social Sciences version 23 for Windows (SPSS Inc., Chicago, IL, USA). Qualitative variables were expressed as frequencies and percentages. Quantitative variables were expressed as mean + standard deviation. To evaluate the agreement between CT and DWMRI in diagnosing acute ischemic stroke, significance tests were performed using Cohen's kappa test. Landisand Koch suggested that a kappa greater than 0.75 represented excellent agreement, a kappa less than 0.40 represented poor agreement, and a kappa between 0.40 and 0.75 represented moderate to good agreement. Apparent diffusion coefficient (ADC) correlated with time after stroke. ADC values in hyperacute and acute strokes significantly decreased, whereas subacute, stable, and chronic strokes gradually increased.

RESULTS

Total 110 patients were enrolled in this study. Table-1 shows that almost one third (32.7%) patients belonged to age ≥70 years. The mean age was 61.11±12.49 years with range from 32 to 90 years. Fig- 1 shows the sex distribution of the study subjects, it shows that 60% patients were male and 40% female, with a male to female ratio of 1.5:1. Occupational distribution of the study subjects showed that more than one third (38.2%) patients were retired from job, followed by house wife (34.5%), service holder (18.2%) and business man (9.1%).

Table-1: Distribution of the study subjects by age (n=110)

Age (in years)	Number	Percentage
30-39	04	3.6
40-49	08	7.3
50-59	28	25.5
60-69	34	30.9
70 Above	36	32.7
Mean±SD	61.11 ± 12.49	
Range(min-max)	32-90	

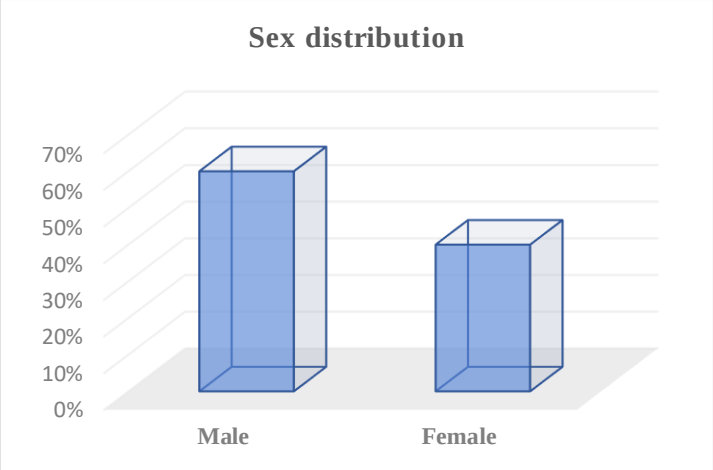

Fig-1: Sex distribution of the study subjects.

Table-2: Distribution of the study subjects by time elapsed in hours after onset of clinical presentation (n=110)

DurationofClinical Presentation(hours)	Number	Percentage
6-10	12	10.9
11-15	38	34.5
16-20	42	38.2
21-24	18	16.4
Mean±SD	15.89±4.39	
Range(min-max)	6-24	

Table-2 shows that more than one third (38.2%) patients arrived for diagnostic evaluation about 16- 20 hours after clinical presentation. The mean duration after onset of clinical presentation was 15.89 ± 4.39 hours with a range of 6 to 24 hours.

Table-3: Distribution of the study subjects by involvement of vascular territory (n=110)

VascularTerritory	Number	Percentage
Anteriorcirculation	52	47.3
Posteriorcirculation	06	5.5
Both	28	25.5

Table-3 shows the distribution of the study subjects by involvement of vascular territory. It was observed that almost half (47.3%) patients undergone infraction in anterior circulation followed by 28 (25.5%) in both and 6 (5.5%) in posterior circulation.

Table-4-1: Distribution of the study subjects by vascular segmental involvement of infarct (n=110)

Anterior Circulation ASPECTS	N	%
M1	26	23.6
M2	8	7.3
M3	20	18.2
M4	0	0.0
M5	4	3.6
M6	2	1.8
Caudatenucleus	0	0.0
LentiformNucleus	52	47.3
Insula	4	3.6
InternalCapsule	52	47.3

Table-4:2 (Continue)

Posterior Circulation ASPECTS	N	%
Thalamus	4	3.6
Pons	12	10.9
Midbrain	0	0.0
Occipital Lobe	8	7.3
Cerebellar Hemispshere	16	14.5
Posterior Circulation ASPECTS	N	%

Table-4(1&2) shows the distribution of the study subjects by vascular segmental involvement of infarct. It was observed that one fourth (23.6%) patients undergone infarction in M1 vascular territory (anterior circulation ASPECTS) followed by 52 (47.3%) in lentiform nucleus, 4 (3.6%) in insula and 52 (47.3%) in internal capsule. 16 (14.5%) patients undergone infraction in cerebellar hemisphere (posterior circulation ASPECTS) followed by 12 (10.9%) in pons, 8 (7.3%) in occipital lobe and 4 (3.6%) in thalamus.

Table-5: Distribution of the study subjects by mass effect (n=110)

Mass Effect	Number	Number
Present	14	12.7
Absent	96	87.3
MRI		
Present	14	12.7
Absent	96	87.3

Table-5 shows the distribution of the study subjects by mass effect which was 14 (12.7%), detected both by CT & MRI.

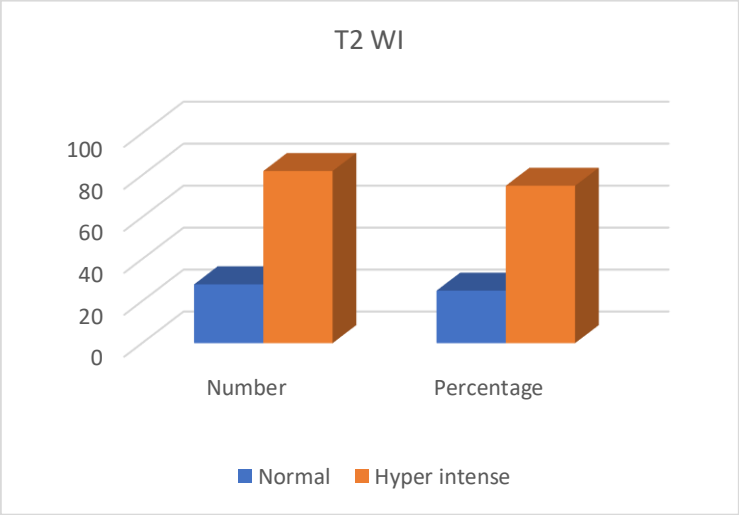

Fig-2: Distribution of the study subjects by T2 Weighted Imaging (T2WI) (n=55)

Fig-2 shows the distribution of the study subjects by T2 WI. It was observed that (75%) lesions were hyper intense and (25%) were normal.

Table-6: Distribution of FLAIR and parenchymal hypo-attenuation (CT) (n=110)

FLAIR	Number	Percentage	CT Parenchymal Hypo-attenuation	Number	Percentage
Normal	26	23.6	Present	84	76.4
Hyper intense	84	76.4	Absent	26	23.6

Table-6 shows the distribution of the study subjects by FLAIR. It was observed that more than 76.4% lesions were hyper intense and about (23.6%) were normal in FLAIR. The study subjects by diffusion restriction (DWMRI), where more than (78.2%) patients showed diffusion restriction in DWMRI. Among 76.4% patients showed parenchymal hypo attenuation (CT).

Table-7: Distribution of the study subjects by CT hypo attenuation with MRI diffusion restriction (n=110)

Parenchymal Hypoattenuation	Diffusion Restriction				p-value
	Present(n=86)		Absent(n=24)		
	N	%	N	%	
Present(n=42)	82 (a)	95.3	2 (d)	8.3	0.001[s]
Absent(n=13)	4 (c)	4.7	22 (d)	91.7	

Table-7 shows that among 43 diffusion restriction positive cases of acute ischemic stroke 82 (a) cases were positive for parenchymal hypo attenuation and 4 (c) case was negative. Among 24 diffusion restricted negative subjects 2 (b) case was positive for acute ischemic stroke evaluated by parenchymal hypoattenuation. Among total 110 cases 22 (d) cases were negative based on CT parenchymal hypoattenuation. The result of the two modalities {parenchymal hypoattenuation (CT) with diffusion restriction (MRI)} analysis showed a Kappa value of 0.858 with p value <0.01. This measure of agreement was statistically significant with excellent agreement between parenchymal hypoattenuation (CT) with diffusion restriction (MRI). (Landis and Koch, suggested that a kappa greater than 0.75 represents excellent agreement, a kappa below 0.40 represents poor agreement and a kappa of 0.40 to 0.75 represents intermediate to good agreement.)

Table-8: Distribution of the study subjects by ADC value determined by MRI (n=110)

ADCValue	Number	Percentage
Below$0.6X10^{-3}mm^2/s$	82	74.5
Above$0.6X10^{-3}mm^2/s$	2	1.8
Mean±SD	0.44±0.1	
Range(min-max)	0.25-0.57	

Table-8 shows the distribution of the study subjects by ADC value. It was observed that almost three forth (74.5%) patients had a value below $0.6X10^{-3}mm^2/s$. The mean ADC value below $0.6X10^{-3}mm^2/s$ was 0.44 ± 0.1 with range from 0.25 to 0.54.

DISCUSSION

Diagnosis of stroke largely depends on clinical presentation. Stroke-mimics account for 19%-30% of suspected stroke presentations, with diverse underlying etiology. Physicians need to consider a broad differential diagnosis when evaluating a patient presenting with a focal neurological deficit. The aim of present study was to establish that DWMRI is better than CT scan in diagnosis of acute Ischemic stroke. Suspected stroke patients were included in this study. DWMRI was compared with CT scan. Regarding the distribution of the study patients by age, it was observed that almost one third (32.7%) patients belonged to age ≥70 years. The mean age was 61.11±12.49 years which ranged from 32 to 90 years. In accordance with our study, authors reported that out of 503 patients with acute ischemic stroke admitted to emergency department in one center, mean age (+SD) was 68.45 (+8.76), and the age range was from 28 to 92 years. [8] In present study, the distribution of the study patients by sex showed that almost (60%) patients were male followed by (40%) female. In accordance with our study, authors stated that about 46.1% of patients were female, and 53.1% were male. [9] In the current study, regarding the distribution of the study patients by occupation, it was observed that more than one third (38.2%) patients were retired from job followed by house wife (34.5%), service holder (18.2%) and business man (9.1%). Researchers stated that physical activity has a significant role in the development of stroke in working adults.[10] In our study, regarding the distribution of the study patients by clinical presentation, it was observed that (20%) patients experienced headache, one third (32.7%) had vertigo, about half (49.1%) had vomiting, (70.9%) had hemiparesis/hemiplegia, 8(14.5%) had impaired consciousness, majority (81.8%) had speech disturbance, 8(14.5%) had visual disturbance, 2 (3.6%) had hearing disturbance and (10.9%) presented with cranial nerve palsy. The most common presenting symptoms for ischemic stroke are difficulty with speech and weakness on one half of the body. [11] In the current study, regarding the distribution of the study patients by vascular territory, it was observed that almost half (47.3%) patients involved anterior circulation followed by 28 (25.5%) involved both anterior and posterior circulation and 6 (5.5%) involved only posterior circulation. Almost in accordance with our study, authors reported that approximately 20–25% of all acute strokes occur in the posterior circulation. [12] In the current study, the distribution of the study patients by vascular segmental involvement of infarct showed (23.6%) patients in M1 segment (anterior

circulation ASPECTS) followed by 26(47.3%) in lentiform nucleus, 2(3.6%) in insula and 52 (47.3%) in internal capsule. 16 (14.5%) patients undergone infarction in cerebellar hemisphere (posterior circulation ASPECTS) followed by in 12 (10.9%) in pons, 8 (7.3%) in occipital lobe and 4 (3.6%) in thalamus. In our study, regarding the distribution of study patients by mass effect it was observedthat 14 (12.7%) showed mass effect in both CT scan and DWMRI. In previous study reporting mass effect to take place is only 40 to 50 percent of patients with ischemic stroke. [13-16] In current study, distribution of study patients by T2 WI and FLAIR showed that (75%) patients were hyper intense and (25%) normal. Authors suggested that focal hyper intensities were found in 142 of 307(46.3%) and with T2 weighted imaging and in 89 of 159 (56%) patients with FLAIR imaging. [17] Regarding the distribution of the study patients by ADC value below $0.6x10^{-3}mm^2/s$, it was observed in our study that almost (74.5%) patients had values below $0.6X10^{-3}mm^2/s$. The mean ADC value below 0.6×10^{-3} mm^2/s was 0.44±0.1 with range from 0.25 to 0.54. The mean <50% ADC range volume and 50% to 60% ADC range, both of which represent absolute ADC values of $<0.50\times10^{''3}mm^2$. [18] In this present study, regarding the distribution of the study patients by diffusion restriction (DWMRI) and parenchymal hypo attenuation it was observed that more than (78.2%, 76.4%) patients showed diffusion restriction (MRI) and parenchymal hypoattenuation CT. A total of 86 positive cases of acute ischemic stroke assessed by diffusion restriction were observed. Of these, 82 were positive for parenchymal hypotension and 4 were negative. No hypotension was detected. A total of 26 cases were assessed as negative by CT parenchymal hypotension, including 2 cases of positive acute ischemic stroke assessed by diffusion restriction. The agreement analysis of two modalities [parenchymal hypo attenuation (CT) with diffusion restriction (MRI)] was observed to be 0.858 (Kappa value) with p value <0.01. This level of agreement was statistically significant, and the agreement between parenchymal hypotension (CT) and diffusion restriction (MRI) was excellent. Fiebach et al. [19] showed that the kappa agreement between CT scans and DWMRI in 100 patients was 0.6, which is consistent with our current study. Our results suggest that DWMRI is superior to CT examination. Both modalities can be used with confidence, but both have advantages and disadvantages. Although CT is more widely used in our country, DWMRI has been proven to be very superior in detecting acute ischemic stroke. Therefore, when MRI is available, we strongly recommend DWMRI to accurately diagnose acute ischemic stroke.

CONCLUSION

In conclusion, although CT is more widely used in our country, DWMRI has been shown to be significantly superior in detecting acute ischemic stroke. Therefore, when MRI is available, DWMRI is highly recommended to accurately diagnose acute ischemic stroke. Furthermore, lesion volume on acute DWI, but not on acute CT, was highly correlated with final infarct volume.

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