ORIGINAL RESEARCH PAPER
Volume - 9 | Issue - 11 | November - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ROLE OF DIFFUSION WEIGHTED MRI IN EVALUATION OF STROKE

Radiology

Dr. Ayesha Begum* General Medicine Postgraduate.*Corresponding Author
Dr. Shaik Ismail Radiologist.
Dr. J.Veera Balaji MD Assistant Professor
Dr. Uzma Afreen Radiology Postgraduate.
Dr. A.Himabindhu Radiology Postgraduate.

ABSTRACT

BACKGROUND AND PURPOSE: Diffusion-weighted imaging (DWI) is a routinely performed sequence in MRI for evaluation of acute ischemic stroke(AIS) and is highly sensitive in detection of early infarcts. The purpose of the study was to evaluate the clinical efficacy, sensitivity and specificity of DWI for the diagnosis of AIS among patients with suspected AIS. **METHODS AND MATERIAL:** In this study, all patients with clinically diagnosed AIS, aged >18 yrs, admitted in GGH, Kakinada, were imaged with a neuroimaging protocol using MRI with conventional and DWI.

AIMS

1) To evaluate the accuracy of DWI and compare conventional MR imaging and DWI in the radiological diagnosis of AIS.
2) To evaluate the clinical efficacy, sensitivity, and specificity of DW MR imaging in patients with acute infarction.
3) To detect the frequency of false-negative DWI in acute stoke

RESULTS: In present study 159 cases with final diagnosis of AIS, DWI has accuracy of 94.6%, FLAIR 88.7% and T2 79.2%.DWI detected additional ischemic lesions not identified on conventional sequences.DWI showed 81% sensitivity and 100% specificity in hyper acute stroke cases with presentation < 6hrs. DWI had high accuracy in cases presenting after 6hrs with abnormal signal on DWI noted in 142 out of 148 cases (95.37%).Over all sensitivity and specificity of DWI in suspected cases of AIS is 94.9% and 92.3% respectively .Negative DWI with AIS constituted approx 5% of cases, with localization to brain stem in 75% and non-brainstem lacunar stroke in 25%.All the false negative cases of AIS were imaged within 24hrs of symptom onset. Of the 33 DWI negative cases of AIS, stroke mimics constituted (39.4%) cases with seizures as the most common mimics. **CONCLUSION:** DWI is accurate imaging method than conventional MRI in detecting early lesions in AIS.

KEYWORDS

DWI, MRI, T2, FLAIR.

INTRODUCTION

Stroke is defined by WHO as 'a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 hour or leading to death with no apparent cause other than a vascular origin.'(1)

Stroke is the second leading cause of death worldwide and it is also one of the leading cause of adult disability (2) and dementia in adults aged>65yrs , close to 25% stroke survivors develop dementia(3).

Ischemic stroke is responsible for 80 – 85% of all strokes worldwide. The TOAST (Trial of Org10172 In Acute Stroke Treatment) classification describes five subtypes of ischemic stroke(4)

The NIH Stroke Scale (NIHSS) was used as a diagnostic method for quickly assessing the severity of a stroke experienced by patient(5)(6)

Stroke mimic

A stroke mimic is defined as a nonvascular disease that presents with stroke-like symptoms, often indistinguishable from an actual stroke. The proportion of stroke mimics varies between 1% and 16% in hospital-based intravascular thrombolysis registers(7)(8).

Examples of stroke mimics- Seizures, Migraine, Brain tumors, Herpes simplex encephalitis, Hypoglycemia, Transient global amnesia, Hypoxic-ischemic encephalopathy, Wernicke's encephalopathy(9).

Diffusion weighted (DW) magnetic resonance (MR) imaging provides potentially unique information on the viability of brain tissue. DWI findings have shown high levels of diagnostic accuracy in detection of ischemia. Now diffusion weighed sequences with ADC maps have become essential components of a typical MR imaging study. Brain attack protocol commonly being used consists of T2W sequence, fluid-attenuated inversion recovery (FLAIR) sequence, a susceptibility sequence to rule out hemorrhage and a DW MR sequence which gives comprehensive information which is crucial in diagnosing ischaemia. DWI is very sensitive and relatively specific in detecting acute ischemic stroke Diffusion-weighted (DW) magnetic resonance (MR) imaging provides image contrast that is dependent on the molecular motion of water, which may be substantially altered by disease diffusion-weighted imaging allows the detection of ischemic tissue within minutes after onset of stroke. Diffusion-weighted images displayed a significant relative hyperintensity in ischemic regions as early as 45 min after onset of ischemia whereas T2-weighted spin-echo images failed to clearly demonstrate brain injury up to 2-3 h post occlusion.

Study method

In this study, all patients with suspected AIS admitted to the emergency department of Government General Hospital, Kakinada, during the period , July 2018 to December 2019 were evaluated by the physician and clinical diagnosis of stroke was compared with radiological imaging.

Study Design

This is a hospital based cross sectional study. Patients with symptoms of AIS attending GGH, Kakinada were examined within 15-30 min of arrival to hospital and patients were then imaged with a neuro imaging protocol using MRI with conventional and DWI.

INCLUSION CRITERIA

1) He or she aged more than 18 years.
2) Clinical diagnosis of acute cerebral infarction with cerebral MRI within 72 hrs of symptom onset.

EXCLUSION CRITERIA

Contraindications to MRI (metallic implants, pacemakers).

Cerebral infarction

Cerebral infarction was diagnosed and managed by physician/ neurologist according to the 2018 AHA/ASA (American Heart Association, American Stroke Association) guidelines.

T2, FLAIR, DWI and ADC were analysed systematically for all patients. In all cases, DWI and ADC images were analysed first followed by T2 and FLAIR. Hyperintense signal corresponding to the area of abnormal signal on DWI/ADC were considered positive for acute ischaemic lesions.

RESULTS

Of the 186 cases of suspected AIS, 159 cases had a final diagnosis of ischaemic stroke of which 151 cases showed abnormal findings on DW ,8 cases had a final diagnosis of stroke with negative DWI. Stroke mimics constituted 15 cases; 2 cases (false positive) had abnormal signal on DWI and 13 cases (true negative) had no abnormal signal on DWI. 12 cases presented with focal neurological deficit consistent with AIS had symptoms resolved within 24hrs with final diagnosis of TIA with no abnormal signal on DWI. Sensitivity, *specificity* and accuracy of conventional MRI (T2/FLAIR) were compared to DWI in identifying AIS. Sensitivity and specificity of DWI and percentage of DWI negative patients in suspected cases of AIS was studied.

Using chi-square test, the p-value calculated for DWI in suspected case of AIS was found to be statistically significant (p-value-<0.001).

WORK FLOW CHART

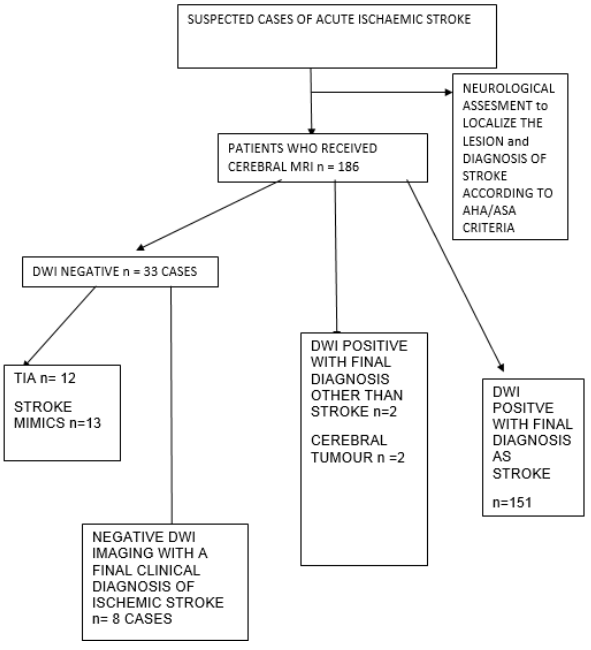

Table 1. Demonstrating anatomical location of acute lesions in DWI positive cases(151 cases with 235 acute lesions) and Clinically Suspected Anatomic Localization localization of the ischaemic lesion to specific anatomical site and vascular territory distribution in DWI negative cases with final diagnosis of stroke n=8.

DWI positive cases	n=151 cases with 235 acute lesions	DWI negative cases	n=8
Anatomical Location	**number**	**Clinically localized to anatomical site**	**number**
Lobar(including hippocampus)	115	Brainstem	6
CGR and thalamus	37	Non brainstem Lacunar strokes(CGR)	2
CSO & corona radiata	28		
Brainstem	24		
Cerebellum	31		

TABLE 2. Number (and percentage) of ischemic lesions detected on T2W, FLAIR, and DWI Scans in the acute ischaemic stroke compared with time between onset and MRI aquisition (in 151 patients with DWI positive stroke with 235 acute lesions.

All Lesions detected	0–6hrs	6–12hrs	>12–24hrs	>24 hrs to 96hrs
T2	0	65/90(72.2%)	96/108(89.6%)	20/20
FLAIR	3/17 acute lesions	80/90(88.8%)	103/108(97.16%)	20/20
DWI	17 acute lesions	90 acute lesions	108 acute lesions	20 acute lesions

A total 235 acute lesions were detected on DWI; FLAIR correctly identified 206(87.65%) and T2 identified 181 (77%) of all the acute lesions detected on DWI.

Considering a time period of less than 6hrs DWI identified 17 acute lesions in 9 cases, and FLAIR 3 lesions in 3 cases.

Between 6 to 12 hrs, 90 acute lesions were identified on DWI; with FLAIR showed 80 (88.88%) and T2 identified 65 (72.22%) of the acute lesions seen on DWI.

Table 3. Demonstrating DWI positive cases out of total cases with final neurological diagnosis of AIS presented with in 72hrs period in the present study.

	0–6 hrs	6–12 hrs	>12–24 hrs	>24 hrs to 72hrs
DWI positive/Total cases with final diagnosis of AIS	9/11 cases	51/54 cases	71/74 cases	20/20 cases
Total cases with at least a single lesion detected on FLAIR/Total cases with final diagnosis of AIS	3/11 cases	47/54 cases	71/74	20/20 cases

Table 4. Baseline Characteristics and Comparison between Strokes and Stroke Mimics.

	Stroke mimics n=15 excluding TIA	Stroke
Mean age, years (SD)	53.1yrs	59.4yrs(±13)
Women	5	71 (44.7%)
Men	10	88 (55.3%)
Time to DWI Imaging (mean)	18.3hrs	16.15hrs
DWI done	15 cases	159 cases
DWI positive	2(15.3%)	151(94.9%)

Table 5. Baseline Characteristics and Comparison between TIA and DWI negative acute ischaemic stroke.

	TIA n=12	NEGATIVE DWI ACUTE ISCHAEMIC STROKE N=8
Mean age, years (SD)	60.3 yrs	57.1 yrs
Women	5	5(62.5%)
Men	7	3 (37.5%)
Time to DWI (mean)	8.9hrs	9.8 hrs

TABLE 6. Demonstrating distribution of all the patients between the presence of a DWI lesion or not, and the final diagnosis being a stroke or not.

TRUE POSITIVE	FALSE POSITIVE
SUSPECTED AIS WITH IMAGING SUGGESTIVE OF ISCHAEMIC STROKE	SUSPECTED AIS WITH ABNORMAL SIGNAL ON DWI CONSISTENT WITH DIAGNOSIS OTHER THAN STROKE
151	2
FALSE NEGATIVE	**TRUE NEGATIVE**
SUSPECTED AIS WITH NEGATIVE DWI WITH FINAL DIAGNOSIS AS ISCHAEMIC STROKE	SUSPECTED AIS WITH NEGATIVE DWI WITH FINAL DIAGNOSIS OTHER THAN STROKE
8	25

Table 7. Statistical evaluation of Diffusion Weighted Imaging In suspected cases of Acute Ischaemic Stroke Sn, Sp Positive and negative likelihood ratio, positive and negative predictive value.

	Value	95% confidence interval
Sensitivity	94.97%	90.33% to 97.80%
Specificity	92.31%	74.87% to 99.05%
Positive Likelihood Ratio	12.82	3.38 to 48.67
Negative Likelihood Ratio	0.05	0.03 to 0.11

Disease prevalence	85.48%	79.59% to 90.21%
Positive Predictive Value	98.69%	95.21% to 99.65%
Negative Predictive Value	75.76 %	61.20% to 86.09%

Table 8. Demonstrating relative sensitivity and specificity of T2 and FLAIR sequences for acute infarct/s for the cases presenting within 12hrs compared to DWI.(i.e. in DWI positive cases).

MRI Sequence	Sensitivity	95% CI	Specificity	95% CI
T2	67.01%	56.73% to 76.22%	59.52 %	43.28% to 74.37%
FLAIR	72.16%	62.14% to 80.79%	62.50 %	45.8% to 77.27%

Table 9. Demonstrating sensitivity and specificity of DWI in hyperacute infarcts presenting less than 6hrs.

	Sensitivty	Specificty
DWI	81.82% (48.22% to 97.72%)	100% (29.24% to100%)

Out of 11 cases with a final diagnosis of acute ischaemic stroke presenting less than 6hrs, DWI showed abnormal signal in 9 cases; 2 cases with a final diagnosis of acute ischaemic stroke had no abnormal signal on DWI.

Table 10. Summary of the diagnoses found in this present study.

Acute stroke identified on DWI	151
Clinical stroke without DWI abnormality	8
Non Ischemic	
Tumours	2
Seizures	4
Migraine	2
OLD CVA(Aggravated with Secondary Infection, CCF)	2
Vertigo/Giddiness/Occipital Headache	3
Metabolic Encephalopathy/Acute Confusional State(Alcohol Abuse)	2
TIA	12

DISCUSSION

AIS is a highly debilitating or lethal disease and its early confirmation closely relies on magnetic resonance imaging. DWI can detect the presence of infarct in its early stage with a reported sensitivity of 88% to 100% . Currently, DWI is widely accepted as the de-facto clinical reference standard for infarct core lesion.

The present study included 186 cases of suspected AIS. Various aspects of DWI and related issues were evaluated.

The present study has a mean age of 59.6yrs in DWI positive acute ischemic stroke cases and a male preponderance with 85 males in 151 DWI positive cases. The mean age in the present study considering all DWI positive and DWI negative cases with a final diagnosis of AIS is 59.4yrs.This is in accordance to results by Maikin *et al.*, Lian Zuo *et al.*

The DWI negative stroke cases showed a female preponderance 95 out of 8 negative DWI cases-62.5%) Similar results were noted by Doubal *et al.*

CONVENTIONAL AND DIFFUSION IMAGING IN EVALUATION OF STROKE.

This study demonstrates some of the advantages of adding DWI to conventional sequences in the MRI protocol for the evaluation of acute stroke. In the present study considering cases with a final diagnosis of AIS, the mean time between the onset of symptoms and the MR investigations was 16.15 hours (range, 4.5 to 72 hours). Eleven patients were imaged in the hyper-acute stage (less than 6 hours after onset), 54 patients were imaged between 6 and 12 hours after onset, 74 patients were imaged between 12 and 24 hours, and 20 patients were imaged between 24 and 72 hours after onset of symptoms. In the present study, 151 cases were imaged within 72 hrs of symptom onset and a total of 235 acute lesions were detected on DWI (multiple infarcts were noted in 43 cases).In the present study if the period within 72hrs of symptom onset of ischemic stroke is considered, DWI identified at least a single lesion in 151 out of 159 cases(94.96%) (8 cases had a final diagnosis of stroke, although DWI was negative). In the corresponding period, FLAIR correctly identified 206 (206/235, 87.65%) lesions and T2 identified 181 (181/235, 77.1%). These results are in accordance with the study of Everdingen *et al.* who found that DWI identified 98% of acute lesions and conventional MRI (FLAIR/T2) identified 91% and 71% of lesions respectively. In the present study, considering all cases with a final neurologic diagnosis of stroke, DWI was positive in 94.3% of cases, whereas FLAIR and T2 identified 88.7% and 79.2% of cases respectively. Similar results were also noted in a study by Lansberg et el who found DWI, FLAIR, and T2 identified acute ischaemic stroke in 94%, 81% and 74% of cases respectively. In the present study, T2 weighted images could not detect 54 out of 235 acute lesions (23%) identified on DWI.L et al51 where 153 cases imaged within a range of 6 hours to 77 days after stroke had DWI positivity in only 70% . Our results confirm that DWI is a very useful imaging method to detect ischemic lesions in the early stroke.

Sensitivity and Specificity of Conventional MR (T2/FLAIR) compared to DWI.

Regarding relative sensitivity and specificity for acute lesions using T2 and FLAIR compared to DWI, in the present study, T2 has shown sensitivity of 67.01% and specificity of 59.52 % and FLAIR had sensitivity of 72.16% and specificity of 62.50% .These figures are in accordance with study of Lansberg *et al.* wherein T2W imaging had a sensitivity and specificity of 57% and 69% and FLAIR demonstrated sensitivity of 58% and specificity of 66%.

Sensitivity and Specificity of DWI In hyperacute Stroke (<6HRS)

In the present study, DWI indicated stroke (hyperacute) in 9 out of 11 patients, all of whom had a final diagnosis of stroke. The sensitivity and specificity for DWI in hyperacute stroke is 81.82% and 100% respectively. This result is of special interest when considering neuroprotective treatment for these patients.

Similar results were found by Gonzalez et al(10) in 22 cases presenting within 6hrs with DWI having 100% sensitivity and 100% specificity. Lovbald *et al (11)* studied 194 stroke cases presenting at less than 24 hrs. In the hyperacute phase (less than 6hours), diffusion-weighted imaging was positive in 32 of 34 cases of infarction, with a sensitivity of 94% and specificity of 100%. Although MRI is more time consuming and less available than CT, MR imaging (DWI in particular) has significantly higher sensitivity and specificity in the diagnosis of hyperacute ischaemic infarction, where therapeutic intervention can be done.

Sensitivity and Specificity of DWI in Suspected Cases OF AIS (0-72HRS)

Diffusion-weighted imaging (DWI) is a relatively new magnetic resonance imaging technique that detects the tiny random movements of water molecules (diffusion) in tissues. This technique allows a map of the average apparent diffusion coefficient (ADC) to be calculated. After the onset of an ischemic stroke, the ADC of brain tissue is significantly reduced because of cytotoxic edema. With progression of time, the rapid initial drop in ADC is followed by a return to "pseudonormal" values at approximately 1 week. Subsequently, elevated ADC values are seen at chronic time points. However, DWI is remarkably sensitive in detecting and localizing acute ischemic brain lesions and allows differentiation of acute regions of ischemia from chronic infarcts. There is a high correlation between abnormal DWI lesions and possible diagnosis of stroke.

In the present study, analysis of DWI showed a high sensitivity, specificity, and positive predictive value(PPV) in the diagnosis of AIS. DWI had a sensitivity of 94.97% and specificity of 92.31% for the detection of an AIS (0-72hrs) and accuracy of 94.6%. DWI had a PPV of 98.69% and a negative predictive value(NPV) of 75.6%. Hyperintense lesions on DWI were observed in clinically relevant brain regions in 153 cases (82.2%) of 186 cases of clinically suspected AIS; however, two had non ischaemic diagnosis (tumours).

DWI demonstrated a diagnostic accuracy of 94.6% and a positive likelihood ratio of 12.82, which points to a large and often conclusive increase in the likelihood of an ischaemic stroke if abnormal signal is detected in a suspected case of acute ischaemic stroke; negative likelihood ratio is 0.05, indicating a low probability of acute stroke when this test was normal.

In agreement with findings of the present study, a previous study by

Brusner *et al*. on DWI found sensitivity of 90.4% and specificity 97% in stroke diagnosis. A study by Lovbald *et al*.[12] had showed similar results with a sensitivity 88% and specificity of 95% for DWI in suspected cases of AIS.

Our analysis shows a high sensitivity and specificity for DWI in the diagnosis of acute cerebral infarction. DWI negative cases were TIAs, non ischemic events or AIS cases with negative imaging; the latter could be explained by symptomatic hypoperfusion or small strokes below the spatial resolution of the technique as well as by small brain stem strokes. A signal increase on DW-images in combination with a low signal on ADC map must not be considered a definite proof of brain ischaemia. However, this feature has a specificity of 95–100%.

The present analysis highlights the use of DWI in clinical practice to assess patients with signs and symptoms suggestive of acute stroke. As diffusion-weighted imaging is part of the diagnostic process; a positive diffusion-weighted study is likely to increase the probability of a positive diagnosis (high sensitivity) and a negative diffusion weighted study is more likely to increase the probability of a negative diagnosis (high specificity).

DIFFUSION WEIGHTED IMAGING AND BRAINSTEM STROKE.

Negative DWI Imaging in Stroke

The present study aimed at evaluating DWI in patients with persistent neurologic deficit due to an AIS and to identify which stroke lesions were most likely to be missed by DWI. In the present study out of 159 cases with a final clinical diagnosis of acute ischaemic stroke with 131 cases presenting within 24 hrs and 123 cases with positive DWI and 8 cases with negative DWI imaging.

In the present study 8 (5.1%) out of 159 cases with final diagnosis of AIS and presentation less than 72hrs had negative DWI. The results of the present study are slightly better as compared to with Lian Zuo *et al(13)* who investigated 349 cases of AIS within 72hrs with 316 DWI positive and 33 (9.4%) DWI negative cases.

However, a controversy exists, as the rate of negative DWI studies in acute stroke varies among studies, ranging from 0% to 30%. The present study 8 cases (5.1%) with final diagnosis of acute ischaemic stroke have negative DWI. Similar results were noted by Oppenhiem *et al(14)*. who reviewed MR images obtained within 48 hours of stroke onset in 139 patients - eight cases (5.8%) had false-negative initial DWI studies.

The results of the present study are similar to Lansberg *et al(15)*. where 3 (6%) of 49 patients with clinically diagnosed acute stroke did not show lesion on the DWI/ADC sequence. In all 3 patients, the clinical diagnosis was a posterior circulation infarct, likely located in the brainstem.

DISTRIBUTION OF ISCHAEMIC LESIONS IN DWI NEGATIVE STROKE

In the present study 8 cases with final clinical diagnosis of AIS had normal MRI. In 6 (75%) cases, lesion was localized to brain stem and 2(25%) cases had non brainstem lacunar stroke.

Most of DWI negative cases of AIS had non-disabling or resolving deficits suggestive of small infarcts with a localization in the brain stem. Similar results were noted by Lovbald *et al.* who studied 194 cases presenting within 24hrs. They have found 18 patients who had negative diffusion-weighted images in whom the final diagnosis was stroke; most had nondisabling or resolving deficits suggestive of small infarcts with a localization in the brain stem.

In the present study out of 33 DWI negative cases, 8 cases had a final diagnosis of AIS (8/33, 24.2%). Similar results have been noted in a study by Sylaja *et al (16)*. who investigated frequency of DWI negative cerebral ischemia in 401 patients.103 patients (25.6%) had an initial negative DWI study.

The relationship between DWI negativity and brainstem location has been confirmed in a large prospective study by Achalela *et al.* in which 190 patients had a final clinical diagnosis of acute ischemic stroke.MRI was positive in 157 of 190 (83%;77-88%)cases of acute ischemic stroke, with a false negative rate of 17%. By stepwise multivariable logistic regression, false-negative MRI diagnoses of ischaemic stroke were associated with brainstem location, low NIH stroke scale (<4) and less time period (<3hrs) between symptom onset and scan.

In the present study in DWI negative cases 2 cases were given a clinical diagnosis of non brainstem lacunar stroke. This is analogous with findings of Sylaja *et al (16).* who noted that lacunar strokes excluding the brain stem are also an important cause for DWI negativity, accounting for 50% of their DWI negative stroke patients .

Cerebral DWI is a sensitive technique for acute cerebral infarction. Current literature indicates negative DWI on initial cerebral MRI also correlates with site of cerebral infarction with negative DWI lesions seldom being reported in patients with anterior circulation infarction.

Small Infarcts in the posterior circulation may not become detectable even on repeat cerebral MRI. It has been reported that there was a gap in time between the development of neuronal dysfunction due to focal ischemia and water diffusion difficulty, which may cause DWI delay and the degree of hypoperfusion in the early phase of ischemia may remain below the threshold required to form an image with DWI as the reason for the false negativity(3) (17). There is a possibility that in some small (non disabling) strokes,a decline in blood flow was severe enough to cause symptoms, but not severe enough to cause a DWI lesion, or that the DWI lesion was transient, was missed by scanning, and did not show up on structural MR sequences either (these are known to be less sensitive to small infarcts). Another contributor to delayed positivity on DWI is inadequate signal to ratio in the early stage of the disease or MR artefacts interfering with DWI.

True negative findings in the present study were either TIAs or non ischemic events .False negative findings could be explained by symptomatic hypoperfusion or small strokes below the spatial resolution of the technique as well as by small brain stem strokes[18]. Small brain stem strokes constituted approximately 75% (6 out of 8 cases) of DWI negative strokes in the present study.

The shortcoming of the present study is that final diagnosis is based on clinical diagnosis without repeat MR imaging. We acknowledge that there is no true gold standard for the stroke diagnosis other than the clinical impression supported with imaging.

Effect of time to initial cerebral MRI and infarct location on DWI

In the present study 8 cases final diagnosis of stroke had negative DWI. All the DWI negative cases presented within 24 hrs. The mean time from symptom onset to MRI in the present study is 9.8hrs (range 5.5 – 15 hrs). In a multivariate analysis by Lian Zuo[13]showed that time to initial cerebral MRI is an important for positive DWI with time to initial MRI within 24 hours of disease onset more likely to yield negative DWI study.

Oppenhiem *et al.(14)* showed similar results with all false negative cases occurred in patients imaged within the first 24 hours after the onset of symptoms.

Based on results in the present study, a negative DWI study in suspected case of AIS should alert the clinician to search for non ischemic conditions. However, if the signs and symptoms are suggestive of AIS, the clinician should not automatically exclude the diagnosis of stroke if DWI is negative as the occurrence of negative MRI in a patient with minor stroke is not uncommon.

Normal diffusion-weighted MRI during stroke-like deficits

In the present study, 33 out of 186 cases of suspected AIS had no abnormal signal on DWI .Of these 33, 8 cases (24.2%) were given a final diagnosis of AIS.12 cases had resolving deficits consistent with TIA. 15 cases were stroke mimics; 4 were seizures, 2 migraine, 3 vertigo and occipital headache, 2 tumors, 2 metabolic encephalopathy and 2 cases of unmasking prior neurological deficit in the setting of CCF/infection.

Of the 15 cases of stroke mimics, most common SM was seizures (4/15, 26%). Similar results were noted by Georgios Tsivgoulis et al(7) who analysed stroke registry data of consecutive acute ischemic stroke admissions treated with intravenous thrombolysis over a period of 6yrs and found seizures as common SM in 19.6% cases and migraine in 19.6% cases.

In this analysis, diffusion-weighted imaging showed a high sensitivity, specificity, and positive predictive value in the diagnosis of ischemic stroke. The negative predictive value was only 75.6%, and a final diagnosis of TIA or stroke was made in 87.3% of the cases. Thus, a negative diffusion weighted imaging study did not entirely rule out a diagnosis of stroke or ischemia.

CONCLUSION

On basis of the present study, we conclude that DWI is accurate in detecting AIS in unselected patients arriving to the Casualty with focal symptoms suggestive of this condition.DWI demonstrated a high sensitivity (94.7%) , specificity (92.3%) and diagnostic accuracy (94.6%) and a positive likelihood ratio over 12, which points to a large and often conclusive increase in the likelihood of an ischemic stroke in DWI positive cases. Negative likelihood ratio is 0.05, indicating a low probability of acute stroke when this test is normal.

A further advantage of DWI over other MR sequences is to demonstrate fresh lesions in cases of chronic infarcts and additional lesions in cases of multiple infarcts.

We further conclude that false negativity of initial DWI in patients with acute stroke is not rare. Time to initial cerebral MRI and site and size of infarct are an important factors affecting DWI positivity. Time to initial MRI within 24 hours of disease onset and lacunar or brainstem infarcts are more likely to yield negative DWI studies. Therefore, the diagnosis of stroke should not be excluded based on early negative DWI findings.

REFERENCES

1. Sacco Ralph L., Kasner Scott E., Broderick Joseph P., Caplan Louis R., Connors J.J. (Buddy), Culebras Antonio, et al. An Updated Definition of Stroke for the 21st Century. Stroke. 2013 Jul 1;44(7):2064–89.
2. Goldman's Cecil Medicine - 24th Edition [Internet]. [cited 2020 Sep 13]. Available from: https://www.elsevier.com/books/goldmans-cecil-medicine/9781437716047
3. Prevalence of Stroke and Associated Risk Factors in Older Adults in Havana City and Matanzas Provinces, Cuba (10/66 Population-Based Study). MEDICC Rev. 2010;12(3):20.
4. Adams HP, Bendixen BH, Kappelle LJ, Biller J, Love BB, Gordon DL, et al. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. Stroke. 1993 Jan;24(1):35–41.
5. Odderson IR. The National Institutes of Health Stroke Scale and its importance in acute stroke management. Phys Med Rehabil Clin N Am. 1999 Nov;10(4):787–800, vii.
6. Powers DW. Assessment of the stroke patient using the NIH stroke scale. Emerg Med Serv. 2001 Jun;30(6):52–6.
7. Tsivgoulis G, Alexandrov AV, Chang J, Sharma VK, Hoover SL, Lao AY, et al. Safety and Outcomes of Intravenous Thrombolysis in Stroke Mimics: A 6-Year, Single-Care Center Study and a Pooled Analysis of Reported Series. Stroke. 2011 Jun;42(6):1771–4.
8. Zinkstok SM, Engelter ST, Gensicke H, Lyrer PA, Ringleb PA, Artto V, et al. Safety of thrombolysis in stroke mimics: results from a multicenter cohort study. Stroke. 2013 Apr;44(4):1080–4.
9. Stadnik TW, Demaerel P, Luypaert RR, Chaskis C, Van Rompaey KL, Michotte A, et al. Imaging tutorial: differential diagnosis of bright lesions on diffusion-weighted MR images. Radiogr Rev Publ Radiol Soc N Am Inc. 2003 Feb;23(1):e7.
10. González RG, Schaefer PW, Buonanno FS, Schwamm LH, Budzik RF, Rordorf G, et al. Diffusion-weighted MR imaging: Diagnostic accuracy in patients imaged within 6 hours of stroke symptom onset. Radiology. 1999 Jan;210(1):155–62.
11. Keir S. L., Wardlaw J. M. Systematic Review of Diffusion and Perfusion Imaging in Acute Ischemic Stroke. Stroke. 2000 Nov 1;31(11):2723–31.
12. Systematic Review of Diffusion and Perfusion Imaging in Acute Ischemic Stroke | Stroke [Internet]. [cited 2020 Oct 5]. Available from: https:// www. aha journals. org/doi/full/10.1161/01.str.31.11.2723
13. Zuo L, Zhang Y, Xu X, Li Y, Bao H, Hao J, et al. A retrospective analysis of negative diffusion-weighted image results in patients with acute cerebral infarction. Sci Rep. 2015 Mar 17;5(1):8910.
14. Oppenheim C, Stanescu R, Dormont D, Crozier S, Marro B, Samson Y, et al. False-negative Diffusion-weighted MR Findings in Acute Ischemic Stroke. Am J Neuroradiol. 2000 Sep 1;21(8):1434–40.
15. Lansberg MG, Norbash AM, Marks MP, Tong DC, Moseley ME, Albers GW. Advantages of adding diffusion-weighted magnetic resonance imaging to conventional magnetic resonance imaging for evaluating acute stroke. Arch Neurol. 2000 Sep;57(9):1311–6.
16. Sylaja P.N., Coutts Shelagh B., Krol Andrea, Hill Michael D., Demchuk Andrew M. When to Expect Negative Diffusion-Weighted Images in Stroke and Transient Ischemic Attack. Stroke. 2008 Jun 1;39(6):1898–900.
17. Makin SDJ, Doubal FN, Dennis MS, Wardlaw JM. Clinically Confirmed Stroke With Negative Diffusion-Weighted Imaging Magnetic Resonance Imaging: Longitudinal Study of Clinical Outcomes, Stroke Recurrence, and Systematic Review. Stroke. 2015 Nov;46(11):3142–8.
18. Improved detectability of acute and subacute brainstem infarctions by combining standard axial and thin-sliced sagittal DWI [Internet]. ResearchGate. [cited 2020 Oct 5]. Availablefrom:https://www.researchgate.net/publication/326166993_Improved_detectability_of_acute_and_subacute_brainstem_infarctions_by_combining_standard_axial_and_thin-sliced_sagittal_DWI