

Diffusion Weighted Magnetic Resonance imaging in the Diagnosis and Management of Acute Stroke

1. Abdul Sattar 2. Ijaz Ahmed 3. Sadia Anjum

1. Asstt. Prof. of Radiology, NMC&H, Multan 2. Asstt. Prof. of Radiology, BMC, Quetta 3. Asstt. Prof. of Radiology, NMC&H, Multan

ABSTRACT

Objective: To evaluate the diagnostic accuracy of diffusion –weighted magnetic resonance (MR) imaging performed within 6 hours of the onset of stroke symptoms

Study Design: Cross sectional study.

Place and Duration of Study: This study was conducted at the Department of Radiology Nishtar Medical College & Hospital Multan from August, 2010 to August, 2011.

Patients and Methods: Diffusion weighted MR imaging, along with conventional MR imaging performed in 36 patients who presented with acute stroke like symptoms within 6 hours of onset of symptoms. Diagnosis was noted. Patients admitted in medical ward. Follow up MR was performed after one week. Findings compared with initial scan. Diffusion weighted MR and conventional MR diagnosis was compared with final clinical diagnosis. Sensitivities and specificities of diffusion weighted and conventional MR imaging (FLAIR, T2-w) noted comparing with final clinical diagnosis

Results: Diffusion weighted MR imaging indicated stroke in 30 patients, all of whom had a final diagnosis of acute stroke Diffusion weighted images were negative in six patients, all of whom had a final clinical diagnosis other than stroke (100% sensitivity ,100% specificity).FLAIR images detected infarcts in 25 patients within 6hours of onset of symptoms out of 30 patients having stroke on final diagnosis(83% sensitivity,100% specificity).T2-w images detected infarcts in 22 patients on initial scan with sensitivity of 73% and specificity of 100%.

Conclusion: Diffusion weighted MR imaging is highly accurate for diagnosing acute ischemic stroke within 6 hours of symptoms onset and is superior to conventional MR imaging.

Key Words: Diffusion weighted imaging (DWI), Fluid attenuation inversion recovery (FLAIR), T2-w imaging.

INTRODUCTION

The advent of thrombolytic and neuro-protective agents has intensified the need for an accurate and timely diagnosis of acute ischemic brain injury. Efforts expended in the emergency department to gain optimal management of acute stroke during its earliest stages could be substantially improved with accurate information about the presence or absence of ischemic brain injury^{1,2}.

During early evolution of cerebral infarction, computed tomography (CT) and conventional magnetic resonance (MR) imaging remain problematic. Diffusion-weighted MR imaging is very sensitive to an early pathophysiological process in cerebral infarction³.

Cytotoxic edema, which is caused by the accumulation of intracellular water due to cell membrane damage minutes after onset of acute cerebral ischemia, causes a restriction of microscopic proton diffusion^{4,5}. In diffusion-weighted MRI, this decrease in water diffusion is presumably reflected in a decrease of the apparent diffusion coefficient (ADC) on ADC trace maps, which is visualized as a hyperintensity on the diffusion weighted images (DWI).Previous studies

showed that DWI is able to visualize cerebral ischemic changes within 5 minutes to 1 to 3 hours after onset of symptoms⁶. Other advantages of DWI are the low number of false negative investigations (5%), the clear discrimination between ischemic lesions and non ischemic brain, and the discrimination between acute and chronic ischemic lesions. With these features, DWI facilitates the determination of the type, site, and extent of cerebral ischemia at an early stage. This might help to predict the clinical outcome of stroke patient⁷⁻⁸.

Recent studies showed that in the acute stage after stroke, DWI is more sensitive for early ischemic changes than T2-w MRI. However, other studies showed that both PD-w imaging and fluid attenuation inversion recovery (FLAIR) imaging are superior to T2-w imaging in the detection of acute ischemic lesions. Therefore, DWI should be compared with T2-w and FLAIR imaging as well.

MATERIALS AND METHODS

Study was conducted from August, 2010 to August 2011 to compare the diagnostic accuracy of diffusion weighted magnetic resonance imaging with conventional magnetic resonance imaging in patients

with acute stroke presenting within 6 hours of onset of symptoms

Total of 36 patients underwent emergency MRI with clinical suspicion of ischemic stroke for less than 6 hours of stroke symptoms and in which emergency CT scan was negative for hemorrhage

MRI was performed according to acute stroke departmental protocol with 1.5 Tesla clinical imaging system (Philips Medical System). Multiplanar multiecho imaging was performed including conventional imaging (T1-w, T2-w and FLAIR) and diffusion weighted imaging. MR images were interpreted by senior consultant radiologist and diagnosis was recorded in every patient.

Follow up MRI brain was performed after one week of symptoms and radiological diagnosis was also recorded. Findings of initial MR imaging, follow up MR and clinical diagnosis were analyzed statistically to compare the accuracy of diffusion weighted imaging with conventional MR imaging taking clinical diagnosis as gold standard

RESULTS

From total of 36 patients, 20(55%) were male and 16(45%) were females. The mean age was 55 years. Out of 36 patients, who underwent for emergency MR imaging, DW-imaging detected ischemic lesions in 30 patients that were confirmed on follow up MR scan and final clinical diagnosis showing 100 % sensitivity, specificity and diagnostic accuracy. Six patients out of 36 showed alternate diagnosis both on MR imaging and on discharge chart.

Table NO.1: Comparison of DWI, T2-w and FLAIR imaging with clinical outcome (final diagnosis) (n=36)

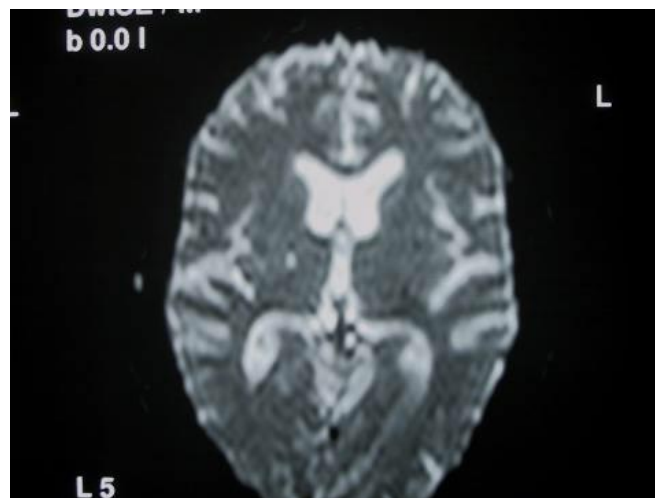
Imaging Findings	Clinical outcome	
	Stroke	No Stroke
Diffusion Weighted MR-imaging		
Stroke	30	0
No Stroke	0	0
FLAIR Imaging		
Stroke	25	0
No Stroke	05	6
T2-weighted Imaging		
Stroke	22	0
No Stroke	08	6

Note-The sensitivities and specificities were 100% and 100% for diffusion weighted MR imaging; 83% and 100% for FLAIR imaging and 73% and 100% for T2-w MR imaging

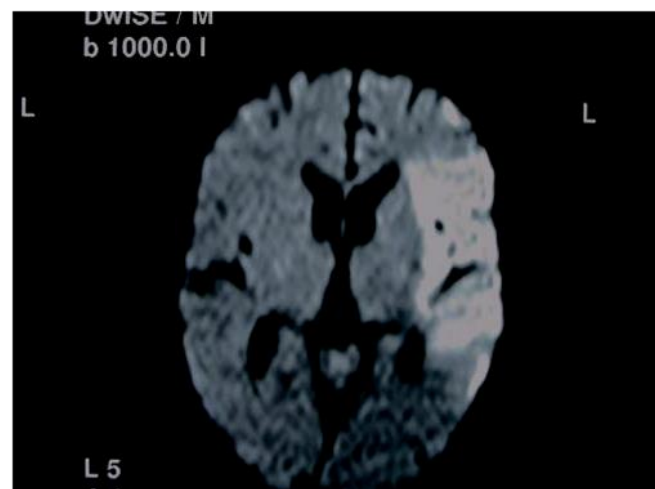
Flair imaging detected ischemic lesions in 25 patients on initial MR scans done within 6 hours of onset of symptoms showing sensitivity, specificity and

diagnostic accuracy of 83%, 100% and 86% respectively.

T2-w imaging detected ischemic lesions in 22 patients on initial MR imaging done within 6 hours of onset of symptoms showing sensitivity, specificity and diagnostic accuracy of 73%, 100% and % respectively.



T2-w image showing no ischemic lesion in a 55 yrs patient with an acute right sided hemiparesis within 6hrs of onset of symptoms. (Fig-1)



Diffusion weighted (DW) image showing hyperintensity along left MCA territory in a 55 yrs patient with an acute right sided hemiparesis within 6hrs of symptoms onset. (Fig-2)

DISCUSSION

During one year period, we performed diffusion weighted MR imaging within 6 hours of symptoms onset in 36 patients who presented with a new neurological deficit of sufficient severity to require hospitalization. Diffusion weighted MR imaging enabled the accurate diagnosis of acute stroke in 30 patients and helped exclude stroke in six. We found

diffusion weighted MR imaging to be significantly superior to conventional MR imaging (FLAIR and T2-weighted imaging) in the diagnosis of hyperacute stroke^{9,10}.

Although there have been several studies about diffusion-weighted MR imaging of patient with acute stroke, this study is different in several important ways. The results of our investigation help confirm those of previous studies, which suggested the high sensitivity of diffusion-weighted imaging in acute cerebral infarction¹⁰⁻¹¹. We evaluated all patients who presented emergently during 1 year of study period, were admitted because of their stroke like symptoms, and underwent diffusion weighted MR imaging in which patients were imaged within 6 hours of onset of stroke like symptoms. Our study provides comparison of diffusion weighted imaging with conventional MR imaging.

Our findings suggest that diffusion weighted MR imaging has the potential to make another contribution to acute stroke management. A negative diffusion weighted image is highly accurate in the exclusion of most acute cerebral infarctions¹². The exception may be very small penetrator artery infarcts in the brain stem. The high accuracy of diffusion weighted MR imaging in excluding the probability of stroke could have a substantial effect on the treatment of patients who present with acute onset of stroke like symptoms. In many circumstances, a negative diffusion-weighted MR imaging may spare patients prolonged and health care resources and help ensure the likelihood that treatment regimens are appropriately matched to patients need^{13, 14}.

An area of great interest in acute stroke imaging is the appearance of transient ischemic attacks (TIA) at diffusion weighted imaging in six patients with a negative diffusion weighted MR image; transient ischemic attack was the final diagnosis. This suggest that diffusion weighted MR imaging is insensitive to transient ischemia, even though it may be sufficiently severe to produce symptoms¹⁵⁻¹⁶.

Diffusion weighted MR imaging provides information that is fundamentally different than that available with CT or conventional MR imaging. In acute ischemic stroke, CT and conventional MR imaging demonstrate changes that are largely depended on same physiological parameter; an increase in tissue water. This results in hypoattenuation and loss of gray-white matter differentiation on CT scan and hyperintensity on T2w and FLAIR images. In distinction to these modalities, diffusion weighted MR imaging can depict Cytotoxic edema. This pathophysiological event occurs

very early as adenosine triphosphate level decrease in ischemic brain, although this explanation for the high contrast signal abnormality observed in acute infarction at diffusion weighted imaging is somewhat controversial, all studies reported to date consistent with the presence of Cytotoxic edema as a significant contributing factor to the abnormal signal^{17,18}.

CONCLUSION

In conclusion, we have found, under clinical circumstances that diffusion weighted MR imaging of the brain is highly accurate in the diagnosis of acute stroke and provides superior lesion contrast compared with that of CT and conventional MR imaging. Our results indicate that diffusion weighted MR imaging may have important role in the treatment of patients who presents with new onset of stroke like neurological deficit.

REFERENCES

1. von Kummer R, Allen KL, Holle R, Bozzao L, Bastianello S, Manelfe C, et al. Acute stroke: usefulness of early CT findings before thrombolytic therapy. *Radiology* 1997;205: 327-333.
2. Mohr JP, Biller J, Hilal SK, Yuh WT, Tatemichi TK, Hedges S, et al. Magnetic resonance versus computed tomographic imaging in acute stroke. *Stroke* 1995; 26:807-812.
3. Brott T, Marler JR, Olinger CP, Adams HP Jr, Tomsick T, Barsan W, et al. Measurements of acute cerebral infarction: lesion size by computed tomography. *Stroke* 1989;20:871-875
4. Yuh WTC, Crain MR, Loes DJ, Greene GM, Ryals TJ, Sato Y. MR imaging of cerebral ischemia: findings in the first 24 hours. *AJNR Am J Neuroradiol* 1991;12:621-629.
5. Lutsep HL, Albers GW, DeCrespigny A, Kamat GN, Marks MP, et al. Clinical utility of diffusion-weighted magnetic resonance imaging in the assessment of ischemic stroke. *Ann Neurol* 1997;41:574-580.
6. Schlaug G, Siewert B, Benfield A, Edelman RR, Warach S. Time course of the apparent diffusion coefficient (ADC) abnormality in human stroke. *Neurology* 1997;49:113-119.
7. Warach S, Chien D, Li W, Ronthal M, Edelman RR. Fast magnetic resonance diffusion-weighted imaging of acute human stroke. *Neurology* 1992; 42:1717-1723.
8. Sevick RJ, Kanda F, Mintorovitch J, Arieff AI, Kucharczyk J, Tsuruda JS, et al. Cytotoxic brain

- edema: assessment with diffusion-weighted MR imaging. *Radiology* 1992; 185:687–690.
9. Singer MB, Chong J, Dongfeng L, Schonewille W, Tuhim S, Atlas SW. Diffusion-weighted MRI in acute subcortical infarction. *Stroke* 1998; 29: 133–136.
 10. Koroshetz WJ, Gonzalez G. Diffusion-weighted MRI: an ECG for "brain attack"? *Ann Neurol* 1997; 41:565–566.
 11. Brant-Zawadski M, Atkinson D, Detrick M, Bradley WG, Scidmore G. Fluid-attenuated inversion recovery (FLAIR) for assessment of cerebral infarction: initial clinical experience in 50 patients. *Stroke* 1996; 27:1187–1191.
 12. Chien D, Kwong KK, Gress DR, Buonanno FS, Buxton RB, Rosen BR. MR diffusion imaging of cerebral infarction in humans. *AJNR Am J Neuroradiol* 1992; 13:1097–1102.
 13. Marks MP, de Crespigny A, Lentz D, Enzmann DR, Albers GW, Moseley ME. Acute and chronic stroke: navigated spin-echo diffusion-weighted MR imaging. *Radiology* 1996; 199: 403-408.
 14. Baird A, Benfield A, Schlaug G, et al. Enlargement of human cerebral ischemic lesion volumes measured by diffusion-weighted magnetic resonance imaging. *Ann Neurol* 1997; 41: 581-589.
 15. Niendorf T, Dijkhuizen RM, Norris DG, Campagne MVL, Nicolay K. Biexponential diffusion attenuation in various states of brain tissue: implications for diffusion-weighted imaging. *Magn Reson Med* 1996; 36: 847-857.
 16. Welch KM, Windham J, Knight RA, et al. A model to predict the histopathology of human stroke using diffusion and T2-weighted magnetic resonance imaging. *Stroke* 1995; 26: 1983-1989.
 17. Sevick R, Kanda F, Mintorovich J, et al. Cytotoxic brain edema: assessment with diffusion-weighted MR imaging. *Radiology* 1992; 185: 687-690.
 18. Lovblad KO, Baird AE, Schlaug G, Benfield A, Siewert B, Voetsch B, et al. Ischemic lesion volumes in acute stroke by diffusion-weighted magnetic resonance imaging correlate with clinical outcome. *Ann Neurol* 1997; 42:164–170.

Address for Corresponding Author:**Dr Abdul Sattar**

Assistant Professor Radiology

Nishtar Medical College & Hospital, Multan

E-mail: drasanjum@gmail.com