



MRI EVALUATION OF THE CEREBRAL LESIONS EXHIBITING RESTRICTION ON DIFFUSION WEIGHTED IMAGES AND ITS CORRELATION WITH APPARENT DIFFUSION COEFFICIENT VALUE

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Abstract

Introduction: Diffusion Weighted Images is conventionally used to identify acute ischemic lesions. It has now become a routine technique in the magnetic resonance protocols for the evaluation of stroke patients. The aim of this study is to correlate MRI findings of such lesions with clinical findings and radiological diagnosis.

Material & Methods: This prospective study was done in the Department of Radiodiagnosis, Chhatrapati Shahuji Maharaj Medical University (upgraded King George's Medical University), Lucknow, over the period of one year from August 2008 to July 2009. The study comprised of subjects which were showing intra-cerebral lesions with restriction on DWI in MRI study. Total 93 subjects with restricted diffusion with age range of (3 to 95 years) were included. Data were analyzed using statistical software package, STATA 9.2 and the difference was considered to be significant if 'p' value was found to be <0.05.

Results: As the time increases the percentage decrease in ADC value of infarcts decreases in a linear relationship. It comes to normal after 1 week. Most the cases of infarcts in which MRI was done within 48 hours had their ADC value less than $400 \times 10^{-6} \text{ mm}^2/\text{s}$. Lesions of encephalitis were found to be appearing on DWI even earlier than other MR sequences. All the 100% cases of abscess and GBM on surgical diagnosis were correctly diagnosed on MRI.

Conclusion: MRI with DWI and ADC values are functional in temporal evolution of infarcts. ADC values may not be a good predictor in diagnosis and differentiating bleed, ADEM and glioblastoma multiforme.

Keywords: Apparent Diffusion Coefficient, diffusion weighted images, magnetic resonance imaging

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INTRODUCTION

Acute cerebral infarct is characterized by hyper intensity on Diffusion Weighted Images (DWI) and low Apparent Diffusion Coefficient (ADC) values. Many theories were proposed to explain the diffusion restriction in acute cerebral ischemia. Decrease in ADC speed in brain tissue is a sensitive indicator of presence and severity of ischemic changes.¹The most probable theory is that the changes are due to increase in the intracellular-extra cellular water ratio secondary to disruption of intracellular energy metabolism and loss of ionic

gradient with cellular swelling, there is reduction in extra cellular space and increased tortuosity of extra cellular space pathways. Increased intracellular viscosity is due to dissociation and fragmentation of intracellular components. An important event in the patho physiological cascade that leads to infarction following ischemia is net movement of water from extra cellular space into intra cellular compartment without increase in total water content in the affected zone. Hence Y2 weighted image will be normal at this stage. Later on, when endothelial breakdown leading to vasogenic edema and total

increase in water content occurs, the T2 weighted image will show bright signal. On the other hand DW imaging is capable of identifying the infarct even before the appearance of vasogenic edema.^{2,3} Chronic infarcts are characterized by elevated diffusion and appear hypo, iso or hyper intense on DW images and hyper intense on ADC maps.⁴ All the lesions with diffusion restriction may not progress to complete infarction. There are few reports of normalization of initial diffusion restriction in well- controlled animal models of ischemia and in human studies. At the same time, as their experience demonstrates, DWI data alone does not allow differentiation between benign astrocytoma and anaplastic tumours, or between anaplastic astrocytoma and glioblastoma.⁵ The information concerning the spreading of infiltrating and growing brain neoplasm is more interesting. The aim of this study is to correlate MRI findings of such lesions with clinical finding and radiological diagnosis with diagnosis after surgery /biopsy whenever undertaken.

MATERIAL AND METHODS

The prospective study done at M.R.I. unit of Department of Radio diagnosis, C.S.M. Medical University, Lucknow during a period of one year from August 2008 to July 2009. Where radiologist evaluating the Magnetic resonance imaging (MRI) was blinded for the clinical data of the patient. Subjects who were showing intra-cerebral lesions with restriction on DWI in MRI study. All those patients were included who referred to Department of Radio Diagnosis for MRI Brain showing restriction on DWI. Total 93 subjects with restricted diffusion with age range of 6 years to 95 years were included.

Technique and Investigation of data:

Conventional T2 Weighted MRI was performed on SIGNA EXCITE 1.5 T GEMSOW (GE) MR SCANNER installed in the department of Radiodiagnosis, C.S.M. Medical University, and Lucknow. A standard head coil with standard restraints was used to fix the subject's head. In addition to axial DW images, conventional fluid-attenuated inversion recovery (FLAIR) T1-, T2-, and proton density-weighted images were obtained.

All imaging studies were completed without any adverse effect or complication.

DWI was performed with a spin-echo echo-planar imaging sequence having a repetition time of 4000 ms, an echo time of 103 ms, and a gradient strength of 25 mT/m covering 19 slices 5 mm thick (interslice gap 1.5 mm, field of view 230x230 mm², and matrix size 96x128 interpolated to 256x256). Diffusion was measured in 3 orthogonal directions (x, y, and z) with 2 b values (b=0 and b=1000 s/mm²). The total acquisition time of the DW images was 20 seconds.

DW images were relocated to a discrete workstation for data analysis. First, the images in the 3 orthogonal directions were co registered. The natural logarithms of the images were averaged to form a rotationally invariant resultant image. With a linear least-squares regression on a pixel- by-pixel basis, the resultant image and the natural logarithm of the reference T2-weighted image (b=0) were fitted to the b values, where the slope of the fitted line was ADC av. The calculations were performed with a commercially available software program (Functool). Range of ADC values in different brain lesions shall be measured and its Distribution in different cerebral lesions shall be determined. ADC values in normal appearing white matter on conventional MRI were measured. ADC map were obtained by spin echo T2 Echo Planar Imaging sequences made sensitized to random diffusion of water molecules using "pulsed magnetic gradient".

Diffusion-Weighted Imaging: Methodology

- Human axial images with increasing diffusion weighting over a range of b values are acquired sequentially.
- The signal change resulting from diffusion is fitted to a single exponential of signal intensities against the h value, the slope of the change being the ADC.
- Resulting computed ADC map is composed of the slopes for all pixels in the original images.

Differences can be noted in the fast and slow diffusion rates (E.g., between cerebrospinal fluid and gray matter) are best visualized at higher b values, given sufficient signal-to-noise ratios. DW examination must contain both a low b values and high b values.^{6,7}

Statistical analysis

Data were analyzed using statistical software package, STATA 9.2 The proportion was reported with its 95% Confidence Intervals (95% CI). Chi square test statistics was applied to test the association between two categorical variables. Two sample t-test was applied to test the difference between the mean of two different groups, it data was normally distributed otherwise Mann Whitney test was applied and the difference was considered to be significant if ‘p’ value was found to be <0.05.

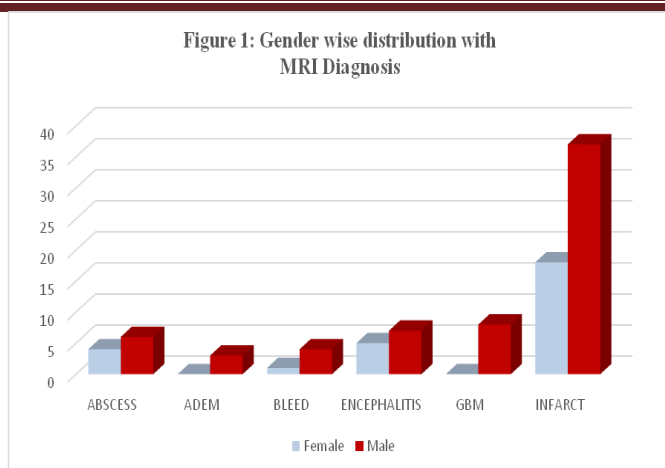
RESULTS

Study included 93 subjects with restricted diffusion with age range of 6 years to 95 years. The study comprised of subjects which were depicting intra-cerebral lesions with restriction on DWI in MRI.

Table 1: Age wise distribution with MRI Diagnosis

Age group	Abscess		ADEM		Bleed		Encephalitis		GBM		Infarct	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<18	4	40.0	2	66.7	0	0.0	8	66.7	0	0.0	2	3.6
18 to ≤60	6	60.0	1	33.3	3	60.0	4	33.3	8	100.0	32	58.17
>60	0	0.00	0	0.00	2	0.0	0	0.00	0	0.0	21	38.17
Total	10	100.0	3	100.0	5	100.0	12	100.0	8	100.0	55	100.0

Table 1 shows that the Majority of Encephalitis cases were seen in young age group less than 18 year of age (66.7%). Most of the infarct cases are seen in more than 18 years and less than equal to 60 years of age (58.17%). 38.17% of cases of total DWI restriction cases above 60 were contributed by infarct. All the cases of ADEM were of below 60 years of age. All the GBM cases were belongs to more than 18 years and less than equal to 60 years.



All the cases of GBM, ADEM are male. 80% cases of bleed were seen in male. Infarct is more common in male. (Figure 1)

Table 2: Distribution of Clinical Diagnosis with MRI Diagnosis

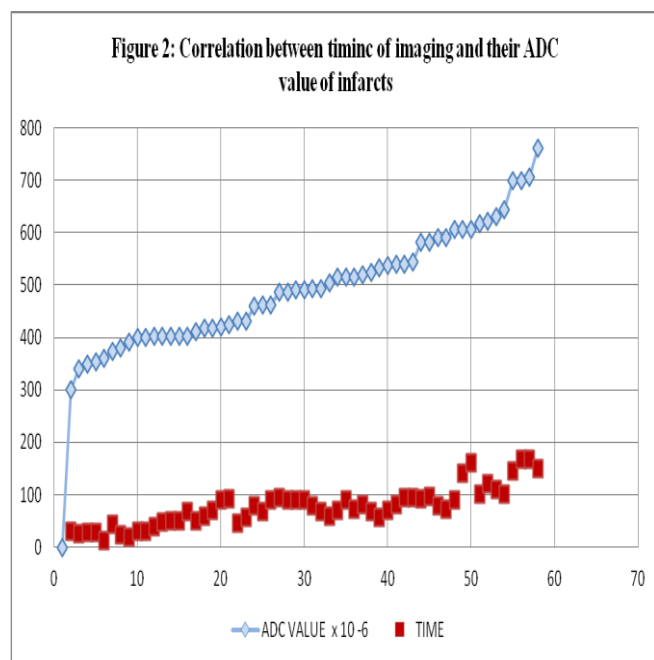
Clinical Diagnosis	ABSCESS		ADEM		BLEED		ENCEPHALITIS		GBM		INFARCT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Abscess	7	70.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
ADEM	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0
Bleed	0	0.0	0	0.0	3	60.0	0	0.0	0	0.0	2	3.6
Encephalitis	0	0.0	2	66.7	0	0.0	8	66.7	0	0.0	4	7.3
Meningitis	0	0.0	0	0.0	0	0.0	4	33.3	0	0.0	0	0.0
SOL	3	30.0	0	0.0	0	0.0	0	0.0	7	87.5	0	0.0
Stroke	0	0.0	0	0.0	2	40.0	0	0.0	1	12.5	4	89.1
Total	10	100.0	3	100.0	5	100.0	12	100.0	8	100.0	55	100.0

Above table 2 illustrates that the distribution of clinical diagnosis with MR diagnosis. 7 out of 10 cases of abscess lamination and rest 3 cases diagnosed as intracranial neoplasm. On clinical examination total 10 cases had given possibility of intracranial neoplasm of which 7 diagnosed as GBM and 3 as abscess on MR evaluation. However 7 out of 8 cases of GBM (on MR diagnosis) had given the possibility of intracranial neoplastic pathology

Table 3: Correlation between timing of imaging and their ADC value of infarcts

Time After Infarct	No. of cases	Average ADC 10^{-6} mm ² /s	% Decreased ADC value
<48 hours	10	374.40	57%
48-96 hours	35	493.11	38%
96 hours-7days	10	650.00	18%

Maximum decrease in ADC value was seen in first 48 hours (57%). ADC value approached near normal value up to 7 days after infarct, (average decrease in ADC value 18%).



Above figure 2 comprised 55 infarct patients. Ten patients underwent imaging during the first 48 hours after clinical stroke, 35 patients between 48 and 96 hours, and ten patients between 4 and 7 days. The trace value of the estimated diffusion tensor was used for each ADC measurement, representing the average of region-of interest values along the three principal diffusion axes. On the average, ADC values decreased by about 35%. ADC values were initially falling by approximately 60% but returning nearly to normal by the end of the 1st week. In first 48 hours the ADC value decreased by 57 %, in next 48 hours by 38% in our study and it returns up to normal at the end of 1st week .

Table 4: Correlation between Surgical and MRI diagnosis

SURGICAL DIAGNOSIS	MRI DIAGNOSIS	
	ABSCESS	GBM
ABSCESS	5(100%)	0(0.0%)
GBM	0(0.0%)	5(100%)

All the 100% cases of abscess and GBM on surgical diagnosis were correctly diagnosed on MRI (table 4)

DISCUSSION

This prospective study was done at M.R.I. Unit of Department of Radio diagnosis, C.S.M. Medical University, and Lucknow during a period of one year from August 2008 to July 2009. In present study, 12 cases of encephalitis were diagnosed correctly on clinical examination. 4 cases of encephalitis were diagnosed as meningitis on clinical evaluation. On clinical examination total 10 cases had given possibility of intracranial neoplasm of which 7 diagnosed as GBM and 3 as abscess on MR evaluation. However 7 out of 8 cases of GBM (on MR diagnosis) had given the possibility of intracranial neoplastic pathology. 94% cases were diagnosed as stroke on clinical examination. 3 out 5 cases bleed were diagnosed correctly on clinical evaluation. In addition, study performed by, Jonathan H. Burdette et al⁸ reported that MR imaging results each infarction imaged during the 1st week was noted to be markedly hyper intense to normal brain on DW images. However, the relative values of ADC differed markedly as a function of time during this period. Thus on comparison with this study, present finding shows agreement in temporal evolution of infarct and change in their ADC value along with time. At the end of one week ADC value come to near normal value and diffusion hyper intensity mainly contributed by the T2 shine through effect. In that sequence, present stated that reliable time of clinical ictus could be established in all patients to within plus or minus 6 hours. Each infarction imaged during the 1st week was noted to be markedly hyper intense to normal brain on DW images. Examination of the time course of these changes is even more informative. Our findings shows that with use of current diffusion gradients with maximum b values of 1,000 sec/mm², for the first 2-3 days, the increased SI on DW images

results principally from restricted diffusion (i.e. shortening of ADC). Thereafter, T2 effects provide the dominant mechanism of image contrast. Correlation between MR diagnosis and surgical/histopathological diagnosis. Surgical / histopathological diagnosis was available in 10 out of 93 cases. In which 5 cases were of abscesses, 3 of GBM and 2 of high grade glioma. All the 100% cases of abscess and GBM on surgical diagnosis were correctly diagnosed on MRI. Furthermore, McCabe et al⁹ stated after study that DWI could be positive in the early disease phase, even when PCR findings are negative. Lesions could be recognized as early as 40 h after symptom onset in adults. In present study earliest lesion appears on DWI is 48 hours after onset of symptoms. However the lesion is not appeared on other sequences. Thus, present study shows agreement with above study. Sener¹⁰ demonstrated decreased ADC values in diseased parenchyma in encephalitis and, in my study, the apparent diffusion coefficient values were decreased in the cortical lesions of all cases compared with normal tissue. Thus present study is showing concord with his findings.

CONCLUSION

As the time increases the percentage decreases in ADC value of infarcts decreases in a linear relationship. It comes to normal after 1 week. Most the cases of infarcts in which MRI was done within 48 hours. MRI with DWI and ADC values are functional in temporal evolution of infarcts. ADC values may not be a good predictor in diagnosis and differentiating bleed, ADEM and glioblastoma multiforme.

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