ROLE OF DIFFUSION WEIGHTED IMAGING IN EVALUATION OF INTRACRANIAL PATHOLOGIES

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ABSTRACT

Background: Diffusion weighted MRI imaging is a new technique which measures the microscopic motion of water protons. It provides image contrast that is dependent on the motion of water molecules, which may be substantially altered by disease.

Methodology: In our prospective study a total of 80 cases of various intracranial pathologies were evaluated.MR imaging including T1, T2, fluid attenuation inversion recovery (FLAIR), gradient sequences, ADC and diffusion weighted imaging were obtained in various planes.

Aims & Objectives: To assess the role & efficacy of Diffusion-weighted imaging in evaluation of intracranial pathologies. To assess the role & efficacy of Diffusion-weighted imaging in evaluation of early infarcts & differentiating early infarcts from chronic infarcts. To assess the role of Diffusion-Weighted MR Imaging for differentiating Rim-Enhancing Brain lesions.

Results: Infract was the most Common lesions detected in our study. DW MRI is highly sensitive in detection of hyperacute and acute infract as compared to conventional MR (T2 & FLAIR). Other detected lesions include Meningioma, Abscess, Encephalitis, Acute Hematoma, ADEM, Medulloblastoma & Subdural Empyema.

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INTRODUCTION

Diffusion weighted imaging is a technique that assesses local environment at the cellular level to determine changes in the random movement of water protons. Restricted diffusion appears as an area of increased signal on DWI and reduced signal on ADC maps which are calculated from a matrix of tensor vectors obtained in three planes without and with application of diffusion gradients. The amount of diffusion weighting of a DW image depends on the magnitude of the applied gradients, how long they are switched on, and the time between the two lobes.

Acute cerebral infarct results in anoxic injury to the cell membrane. This results in reduced movement of water

molecules between extra and intracellular compartments. Thus the earliest imaging feature of stroke is hyperintensity on DWI. ADC values vary with the age of the ischemic stroke, a fact that can affect the analysis of clinical cases. In the first few hours after onset of ischemia, water diffusion decreases rapidly.

Whereas DWI is most often used to identify acute arterial ischemia, other processes that interfere with or restrict the movement of water can cause notable changes on DWI, including neoplastic lesions, encephalitis, pyogenic abscesses and occasionally demyelinating disease. Water diffusivity in the extracellular space is inversely related to the constituents of intracellular space; cells with a high nucleus to cytoplasm ratio and tissues with high cellularity cause increased volume of intracellular space, resulting in diminished mobility of water protons with restriction of diffusion. Thus reduced diffusion can be seen in highly cellular tumors such as lymphoma, meningioma and glioblastoma. Several reports have reported an inverse correlation between ADC value and glioma grade for grade II through IV astrocytomas.[1]

Enhancing lesions of the brain include abscesses and tumors. The center of abscesses show restricted diffusion and thus high signal intensity on DWI as compared to necrotic tumors which show low signal intensity. Thus DWI is useful in providing a greater degree of confidence in distinguishing brain abscesses from cystic or necrotic brain tumors than conventional MRI.[5]

Multiple sclerosis is the most common demyelinating disease. DWI may improve lesion detection when combined with standard T2-weighted techniques. On DWI, acute lesions may show increased ADC due to vasogenic edema and myelin destruction with axonal preservation; or decreased ADC due to intramyelinic edema.[2,3]

DWI is also an effective way of differentiating an arachnoid cyst from epidermoid tumors. Both lesions present similar signal intensity characteristic of cerebrospinal fluid (CSF) on T1 and T2 sequences. On DWI, epidermoid tumors are hyperintense whereas arachnoid cysts are hypointense, demonstrating high diffusivity. Thus DWI has a wide range of applications in the evaluation of intracranial pathological conditions. It provides a specific diagnosis in few situations, and adds to the information provided by conventional sequences in many others. It is in this backdrop, that the objectives set out in this research programme will enable us to understand the appearances of various intracranial lesions on diffusion weighted images. The signal characteristics of these lesions on ADC images and T2 FLAIR images will also be described.

MATERIALS & METHODS

The study was performed at the Department of Radio diagnosis, RNT Medical College, Udaipur to describe the features of intracranial lesions on diffusion weighted imaging and to compare these features with ADC and T2 FLAIR image

The criteria for inclusion of the patients in the study included those patients who were clinically referred for diffusion weighted MRI of the brain and were detected to have any of the following:-

1. Infarction and hypoxic ischemic injury
2. Infective conditions
3. Tumors – extra axial and intra axial.
4. Demyelination
   - Metabolic or toxic insults to the brain
   - Degenerative disorders

This consists of a study of 80 patients with intracranial lesions detected on imaging. MRI protocol consisted of the following

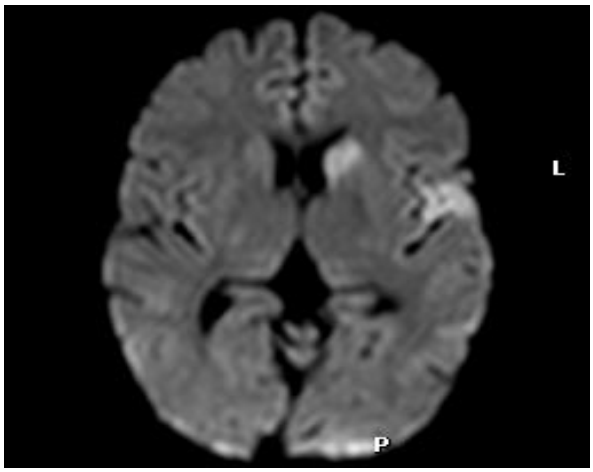
- A head coil was used
- Axial diffusion weighted images of the brain
- T1W images of the brain
- Axial T2W FLAIR images of the brain
- ADC images were reconstructed from the diffusion weighted images

Following parameters were examined:

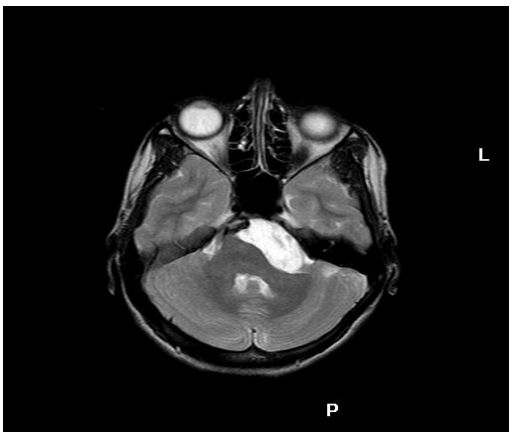
- Morphological changes
- Gyral Swelling
- Sulcal Effacement.
- Signal intensity alteration in T1, T2 and FLAIR images
- Altered signal intensity areas in DW Image

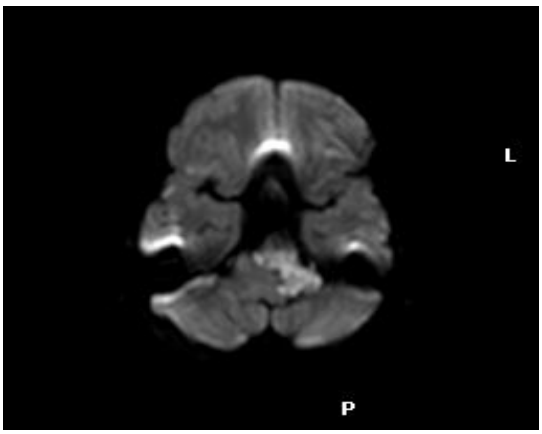
Observation-HYPERACUTE INFARCT

The present study was carried out to describe imaging characteristics of intracranial lesions on DWI and to compare them with ADC and T2 FLAIR images. Most common detected lesions were infract following by other lesion Meningioma, ,Abscess,Encephalitis, Acute Hematoma,ADEM ,Medulloblastoma & Subdural Empyem

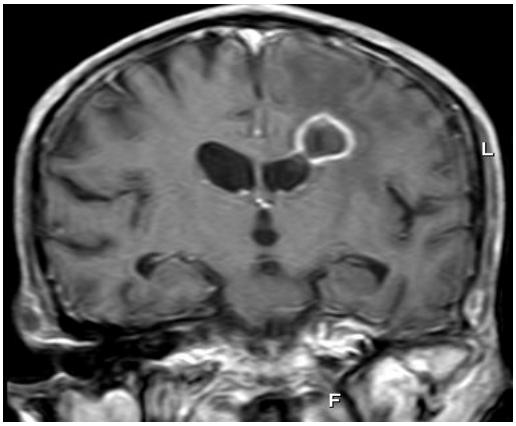


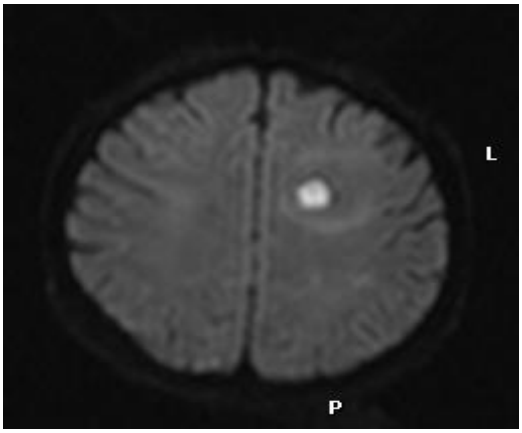
DW Axial Image Shows Restricted Diffusion in Left Caudate Nucleus & Perisylvian Region



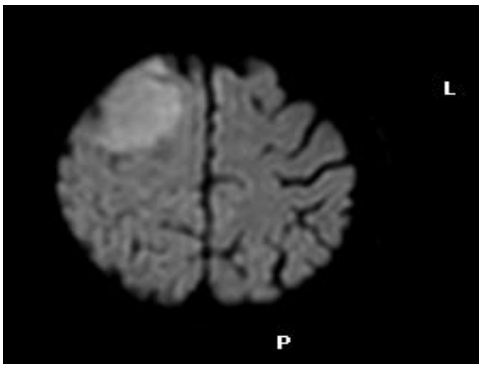


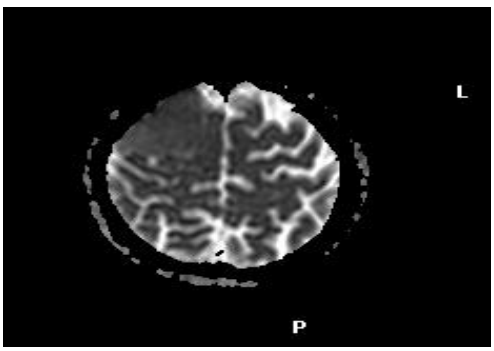
Epidermoid Shows Restricted Diffusion In Left CP Angle





BRAIN ABSCESS Shows Restricted Diffusion in Infracted Core





MENINGIOMA Shows Restricted Diffusion with Hypointensity on ADC

Table 1 : Showing various pathologies detected by diffusion imaging
(Total No. of cases 80 and Total No. of lesion 125)

CNS Lesion	No.of casesN(%)	No.of lesion N(%)
Infract	50(62.5)	85(68.0)
Meningioma	10(12.5)	10(8.0)
H. Encepahlitis	2(2.5)	7(5.6)
Epidermoid	3(3.75)	2(2.4)
Medulloblastoma	1(1.25)	1(.8)
Subdural empyema	1 (1.25)	1 (8)
Abcess	7 (8.75)	9 (7.2)
Acute hematoma	4 (5.00	6 (4.8)
ADEM	2 (2.5)	3 (2.4)
Total	80 (100)	125 (100)

Table 2 : Distribution of cases of infarct
(Total number of cases = 50)

Cases distriution	No. of cases	No, of lesions	% of total lesions
0-6hrs (hyperacute)	5(10)	8	9.41
6hrs-1 week (acute)	36(72)	60	70.5
1-3weeks (Subacute)	4(8)	9	10.5
>3 weeks (Chronic)	3(6)	8	9.41
TIA	2(4)	0	0
total	50(100)	85	100

Table -3 : Comparative analysis of conventional MR, FLAIR, and diffusion MR in the detection of cerebral infarction (No. of cases = 50, no. of lesions = 85)

Age of infract	Conventional *MRI* T1W N0.(%)	T2W No. (%)	FLAIR No.(%)	Diffusion MR No.(%)
Hyperacute	**2**(25)	6(75)	**7(87.5)**	8(100)
Acute	**48 (80)**	**58(96.6)**	**58(96.6)**	**60(100)**
Subacute	**9(100)**	**9(100)**	**9(100)**	**9(100)**
Chronic	**8(100)**	**8(100)**	**8(100)**	**8(100)**
Total	67(78.8)	81(95.20)	**83(97.6)**	**85(100)**

DISCUSSION

Diffusion weighted MRI provides image contrast that is different from that provided by conventional MRI sequences. It provides a technique for mapping proton contrast that reflects the microvascular environment. This imaging technique is sensitive to early ischemic insult. DWI is performed with a pulse sequence capable of measuring water translation over short distances. This water diffusion is much slower in certain pathological conditions as compared with normal brain.[4]

In this study 80 patients with intracranial lesions detected on DW MRI of the brain were included. It was found that DW MRI provides adjunctive information for intracranial lesions including stroke, neoplasms, infections, hypoxic ischemic encephalopathy and extra axial lesions in conjunction with conventional MRI.

In Infarcts the sensitivity and specificity of DWI in the detection of acute ischemia is 100%. The difference in sensitivity of DWI and conventional MRI sequences is more in the initial time period and decreases as time progresses. Results of this study are correlated with a study done by Gonzalez et al[5] who concluded that DWI is superior to conventional MRI in the diagnosis and characterization of acute infarct.

Inhypoxic ischemic injury diffusion-weighted imaging has proved to be more sensitive than conventional MR imaging sequences for early detection of hypoxic ischemic brain injury. Fu JH et al.[6] compared conventional MRI sequences to DWI in the evaluation of HII and found that DWI showed abnormal high signal intensity in the brain in patients in whom the conventional MR sequences were initially normal. Schaefer et al[7] concluded that HII lesions not seen on routine MR images are identified on DW MR images.

All cases of neonatal HII included in this study showed true diffusion restriction.

In infections several studies have shown that DWI can differentiate necrotic tumors from abscesses as both can show rim like enhancement on post contrast images. Lai et al[8] has shown that abscess cavity shows high signal intensity on DWI and a low signal on ADC image. This is not seen in the necrotic component of brain tumors. They concluded that DWI may enable one to distinguish brain tumors from necrotic tumors. Also, it helps in the evaluation of partially treated abscesses and to look for their recurrence.

In this study, 100% of cases of abscess showed true diffusion restriction. The cystic or necrotic component of none of the tumors included in this study showed restricted diffusion.

The tumors, specially in intra axial tumors MR imaging is the most sensitive method of detecting tumors of the brain. It is however not specific enough to determine the histological nature of most tumors. DWI can differentiate between tumor and infection and can provide information about the cellularity of tumors, thereby helping in characterization and grading of tumors. [9] Cruz CH et al[10] showed that highly cellular tumors such as high gradegliomas and lymphomas can have low ADC values and show restricted diffusion. It was also shown that medulloblastoma may be differentiated from other pediatric brain tumors by the presence of diffusion restriction. The solid portion of hemangioblastomas has high ADC values due to their rich vascular spaces. The findings of this study were similar.

Similarly, in extra axial tumors diffusion weighted MR plays a key role in differentiating arachnoid from epidermoid cysts. Schaefer et al[11] showed that conventional MR cannot be reliably used to differentiate these two lesions as both have CSF like signal intensity on conventional MR sequences. However, on DWI epidermoid cyst shows restricted diffusion while arachnoid cyst shows CSF like intensity.

CONCLUSION:

- 80 patients - 45 males and 35 females.
- Age group - 2 years to 85 years
- Out of 80 cases, 2 cases showed no findings on MR (conventional and diffusion MR), and a total of 125 lesions was found in 78 cases.
- Infarct (68%) was the commonest lesion
  - Acute infarcts (70%) m/c
  - Subacute infarcts (10.5%)
  - Hyperacute infarcts (9.41%)
  - Chronic infarcts (9.41%)
- Overall the most common arterial territory to be involved was MCA (54%) followed by PCA (16.45%)
- In cases of acute infarcts, T2WI and FLAIR could detect 96.6 % and diffusion MR had 100% detection rate.
- Diffusion MR, conventional MR and FLAIR had equal (100%) detection rate for subacute infarcts.
- Both conventional and diffusion MR (100%) had an equal detection rate for chronic infarcts.
- So main difference was the sensitivity to detect hyper acute & acute infacts.

Among the non-infarct lesions,

- Meningioma (8%) m/c
- Other lesions included
  - Abscess(7.2%)
  - Encephalitis(5.6%)
  - Acute Hematoma (4.8%)
  - ADEM (2.4%),Medulloblastoma & Subdural Empyema(0.8%) eac
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