INDIAN JOURNAL OF
APPLIED BASIC
MEDICAL SCIENCES

IJABMS
Peer Reviewed Journal
E-ISSN: 2249-7935
ISSN: 0975-8917

ROLE OF DIFFUSION WEIGHTED MAGNETIC RESONANCE IMAGING IN BRAIN PATHOLOGIES

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Abstract

Background: *Diffusion weighted imaging (DWI) has a wide range of applications in the evaluation of brain pathologies. This study was conducted to correlate Diffusion weighted MR imaging features of brain pathologies with other MRI sequences, to evaluate the role of DWI in brain pathologies. A prospective, observational and cross section study was performed of 100 patients in 6-month period. Patient with clinical suspicion of stroke, CNS infections, head injury, demyelination and tumor were included. All MRI studies were done on Siemens magneto essenza 1.5 T MRI. Age wise distribution, complaints, intra and extra axial location of tumor, presence and absence of restricted diffusion and findings of various sequences of MRI were studied.* ***Methods:*** *The present study was conducted in the Department of Radiology at AMC MET Medical college and LG hospital. Participants after understanding the study protocol and procedure were asked to give their written consent for the study.* ***Results:*** *in our study maximum cases were observed from 5th to 6th decades. 91 cases were intra-axial, 9 were extra-axial. 52% cases of stroke comprised of arterial infarct (39%), venous infarct (4%), HIE (3%), PRES (4%) and parenchyma haemorrhage (2%). 17% of cases were tumours which included glioma, metastases, GBM and hemangiopericytoma. 5% case of cavernous haemangioma and 5% cases of arachnoid cysts. 15% case of brain infections were included. All acute and subacute arterial infarcts and all venous infarcts showed restriction on diffusion weighted images and chronic cases did not show restriction. High grade gliomas, astrocytomas, and metastases showed diffusion restriction.*

Keywords: *DWI, Intracranial brain pathology, MRI (Magnetic resonance imaging), T2W (T2 weighted), FLAIR, ADC.*

INTRODUCTION

Diffusion weighted imaging (DWI) is a technique that assesses local environment at the cellular level to determine changes in the random movement of water protons. Whereas DWI is best 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 occasional demyelinating diseases. Reduced diffusion can be seen in highly cellular tumors such as lymphoma, meningioma and glioblastoma. Several reports have suggested an inverse correlation between ADC value and glioma grade 2 to grade 4 astrocytoma.[1]

The signal intensity of gliomas on DWI is variable (hyper, iso or hypo intense), and a subtle hyper intensity is a common nonspecific finding. Tumor cellularity is probably a major determinant of ADC values of brain tumors, although probably not the only one. ADC values cannot be used in individual cases to differentiate glioma types reliably (the ADC values of patients with grade 2 astrocytoma and glioblastoma overlap). The ADC values of solid gliomas, metastasis and meningioma were in the same range. In cases of lymphomas, however there was a good contrast with the white matter, with strongly reduced ADC values. Further studies are needed to define clearly the ability of DWI to help differentiate various brain tumors and to help grade gliomas.[2]

DWI is useful in providing a greater degree of confidence in distinguishing brain abscesses from cystic or necrotic brain tumors than conventional MRI.[3] Thus, it may increase the diagnostic accuracy when combined with other sequences. Likewise, in Creutzfeldt-Jakob disease, DW imaging helps differentiate from infarct by showing persistent restricted diffusion.[4]

Thus, diffusion weighted imaging (DWI) has a wide range of applications in the evaluation of brain pathology. It provides a specific diagnosis in few situations, and adds to the information provided by conventional sequence in many others.

METHODS

The study was conducted in the Department of Radio diagnosis AMC MET Medical college and LG hospital, Ahmedabad. Imaging was done with Philips 1.5 tesla magnetic resonance imaging equipment for 6months in 2019

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Inclusion criteria:
All patients with diffusion weighted magnetic resonance imaging reference for infarction, hypoxic ischemic injury, infective condition, tumors, demyelination, metabolic and toxic insult to brain, Degenerative disorder irrespective of age and sex were included in the study.

Exclusion criteria:
- Patient who has aneurysmal clip in their brain.
- Patient with claustrophobia
- Patient having orthopedic implant.

Patients underwent the examination after contraindications for MRI were excluded and consent was taken. All the MRI scans in this study were performed using 1.5T MRI scanner. MRI Protocol consisted of the following:

MRI Protocol consisted of the following:

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

All patients clinically suspected of acute and chronic stroke, ischemia; intracerebral hemorrhage; Intracranial tumors, Extra axial masses, Cerebral abscess and Encephalitis, demyelination, sustained seizure activity, metabolic or toxic insults to the brain and leukodystrophy were included in this study. Patient was placed in supine position and brain coil was used. MRI features of lesion detected were studied – site (intra or extra axial), margins, perilesional edema, appearance on DWI and ADC T1WI, T2WI, FLAIR images, presence of classification or hemorrhage any enhancement in contrast study. Non-Ionic intra venous contrast gadopentetate dimeglumine was administered in patients with normal renal function tests wherever necessary. The recommended dosage of gadopentetate dimeglumine injection is 0.2 mL/kg (0.1 mmol/ kg) administered intravenously. Though in general protocol, all required specific sequences were taken.

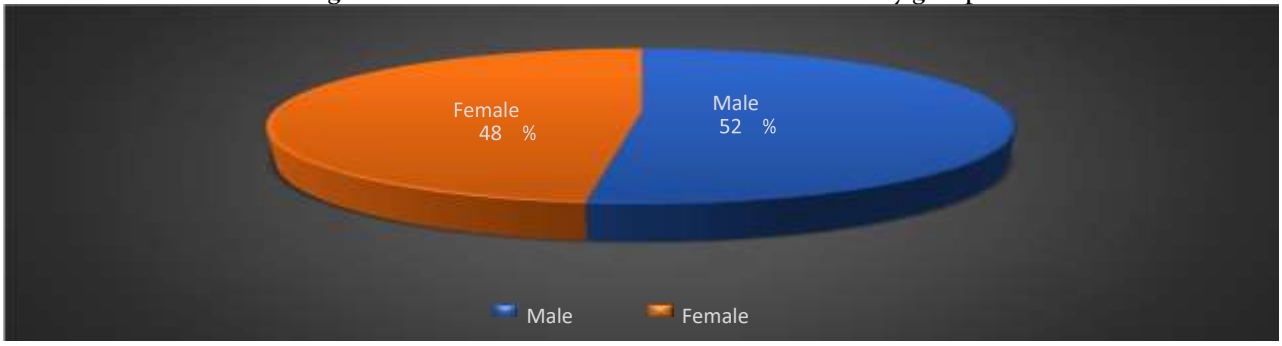
OBSERVATIONS AND RESULTS

Table-1: Age wise distribution of cases in study group

Age (Yrs.)	No of cases	Percentage
0-10	06	06%
11-20	11	11%
21-30	11	10%
31-40	09	09%
41-50	13	13%
51-60	18	18%
61-70	16	16%
>70	16	16%
Total	100	100%

The most common age group involved in our study was between 51-60 years.

Figure 1: Gender wise distribution of cases in study group



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APPLIED BASIC
MEDICAL SCIENCES

IJABMS
Peer Reviewed Journal
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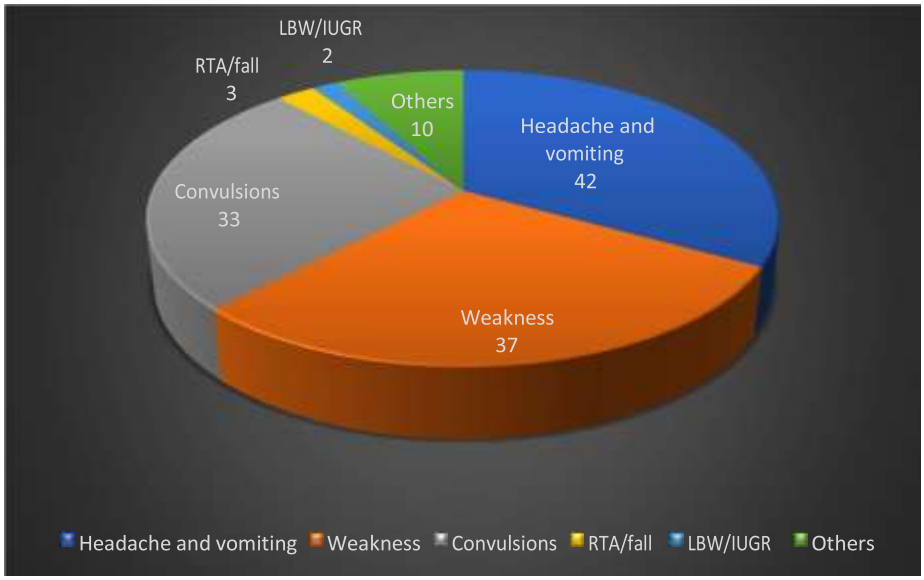
In our study there is both gender patients are almost equally involved.

Figure 2: Complaints wise distribution of cases in study group.



The most common presenting complaint/ symptom in our study were headache and vomiting followed by weakness.

Table-2: Restricted diffusion wise distribution of cases in study group

Restricted diffusion	No of cases	Percentage
Present	59	59%
Absent	41	41%
Total	100	100%

Out of 100 patients in our study patients 59% showed restriction of diffusion while 41% did not show restriction.

Table-3: Tumors showing restricted diffusion on diffusion weighted images in study group

Tumors	No of cases	Percentage
Restricted diffusion	12	70.60%
Non-restricted diffusion	05	29.40%
Total	17	100%

In our study out of the 17 tumor cases we studied 12 (70.60%) of the cases showed restricted diffusion while the 5 (29.40%) did not show restricted diffusion.

Table-4: Infective etiology wise distribution of cases in study group

Infective etiology	No of cases	Percentage
Bacterial abscess	03	20%
Subdural empyema	01	07%
Neurocysticercoses	05	33%
Tuberculous granuloma	06	40%
Total	15	100%

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Table-5: MRI diagnosis wise distribution of cases in study group

MRI diagnosis	No of cases	Percentage
Arterial infarct	39	39%
Venous infarct	04	04%
Parenchymal hemorrhage	02	02%
PRES	04	04%
Hypoxic ischemic encephalopathy	03	03%
Glioma	06	06%
Astrocytoma	01	01%
Metastases	04	04%
Glioblastoma multiforme	01	01%
Meningioma	04	04%
Hemangiopericytoma	01	01%
Arachnoid cyst	05	05%
PML	01	01%
Cavernous malformation	05	05%
Viral encephalitis	05	05%
Bacterial abscess	03	03%
Subdural empyema	01	01%
Neurocysticercosis	05	05%
Tuberculous granuloma	06	06%
Total	100	100%

DISCUSSION

According to our study no significant difference in gender distribution of brain pathologies with the ratio of M: F being approximately 1:1. In our study the age distribution wise maximum cases were seen in age group between 51-60 years. The youngest patient was a child of 22 days with hypoxic ischemic encephalopathy and the oldest patient was of the age group of 86 years with acute arterial infarct in both cerebral and right cerebellar hemisphere.

Our study consisted of fifty-two patients with stroke. Out of these, 39 were of arterial infarct with being 16 acute infarcts and 23 being sub-acute or chronic. 4 were of venous infarcts of which 1 was non-hemorrhagic and 3 were hemorrhagic, 4 of progressive reversible encephalopathy syndrome, 3 of Hypoxic ischemic encephalopathy and 2 of parenchyma hemorrhage. Restriction was seen in all the acute infarcts and not seen in chronic cases.

Diffusion weighted MRI 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.[5]

The sensitivity and specificity of DWI in the detection of acute ischemia is almost 100%. DWI is superior to conventional MRI in the diagnosis and characterization of acute infarct. Thus, DWI was noted to be superior to T2WI in detection of acute infarcts.[6] In subacute infarcts and chronic infarcts, abnormal signal was noted on T2WI and on DWI in all patients. Thus, there was no difference in their sensitivity for later stages of infarcts. In chronic infarcts, the signal on DWI and ADC images is variable and depends on a combination of T2 signal and increased ADC values.

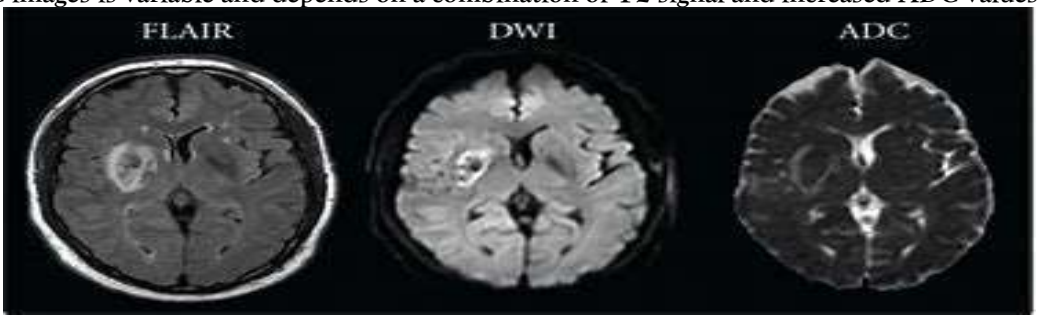

Figure: 3 Acute non-hemorrhagic infarcts in left occipital lobe (PCA territory) appearing hyperintense on Axial FLAIR, showing restricted diffusion on DWI with low ADC values.

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Hypoxic ischemic injury

Hypoxic ischemia encephalopathy limits the oxygen supply to areas of brain with high metabolic activity. Patterns of HIE vary according to the time and duration of the insult. Diffusion weighted MR imaging is the earliest sequence to detect hypoxic ischemic encephalopathy due to early cytotoxic edema. There is restricted diffusion seen in affected areas of brain in HIE appearing bright with reduced apparent diffusion coefficient on ADC images. Restricted diffusion is a dynamic process beginning on day 1 of life and progress over next week. ADC pseudo normalization occurs at the end of first week.[7] So, compared conventional MRI sequences to DWI in the evaluation of Hypoxic ischemic injury and found that DWI showed abnormal high signal intensity in the brain in patients in whom the conventional MR sequences were initially normal.[8]

Infections

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. The cystic or necrotic component of none of the tumors included in this study showed restricted diffusion. Tubercular granulomas and NCC could not be detected on DWI alone and needed ADC and T2W images for lesion detection probably due to the poor spatial resolution of diffusion weighted imaging. Extradural empyema noted in this study showed true diffusion restriction. The thick nature of this collection causes reduced water diffusivity similar to abscesses.

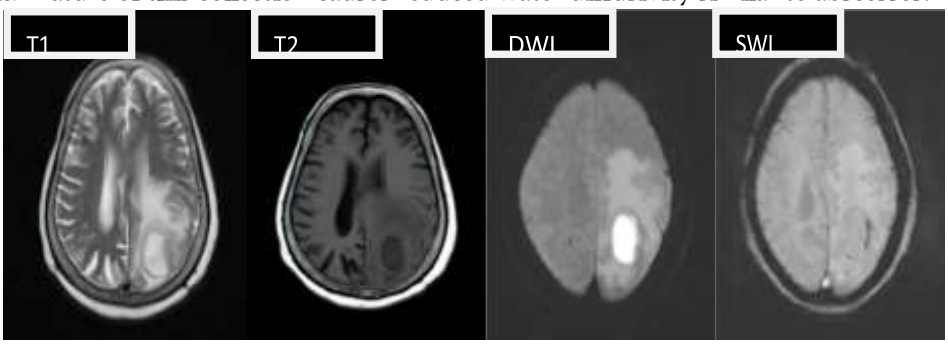
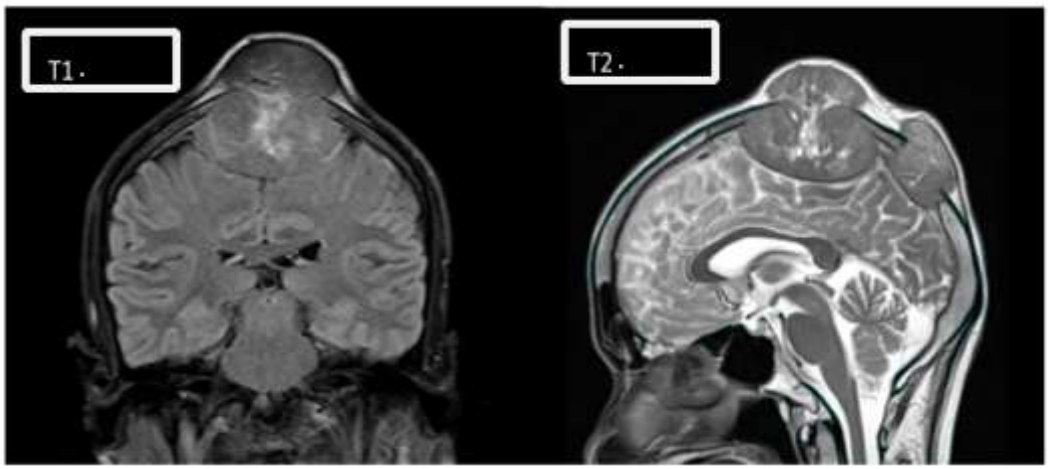


Figure 4: large irregular heterogeneously hyperintense lesion involving left parietal region on T2W images which appears hypointense on T1W images. The lesion shows thick irregular isointense walls. It appears bright on DWI. SWI reveal peripheral hypointense area involving the lesion.

Intra axial tumors

In the present study, GBM showed true diffusion restriction. None of the low-grade gliomas or astrocytoma showed restricted diffusion. The single case of hemangiopericytoma seen in this study showed hypointense on T2W & FLAIR images with intralesional hyperintense areas and high signal on ADC images in its solid component suggesting high water diffusivity. DWI can differentiate between tumor and infection and can provide information about the cellularity of tumors thereby helping in characterization and grading of tumors. Cruz CH et al, showed that highly cellular tumors such as highgrade gliomas and lymphomas can have low ADC values and show restricted diffusion.[9]



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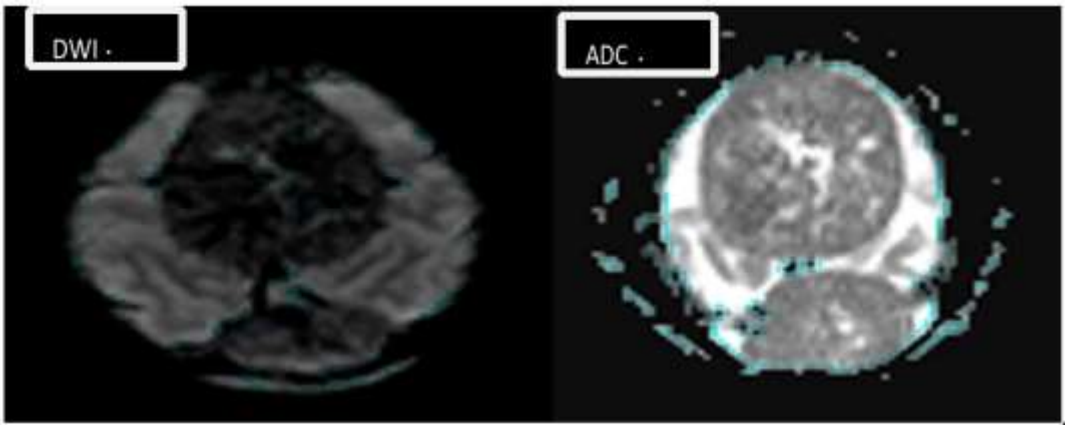

Figure 5: coronal section of hemangiopericytoma on T1W and T2W images and axial section on DWI and ADC

Extra axial tumors

Schaefer et al, showed that conventional MR cannot be reliably used to differentiate these two lesions as both have CSF like signal intensity on conventional MR sequences.[10] This was also demonstrated in a study by Cruz et al, in which arachnoid cysts had ADC values similar to CSF.[9] In the present study all 5 cases of arachnoid cysts had signal similar to CSF on DWI and ADC images. Tadeusz et al and Cruz et al concluded that most meningiomas are isointense on DWI.[9,11] Only few may show restricted diffusion depending on their cellularity. In their study 23% of meningiomas showed restricted diffusion. This study had similar results with 25% of meningiomas showing true diffusion restriction.

Posterior reversible encephalopathy syndrome

Four cases of PRES were included in the present study. All the lesions were hyperintense on T2 FLAIR images. Two cases showed no change on DWI or ADC images. Chou MC et al study included 12 cases of PRES and diffusion weighted imaging were done in 10 cases. [12]

Demyelination

Case of demyelination seen in this study did not show restricted diffusion and had increased signal on T2 FLAIR images. Studies done by Christiansen P et al and Larsson H et al, have shown that most foci of demyelination do not show restricted diffusion. [13,14]

Others

Schwartz et al, showed that the edema of hypertensive encephalopathy is of vasogenic type.[15] The results of this study are similar. None of the cases of PRES seen in this study had features of restricted diffusion. No signal change was noted in periventricular leukomalacia seen in this study, while the single case of adrenoleukodystrophy showed features of vasogenic edema.

STAGE	T1WI	T2WI	DWI	ADC
Hyper acute	Iso	Hyper	Hyper	Low
Acute	Iso	Hypo	Hypo	-
Early acute	Hyper	Hyper	Hypo	-
Late acute	Hyper	Hyper	Hyper	Hyper

CONCLUSION

DWI sequence is extremely useful in detection, etiopathogenesis and prognosis of brain pathologies like infarcts, abscess and tumors. The DW MR is a very useful sequence in evaluating stroke like symptoms. DW sequences are the only available best modality to detect hyper acute infarcts within its window period i.e. 6 hours. In patients with multiple infarcts diffusion weighted imaging can identify the acute lesions. DWI is useful in early detection of HIE, when conventional MRI sequences are normal. DWI is extremely useful in detection of cytotoxic edema in acute cortical laminar necrosis. DWI is useful in detection of atypical MRI findings of PRES which show cytotoxic edema. DW MR is not very useful to grade tumors but may serve as a guide to a highly cellular area for stereotactic biopsy. Also, tumor margins are not clearly delineated on diffusion weighted imaging as compared to T1 and T2W imaging. Highly cellular tumors show low ADC values. DWI is very useful in differentiating the epidermoid from arachnoid cysts which may not be possible on conventional MRI sequences. In cerebral venous sinus thrombosis (CSVT), DWI can separately evaluate

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vasogenic edema, reversible cytotoxic edema and cytotoxic edema due to venous infarction. DWI is useful in detection of encephalitis. DWI is useful in detection of cerebral abscess and differentiating it from tumors. In case of demyelinating diseases, by showing peripheral diffusion restriction DWI can identify an active lesion and can help in prognosis and response to treatment. In cases of trauma especially diffuse axonal injury, diffusion weighted imaging may identify more lesions compared to conventional MR sequences which is useful for prognostic and patient management.

ACKNOWLEDGEMENTS: none

CONFLICTS OF INTEREST: none

FUNDING: Nil

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