Section: Radiology

Original Research Article

ROLE OF DWI IN INTRACRANIAL PATHOLOGIES WITH ITS COMPARISON TO FLAIR AND T2W IMAGING

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Received : 08/10/2022
Received in revised form : 11/12/2022
Accepted : 08/01/2023

Keywords:
Deffusion Weighted Imsging, Stroke, Intracranial Space Occupying Lesions.

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DOI: 10.47009/jamp.2022.5.1.90

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (1); 433-437

Abstract

Introduction: Diffusion-weighted MRI sequence is a special and advanced MRI technique that depends on the random movement of water molecules within and between the intracellular and extracellular spaces. Image contrast in diffusion-weighted images is dependent on the molecular motion of water. Conventional MR provides information like visualization of a mass lesion, information on mass location, its homogeneity, and signal intensity, the presence of perilesi
onal edema, and degree of contrast enhancement, but In conventional MRI imaging, staging of brain stroke and hematoma, cellularity, architecture, tumor grade, aggressiveness, histological criteria of the tumor cannot be evaluated, for this purpose diffusion-weighted sequence is required. **Aims and objective:** We aim to analyse the role of DWI in the evaluation of intracranial lesions by describing the features of intracranial lesions on diffusion-weighted imaging and comparing them with ADC and T2/FLAIR images so as to help differentiate among them. We aim to characterize the staging of acute brain ischemia, diagnose white matter diseases, differentiate cystic SOLs, and differentiate a multitude of Infections inflicting the central nervous system. **Method and Material:** The study was carried out in the Department of Radiodiagnosis, at G.G hospital, Shri M.P. shah government medical college with 100 patients who underwent DWI and conventional MR imaging of the brain during the period of 12 months. Participants after understanding the study protocol and procedure were asked to give their written consent for the study. **Result:** Out of 100 patients (age ranging from 14 days to 95 years), out which 28 patients having infarcts with or without hemorrhagic transformation were studied in which sensitivity and specificity of DW imaging was 100% within the initial 6 hours, which is far more superior than conventional MR imaging. Amongst the patients with brain tumors, variable patterns of diffusion were noted. This variability can be attributed to the varying cellularity of different tumors. Although subgroups like gliomas, meningioma, and metastasis showed consistency with other comparative studies. There were patients with cystic SOLs and demyelinating disorders that showed imaging findings consistent with other comparative studies reaffirming the role in their characterization, except for a few inconsistent lesions in patients with multiple sclerosis. Conclusion: Diffusion-weighted MRI provides magnanimous strides in the characterization of the intracranial lesion and immensely facilitates T2-weighted and FLAIR imaging techniques.

INTRODUCTION

Diffusion-weighted imaging provides microscopic information from water protons which is not possible using conventional magnetic resonance imaging. DWI measures the random (Brownian) extra, intra, and transcellular motion of water molecules. Diffusion imaging is based on the natural sensitivity of MRI to motion. In a DWI sequence, diffusion sensitization gradients are applied on either side of the 180° refocusing pulse. The parameter "b value" decides the diffusion weighting and is expressed in s/mm.[2] It is proportional to the square of the amplitude and duration of the gradient applied. Diffusion is qualitatively evaluated on trace images

ISSN (O): 2687-5365; ISSN (P): 2753-6556

and quantitatively by the parameter called apparent diffusion coefficient (ADC). Tissues with restricted diffusion are bright on the trace image and hypointense on the ADC map. ADC is the most widely used parameter derived from the conventional DWI sequence, representing the level of restriction to the motion of water molecules in the extracellular compartment. The term "apparent" relates to the fact that this motion is also influenced by other physiological processes, such as heartbeat, breathing, or CSF pulsation. The main advantage of ADC relies on its widespread availability. DWI is of prime importance in brain imaging because of its high sensitivity in detection of stroke, which is one of the important differential diagnoses in virtually all patients who present with a neurologic complaint. It is very useful in differentiating acute stroke from other conditions which may present with acute neurological deficit. DWI is a very useful sequence in the detection of hyperacute stroke which might be missed in conventional MRI sequences.[1] Apart from its application in stroke, DWI provides adjunctive information in other cerebral diseases such as neoplasms, intracranial infections, traumatic brain injury and demyelinating diseases.

METHOD AND MATERIAL

The study was carried out in the Department of Radiodiagnosis, at G.G. hospital, Shri M.P. Shah government medical college with 100 patients who were undergone conventional MR imaging of the brain during the period of 12 months. Imaging was done with Siemens Magnetom Essenza 1.5 Tesla MR machine using head coil. These patients were prospectively subjected to DWI along with a conventional MRI study. The MRI images are stored in DICOM format. The reports (findings) of all these patients were collected in printed format along with documentation of clinical details, follow-up, and other data. Basic imaging protocol consisted of fast spin echo T2WI in axial and sagittal planes and DWI, T1 WI in the axial plane, and FLAIR images in the axial and coronal plane. Contrast studies were performed wherever tumor and infection were suspected on initial diagnosis.

Inclusion Criteria

- Patients with neurological symptoms of a space-occupying brain lesion or cerebrovascular attacks or infective etiology or some demyelinating disease.
- Patients with a history of some old cerebrovascular attacks or space-occupying brain lesions or infective etiology, now having any fresh complaints.

Exclusion Criteria

- Patient with history of claustrophobia or not willing to give consent.
- Patients with known contraindications for MRI e.g. Pacemaker, Aneurysmal clips, and Non-MR-Compatible orthopaedic prosthesis.

RESULT

Out of 100 patient 56 patients were male and 44 were female patients. (M:F ratio 1.27:1). Majority of the patients (60%) included in this study were in 21 to 60 years of age with patients age ranges from 14 days to 95 years.
Among all patients in this study, solid SOLs etiology was the commonest diagnosis accounting for 33% of patients. The next common diagnosis in the patients of this study was 'ischemic' seen in 32 (32%) patients. Infections, cystic SOLs, others, and demyelinating diseases were the groups of diagnoses which followed in descending order of frequency next to the above mentioned two groups of diagnoses.

STROKE

Out of 28 parients of ischemic stroke, majority of patients being in 6th and 7th decades. 22 patients were male and 6 were female.

Table 1: Patients with ischemic stroke classified based on the duration of symptoms. (n=28)

Duration of symptom	No. of patients (%) N=28	Lesion detected on DW MR	Sensitivity of DW MR (%)	Lesion detected on T2W MR	Sensitivity of T2W MR (%)	Lesion detected on FLAIR MR	Sensitivity of FLAIR MR (%)
0-6 HRS	4 (14%)	4(14%)	100	-	0	-	0
6-24 HRS	0 (0%)	0	-	-	0	-	0
1 -7 DAYS	15(53%)	15(53%)	100	15(53%)	100	15(53%)	100
1-3 WEEKS	4(14%)	4(14%)	100	4(14%)	100	4(14%)	100
> 3 WEEKS	5(17%)	5(17%)	100	5(17%)	100	5(17%)	100

4 patients showed hyperintensity only on DWI images with corresponding hypointensity on ADC maps. 24 patients showed corresponding lesions in both T2W and DW images. Lesions were diagnosed on DW MR with 100% sensitivity but could not be detected on T2W MR when duration of symptoms was within 6 hours. Lesions were diagnosed on DW MR with a sensitivity of 100% and on T2W MR with sensitivity of 100% when duration of symptoms was 24 hours to 7 days. However, T2W MR images were equally sensitive (100% sensitivity) as DW MR as the duration of symptoms increased beyond 24 hours.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Solid SOLs

Out of 33 patients of solid sol, there are 13 patients of glioma, 5 patients of meningioma, 3 patients of schwannoma and 10 patients of other different histology. All solid SOLs appear hyperintense on T2WI and all (except central gangliocytoma) appears hyperintense on FLAIR imaging. So T2WI and FLAIR imaging do not give much differentiation of these solid SOLs. On DWI, we noticed interesting finding that high grade tumor like high grade glioma, meningioma, schwannoma and ependymoma shows diffusion restriction, while low grade tumor like low grade glioma, central gangliocytoma, craniopharyngioma do not show diffusion restriction on DWI. Few cases of metastases and pituitary macroadenoma show equivocal findings on DWI.

Table 2: imaging characteristic of solid SOLs

Tumors	no. of patients N=33 (%)	T2W MRI	FLAIR MRI	DW MRI	ADC MRI
HIGH-GRADE GLIOMA	5(15.15%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hyper-intense
LOW-GRADE GLIOMA	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
	2(6.06%)	Hyper-intense	Hyper-intense	Hypo-intense	Hypo-intense
	4(12.12%)	Hyper-intense	Hyper-intense	Hyper-intense	Hyper-intense
MENINGIOMA	5(15.15%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
SCHWANNOMA	3(9.1%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
EPENDYMOMA	2 (6.06%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
LYMPHOMA	1 (3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo -intense
DYSEMBRYOBLASTIC NEUROECTODERMAL TUMOR	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo -intense
MEDULLOBLASTOMA	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
MALIGNANT ANAPLASTIC HEMANGIOPERICYTOMA	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
CRANIOPHARYNGIOMA	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hyper-intense
CENTRAL GANGLIOCYTOMA	1(3.03%)	Hyper-intense	Hypo-intense	Hyper-intense	Hyper-intense
PITUITARY MACROADENOMA	1(3.03%)	Hyper-intense	Hyper-intense	Hyperintense	Hypointense
	1(3.03%)	Hyper-intense	Hyper-intense	Hypointense	Iso-intense
METASTASES	1(3.03%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
	1(3.03%)	Hyper-intense	Hyper-intense	Hypo-intense	Hypo-intense

Cystic SOLs

Table 3: Characteristics of other cysts (N-12)

Cyst	No. of patients N=12 (%)	T2W MRI	FLAIR MRI	DW MRI	ADC MRI
Arachnoid cyst	5(42%)	Hyper-intense	Hypo-intense	Hyper-intense	Hyper-intense
Epidermoid cyst	2(17%)	Hyper-intense	Hyper-intense	Hyper-intense	Hypo-intense
Colloid cyst	1(8%)	Hyper-intense	Hyper-intense	Hypo-intense	Hyper-intense
Porencephalic cyst	4(33%)	Hyper-intense	Hypo-intense	Hypo-intense	Hyper-intense

Out of 12 cases of cystic sol, epidermoid cyst shows restricted diffusion, while arachnoid cyst, porencephalic cyst, colloid cyst does not show diffusion restriction.

Infections

Out of 10 cases of infective etiology all cases shows T2 and FLAIR hyperintensity, while on DWI few cases of granulomatous lesions, cerebritis and cerebral abscess show restricted diffusion, while few cases of granulomatous lesions and neurocysticercosis do not show diffusion restriction.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Demyelinating Diseases

Out of 6 cases of demyelination disease, all lesions appear hyperintense on T2 and FLAIR imaging, however on DWI all lesions (except few old cases of multiple sclerosis) show restricted diffusion.

Table 4: Demyelinating diseases: appearance on dw mri, flair mri, and t2w mri(N=6)

DIAGNOSIS	No. of patients (%) N=6	T1WI	T2WI	FLAIR	DWI	ADC
ADEM	1 (16.7%)	hypointense	hyperintense	hyperintense	hyperintense	Hypointense
CANAVAN DISEASE	1(16.7%)	isointense	hyperintense	hyperintense	hyperintense	Hypointense
METACHROMATIC LEUKODYSTROPHY	1(16.7%)	Hypointense	hyperintense	hyperintense	hyperintense	Hypointense
MULTIPLE SCLEROSIS	2(33.3%)	hypointense	hyperintense	hyperintense	hypointense	hyperintense
	1 (16.7%)	hypointense	hyperintense	hyperintense	hyperintense	Hypointense

Infract

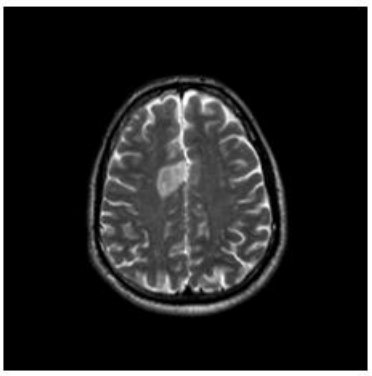

Figure 1: Axial T2WI

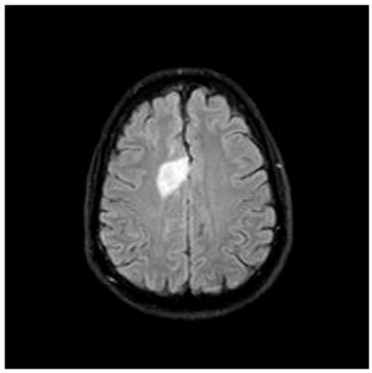

Figure 2: Axial FLAIR

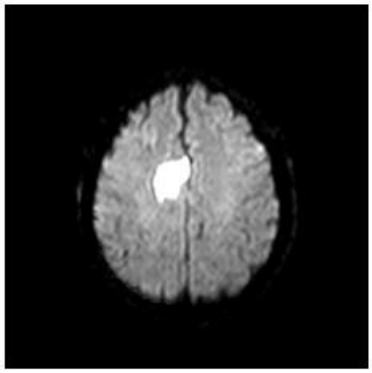

Figure 3: Axial DWI

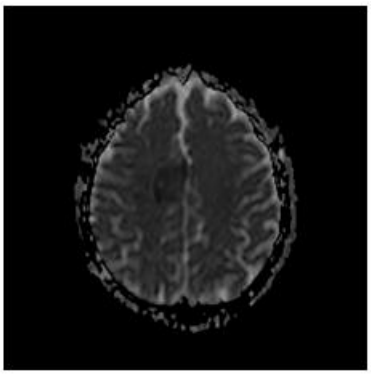

Figure 4: Axial ADC

MRI Findings

On axial T2WI and FLAIR images shows hyperintense area involving cortical and subcortical white matter of right frontal lobe in parasagittal location. On axial DW images it shows diffusion restriction.

DISCUSSION

We have evaluated 100 patients of various intracranial pathologies with its subtypes, in which DWI is having particular role for diagnosis and further lesion characterisation I stroke, solid and cystic SOLs and demyelinating disease. In MRI evaluation of stroke patients DWI far more superior than T2 and FLAIR imaging in early 6 hours of onset of symptoms and is equally sensitive to T2WI and FLAIR if imaging is done after 6 hours of onset of symptoms The results of the present study are consistent with findings of similar study done by Gonzalez RG et al[1] and meta-analysis published in American Academy of Neurology.[2] In various solid and cystic intracranial SOLs, DWI is important parameter for lesion characterisation, grading and evaluation of cellularity in addition to its role in diagnosis of lesion. It is having game changing role in diagnosis of certain lesions like epidermoid cyst, as it is only cystic SOL which shows restriction on DWI. Most of solid and cystic SOL appears hyperintense on T2W and FLAIR sequence irrespective of their cellularity and grading. These results parallel the results of a study conducted by Kono K et al[3], Tien et al[4], Kitis O et al[5], and Hayashida et al[6] and findings of study conducted by

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Cruz et al[7], Shuda Chen et al[8], Tadeusz W. Stadnik et al[9] and Schaefer et al[13]. There are equivocal findings on DWI in various cases of intracranial infection. Most cases of various demyelinating disease show restriction on DWI except few old cases of multiple sclerosis. Similar pattern of results was seen in studies by Rovaris M et al[10], Inglese M et al[11] Tievsky AL et al.[12]

CONCLUSION

Diffusion weighted MRI is a valuable technique that provides unique information about the physiological state of brain tissue. DWI is far more superior in diagnosis of stroke as out of 28 patients 4 patients have positive findings only in DWI and rest of 24 patients have also positive findings in DWI. So DWI is having 100% sensitivity and specificity in early as well as late stroke while T2W and FLAIR imaging have 85% sensitivity in stroke diagnosis. In the setting of multiple infracts, it helps in determining the age of infarcts and in differentiating acute, subacute and chronic infarcts. However, it has also shown promising results in the characterization of other intracranial abnormalities. Most of the solid and cystic SOLs appear similar characteristic on T2WI and FLAIR images, while DWI gives useful information regarding tumor cellularity, highly cellular tumor shows propensity towards diffusion restriction, epidermoid being only cystic SOL which show diffusion restriction. Most of demyelinating lesions of brain show diffusion restriction. Thus, DWI helps in the evaluation of a variety of intracranial disease processes as described. DWI along with other conventional MRI sequences helps in narrowing down the differential diagnosis of various intracranial lesions and must be included in any standard brain imaging protocol.

REFERENCES

1. Gonzalez RG et al. Diffusion weighted MR imaging: Diagnostic accuracy in patients imaged within 6 hours of stroke symptom onset. J Radiology 1997; 203:155-62.
2. Evidence-based guideline: The role of diffusion and perfusion MRI for the diagnosis of acute ischemic stroke: Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Neurology. 2010;75:938-938
3. Kinuko Konoa, Yuichi Inouea, Keiko Nakayamaa, Miyuki Shakudoa, Michiharu Morinoa, Kenji Ohataa, Kenichi Wakasaa and Ryusaku Yamadaa, The Role of Diffusion-weighted Imaging in Patients with Brain Tumors, American Journal of Neuroradiology 22:1081-1088 (6 2001)
4. Tien DR, Feirsberg JG, Friedman H, Brown M, MasFall J. MR imaging of high-grade cerebral gliomas: value of diffusion-weighted echoplanar pulse sequences. Am J Roentgenol 1994;162:671-677
5. Kitis O, Altay H, Calli C, et al. Minimum apparent diffusion coefficients in the evaluation of brain tumors. Eur J Radiol 2005;55:393-400.
6. Hayashida Y, Hirai T, Morishita S, Kitajima M, Murakami R, Korogi Y et al. Diffusion-weighted Imaging Of Metastatic Brain Tumors: Comparison With Histologic Type And Tumor Cellularity. AJNR Am J Neuroradiol 2006; 27: 1419-1425
7. Cruz CH, Gasparetto EL, Domnigues RC. Diffusion weighted MRI in brain tumor. Neuroimaging clinics 2011 february;21(1):27-49
8. Shuda Chen, Fusao Ikawa, Kaoru Kurisu, Katsunori Arita ET AL Quantitative MR Evaluation of Intracranial Epidermoid Tumors by Fast Fluid-attenuated Inversion Recovery Imaging and Echo-planar Diffusion-weighted Imaging AJNR Am J Neuroradiol 22:1089-1096, June/July 2001.
9. Tadeusz WS, Philippe D, Robert RL, Christo C, Katrijn L. Van R, Alex M and Michel JO. Imaging Tutorial: Differential Diagnosis of Bright Lesions on Diffusion-weighted MR Images. Published online November 1, 2002, 10.1148/rg.e7. Radiographics.2003; 23:e7-e7
10. Rovaris M et al, Diffusion MRI in MS. Neurology 2005;65:1526-32
11. Inglese M et al, Magnetization transfer and Diffusion tensor imaging of acute disseminated encephalomyelitis. Meuroradiology 2002;23:267-72 AJNR Am
12. Tievsky AL et al, Investigaton of apparent diffusion coefficient and diffusion tensor anisotrophy in acute and chronic multiple sclerosis lesions, AJNR Am J Neuroradiology 1999;20:1491-9
13. Schaefer PW, Grant PE, Gonzalez RG. Diffusion weighted MR imaging of brain. Radiology 2000 november; 217:331-345.

ISSN (O): 2687-5365; ISSN (P): 2753-6556