Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL13, ISSUE 05, 2022

Original research article

COMPARISON OF 3D DOUBLE INVERSION RECOVERY (3D DIR), 3D FLUID ATTENUATED INVERSION RECOVERY (3D FLAIR) AND 2D FLUID ATTENUATED INVERSION RECOVERY (2D FLAIR) PULSE SEQUENCES: FOR THE IMAGING OF INFRATENTORIAL IN MULTIPLE SCLEROSIS

[1]Dr. Krishnamurthy N, [2]Dr. Rupa Ananthasivan, [3]Dr. Ullas V Acharya

[1]Assistant Professor, Department of Radiodiagnosis, Vijayanagara Institute of Medical Science, Ballari, Karnataka, India

[2,3]Consultant, Department of Radiodiagnosis, Manipal Hospital 98, Hal Old Airport Rd, Kodihalli, Bengaluru, Karnataka, India

Corresponding Author:
Dr. Krishnamurthy N

Abstract

Magnetic resonance imaging (MRI) has played a very important role in elucidating the pathophysiology, diagnosis and treatment of MS. Conventional T1-and T2-weighted MRI images reveal islands of demyelinating plaques, more frequently found in white matter than grey matter. Patients are enrolled for the study after obtaining an informed consent. After collection of demographic data, clinical history and once the patient satisfies the inclusion criteria for this study, he or she would be subjected to MRI. The patients would be briefed about the procedure. The noise due to gradient coils (heard once the patient was inside the bore of the magnet) and the need to restrict body movements during the scan time would be explained to the patient. DIR imaging with an acceptable acquisition time in combination with a high sensitivity in the detection of MS lesions. In our study, we used 3D DIR, 3D FLAIR and 2D flair pulse sequence at 3T Philips machine. DIR sequence allows a sufficient attenuation of the CSF and the NAWM. FLAIR sequence allows sufficient attenuation of CSF.

Keywords: 3d Double inversion recovery, 3d Fluid attenuated inversion recovery, 2d Fluid attenuated inversion recovery

Introduction

Multiple sclerosis (MS) is the most common chronic inflammatory demyelinating disease of the central nervous system, which resulting in both physical and neurocognitive disability. MS typically affects the white matter, but recent clinical autopsy studies have also reported changes in the grey matter [1].

Magnetic resonance imaging (MRI) has played a very important role in elucidating the pathophysiology, diagnosis and treatment of MS. Conventional T1-and T2-weighted

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MRI images reveal islands of demyelinating plaques, more frequently found in white matter than grey matter. Autopsy studies have also demonstrated inflammatory and pathological changes in MS, which are not present in regions of demyelinating plaques but appear as islands in conventional MRI sequences and are present almost throughout the brain, encompassing both the white and grey matter and appearing macroscopically normal [2].

Thus, the inability to demonstrate such changes using conventional MRI sequences reflects the technical insufficiency of these classical techniques. Conventional magnetic resonance imaging (MRI) does not show any histopathological characteristics apart from an association between specific T2-weighted images of hyperintense lesions (demyelinating plaques) and inflammation with gadolinium uptake [3].

These considerations have necessitated the development of new techniques to obtain a better understanding of MS pathophysiology. Such novel techniques include fluid–attenuated inversion recovery (FLAIR) and double inversion recovery (DIR). Although FLAIR has been used in a routine clinical setting, DIR is more frequently used in experimental studies, although it has recently started to enter clinical use [4].

The FLAIR sequence is a sequence that suppresses the signal of cerebrospinal fluid (CSF) with a reverse cycle (inversion recovery) pulse and a high time Echo (TE values increase) T2-weight. This sequence increases the contrast of supratentorial lesions, in particular lesions that arise in juxtaposition to the CSF compared to the spin echo (SE) and turbo spin echo (TSE) 8. However, some lesions appear in T2-weighted SE sequences, but not in FLAIR sequences, since their T2 relaxation times are different [5].

The DIR sequence was developed by Redpath and Smith. It differs from FLAIR in its utilization of a second inversion pulse. These images have hybrid features of FLAIR and a short time inversion recovery (STIR). Both the white and grey matter play a clear role in the physical and neurocognitive disability of MS patients. However, a sufficient correlation has not been demonstrated between conventional MRI findings and disability, which is mostly due to the inability to demonstrate all of the histopathological changes present in MS *in vivo* using classical MR images. In particular, lesions located at the junction of the grey matter-CSF, grey matter-white matter (juxtacortical areas) and white matter-CSF could not be visualized in conventional MR sequences because of the signal suppression of the grey matter by signals from the white matter and CSF as well as the absence of sufficient contrast. Signals from the CSF are suppressed in FLAIR sequences so that lesions in the parenchymal areas, which are in juxtaposition to the CSF, become more prominent. However, this approach still cannot reveal lesions in the junction of the grey and white matter. In addition, signals from the white matter should be suppressed to detect these lesions. Because the DIR technique can better accomplish this suppression, it is thought that MS plaques located in the grey matter are more easily delineated using DIR. The disturbances in consciousness, cognitive and psychic changes and epileptic fits observed in MS patients in clinical practice cannot be explained by the changes in white matter observed in conventional MR sequences. This is most likely due to the inability of classical MR techniques to detect grey matter lesions [6].

Methodology

Patients are enrolled for the study after obtaining an informed consent. After collection of demographic data, clinical history and once the patient satisfies the inclusion criteria

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for this study, he or she would be subjected to MRI. The patients would be briefed about the procedure. The noise due to gradient coils (heard once the patient was inside the bore of the magnet) and the need to restrict body movements during the scan time would be explained to the patient.

Imaging was performed on a 3T Philips MR system using 3D double inversion recovery (3D DIR), 3D fluid attenuated inversion recovery (FLAIR) sequences with the same parameters, including field of view (FOV), matrix, slice thickness, voxel size and number of signal averaging (NSA) in addition to routine T1, T2, diffusion weighted and 2D Fluid attenuated inversion sequences.

The DIR sequence has two different time inversions (TI1=2550, TI2=450ms): suppressing cerebrospinal fluid (CSF) and white matter signal.

Inclusion criteria

1. Patients with clinically suspected brain lesions which has imaging features of intracranial tumours/tumour mimics.
2. Patients who are already diagnosed and are under treatment.

Exclusion criteria

1. Patients with cardiac pacemakers & metallic implants will not be subjected to MRI.
2. Motion disorder and claustrophobia, if severe may make the examination difficult.

The results of the MR spectroscopy results will be compared to histopathological reports where available.

Results

Table 1: Infratentorial -Cerebellum distribution of patients studied

Brain lesions-Cerebellum	Frequency (%)			% difference		
	3D DIR	3D FLAIR	2D FLAIR	3D DIR vs 3D FLAIR	3D DIR vs 2D FLAIR	3D FLAIR vs 2D FLAIR
▪ 0	13(43.3%)	13(43.3%)	17(56.7%)	0.0%	13.4%	13.4%
▪ 1-5	16(53.3%)	16(53.3%)	13(43.3%)	0.0%	-10.0%	-10.0%
▪ 6-10	1(3.3%)	1(3.3%)	0(0%)	0.0%	-3.3%	-3.3%

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Table 2: Infratentorial-Brain stem distribution of patients studied

Brain lesions-Brain stem	Frequency (%)			% difference		
	3D DIR	3D FLAIR	2D FLAIR	3D DIR vs 3D FLAIR	3D DIR vs 2D FLAIR	3D FLAIR vs 2D FLAIR
▪ 0	10(33.3%)	10(33.3%)	18(60%)	0.0%	26.7%	26.7%
▪ 1-5	20(66.7%)	20(66.7%)	12(40%)	0.0%	-26.7%	-26.7%
▪ 6-10	0(0%)	0(0%)	0(0%)	0.0%	0.0%	0.0%

Table 3: Infratentorial distribution of patients studied

Infratentorial	Min-Max	Mean ± SD	Median	P value
Cerebellum				
▪ 3D DIR	1.13-1.43	1.13±1.43	1.00	-
▪ 3D FLAIR	1.10-1.40	1.10±1.40	1.00	0.317
▪ 2D FLAIR	0.73-1.11	0.73±1.11	0.00	0.003**
Brain stem				
▪ 3D DIR	1.30-1.44	1.30±1.44	1.00	-
▪ 3D FLAIR	1.27-1.39	1.27±1.39	1.00	0.317
▪ 2D FLAIR	0.70-1.09	0.70±1.09	0.00	<0.001**

Wilcoxon Singed rank test, P values obtained in Comparison with 3D DIR.

Discussion

Despite new emerging MR techniques in the diagnostic work-up of patients with suspected or definite MS, including MR spectroscopy and diffusion tensor imaging, the diagnosis of MS is still based mainly on conventional multisequence MR imaging protocols. Over the past few years, inversion recovery pulse sequences, such as FLAIR sequences, have increasingly been incorporated into imaging protocols and guidelines for the detection of inflammatory brain lesions. Because of the attenuation of the CSF, FLAIR imaging is highly sensitive in the detection of supratentorial brain lesions, especially in the juxtacortical and periventricular white matter [7]. A more recently established double inversion recovery imaging technique by using a combination of 2 inversion pulses provides a sufficient attenuation of both CSF and the NAWM. Two major studies focused on the diagnostic value of this type of sequence concerning different applications in clinical neuroimaging, including vascular, infectious, neoplastic and inflammatory CNS diseases. Although the results of these studies were quite promising, especially regarding pathologies in the infratentorial brain region, DIR brain imaging was not established as a standard sequence within the clinical routine because of its relatively long acquisition time and propensity to CSF pulsation artifacts [8].

Higher magnetic field strengths are providing an almost linear increase of the signal-to-noise ratio, and they enable us to invest these higher signal intensity values in faster imaging techniques, including parallel imaging protocols. In addition, high-field MR

ISSN:0975 -3583,0976-2833 VOL13, ISSUE 05, 2022

imaging in patients with MS provides a significantly higher sensitivity in the detection of inflammatory brain lesions compared with lower magnetic field strengths, leading to diagnostic relevance in terms of diagnostic imaging criteria. Therefore, 3T MR imaging is a promising method to achieve

DIR imaging with an acceptable acquisition time in combination with a high sensitivity in the detection of MS lesions. In our study, we used 3D DIR, 3D FLAIR and 2D flair pulse sequence at 3T Philips machine. DIR sequence allows a sufficient attenuation of the CSF and the NAWM.

FLAIR sequence allows sufficient attenuation of CSF [9, 10].

Conclusion

The overall total number of lesions obtained with 3D DIR sequence are more compared with 3D FLAIR and 2 D FLAIR sequences.

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Accepted on 20/05/2022