Research Article

Magnetic resonance imaging of multiple sclerosis

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Abstract

Background: Magnetic resonance imaging (MRI) has an important role in early diagnosis of MS. Multiple sclerosis (MS) is a demyelinating disease of the central nervous system. **Patients and Methods:** forty patients clinically diagnosed to have MS according to McDonald criteria were included and referred to department of radio-diagnosis, Faculty of Medicine, Minia University. Imaging was performed on a 1.5T Philips MR system using double inversion recovery (DIR), fluid attenuated inversion recovery (FLAIR), T2-weighted, T1-weighted and susceptibility-weighted imaging (SWI) sequences with the parameters including field of view (FOV), matrix, slice thickness and voxel size. They were done after the approval of ethical committee of our institution. Data analysis was performed using the SPSS version 20 and p-value as well as comparative study were gained. **Results:** The detection rate of white matter lesions in T2 was (80%); while for grey matter lesions was (12%). In FLAIR sequence, we found that; the detection rate of white matter lesions was (97%); while for grey matter lesions was (26%). As regarding DIR sequence, the detection rate of white matter lesions was (93%); while for grey matter lesions was (95%).Comparative study between serial MRI sequences (T2,FLAIR and DIR) revealed; significant increase in detected number of grey matter lesions; in DIR-MRI sequence ($p < 0.0001$). In SWI, a central vein sign was detected in 97 lesions (66 in periventricular lesions and 31 in subcortical lesions). **Conclusion:** From this study we concluded that new imaging modalities of MRI as regarding DIR and SWI are a valuable MRI sequences in imaging of multiple sclerosis; thus, we recommend adding DIR and SWI sequences in routine MR protocols for MS patients.

Key Words: MRI, multiple sclerosis, Double inversion recovery (DIR), SWI, T2, FLAIR.

Introduction

Multiple sclerosis (MS) is chronic autoimmune, inflammatory demyelinating disease of the central nervous system (CNS). It is recognized as the most common cause of progressive neurologic disability in young adults worldwide with higher rates in females compared to males.[1] It poses a major personal and socioeconomic burden as the average age of disease onset is 30 years which is a time that is decisive for work and family planning.[2] The advances in non-conventional magnetic resonance imaging (MRI) techniques show a more global MS pathology and it is believed that MS may not be truly characterized by ‘‘multiple’’ areas of sclerosis but rather a ‘‘diffuse’’ representation of sclerosis. The acknowledgment of grey matter (GM) involvement in the disease has led to the incorporation of juxtacortical lesions in the recent diagnostic criteria for MS as well as increased interest in the role of normal appearing grey matter (NAGM) damage in determining cognition and disability.[3] Detection of cortical lesions by conventional MRI techniques is difficult. So it is important to detect different types of cortical lesions using new imaging technique as double inversion recovery (DIR) sequence which is used to image the gray matter by nulling the signal from white matter and cerebrospinal fluid (CSF).[4] Double inversion recovery (DIR) imaging provided higher image contrast ratios between lesions and normal-appearing gray matter (NAGM) in all anatomic locations compared with fluid

attenuated inversion recovery (FLAIR) and T2WI imaging (fig. 1). Moreover, DIR imaging provided better delineation of the white matter lesions with higher contrast between the lesions and normal-appearing white matter.[5]

On other hand, susceptibility-weighted imaging (SWI) is another new imaging modality used to assess damage of the brain by iron in multiple sclerosis which might be related to oxidative stress with release of free radicals that has been specifically seen in the vessel walls of veins giving the perivascular relationship with MS (perivenular lesions) with the characteristic central vein sign.[6] Susceptibility-weighted imaging (SWI) has the potential to recognize the presence of iron in MS lesions based on the advantage of the T2*-shortening effect of deoxyhemoglobin in venous blood. [7&8]

Aim of the work

The aim of this study is to assess the efficacy of variable magnetic resonance imaging techniques in assessment of multiple sclerosis as regarding degree of severity by highlighting the role of DIR in imaging the gray matter lesions and presence of central vein sign using SWI.

Patients and method

Study design and population

In a prospective study 40 patients with clinically diagnosed to have MS according to McDonald criteria were included diagnosed in neuropsychiatry department and they were referred to department of radiodiagnosis, Faculty of Medicine, Minia University. The study was done between December 2017 to September 2019. They underwent MRI imaging after meeting the inclusion criteria. All patients signed a written informed consent before MRI examination.

Inclusion and exclusion criteria

All patients included in this study were diagnosed with MS (clinical and laboratory), age of the patient varying between 18 years and 50 years and expanded disability status scale (EDSS) scoring system varying from 1-7. However, general contraindications to MRI as the presence of any paramagnetic substances such as pacemakers, metallic clips or claustrophobic patients were excluded from the study. Also patients with age above 50 years old or less than 18 years and patients with concomitant neurological disease in conjunction with MS were excluded.

Methods

MRI technique

MR imaging was performed using 1.5 Tesla MR Scanner (Ingenia, Philips Healthcare, Netherlands). All patients were imaged in the supine position using standard quadrate head coil. The MRI examination was conducted on the brain including conventional MRI sequences; axial T2 weighted images utilizing the following parameters:, repetition time (TR) of 4800 msec/echo time (TE) of 110 msec, slice thickness of 5 mm, number of signal averages (NSA)=3, matrix 512 x 512, gap 1–2mm, flip angle=90º and field of view (FOV)= 230mm. Axial and sagittal FLAIR images utilizing the following parameters: repetition time (TR) of 6000 msec/echo time (TE) of 140 msec, slice thickness of 5 mm, (NSA) 3, matrix 512x 512, gap 1–2 mm, flip angle=90º and FOV = 230mm. Axial DIR images utilizing the following parameters: repetition time (TR) of 96 msec/ echo time (TE) of 25 msec, slice thickness of 3mm, matrix 512x 512, gap 1–2mm and FOV = 230mm. Axial SWI images utilizing the following parameters: repetition time (TR) of 43 msec/echo time (TE) of 25 msec, slice thickness of 3mm, matrix 300x300, gap 1–2mm, flip angle=20º and FOV = 230mm.

Data processing and image interpretation:

The images were transformed to Philips 881030 Intelli-Space IX/LX Workstation. Each MR sequence findings were evaluated as following:

Image interpretation:

Conventional and advanced MRI sequences were evaluated for: the total number of the lesions in T2, FLAIR, DIR and SWI. Lesion location (White matter: including peri-ventricular and subcortical regions- Grey matter: including basal ganglia and cortical regions - infratentorial: including brainstem and cerebellar regions) in T2,

FLAIR and DIR. Number of cortical lesion in FLAIR, T2 and DIR. Number of lesions in white matter (deep white matter and subcortical regions) in T2, FLAIR and DIR. Number of lesions with central vein sign in SWI. Each lesion appears in FLAIR in periventricular and subcortical regions were correlated with its similar on SWI and it was assessed if a central vein present or not.

Statistical analysis

Statistical analysis was performed using the SPSS software for Windows v. 20 (SPSS Inc., Chicago, IL). Tests of significance (Repeated measures ANOVA, Cochran's Q tests, Kappa statistics and ROC Curve analysis). P-values less than 0.05 (5%) was considered to be statistically significant. Mean, standard deviation (± SD) and range for parametric numerical data, while median and inter-quartile range (IQR) for non-parametric numerical data. Frequency and percentage of non-numerical data.

Results

Our study included 30 female patients with multiple sclerosis according to McDonald criteria. We found that; the mean age of all patients was (36.24) years and as regarding gender of the patients (84%) of patients were females and (16%) were males. (65%) of patients had visual disorder, (57%) had tingling and numbness; (40%) had muscle weakness and (9%) of patients had hemiparesis. We found that detection rate of white matter lesions in FLAIR sequence was (97%); and of grey matter lesions was (26%). In DIR sequence, the detection rate of white matter lesions was (93%) while for grey matter lesions was (95%). In T2, it was (80%) for white matter lesions and (12%) for grey matter lesions. Comparative studies between T2, FLAIR and DIR sequences revealed significant increase in sensitivity and specificity of detection of grey matter lesions in DIR sequence with highly significant statistical difference ($p < 0.001$) as in (table I).

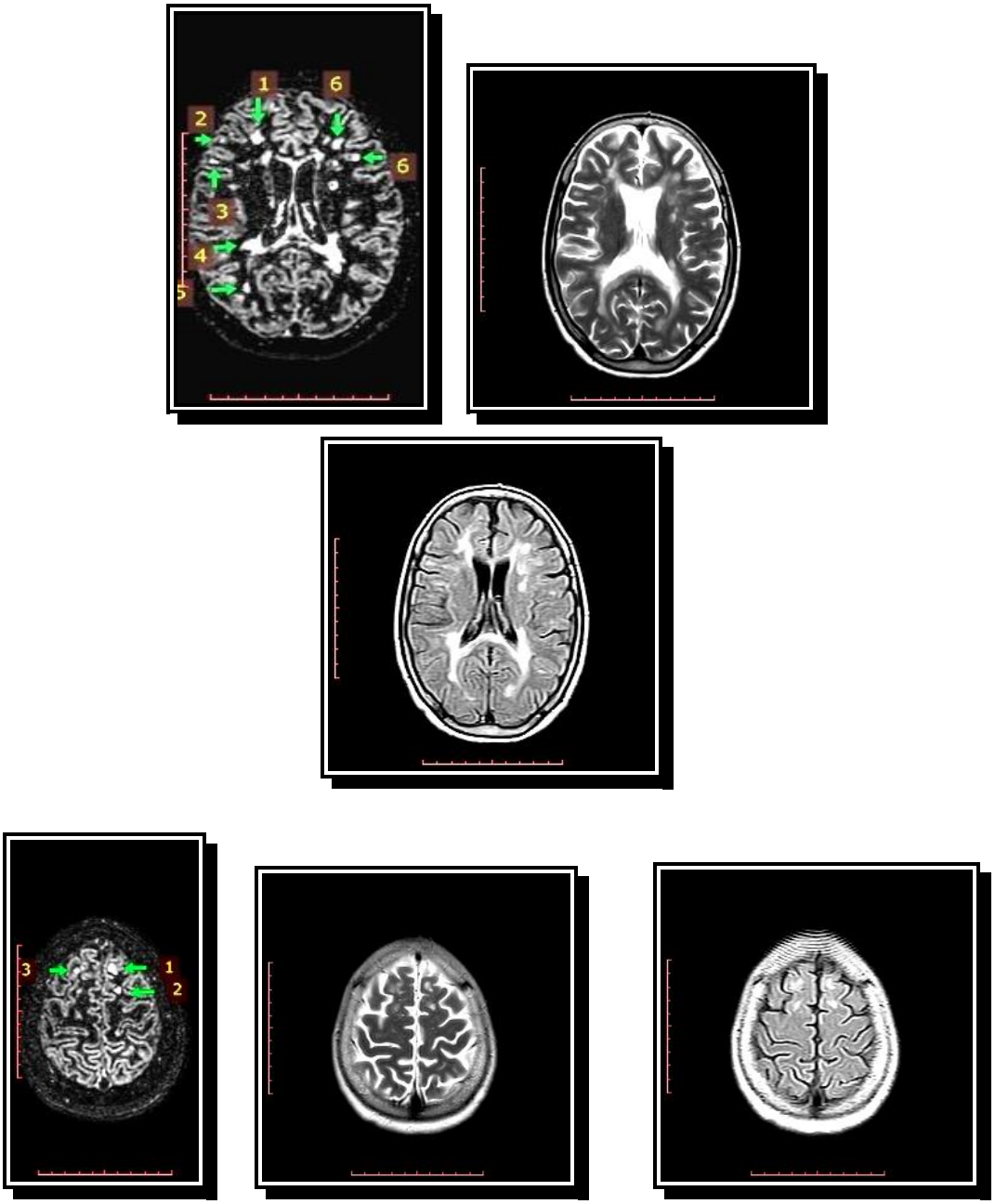
However, no significant difference in detection of white matter lesions could be detected between three pulse sequences ($p>0.05$). Double inversion recovery (DIR) was significantly superior to FLAIR sequence in detection of infratentorial lesions ($P<0.001$). As regar-ding detection of overall MS lesions in whole brain, DIR sequence showed signi-ficant increase in sensitivity and specificity of detection of the total lesions over T2 and FLAIR sequences ($P=0.004$). In SWI, a central vein was detected in 97 lesions (66 in periventricular lesions and 31 in subcortical lesions).

In FLAIR, a central vein was detected in 55 lesions (40 in periventricular lesions and 15 in subcortical lesions). Comparative studies between FLAIR and SWI sequences revealed significant increase in sensitivity and specificity of detection of periven-tricular lesions with central vein sign in SWI sequence with highly significant statistical difference ($p < 0.0001$).

Table: detection of grey matter lesions in each pulse sequence using Roc-curve analysis:

Variable	AUC	P value	SE
Grey matter lesions in FLAIR	0.721	0.0001	0.045
Grey matter lesions in DIR	0.980	<0.0001	0
Grey matter lesions in T2	0.450	0.016	0.033

SE= Standard Error, AUC= Area under curve, ROC =Receiver operating characteristic.



Axial DIR, T2 and Flair show multiple MS plaques at different anatomical locations (1= juxtracortical lesion, 2= cortical lesion, 3= WM lesion, 4=periventricular confluent lesion, 5= nodular WM lesion and 6=WM lesion). (C)Axial DIR, T2 and Flair show MS plaques at another level (1= leukocortical lesion, 2= WM lesion and 3= juxtracortical lesion).

Discussion

Multiple sclerosis is chronic inflammatory autoimmune disease. MRI has been part of the International Panel criteria for the diagnosis of MS since 2001 and its use has become increasingly vital as reflected in the last changes by the committee guidelines. It plays major role in elucidating the mechanisms underlying disease progression and in monitoring the accumulation of abnormal features underpinning disability. Multiple sclerosis has heterogeneous clinical and imaging manifestations which differ between patients and change within individual patients over time. So these caveats should be borne in mind as

conventional MRI cannot explain the wide heterogeneity of the clinical outcomes of the disease so recent researches emphasizes the importance of non conventional MRI to allow visualization of its various patho-physiological mechanisms. The acknowledgment of grey matter (GM) involvement in the disease has led to the incorporation of juxtacortical lesions in the recent diagnostic criteria for MS as well as increased interest in the role of normal appearing grey matter (NAGM) damage in determining cognition and disability. From this point of view, it is important to detect cortical and deep grey matter lesions using DIR which used to selectively image the gray matter by nulling the signal from white matter and cerebro-spinal fluid. Detection of perivenular lesions in the brain (the "central vein sign") is also important as it improves the pathological specificity of MS diagnosis.[9] Our study aims to assess grey matter lesions in patients known to have multiple sclerosis using DIR, FLAIR and T2 as well as detect central vein sign using SWI which increase diagnostic accuracy of MS. This study included 30 patients were diagnosed to have MS according to MacDonald's criteria and their age varying between 25 to 40y. Most of our patients were females (84%) and the most affecting symptoms were visual disorders and numbness.

In the current study DIR was the most important sequence in detection of grey matter lesions (cortical or deep grey matter lesions). Double inversion recovery (DIR) allows visualization of juxta-cortical (which just abuts the cortex) and intracortical lesions.[10] An assessment of cortical lesions (CL) contributes to the identification of patients with CIS who are at risk of evolution to definite MS.[11,12] We are in agreement with several authors as De Graaf et. al. and Simon et. al studies who reported that the DIR showed more intra-cortical lesions compared to FLAIR and T2WI sequences. We agree with M.P. Wattjes et. al. study who stated that total number of the lesions were higher in DIR sequence than FLAIR and T2 sequences. In addition, we agree with him that DIR has higher sensitivity for the infratentorial region compared with the FLAIR sequence.

Central vein assessment, provided by susceptibility-based MRI, significantly improves the diagnostic accuracy and specificity of MS diagnosis as it can differentiates MS from vasculopathies involving CNS which are difficult to diagnose accurately as they have clinical and radiological presentations very similar to MS. As concerning radiological findings of central vein sign in SWI, we agree with Lane JI et al, who stated that there is significant increase in sensitivity and specificity of detection of periventricular lesions with central vein sign in SWI sequence over FLAIR sequence.

Conclusion

Finally, in our study we were in agreement with the findings reported by the other studies regarding the greet value of DIR sequence in detecting grey matter lesions particularly cortical lesions over other sequences (T2WI and the FLAIR sequences) and its vale to detect more MS lesions than other sequences. In this issue we also detect that central vein sign in SWI increase diagnostic accuracy of MS. Future implementation of automated imaging post-processing techniques (i.e., central vein sign detection) should allow direct translation of the central vein sign into the everyday clinical practice.

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Conflict of Interest:- Nil.

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