Med. J. Cairo Univ., Vol. 89, No. 4, September: 1459-1462, 2021
www.medicaljournalofcairouniversity.net

Added Value of Susceptibility Weighted Imaging (SWI) in Diagnosis of Multiple Sclerosis (MS)

RANIA A. ANAN, M.Sc.*; MOHAMED A. EL-ADALANY, M.D.*; TAMER M. BELAL, M.D.** and SABRY A. EL-MOGY, M.D.*

The Departments of Radiology and Neurology**, Faculty of Medicine, Mansoura University*

Abstract

Background: There are a number of challenges in MS clinical practice, including the limitations of conventional MRI techniques in the diagnosis, subtyping, predicting disease course, and monitoring of people suffering from MS. Susceptibility Weighted Imaging (SWI) is a relatively new MR sequence that has the ability for simultaneous visualization of hyperintense MS lesions and their central veins.

Aim of Study: To assess the role of MR susceptibility weighted imaging in comparison with T2 and FLAIR sequences in evaluation of MS lesions.

Patients and Methods: In this prospective study, 30 patients with clinical diagnosis of MS were enrolled. All patients were undergone brain MRI consisting T2W, FLAIR and SWI sequences. All sequences were analyzed for the presence and number of MS plaques. Moreover, the detection of central veins in MS plaques were assessed by SWI.

Results: Our study included 30 MS patients: 5 patients (16.7%) had disease duration more than 5 years and 15 patients (83.3%) with disease duration less than 5 years. All obtained sequences showed fewer number of plaques as the disease duration was less (p<0.05). SWI has also the ability of detection central vein in MS plaques.

Conclusion: SWI is an additional sequence, that together to conventional MRI sequences, helps to characterize the white matter lesions detected in multiple sclerosis diagnosis with superiority of detecting central veins which improves the understanding of the MS pathogenesis.

Key Words: *Central vein sign – Multiple sclerosis – Susceptibility weighted imaging.*

Introduction

MULTIPLE Sclerosis (MS) is the most common autoimmune neurological disorder affecting young adults. It is pathologically characterized by multifocal inflammation, demyelination, axonal injury and neuronal loss **[1]**.

Correspondence to: Dr. Rania A. Anan,
E-Mail: ronyanan87@gmail.com

Although the etiology of this disorder is still unknown, it is believed that inflammatory and auto-immune processes mediated by lymphocytes are the initiator of multiple sclerosis **[2]**.

Conventional Magnetic Resonance Imaging (MRI) has high sensitivity in demonstrating MS dissemination in time and space **[1,3]**. It is also useful for monitoring of disease activity which can help to guide treatment decision and appropriate management to reduce relapse occurrence and slow disease progression to disability **[4,5]**. T2-weighted sequence has high-sensitivity for detection of hyperintensities in white matter. This high signal in T2W could be due to wide range of pathologies including edema, mild demyelination and glial scars **[6]**.

Several recent studies applying SWI to MS have reported that minimum intensity projection (min IP) SWI and/or its source images before post processing (i.e. SW magnitude and phase images) can detect MS plaques with greater sensitivity than structural MR imaging (such as T2 weighted and FLAIR images) and can visualize various signal patterns not previously recognized within the plaques **[7]**. It is also a relatively new MR sequence that has the ability to draw a venous map thus demonstrating the central vein sign within MS lesions **[8]**.

The aim of this study was to assess the results of SWI sequence for evaluating the MS plaques in comparison with T2W and FLAIR sequences. In addition, the ability of SWI to detect central vein in MS plaques was assessed.

Patients and Methods

This is a prospective study which has been conducted from January 2018 to January 2020 in

Department of Diagnostic Radiology, Faculty of Medicine, Mansoura University. This study has been approved by our Local Ethics Committee.

Patients:

Our study included 30 patients (22 females and 8 males; with main age 30.97±9.79 years (range: 17-54 years), with diagnosis of multiple sclerosis fulfilling McDonald criteria [3] with at least one year passing from the initiation of their symptoms were included in this study after getting informed consent. The demographic data of patients including age, gender, disease duration were collected.

Inclusion criteria:

The inclusion criteria were having McDonald criteria based on disease duration and location of plaques and minimally 1 year passed from initiation of the MS disorder.

Exclusion criteria:

The exclusion criteria were presence of any contraindication for MRI imaging.

Image acquisition:

All patients were undergone brain MRI using 1.5 Tesla MRI system (GE SIGNA Explorer) using a 16-channel head coil in supine position. All patients underwent a brain MRI examination with a uniform protocol (FLAIR, T2-weighted sequences in different planes and SWI (Table 1).

Table (1): MRI parameters used.

Parameter	SWI	FlAIR	T2
Field of view (mm)	230	230	230
Matrix	512 X 256	256	256
Slice thickness (mm)	3.6	5	5
Voxel size	0.9	0.9	0.9
Repetition time	77.3	6500	6735
Echo time	49.2	118.9	106
Inversion time	–	1967	
Acquisition time	4min.	4min. 18s	2min. 11s
Flip angle	15	90	160

Image analysis:

The number and location of plaques were collected from all obtained sequences. Moreover, central vein detection has been considered in SWI sequences. To better differentiate the signal void of a vessel, the Min IP post-processed SWI images were also used.

Statistics:

The collected data are presented as mean ± Standard Deviation (SD), number (percent) and range (minimum-maximum values). Statistical analyses have been conducted using SPSS software package version 22.0. p-value less than 0.05 was considered statistically significant.

Results

In our study, 30 patients fulfilling inclusion criteria were enrolled. 8 cases were male (26.7%) and 22 cases were female (73.3%). The mean age was 30.97±9.79 years (range: 17-54 years) Table (2). Five patients (16.7%) had the disease for more than 5 years and 15 patients (83.3%) with disease duration less than 5 years Fig. (1).

Table (2): Demographic characters of the studied cases.

Variables	MS patients (n=30)		Test of significance
	No	%	
Sex:			
Male	8	26.7	t=10.53
Female	22	73.3	p=0.002*
Age/years:			
Mean ± SD	30.97±9.79		χ^2=9.15
Range	17-54		p<0.001 *

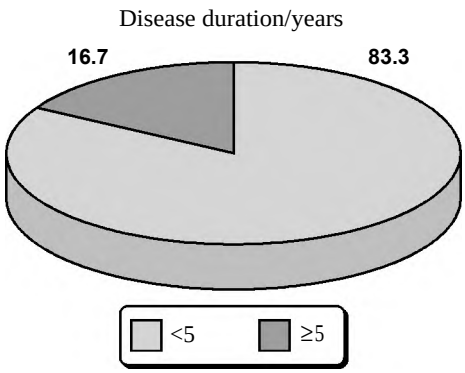

Fig. (1): Pie chart of the disease duration for MS cases.

Three different MRI sequences (T2W, FLAIR and SWI) were evaluated. The number of detected plaques for each patient were calculated in all three sequences. The median numbers of plaques categorized based on duration of MS disorder are summarized in (Table 3). Median numbers of detected plaques in patients with more than 5 years' disease duration were 24 (18-31) in T2W sequences, 25 (18-33) in FLAIR sequences and 25 (14-31) in SWI sequences. However, the median numbers of plaques in patients with less than 5 years' disease duration were 12 (3-40), 13 (3-37) and 12 (3-38) in T2W, FLAIR and SWI sequences, respectively. All types of MRI sequences used in this study

showed that there are significantly higher numbers of plaques in patients with more than 5 years' disease duration than cases with less than five years' disease duration (p=0.01). Calculating the numbers of plaques using SWI sequences indicated that this type of MRI technique has similar power with T2W and FLAIR in detecting MS plaques. Furthermore, SWI has superiority than T2W and FLAIR, as presence of central vein within MS plaques could be easily assessed by this MRI technique. Therefore, SWI images were analyzed for the presence of central vein within MS plaques in each patient. SWI sequences detected central vein Fig. (2) in all patients with >5 years' disease duration and in 24 patients with <5 years' disease duration [p>0.05, (Table 3)].

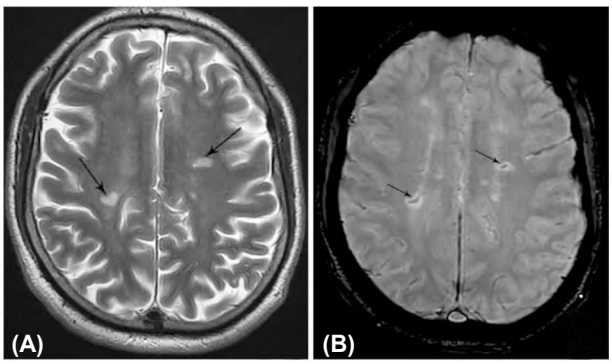

Fig. (2): Axial T2WI image (A) show two hyperintense MS lesions in the periventricular region (black arrows) with no surrounding edema or mass effect. On corresponding SWI images (B), the central vein sign appears as a thin hypointense line indicating a small central vein within the MS lesions.

Table (3): Measured variables from obtained MRI sequences.

Variables	<5 years disease duration (25 cases)	›_5 years disease duration (5 cases)	p-value
Median number of plaques in T2W	12 (3-40)	24 (18-31)	p=0.01 *
Median number of plaques in FLAIR	13 (3-37)	25 (18-33)	p=0.01 *
Median number of plaques in SWI	12 (3-38)	25 (14-31)	p=0.019*
Detection of central veins in SWI:			
Yes	24 patients	5 patients	p>0.05
No	1 patient	0	

Discussion

In this prospective study, we assessed the potential of SWI sequences of MRI for detection and evaluation of MS plaques in patients with short term (<5 years) and long term (>5 years) disease duration in comparison with usual MRI techniques including T2W and FLAIR sequences.

The demographic data of enrolled patients showed mean age of being young adult and also superiority of females. These results are similar with results of epidemiologic studies about MS done by Rojas et al., 2017 which have shown high prevalence of MS in young adults and females **[9]**.

Plaques were quantified in each MRI sequence for each patient to compare the capability of SWI for detection of MS plaques with T2W and FLAIR. We found that SWI has similar capability for detection of MS plaques as T2W and FLAIR. This was similar to the results of a previous study done by Johari et al., 2018. Other previous study done by Haacke et al., 2009 had showed high potency of SWI in detecting MS lesions compared to conventional methods **[10,11]**.

We also have evaluated the SWI for presence of central veins in MS lesions. Central veins were detected in 29 cases out of 30. We here showed that more than 95% of evaluated SWI sequences confirmed the presence of central vein in demyelinating lesions which is approving MS diagnosis. This is helpful for understanding the pathogenesis of MS in which inflammatory demyelinating white matter lesions usually occur around small veins.

Conclusion:

SWI at least has similar power for detection of MS lesions as T2W and FLAIR. Also, the capability of SWI in detection of central veins within MS lesions is so valuable for confirmation and monitoring of MS disease. So, we recommend the use of SWI sequences in the routine MR evaluation of MS patients.

References

1- NOSEWORTHY J.H., et al.: Multiple sclerosis. N. Engl. J. Med., 343: 938-52, 2000.

2- FILIPPI M., et al.: "MRI criteria for the diagnosis of multiple sclerosis: MAGNIMS consensus guidelines." The Lancet Neurology, 15.3: 292-303, 2016.

3- POLMAN C.H., et al.: "Diagnostic criteria for multiple sclerosis: 2010 Revisions to the McDonald criteria." Annals of Neurology, 69.2: 292-302, 2011.

4- MILLER D.H.: "Biomarkers and surrogate outcomes in neurodegenerative disease: Lessons from multiple sclerosis." NeuroRx 1.2: 284-94, 2004.

5- GIOVANNONI, GAVIN, et al.: "Brain health: Time matters in multiple sclerosis." Multiple sclerosis and related disorders 9: S5-S48, 2016.

6- ZIVADINOV R., et al.: A pilot, longitudinal, 24 week study to evaluate the effect of interferon beta1a subcutaneous on changes in susceptibility weighted imaging-filtered phase assessment of lesions and subcortical deep-gray matter in relapsing-remitting multiple sclerosis. Ther. Adv. Neurol. Disord., 8.2: 59-70, 2015.

7- MITTAL S., et al.: "Susceptibility-weighted imaging: Technical aspects and clinical applications, part 2." American Journal of Neuroradiology, 30.2: 232-52, 2005.

8- AL-ZANDI S.H., et al.: "Central vein sign detected by SWI at 3 T MRI as a discriminator between multiple sclerosis and leukoaraiosis." The Egyptian Journal of Radiology and Nuclear Medicine, 49.1: 158-64, 2018.

9- ROJAS J.I., et al.: Gender ratio trends over time in multiple sclerosis patients from Argentina. Journal of Clinical Neuroscience, 38: 84-6, 2017.

10- JOHARI M.S., et al.: Assessing Multiple Sclerosis Brain Plaques using Susceptibility-Weighted Imaging in Comparison with T2W and FLAIR. Clin. Radiol. Imaging J., 2 (2): 000122, 2018.

11- HAACKE E.M., et al.: Characterizing iron deposition in multiple sclerosis lesions using susceptibility weighted imaging. J. Magn. Reson. Imaging, 29.3: 537544, 2009.

القيمة المضافة للتصوير المغناطيسى المرجح الحساسية فى تشخيص التصلب المتعدد

التصلب المتعدد هو مرض مناعى يصيب الجهاز العصبى المركزى وهو السبب الأكثر شيوعاً للإعاقة العصبية والمشاكل البصرية لصغار السن فى جميع أنحاء العالم، فهو يمثل حوالى ١.١٤٪ من الأمراض العصبية.

يعد التصوير المغناطيسى المرجح الحساسية أحد وسائل التصوير الحديثة والذى يستطيع إيجاد التباين بين الأنسجة المختلفة من خلال إستخدام تغيرات الحساسية المغناطيسية للأنسجة لذا يمكنه المساعده فى الكشف عن بعض المواد مثل الدم الغير مؤكسج والحديد والكالسيوم وغيرها وبالتالى يمكن إستخدامه فى تشخيص ومتابعة الأمراض المتعلقة بهذه المواد أهمها مرض التصلب المتعدد وجلطات المخ وأورام المخ وإصابات المخ الناتجة عن الصمات ومرض المويا مويا ونزيف المخ وغيرها.

تهدف دراستنا إلى تقييم قدرة التصوير المغناطيسى المرجح الحساسية بالمقارنة بفحص الرنين المغناطيسى التقليدى فى تشخيص مرض التصلب المتعدد وإظهار ما إذا كان له أفضلية من خلال إبراز الأوردة القشرية النخاعية داخل آفات المادة البيضاء الناتجة من مرض التصلب المتعدد.

لقد أجريت هذه الدراسة على ٣٠ مريض يعانون من أعراض التصلب المتعدد وكان متوسط أعمارهم ٣٠.٩ سنة.

وقد أظهرت نتائج دراستنا أن التصوير المرجح الحساسية له نفس قدرة الرنين المغناطيسى التقليدى على إكتشاف وتمييز آفات المادة البيضاء الناتجة من مرض التصلب المتعدد. كما أنه يمكن أن يحسن نتائج الرنين المغناطيسى فى مرضى التصلب المتعدد من خلال الكشف عن علامة الوريد المركزى داخل لويحات التصلب المتعدد.

لذا نستنتج أن التصوير المرجح الحساسية فحص واعد يمكنه تحسين دقة تشخيص مرض التصلب المتعدد من خلال الكشف عن علامة الوريد المركزى. لذلك نوصى بإستخدامه كجزء من فحص الرنين المغناطيسى الروتينى المستخدم فى تقييم المرضى الذين يعانون من آفات المادة البيضاء.