Double inversion recovery in evaluation of multiple sclerosis: a narrative review

Recuperación de doble inversión en la evaluación de la esclerosis múltiple: una revisión narrativa

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Abstract

Double Inversion Recovery (DIR) is an accurate method used to evaluate the Multiple Sclerosis (MS). There are also other techniques suggested for this purpose, but those are not as accurate as DIR. It is important because it could be helpful to diagnose the patients with MS in early stages and it makes the therapists able to start the therapy process in right time. This fact is accepted, but there is a lack of researches about it and still there is a need to other researches with clear methodology. This narrative review aimed to have a look on previous studies done about DIR.

Keywords: Double Inversion Recovery; Multiple Sclerosis; diagnose; therapy

Resumen

La recuperación por doble inversión (DIR) es un método preciso utilizado para evaluar la esclerosis múltiple (EM). También se sugieren otras técnicas para este propósito, pero no son tan precisas como DIR. Es importante porque podría ser útil diagnosticar a los pacientes con EM en etapas tempranas y hace que los terapeutas puedan iniciar el proceso de terapia en el momento adecuado. Se acepta este hecho, pero hay una falta de investigaciones al respecto y todavía hay una necesidad de otras investigaciones con una metodología clara. Esta revisión narrativa tuvo como objetivo echar un vistazo a los estudios anteriores realizados sobre DIR.

Palabras clave: Recuperación de doble inversión; Esclerosis múltiple; diagnosticar; terapia

Introduction

DIR in the MR imaging protocol plays an important role in detecting lesions in grey matter, which help to understanding the physical and neurocognitive disability observed in MS patients.

Multiple sclerosis (MS) is a neurodegenerative condition affecting the central nervous system[1,2]. MS is characterized by areas of cellular response, demyelination, axonal loss, and gliosis within CNS with a predilection for the optic nerves, brainstem, and cerebellar[3].

Conventional magnetic resonance imaging(MRI) sequences (such as T2-weighted images and fluid-attenuated inversion recovery (FLAIR) are currently regarded as routine protocol in MS lesion diagnostic Despite this, the Double Inversion Recovery (DIR) MRI sequence has become increasingly utilized for multiple sclerosis (MS) lesion diagnosis because of its arguably superior sensitivity when compared to conventional techniques.

Detection of the cortical lesions of MS: Detection of the cortical lesions of MS is unlikely using conventional sequences. However, over the last decade, the use of double inversion recovery (DIR) sequences has improved their detection, such that the presence of cortical lesions has been integrated into the 2017 revised MRI criteria for DIS[4]. However, DIR can only detect about 18% of cortical lesions based on radiological and neuropathological evaluation, which means that other lesion goes unfortunately undetected[5].

FLAIR sequence is sensitive to all pathological lesions, thus, feasible to differentiate between the abnormality and normal tissue as the CSF is suppressed. FLAIR sequence was developed together with DIR (double inversion recovery) due to the inability for the T1- and T2-weight to give insights to understand MS pathophysiology[6].

Kolber et al.[7] (2015) conducted a study of the usefulness of FLAIR for the detection of cortical lesions associated with MS. With a sample of 122 patients, the researchers found that while DIR is playing supportive role, FLAIR remains a more useful modality for the detection of cortical lesions related to MS.

DIR and Pulse sequence: DIR is also an MRI pulse sequence that suppresses signal from cerebrospinal fluid (CSF) and white matter of the brain and therefore improve detection of any inflammatory lesion. Its main function is to outline white matter plaques in multiple sclerosis, estimate lesion load, detect infratentorial or spinal cord lesions, and differentiate juxtacortical from grey matter that is mixed with white matter. DIR has a number of advantages, which include better detection of cortical lesions. When using conventional T2-weighted MRI, lesions in the grey matter are poorly visualised. However, the nulling of the CSF signal and white matter signals makes it easier for the operator to detect cortical lesions. It is an important advantage as some researchers find that cortical lesions can precede white matter demyelination. The upshot is that DIR could be a useful technique to detect MS at the earliest stages[7].

Unfortunately conventional MRI sequences such as FLAIR and T2 weighted imaging succeeded in 5-10% of detecting focal cortical lesion, thus highlight low sensitive of the sequences[8-10].That is could be referred to the small size of lesion thus, with insufficient contrast and resolution between NAGM and the plaques under consideration. Moreover low resolution settings may produce partial volume effects between subarachnoid spaces and the surrounding cortex[11]. However, DIR is a new MRI technique introduced with hopes to overcome the drawback of conventional MR imaging techniques. It exhibits high assessment capability, observation and definition of pathophysiology[12,13]. Furthermore, in comparison to conventional sequences, the DIR MRI sequence has been demonstrated to be more sensitive in identifying MS lesions. Additionally it has been proven that DIR is more sensitive to identify MS plaques comparing to conventional MRI sequences[11].

The special in DIR MRI sequence is the capability to manipulate inversion time to suppress not only signal from white matter. Fortunately such a manipulation would eventualy resulted in increase of grey matter's SNR. It was reported by Calabrese and De Stefano (2014) that DIR reported success in detecting more lesions in cortical and deep GM. Importantly, gray matter can be better observed in images due to differences in grey matter, CSF and White matter during TI relaxation phases[14].

DIR and FLAIR and T2W: Difference in the new methodologies is the three-dimensional sagittal single-slab DIR sequence. The technique uses a long as well as short inversion time equivalent to 2530 ms and 350 ms, with a slice section approximately 1.3 mm[9,15-17].

The detection rate of DIR has been found to be highly sensitive than that of FLAIR and T2W. Abidi et al., (2017) investigated the usefulness of DIR among 55 patients in a cross-sectional study in Iran. It was found that 2658 lesions were detected by the DIR modality[18]. In contrast, only 2513 lesions were detected by the FLAIR modality. Again, the finding was quite important as DIR revealed a greater total number of MS lesions significantly across each of the anatomical regions when compared to T2W, and FLAIR.

However, the use of DIR sequence has reported a number of disadvantages due to a poor signal-to-noise ratio. DIR has also been linked to susceptibility to artifacts associated with flow, in which lesion edges can be outlined. Because of the limitations, new developments have been discovered and employed as new measures for enhancing the sensitivity while enabling an accurate classification in GM lesions. Kolber et al. (2015) also note that DIR is extremely time consuming and has a specific absorption rate (SAR) which is higher than alternative modalities[7].

Discussion and conclusion

There are also calls to consider different types of inversion recovery sequences in order to provide improvements in evaluating other pathology related to MS onset. One example is phase-sensitive inversion recovery (PSIR) which has been found to have a better sensitivity to DIR for the evaluation of MS related cortical pathology[7]. The upshot is that controversy still remains as to when and whether DIR should be adopted and included as part of the clinical routine for MS.

In 2015, it was shown that the novel 3D double inversion recovery sequence allows better detection of lesions in MS and related inflammatory diseases of the cervical spinal cord, compared with conventional 2D T2WI[19].

One of the key differences between DIR and alternate MRI techniques is the difference in lesion load measurement. When researchers consider the lesion load measurement they are typically concerned with infratentorial, periventricular, deep white matter, juxtacortical, intracortical spaces. Researchers also determine standard deviation. In the study of Abidi et al., (2017), it was found that the infratentorial lesion load measurement was 5.1 with a standard deviation of 7.37 for DIR[18]. In contrast, the load for FLAIR was 4.23 and T2W_TSE, 4.5. Similar patterns were observed across different regions with the narrowest differences seen in the deep white matter and more pronounced differences apparent in the juxtacortical region. In 2015, it was shown that when quantified on axial MRI with high in-plane resolution, upper cervical cord lesion load is significantly and independently correlated with

physical disability and is higher in progressive forms of MS than RRMS[20].

An important study was conducted into the usefulness of DIR for detecting grey matter lesions that are not easily identified or observed using conventional MRI. The study of Vural et al. (2013) found that DIR and FLAIR has much greater detection of lesions[11]. In their study with 34 persons, 29.4 lesions were detected on T2-weighted sequence, while 39.9 lesions were found on each DIR and FLAIR sequences. The researchers found that DIR was more sensitive for detecting lesions in the intracortical regions. Vural et al. (2013) also found that DIR has "an enhanced ability to discriminate between mixed white matter–grey matter, juxtracortical and pure intracortical lesions"[11]. The researchers also found the DIR was a suitable modality for assessing patients who had already undergone Expanded Disability Status Scale (EDSS) tests but who appeared to show high levels of disability. DIR could be applied in routine tests for certain patients to visualize MS.

FLAIR, DIR and T2 images of the healthy control and the MS patients were radiologically analysed to inspect appearance of hyperintense signals that were considered as MS lesions. For each sequence, number of lesion were divided into three anatomical regions (infratentorial lesions; WM lesions; intracortical lesions) and recorded for each sequence. White Matter (WM) lesions were further classified into: periventricular lesions; deep white matter (DWM) lesions, and juxtacortical WM. The number of lesions in each region was determined.

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