Role of new MRI modalities (MR spectroscopy, perfusion and diffusion tensor imaging) in Multiple sclerosis

Essay
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Abstract

Despite technological advances in imaging, multiple sclerosis (MS) remains a clinical diagnosis that is supported, but not replaced, by laboratory or imaging findings. However, imaging is essential in the current diagnostic criteria of MS, for prediction of the likelihood of MS for patients with clinically isolated syndromes, correlation with lesion pathology and assessment of treatment outcome.

Key word

MRI- Spectroscopy-Multiple Sclerosis-MRI modalities-Radiodiagnosis

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ADC	Apparent diffusion coefficient
AIF	Arterial input function
ASL	Arterial spin labeling
BAT	The time of arrival
BBB	Blood brain barrier
CAT	Computed Axial Tomography
CBF	Cerebral blood flow
CBV	Cerebral blood volume
CCSVI	Chronic cerebrospinal venous insufficiency
CDMS	Clinically definite MS
CHESS	Chemical shift selective saturation
CSI	Chemical Shift Imaging
Cho	Choline
CIS	Clinically isolated syndromes
C-MRI	Conventional magnetic resonance
CNS	Central nervous system
Cr	Creatine
CSF	Cerebrospinal fluid
CST	Cortico-spinal tract
DIS	Dissemination in space
DIT	Dissemination in time
DSC	Dynamic Susceptibility Contrast
DTI	Diffusion tensor imaging
DWI	Diffusion Weighted imaging
EDSS	Expanded Disability Status Scale
EPI	Echo-planar imaging

FA	Fractional anisotropy
GA	Glatiramer acetate
Gd	Gadolinium
Gln	Glutamine
Glu	Glutamate
GM	Gray matter
HA	Hunter's angle
HARDI	High angular resolution diffusion imaging
H MRS	Proton Magnetic resonance spectroscopy
Lac	lactate
MAG	Myelin-associated glycoprotein
MD	Mean diffusivity
MTI	Magnetization transfer imaging
MTT	Mean transit time
MRI	Magnetic resonance imaging
MRS	Magnetic resonance spectroscopy
MRSI	Magnetic resonance spectroscopic imaging
mI	myoinositol
NAA	N-acetylaspartate
NAAG	N-acetyl aspartyl glutamate
NAGM	Normal-appearing gray matter
NAWM	Normal-appearing white matter
NMO	Neuromyelitis optica
NMSS	National Multiple Sclerosis Society
NP	Neuropsychological
PRESS	point reserved spectroscopy
ppm	parts per million
PPMS	Primary progressive multiple sclerosis

PRMS	Progressive relapsing multiple sclerosis
rCBV	Relative cerebral blood volume
RGB	Red, green, and blue
ROI	Region of interest
RRMS	Relapsing remitting multiple sclerosis
SNR	Signal-to-noise ratio
SPMS	Secondary progressive multiple sclerosis
STEAM	Stimulated echo acquisition mode
TA	Time of arrival
TE	Echo time
TTP	Time to peak
TR	Repetition time
VOI	Volume of interest
WBNAA	whole-brain NAA concentration
WM	White matter

Introduction

Multiple Sclerosis (MS) is a chronic inflammatory-demyelinating and neurodegenerative disease of the central nervous system (CNS) and the most common cause of non-traumatic disability in young and middle-age .Pathologically, MS is characterized by areas of demyelinated plaques scattered throughout the CNS. The patterns of multiple sclerosis include: Relapsing-remitting, Primary-progressive, Secondary-progressive and Progressive-relapsing

Although the diagnosis of MS is still based on clinical findings, magnetic resonance imaging (MRI) is now integrated in the diagnostic criteria of the disease because of its unique sensitivity in demonstrating dissemination in space and time of demyelinating lesions in the brain and spinal cord.

Conventional MRI (including T2-weighted, pre- and post-contrast T1-weighted scans) has had a huge impact on MS by enabling an earlier diagnosis, and by providing surrogate markers for monitoring response to current disease-modifying treatments and upcoming experimental agents. Despite its increasing role in the clinical management and scientific investigation of MS, However, serial studies of lesion measures have yielded generally disappointing correlations with the development of clinical disability. A potential explanation for this is the presence of abnormalities, beyond the visible lesions, in the normal appearing white matter (NAWM) and grey matter (NAGM), so conventional MRI is limited by low pathological specificity and low sensitivity to diffuse damage in normal-appearing white matter (NAWM) and gray matter (NAGM). In addition, conventional MRI shows only limited associations with clinical status

Diffusion weighted MRI is a quantitative technique able to overcome these limitations by providing markers more specific to the underlying

pathologic substrates of the disease and more sensitive to the full extent of 'occult' tissue damage in patients with MS. Diffusion measures the microscopic Brownian motion of water molecules. This motion is hindered by cellular structures such as cell membranes and axonal cytoskeletons. The diffusion tensor is a mathematical description of the magnitude and directionality (anisotropy) of water molecules movement in the three-dimensional space. Applying diffusion-weighting magnetic field gradients in many directions, one can infer the orientation of the axons, and reconstruct the pathways of the major white matter bundles by diffusion tensor MRI and so-called fiber tracking.

By use of MRI, assessment of brain tissue perfusion in vivo is now possible, abnormalities in diffusivity patterns have been seen both in focal MS lesions and in NAWM and NAGM. Acute MS lesions are characterized by increased perfusion, whereas normal-appearing white and grey matter are characterized by reduced perfusion. And there appears to exist a relationship between decreased white matter perfusion and cognitive dysfunction in patients with MS

In addition to providing information on tissue structure, magnetic resonance (MR) technology offers the potential to investigate tissue metabolism and function MR spectroscopy (MRS) offers a wealth of data on the biochemistry of a selected brain tissue volume, which represent potential surrogate markers for the pathology underlying multiple sclerosis (MS). In particular, the *N*-acetylaspartate peak in an MR spectrum is a putative marker of neuronal and axonal integrity, and the choline peak appears to reflect cell-membrane metabolism. On this basis, a diminished *N*-acetylaspartate peak is interpreted to represent neuronal/axonal dysfunction or loss, and an elevated choline peak represents heightened cell-membrane turnover, as seen in demyelination, remyelination, inflammation, or gliosis. Therefore, MRS may provide a unique tool to evaluate the severity of MS, establish a prognosis, follow disease evolution, understand its pathogenesis, and evaluate the efficacy of therapeutic interventions, which complements

the information obtained from the various forms of assessment made by conventional MR imaging

The extensive application of conventional and modern magnetic-resonance-based techniques to the study of MS has undoubtedly improved our ability to diagnose and monitor the disease, as well as our understanding of disease pathophysiology, As one of the most important tasks for the future is to establish how these advances in MRI technology might contribute to a better correlation between clinical and MRI findings, and thus provide relevant information to improve prognosis and predict therapeutic response.

Aim of work

The aim of the work to review the role of promising MRI approaches (diffusion tensor tractography (DTT) , perfusion MR Imaging and spectroscopy) in MS discussing their pathophysiological implications and emphasizes their clinical relevance.