The Importance of Magnetic Resonance Imaging in the Diagnosis of Multiple Sclerosis

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Pathophysiology of Multiple Sclerosis

Multiple Sclerosis (MS) is an immune-mediated, idiopathic disease of the central nervous system. This disease acts by causing a widely destructive path of the myelination that covers nerve fibers and sometimes reaches to the nerves themselves. The myelin that covers nerve fibers serves the important role of protection and insulation of the nerves as well as altering the electrical properties of its axon. The disruption of this protective layer can cause extreme communication disruption between the brain and the rest of the body due to rapid skipping and interrupted nerve impulses (See Figure 1).[1]

Figure 1. Graphic depiction of the destruction of myelin surrounding a nerve fiber in multiple sclerosis.[2]

Criteria for Diagnosis

There is a very strict criterion for the positive diagnosis of multiple sclerosis. This criterion rests on evidence of inflammatory disease activity in the central nervous system and progressiveness over time. In order to make a definitive diagnosis, a physician must find damage in at least two separate areas of the central nervous system in a Magnetic Resonance Imaging (MRI) scan, find evidence that these damages occurred at least one month apart and rule out all other possible diagnoses. Other optional tests can be used in order to strengthen a diagnosis. These tests include cerebrospinal fluid and evoked potentials.[3]

Role of Magnetic Resonance Imaging

The myelin that covers nerve fibers is made of a fatty substance. Because of this, it will repel water. When this fatty myelin is stripped away from the nerve fibers that it is protecting, more water is able to be retained.[3] The main components that will be accentuated on a MRI scan of the brain are the areas of liquid, which should be cerebrospinal fluid (CSF), and fatty material, which should be myelin. The particular scan type will determine if each of these areas appear as light or dark. Any destruction to myelin will now appear different than the expected accentuation of fat.[4]

T1 Weighted Myelin appears bright with a high intensity signal and CSF appears dark with a low intensity signal (See Figure 2).[4]

T2 Weighted CSF appears bright with a high intensity signal and myelin appears dark with a low intensity signal (See Figure 3).[4]

FLAIR (fluid attenuated inversion recovery) CSF signal is nulled and appears slightly darker and has a lower intensity signal than the usual T2 weighted image. (See Figure 4).[4]

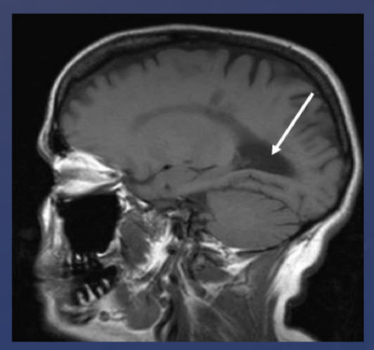

Figure 2. This T1 weighted MRI shows a darkened area of demyelination within the normally bright appearing myelin.[4]

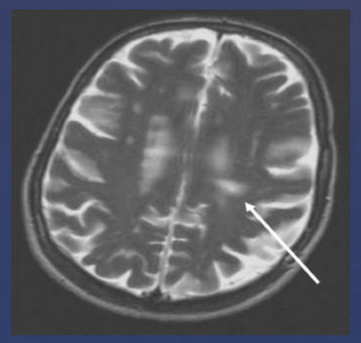

Figure 3. This T2 weighted MRI shows a bright area of demyelination within the normally dark appearing myelin.[4]

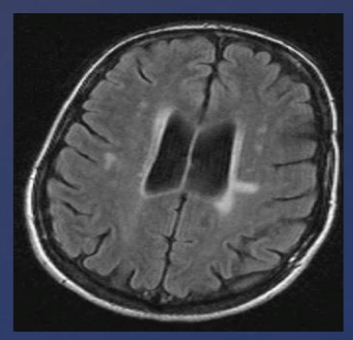

Figure 4. This FLAIR MRI shows the nulled appearance of the usually bright appearance of darkened area of demyelination within the normally bright accentuated myelin.[4]

References

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Imaging of Progressive MS Lesions

Gadolinium is a contrast agent that helps to better identify areas of active inflammation in the brain. Before the scan begins, gadolinium is injected into the vein. When a new sclerotic plaque is formed, the surrounding blood vessels are susceptible to leakage. The gadolinium that was in these blood vessels will then leak out of the vessels and into the plaque. This is a strong indication that the plaque is newly formed (See Figure 5).[3]

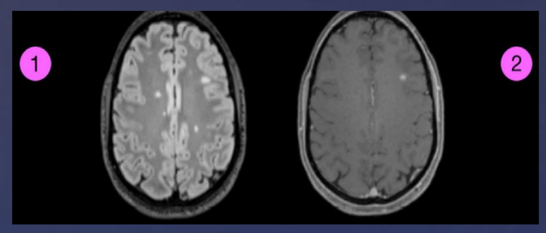

Figure 5. The MRI scan labeled number 1 was taken without the use of a contrast agent. Old MS plaques are visible as white spots. The MRI scan labeled number 2 was taken after gadolinium administration. One new MS plaque is highlighted due to leaky blood vessels.[3]

A beneficial post-processing technique that may be used to strengthen diagnosis is subtraction imaging. This particular technique is especially advantageous when attempting to display lesions over time. Subtraction imaging is performed by digitally subtracting a T1 weighted sequence from the identical sequence performed after gadolinium administration. This results in the removal of the entire T1 signal. The remaining image will then consist entirely of enhancement (See Figure 6).[5]

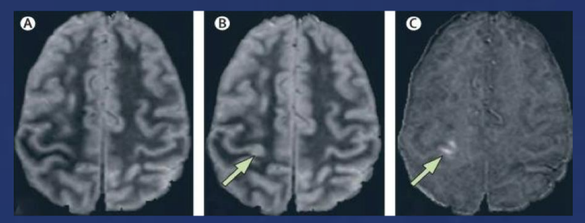

Figure 6. A 44 year-old women with MS had an MRI of her brain at baseline (A) and after 3 years (B & C). The new lesion is difficult to recognize on on the original follow up scan (B), but is clearly visible after subtraction imaging is applied (C).[5]