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Learning Series - #18

Making sense of MRI examination and white matter hyperintensities

Magnetic resonance imaging (MRI) is a technology that uses a powerful magnetic field, radiofrequency pulses, and a computer to produce detailed pictures of internal body structures. It is a very flexible technique that provides ***measures of both structure and function***. An MRI is very useful in imaging non-bony parts or soft tissues of the body. Contrast agents can be used to highlight vasculature, areas of inflammation, and tumors. Unlike some other medical imaging techniques (X-Rat, CT scan), MRI does not involve radioactivity or ionizing radiation.

MRI sequences and its clinical applications:

MRI sequence	Property	Application
T1w	Signal intensity: Fat high, water low	Evaluation of normal anatomy
T2w	Signal intensity: Water high, fat low	Evaluation of pathology
FLAIR	T2 weighted image is manipulated in a way that water is suppressed	Detection of white matter abnormalities (lesions around the brain ventricles - which contain cerebrospinal fluid).
STIR	T2 weighted image is manipulated in a way that fat is suppressed	Evaluation of edemas
Gadolinium	Enhances vasculature or pathologically vascular tissues	• Detect and characterize lesions, inflammation, intracranial metastasis, meningiomas • MR angiography
DWI & ADC	Motion of protons	• Restriction in acute ischemia • Abscess/infection • Cell-rich tissue
Gradient	Fast sequence; highest sensitivity in detecting early hemorrhagic changes	• Detect blood product

Figure 1: some of the frequently used sequences.
T1: longitudinal relaxation time; T2: transverse relaxation time.
T1 and T2 weighted images: demonstrate different tissues based on the timing of the RF pulses.
Diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC).

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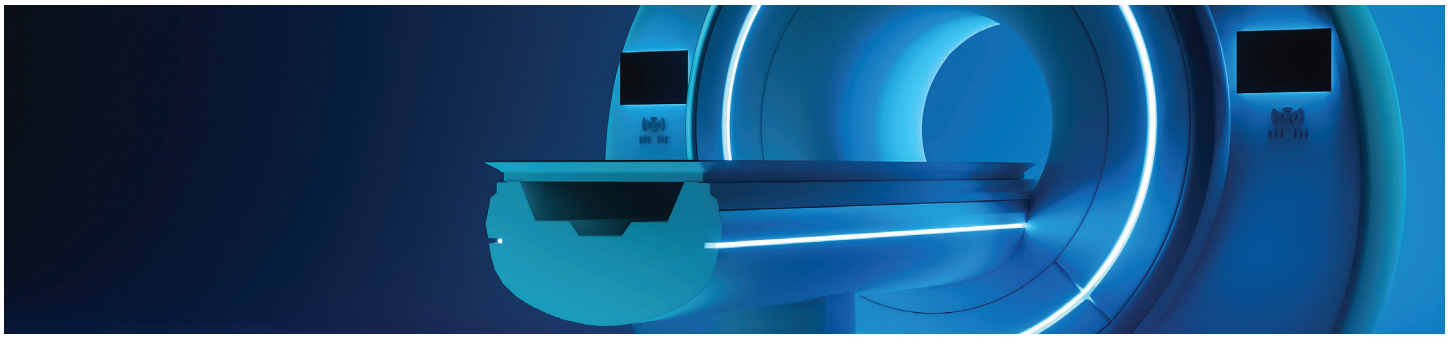
Making sense of MRI examination and white matter hyperintensities (cont'd)

MRI indications

MRI examination	Indications		
Brain	• Ischemia • Sinus thrombosis • Dissection • Vascular malformations	• Infection • Tumors • Multiple sclerosis (MS) • Dementia	• Metabolic disease • Pituitary pathology • Internal auditory canal pathology • Congenital abnormalities • Temporal epilepsy
Spinal cord	• Pre & post-op HNP • Radiculopathy • Myelopathy		• MS • Infection • Tumor
Musculoskeletal	• Joints • Muscles/tendons • Cartilage		• Infection • Tumor • Arthropathies
Abdomen/pelvis	• Characterization of hepatic/adrenal lesions • MRCP • Pancreatic pathology • Intestines • IBD	• Rectal carcinoma • prostate carcinomas • Cervical carcinomas • Perianal fistulas • Endometriosis	
Cardiovascular	• Ischemia • Cardiomyopathies • Intracardial tumors	• Anatomy of large vessels (including aneurysmal screening)	• Infection/inflammation (including myocarditis) • Vasculitis • Sinus thrombosis
Mammography	• Characterization & extent of tumors		
Pregnancy	• Fetal abnormalities		

Figure 2: HNP = Herniated Nucleus Pulposus, MRCP = Magnetic resonance cholangiopancreatography, IBD = Inflammatory Bowel Disease.



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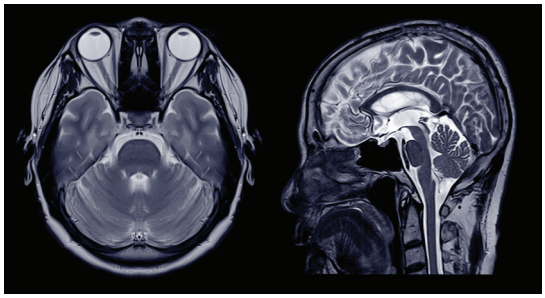
Making sense of MRI examination and white matter hyperintensities (cont'd)

White matter hyperintensities (WMHs)

White matter changes known as ***leukoaraiosis*** are commonly referred to as a ***periventricular white matter disease***, or ***white matter hyperintensities (WMH)***, due to their bright white appearance on T2-weighted MRI scans. These lesions are usually bilateral and symmetrical but can vary to some degree. WMH's are common in MRIs of asymptomatic individuals, and their prevalence increases with age from approximately 10%-20% in those approximately 60 years old to close to 100% in those older than 90 years. They are more common in individuals with a history of cognitive impairment, dementia, or cerebrovascular disease. Aging and hypertension are the main predictors of WMHs, and genome-wide association studies have identified associations with genes involved in blood pressure regulation.

Diabetes, hypercholesterolemia, smoking, carotid artery disease, atrial fibrillation, and heart failure are some of the other risk factors associated with WMHs.



Several different grading scales have been developed to evaluate the severity of WMH. The most used is the ***Fazekas scale***, which divides the white matter in periventricular and deep white matter, and each region is given a grade from 0 (none) to 3 (severe) depending on the size and confluence of lesions. On most MRI reports seen in underwriting the terms mild, moderate or severe are most often encountered.

Treatment: There isn't a specific treatment. The goal is to treat the cause of the damage and stop the disease from getting worse (i.e good control of hypertension and cholesterol).

Underwriting considerations

- Even if WMHs become more common with advancing age, their prevalence is highly variable.
- Similar to small subcortical infarcts (formerly termed "lacunar strokes"), lacunes, cerebral microbleeds, and enlarged perivascular spaces, WMHs are a manifestation of small vessel disease.
- WHMs can increase in size, shrink, or, in rare instances, disappear. They don't always signify permanent myelin loss or axonal damage but subtle shifts in water content. The severity of the lesions is the most important factor for progression. In general, minimal and mild ones don't worsen substantially.
- Deep white matter hyperintensities (DWMH's) are associated with a more severe and resistant form of depression. Clinical presentation is likely cognitive dysfunction, psychomotor slowing, and apathy. They are also closely associated with late-onset depression and their progression is associated with worse outcomes in geriatric depression.
- Lacunar ischemic stroke is more closely associated with white matter lesions (WMLs) than cortical ischemic stroke. Changes noted on MRI follow the vascular territory of the occluded blood vessel, which is characteristic of cerebrovascular disease and helps in differentiating it from other disease entities.
- Hemorrhagic strokes are usually bright on T1 weighted image.
- WHMs are not benign markers of aging, they represent predictors of increased risk of stroke, cognitive abnormalities, depression and all-cause mortality. WMH could be considered as the neuroimaging marker of ***brain frailty***.