Redefining MRI:
From Image to Insight

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Revisiting Idiopathic Normal Pressure Hydrocephalus: MRI Insights into White Matter, Neurofluid Dynamics, and Neurodegeneration

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Idiopathic normal pressure hydrocephalus (iNPH) is classically recognized as a potentially treatable dementia characterized by ventriculomegaly, gait disturbance, cognitive impairment, and urinary urgency or incontinence. However, iNPH should not be regarded simply as a disease of enlarged ventricles or disturbed cerebrospinal fluid (CSF) absorption. Modern MRI and diffusion imaging suggest that iNPH also has an important white matter component, in which chronic ventricular expansion, altered CSF pulsatility, vascular dysregulation, periventricular edema, ischemia, and impaired waste clearance form a self-reinforcing pathological cycle.

This lecture will revisit iNPH from the perspectives of white matter, neurofluid dynamics, and neurodegeneration. Conventional MRI findings, including disproportionately enlarged subarachnoid-space hydrocephalus (DESH) remain central for diagnosis. At the same time, iNPH frequently overlaps with age-related comorbidities, including Alzheimer pathology, subcortical small vessel disease, and parkinsonian tauopathies. Distinguishing “true iNPH” from NPH-like phenotypes associated with neurodegeneration is therefore clinically important.

Diffusion MRI offers a useful framework for understanding iNPH-related white matter pathology. Reduced fractional anisotropy and increased mean or radial diffusivity in association and commissural fibers suggest demyelination and loss of white matter integrity. Particular attention will be given to diffusion tensor image analysis along the perivascular space (DTI-ALPS). In iNPH, the ALPS index is often reduced, correlates with clinical severity and callosal angle, and may increase after shunt surgery, especially in responders. Nevertheless, the ALPS index should not be interpreted as a direct measurement of glymphatic flow. It is influenced by white matter geometry, crossing fibers, aging, and microstructural damage. Its greatest value may be as a composite marker reflecting the interaction between perivascular/interstitial fluid dynamics and white matter microstructure.

The key message is that iNPH is both a disease of CSF and a disease of white matter. Recognizing this dual nature may improve MRI-based diagnosis, patient selection for shunt surgery, and interpretation of neurofluid biomarkers in the aging brain.

Keywords: *iNPH, MRI, White matter, Neurofluid, Neurodegeneration*