Redefining MRI:
From Image to Insight

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Educational Session 2: Basics of Physiologic MRI

SY12-3

Basic of MR Spectroscopy and Clinical Application

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MR spectroscopy (MRS) enables noninvasive extraction of biochemical information from living organs, complementary to conventional MRI. In clinical practice, however, MRS remains technically demanding because spectra are often degraded by low signal-to-noise ratio, spectral overlap, and unknown background signals. As a result, reliable metabolite quantification can be challenging even with state-of-the-art analysis tools such as LCModel.

In this lecture, the basic principles of MRS will first be introduced, focusing on proton MRS of the brain, one of its most extensively studied yet technically challenging applications. The standard data acquisition and analysis pipeline will be reviewed.

Next, spectral editing methods will be introduced as strategies to address the limitations of standard MRS. As a clinically relevant example, 2-hydroxyglutarate (2HG) will be discussed in the context of isocitrate dehydrogenase (IDH)-mutated brain tumors. Although 2HG has potential value for diagnosis, treatment monitoring, and disease management, its reliable quantification remains challenging because of spectral overlap and low concentration, similar to the case of gamma-aminobutyric acid (GABA).

The lecture will then move to MR spectroscopic imaging (MRSI), also known as multi-voxel MRS or chemical shift imaging. MRSI extends single-voxel spectroscopy by enabling spatial mapping of metabolites, but its clinical application is limited by long scan time, low spatial resolution, and reduced spectral quality. Recent acceleration approaches will be briefly reviewed, which aim to extend metabolite mapping from relatively simple singlet resonances to challenging J-coupled metabolites such as GABA and 2HG.

Finally, emerging directions will be briefly discussed, including functional MRS for measuring dynamic metabolic changes during brain activation and deep learning methods for metabolite quantification and MRSI quality management. The overall goal of the lecture is to provide a conceptual foundation for understanding the strengths, limitations, and clinical potential of MRS and MRSI.

Keywords: *Magnetic resonance spectroscopy, Magnetic resonance spectroscopic imaging, Brain, Metabolite, Quantification, Noninvasive*