AbstractID: 2826 Title: High Field MRI - Technology, Applications, Safety, and Limitations

Signal-to-noise ratio in conventional magnetic resonance imaging (MRI) is inextricably tied to the static magnetic field strength (B_0). Until recently, most clinical MRI scanners operated at field strengths at or below 1.5 Tesla. However, due to technological advancements in magnet design and shielding, which ease siting requirements, 3 Tesla clinical scanners are now enjoying wide commercial availability and there is a push for even higher field whole body scanners (7-9Tesla) throughout the industry.

The drive towards high-field MRI is fueled by the benefits of potentially higher signal-to-noise ratios, contrast-to-noise ratios, and spectral resolution. In many cases, these benefits translate directly into higher spatial and/or temporal resolution than previously possible with MRI at lower fields as well as the ability to explore new territory, such as molecular imaging. There are, however, very real technological, physical and safety limitations that must be navigated and may limit the full realization of these benefits at high-field. Technology issues include homogeneity of the static and radiofrequency magnetic fields, higher gradient coil performance and linearity, and the design of robust radiofrequency array coils for signal reception. At high-field, physics concerns include changes in relaxation kinetics, increased susceptibility effects and other changes in contrast mechanisms. Safety limitations include higher power radiofrequency pulses and the potential for tissue heating or coil burns, stimulation effects from stronger, faster switching gradients and physiological effects of motion within the high-field environment and, most prominently, the potential dangers associated with the main magnetic field, such as ferromagnetic projectiles in the scan room and effects on implanted medical devices, many of which have yet to be evaluated at fields above 1.5 Tesla.

Ultimately, design of protocols and acquisition methods that account for these limitations need to be pursued in order to reap the benefits of high-field MRI without compromising patient safety. Many MR imaging techniques have already seen demonstrable improvement at higher fields and have driven the development and distribution of high-field systems. Techniques in functional magnetic resonance imaging relying on blood-oxygen level dependent contrast mechanisms, techniques in angiography and techniques in dynamic susceptibility contrast perfusion imaging all benefit from higher fields. Changes in relaxation kinetics can provide enhanced contrast for angiography and arterial spin labeling techniques. Additionally, proton MR spectroscopy methods for brain and body imaging benefit from the higher spectral resolution of high field as do multi-nuclear techniques.

This course will review the technology and physics behind the emerging high-field systems (3-9 Tesla) with emphasis on the commercially available and widespread 3 Tesla systems. Major applications of high-field MRI will be addressed with an eye on the future. Aspects of safety in high-field MRI will also be covered, paying particular attention to how safety considerations may influence the development and implementation of patient protocols at higher fields.

Educational Objectives:

1. Introduction to relevant high-field technology, physics and techniques.
2. Understand benefits and limitations of high-field MRI.
3. Understand safety concerns associated with high-field MRI systems.
4. Awareness of some of the most relevant applications of high-field MR imaging.