AbstractID: 2824 Title: Advanced MRI - An Overview of Techniques and Applications

The wide range of contrast mechanisms available in MRI has made it the modality of choice in many soft tissue imaging applications. Over the past decade, improvements in gradient and radiofrequency subsystems have allowed for dramatic increases in image acquisition rates and improved system stability. As a result, non-invasive MR techniques for assessing tissue function, in addition to providing anatomic detail, have become common. This presentation will provide an overview of advanced MR techniques that are, or are becoming, common in clinical practice.

Assessing changes in ^{1}H diffusion: On virtually all state-of-the-art high-field MR scanners, diffusion imaging techniques are available. In diffusion imaging, diffusion-sensitizing gradients are applied during an echo-planar spin-echo sequence to sensitize the acquired signal to the rate of proton diffusion. Diffusion-weighted images are very commonly used in the assessment of acute stroke and are also widely used in oncology. In addition, by appropriately applying the diffusion-sensitizing gradients, diffusion tensor information can be obtained in order to non-invasively map white matter tracts.

Assessing biochemical changes: Automated magnetic field homogeneity adjustment, high quality localization, and efficient water suppression techniques have allowed for routine acquisition of 1H MR spectroscopy data in brain and, more recently, in prostate. Other applications, particularly in breast, are also actively being pursued and will be discussed.

Assessing the microvascular environment: Two techniques have been used to assess changes in the microvascular environment due to natural progression of disease or, more commonly, in response to therapeutic interventions. The first is dynamic contrast enhanced MRI, in which T1-weighted images are acquired rapidly before, during, and following the administration of a bolus of paramagnetic contrast agent. The kinetics of the contrast agent uptake are analyzed using a variety of techniques, including two-compartment pharmacokinetic modeling, to assess changes in microvascular permeability and volume. The second technique, dynamic susceptibility change MRI, obtains ultrafast T2*-weighted imaging before, during, and following a bolus paramagnetic agent injection. The decrease in signal intensity, concomitant to the dephasing of spins as the paramagnetic agent passes through the microvasculature, is proportional to the regional blood volume and deconvolution techniques can be used to determine the blood volume, flow, and permeability.

Assessing areas of neuronal function: Blood oxygen level dependent (BOLD) techniques, using ultrafast echo-planar gradient-echo imaging, are used to indirectly map areas of neuronal activation and might also be used to assess changes in tissue oxygenation by detecting changes in the local oxyhemoglobin-to-deoxyhemoglobin ratios. Such techniques are being used in presurgical planning and in basic neuroscience research in areas such as memory, expressive and receptive speech, visual-spatial processing, and other cognitive processes.

In this review, the basic physics and acquisition techniques for each of the above applications will be reviewed and selected clinical applications provided.

Educational Objectives:

1. Understand the basic physical and physiological principles of advanced MR techniques used to assess changes in microvascular parameters, cellular volume, and the biochemical status of tissue.

2. Develop an awareness of common applications of these advanced MR techniques.
3. Understand the primary limitations of each technique.