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Scott B. Reeder and Pratik Mukherjee

New Methods in Diffusion-Weighted and Diffusion Tensor Imaging 175

Roland Bammer, Samantha J. Holdsworth, Wouter B. Veldhuis, and Stephan T. Skare

Considerable strides have been made by countless individual researchers in diffusion-weighted imaging (DWI) to push DWI from an experimental tool, limited to a few institutions with specialized instrumentation, to a powerful tool used routinely for diagnostic imaging. The field of DWI constantly evolves, and progress has been made on several fronts. These developments are primarily composed of improved robustness against patient and physiologic motion, increased spatial resolution, new biophysical and tissue models, and new clinical applications for DWI. This article aims to provide a succinct overview of some of these new developments and a description of some of the major challenges associated with DWI.

Diffusion MR Tractography As a Tool for Surgical Planning 205

Jeffrey Berman

Diffusion MR tractography has rapidly become an important clinical tool that can delineate functionally important white matter tracts for surgical planning. One of the goals of brain surgery is to avoid damage to eloquent cortex and subcortical white matter. Diffusion tractography remains the only noninvasive method capable of segmenting the subcortical course of a white matter tract. This article reviews the technical and clinical issues surrounding presurgical diffusion tractography, including traditional diffusion tensor imaging methods and more advanced high angular resolution diffusion imaging approaches, such as q-ball imaging. An overview of the presurgical diffusion tensor imaging and q-ball tractography protocols used at our institution is also provided.

Update on Diffusion Tensor Imaging in Alzheimer's Disease 215

Christopher P. Hess

With estimates of more than 5 million people with Alzheimer's disease (AD) now living in the United States and an increasing prevalence of the disease among the aging population, there is an urgent need for the development of reliable biomarkers for early diagnosis and evaluation of potential therapeutic interventions. Structural MR imaging, the focus of the most intense research in this area to date, has identified characteristic patterns of macroscopic atrophy within larger groups of patients who have clinically probable AD, particularly within the medial temporal lobes. These changes are thought to reflect underlying neuronal cell death, and as a result are consistently demonstrated only in the late stages of the disease. Paralleling the development of new molecular markers for AD pathology in nuclear medicine are a number of encouraging results in the application of functional, perfusion, and diffusion imaging which point to a growing role for MR imaging in the evaluation of AD. This article surveys current research on the use of diffusion MR imaging for the evaluation of patients who have mild cognitive impairment and AD, and summarizes the important unifying results that are beginning to emerge on the potential role for diffusion imaging in practice.

Diffusion-Weighted Imaging, Diffusion-Tensor Imaging, and Fiber Tractography of the Spinal Cord 225

Majda M. Thurnher and Meng Law

In the brain, diffusion-weighted imaging (DWI) is an established and reliable method for the characterization of neurologic lesions. Although the diagnostic value of DWI in the early detection of ischemia has not diminished with time, many new clinical applications of DWI have also emerged. Diffusion-tensor imaging and fiber tractography have more recently been developed and optimized, allowing quantification of the magnitude and direction of diffusion along three principal eigenvectors. Diffusion-tensor imaging and fiber tractography are proving to be useful in clinical neuroradiology practice, with application to several categories of disease, and to be a powerful research tool. This article describes some of the applications of DWI and diffusion-tensor imaging in the evaluation of the diseases of the spinal cord.

Diffusion-Weighted MR Imaging for Whole Body Metastatic Disease and Lymphadenopathy 245

Russell N. Low

Diffusion-weighted (DW) imaging provides a new contrast mechanism for evaluation of tumors of the chest, abdominal, and pelvis. By imaging microscopic motion of water molecules, DW imaging yields new qualitative and quantitative information about tumors that can be used to improve tumor detection, characterize some tumors, and monitor and predict response to treatment. DW imaging techniques provide a host of new tools for the body imager including: magnitude DW images; ADC maps with quantitative analysis; and volumetric display of data including whole body diffusion with background suppression. Experience with these DW techniques for body applications is still accumulating. However, DW imaging has already become an integral part of body MR imaging protocols at many centers.

Diffusion-Weighted MR Imaging in Musculoskeletal Radiology: Applications in Trauma, Tumors, and Inflammation 263

Thorsten A. Bley, Oliver Wieben, and Markus Uhl

Diffusion-weighted imaging is a noninvasive magnetic resonance technique that is capable of measuring icroscopic movement of water molecules (ie, random or Brownian motion) within biologic tissues. Diffusion weighting is achieved with a pulsed-field gradient that leaves ''static'' spins unaffected but causes dephasing of spin ensembles that experience different motion histories according to their diffusion paths, with respect to the direction of the gradient. This article focuses on the interesting opportunities of the use of diffusion weighted imaging in the diagnosis of musculoskeletal diseases, including trauma, tumor, and inflammation.

Fundamentals of Quantitative Dynamic Contrast-Enhanced MR Imaging 277

Michael J. Paldino and Daniel P. Barboriak

Quantitative analysis of dynamic contrast-enhanced MR imaging (DCE-MR imaging) has the power to provide information regarding physiologic characteristics of the microvasculature and is, therefore, of great potential value to the practice of oncology. In particular, these techniques could have a significant impact on the development of novel anticancer therapies as a promising biomarker of drug activity. Standardization of DCE-MR imaging acquisition and analysis to provide more reproducible measures of tumor vessel physiology is of crucial importance to realize this potential.

The purpose of this article is to review the pathophysiologic basis and technical aspects of DCE-MR imaging techniques.

Diffusion and Perfusion MR Imaging of Acute Ischemic Stroke 291

Ashley D. Harris, Shelagh B. Coutts, and Richard Frayne

Diffusion and perfusion MR imaging have proven to be highly useful in the clinical description and understanding of acute and hyperacute ischemic stroke. In this article, the authors give a brief overview of the basic concepts of diffusion and perfusion imaging and describe some of the current developments, applications, challenges, and limitations of these techniques as applied to cerebral ischemia.

Arterial Spin-Labeled MR Perfusion Imaging: Clinical Applications 315

Jeffrey M. Pollock, Huan Tan, Robert A. Kraft, Christopher T. Whitlow, Jonathan H. Burdette, and Joseph A. Maldjian

Arterial spin labeling (ASL) imaging soon will be available as a routine clinical perfusion imaging sequence for a significant number of MR imaging scanners. The ASL perfusion technique offers information similar to that provided by conventional dynamic susceptibility sequences, but it does not require the use of an intravenous contrast agent, and the data can be quantified. The appearance of pathology is affected significantly by the ASL techniques used. Familiarity with the available sequence parameter options and the common appearances of pathology facilitates perfusion interpretation.

Dynamic Contrast-Enhanced MR Imaging of the Liver: Current Status and Future Directions 339

Richard Kinh Gian Do, Henry Rusinek, and Bachir Taouli

Dynamic contrast-enhanced magnetic resonance imaging (DCE-MR imaging) is emerging as a tool that can quantify changes in liver perfusion that occur in both diffuse and focal liver diseases. Recent data show promise for DCE-MR imaging of the liver in diagnosing fibrosis and cirrhosis before morphologic changes can be detected. It may also be valuable in the assessment of hepatocellular carcinoma and liver metastases. Acquisition parameters, postprocessing methods, applications, and recent results of DCE-MR imaging of the liver are also described. Finally, it reviews the limitations and future directions of DCE-MR imaging for liver applications.

Dynamic Contrast-Enhanced Breast MR Imaging 351

Marianne Moon, Daniel Cornfeld, and Jeffrey Weinreb

This article discusses the basic principles of dynamic contrast-enhanced MR imaging (DCE-MR imaging) of the breast, including technical parameters, image acquisition, and image interpretation. Clinical DCE-MR imaging of the breast has undergone considerable growth from a once investigational technique to an important clinical tool in widespread use. Progress in MR technology and refinement of MR imaging parameters now allow for concurrent acquisition of high-spatial-resolution and adequate-temporal-resolution images, which are necessary for accurate assessment of breast lesion morphology and qualitative kinetic analysis. More advanced DCE-MR imaging techniques involving higher-temporal-resolution images and rigorous quantitative analysis of the time signal enhancement curves are currently an area of research.

Dynamic Contrast-Enhanced MR Imaging in the Evaluation of Patients with Prostate Cancer 363

Colm J. McMahon, B. Nicolas Bloch, Robert E. Lenkinski, and Neil M. Rofsky

Prostate cancer is a common tumor among men, with increasing diagnosis at an earlier stage and a lower volume of disease because of screening with prostate-specific antigen (PSA). The need for imaging of the prostate stems from a desire to optimize treatment strategy on a patient and tumor-specific level. The major goals of prostate imaging are (1) staging of known cancer, (2) determination of tumor aggressiveness, (3) diagnosis of cancer in patients who have elevated PSA but a negative biopsy, (4) treatment planning, and (5) the evaluation of therapy response. This article concentrates on the role of dynamic contrast-enhanced MR imaging in the evaluation of patients who have prostate cancer and how it might be used to help achieve the above goals. Various dynamic contrast enhancement approaches (quantitative/semiquantitative/qualitative, high temporal versus high spatial resolution) are summarized with reference to the relevant strengths and compromises of each approach.

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