Whole Body Volumetric Diffusion-weighted Imaging (DWI)

T. Takahara[1]

[1]Tokai University School of Medicine, Kanagawa, Japan

Diffusion-weighted imaging (DWI) is a powerful tool to distinguish abdominal lesions from surrounding normal tissue; the Motion Probing Gradients suppress most of the background tissue because of its large apparent diffusion coefficient (ADC), whereas many lesions with small ADCs are not suppressed and are highlighted. We tend to believe that signal suppression by MPGs is only proportional to the degree of motion, irrespective of the nature of that motion. A common misconception is that bulk tissue motion does not allow DWI. As an example: in spite of the fact that respiratory motion involves motion on a much larger scale than (microscopic) diffusion, contrast generation due to MPG can directly be related to diffusion only. MPGs only suppress incoherent motion as observed in diffusion and perfusion studies. Respiratory motion can be regarded as "coherent" motion during the very short period in which the MPGs are applied (usually less than 50ms). This implies that DWI can be performed even during free breathing and lesions in moving visceral organs can be visualized (at the expense of some image blurring.) Overall image quality in DWI is determined by multiple parameters, such as sharpness, spatial resolution, SNR, etc. Free breathing DWI can be used to dramatically increase SNR, which is one of the main drawbacks of conventional DWI. This concept is called "Diffusion weighted Whole body Imaging with Background body signal Suppression" (DWIBS) [1]. Ballon et al. [2] reported a similar technique for monitoring treatment effect of bone metastases. Although their concept was aimed at visualizing static tissue, some moving visceral organs were also visualized. The concept of DWIBS enables thin slice acquisition and wide coverage (typically 4mm and 240mm, respectively), enabling in volumetric usage such as multi-planar reformatting (MPR), maximum intensity projection (MIP), volume rendering (VR), and volume measurements.

Volumetric DWI is useful to understand tumor distribution, especially in case of tumor scattering such as peritoneal dissemination. Similarly, it can reveal peripheral nerves, providing a very powerful methodology called diffusion-weighted MR-neurography [3]. It can be done in a short time with use of unidirectional MPGs. It also visualizes other pathology such as inflammatory processes and traumatic lesions. Volume rendering is not only useful to understand the shape of the lesion, but also to estimate the volume of the lesion, especially in follow up examinations during treatment.

Whole body scanning can be done by merging image stacks taken in sequential locations. There are three ways to obtain whole body images in DWIBS; using a whole body coil, using a sequential coil set up, and by using a single coil array with a sliding technique. Several reports have been published recently on the feasibility of DWIBS [4], DWIBS comparisons at 1.5T and 3.0T [5], and how DWIBS results compare with FDG-PET [6] studies in cancer patients.

Some of the DWIBS applications are still in its infancy. A higher number of receiver channels will allow increasing the parallel imaging factor, resulting in higher spatial resolution; acquisition of 1x1x1 mm voxel will be able in the near future. The concept of DWIBS can be extended to the navigator echo technique. Tracking only navigator echo (TRON) [7] enables us to avoid prolongation of scanning time in respiratory triggered DWI. This can be combined with cardiac triggering, in a reasonable scan time. As DWIBS can be used as an adjunct to morphological imaging to increase conspicuity of lymph nodes (sensitivity), its use in combination with specific contrast agents (USPIO's in particular) to increase specificity may enable improved screening regimes for pathological lymphnodes.

References:

1. Takahara T, Imai Y et al. Radiat Med 22:275-282, 2004
2. Ballon D, et al. Magn Reson Med 52:1234-1238, 2004
3. Takahara T, et al. ISMRM proceedings (Kyoto) 2518, 2004
4. Li S, et al. JMRI 26:1139-1144, 2007
5. Murtz P, et al. Eur Radiol 17:3031-3037, 2007
6. Komori T et al. Ann Nucl Med 21:209-215, 2007
7. Takahara T, Ogino T, et al. ISMRM-ESMRMB proceedings (Berlin) 3843, 2007