Diffusion in the Body: Pitfalls and Challenges

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Highlights:

- DWI utilizes large gradients to create sensitivity to the diffusion of water molecules in tissues
- Echo Planar Imaging (EPI) is the most commonly utilized pulse sequence for DWI because of its extended readout
- Due to the designed sensitivity to motion of DWI, bulk motion can severely degrade image quality
- Sources of off-resonance are also problematic because of the extended readout of EPI
- The multiple occurrences of motion or off-resonance in the body are the primary challenges of body DWI
- Further challenges include the interpretation of contrast in qualitative DWI images

Target Audience: clinicians and technologists

Objective: At the completion of this talk, attendees will have a high-level understanding of diffusion-weighted signal generation and the motivation for using echo planar readouts with DWI. Attendees will also understand why specific aspects of body MRI, namely bulk motion and sources of off-resonance make DWI in the body particularly challenging. Finally, attendees will be familiar with the considerations for DWI contrast interpretation as well as with how artifacts that vary with b-value can affect creation of ADC maps.

Summary:

The signal in Diffusion Weighted Imaging (DWI) reflects the difference between the diffusion of excited spins in different tissues. The distinguishing characteristic of diffusion-weighted sequences is the application of gradients that provide sensitivity to the microscopic motion of the excited spins. In body MRI, DWI is utilized for a number of applications including in the liver, kidney, breast, and prostate. However, DWI in the body can be particularly challenging due to motion and off-resonance. The necessity for diffusion-weighted sequences to be sensitive to the microscopic motion of excited spins also renders them highly susceptible to artifacts from other sources of motion. Thus motion compensation strategies like breath-holding, navigators, and respiratory triggering are a necessity with DWI in the body. DWI sequences are designed to compensate for this susceptibility to bulk motion but there are associated trade-offs. Most common DWI sequences utilize echo planar imaging (EPI) based methods to reduce bulk motion artifacts but these sequences also introduce a greater susceptibility to artifacts due to off-resonance. Sources of off-resonance lead to signal dropout, image distortion and shifting of signal from different chemical

species like fat. The tools available to reduce these artifacts include parallel imaging, shimming, and suppression of specific chemical species. Further challenges in DWI in the body include interpretation of contrast due to effects like T2 shine-through or the contribution of perfusion when small diffusion gradients are utilized. Ultimately, the optimal balance of these considerations in sequence design will depend on the specific anatomy being scanned. An understanding of these trade-offs in DWI can help to form a framework for DWI protocol development as well as for artifact recognition and trouble-shooting.

References

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