The application of full body diffusion weighted imaging in oncology

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Abstract

The term PET like MRI refers to the full body diffusion weighted imaging to diagnose metastises in the body. The gold standard of clinical in vivo imaging of metastesis is the utilisation of [^{18}F]FDG radiotracer for PET imaging. FDG is trapped within the metabolically active tumour cells and provides the basis for functional imaging and Maximum Intensity Projections (MIPS) display. MRI full body diffusion weighted imaging has shown promise as a method for displaying similar data to that of PET imaging. The main advantages of this method is that it does not require a radiotracer and that it has a faster clinical through put. However there are barriers to the application of this method in a clinical setting.

1 Introduction

Diffusion weighted imaging is the measurement of the apparent intrinsic self-diffusion property (D) of a fluid according to Brownian motion. Hence D reflects the mobility of the molecules in their microenvironment. Proton NMR (and therefore MRI) can be made sensitive to dynamic displacements of water molecules between 10^{-8} and 10^{-4} m in a timescale of a few milliseconds to a few seconds and these displacements are of the same order of magnitude as cellular dimensions within biological tissues. The water diffusion is affected by the microdynamics of cellular transport between different sub-compartments of the heterogeneous tissue structure as well as by the presence of non-permeable membranes; therefore measurements of D at different parameters, such as the diffusion time, can highlight different properties of the tissues morphology. By entangling the rate of diffusion with relaxation time provides a unique image contrast of the diffusion coefficient referred to as the apparent diffusion coefficient (ADC). The main application of DWI in clinical and research setting are the evaluation of acquired brain injury including stroke and traumatic brain injury[1-6].

However ADC of cancer cells and tumour sites is reduced due to increased cell diameters and the dense cellular composition in comparison to surrounding tissue. Therefore, the imaging sequence should be able to produce similar outputs to PET imaging in the study of secondary metastases which are faster and without the need for contrast agents.

2 Current application and limitations

The application of fully body scanning with Diffusion weighted imaging has only recently evolved into a usable structure. The main limitation has been the development of a sequence that can be utilised in a free breathing as breath hold scanning has SNR limitations due to short acquisition times eliminating the possibility of thin slice acquisitions with good SNR for PET like MIPS display. The first protocol allowing free breathing DWIBS was developed on a Philips™ 1.5 T scanner [7]. The protocol relied on a STIR with EPI in free breath with the signal average is performed on the reconstructed image and not in K-space. This aims to average out the motion artefact.

The other vendors have produced similar imaging sequences like Siemens™ REVEAL however GE™ have yet to produce a DWI full body sequence. The main limitations of the sequence design and the future bases for future research:

Scientific limitations

1. Lack of understanding of DW-MRI at a microscopic level
2. False positives, any densely packed tissue mass (e.g. cyst) will look like a tumour
3. No accepted standards for measurements and analysis
4. Multiple data acquisition protocols depending on body part and usage of data
5. Qualitative to quantitative assessments
6. Multi-exponential decay components which affect the calculated ADC values

Vendor specific

1. Rapid evolution of body imaging protocols and coils
2. Incomplete validation and documentation of reproducibility
3. Divergent nomenclature and symbols
4. Lack of working methodologies, accepted quality assurance
5. No (QA) standards, and physiologically realistic phantoms
6. Requires improving measurement and analysis methods with repeatability, and reproducibility.

3 Conclusion

The main barrier to the application of this method in a clinical setting is the possibility of false positives of non-cancerous lesions or cysts in patients. This is the main challenge to the application of this method.

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