DWI is a Relevant Biomarker in Cancer

Dr. Dow-Mu Koh
Royal Marsden Hospital, UK

Extracranial diffusion-weighted MRI (DWI) is being employed in oncology as a tool to improve cancer detection, disease characterization, assessment of treatment response, disease surveillance and the identification of disease relapse. As MR technology continues to improve, it is now possible to acquire high quality DWI images at both 1.5T and 3.0T, including whole body DWI studies for oncological assessment.

The attraction of DWI as a technique, lies in its relative ease to perform, not requiring any exogenous contrast administration, and it can be quickly measured. Depending on the choice of and the number of diffusion-weightings (b-values) applied, it is possible to derive different quantitative parameters that reflect water proton mobility in tissues, thereby providing novel diagnostic, response, predictive and prognostic biomarkers.

By far the most widely used quantitative parameter derived from DWI is the apparent diffusion coefficient (ADC), which can be calculated from DWI performed using two or more b-values. The ADC has been found to be a generally stable measurement, with good measurement reproducibility (typically of the order of 10-30% in coefficient of repeatability in well-conducted studies). Furthermore, inter-scanner variability in the body has been reported to be in the region of 14%. This is despite a lack of standardization in the choice of imaging protocols across many reported studies. International consortiums are currently addressing the issue of technical standardization.

The ADC value has been found to aid cancer detection (e.g. in prostate cancer) and reflect the tumour grade and biological aggressiveness (e.g. in pancreatic, hepatocellular carcinoma, neuroendocrine and prostate cancers). However, the use of ADC appears to have the greatest potential for the evaluation of tumour response to treatment. The ADC value has been shown to significantly increase in responders to chemotherapy, radiotherapy, embolization treatment and novel therapeutics. ADC is increasingly being evaluated as a response biomarker in bone disease, where current response criteria are suboptimal or ineffective. The ADC value has also been found in small studies to be of predictive and/or prognostic value. Nonetheless, many of these observations would need to be confirmed/ validated in larger cohort studies.

There is also increasing recognition of the non-monoexponential signal attenuation behaviour of tissues on DWI, both at low b-values and at ultra-high b-values. By applying the principles of intravoxel incoherent motion (IVIM), we can derive the perfusion fraction (f) and pseudodiffusion coefficient (D*) that reflect the fast component of diffusion in tissues, usually ascribed to microcapillary perfusion. By observing the signal attenuation behaviour at ultra-high b-value, we can evaluate the diffusion kurtosis (K), which may reflect the water diffusion related to cellular membrane barriers, including intracellular water motion. Nonetheless, these measurements are often associated with poorer measurement repeatability and development of these as biomarkers requires further research efforts.

References

1. Koh DM, Collins DJ. Diffusion-weighted MRI in the body: applications and challenges in oncology. AJR Am J Roentgenol. 2007 Jun;188(6):1622-35.

2. Padhani AR, Liu G, Koh DM, Chenevert TL, Thoeny HC, Takahara T, Dzik-Jurasz A, Ross BD, Van Cauteren M, Collins D, Hammoud DA, Rustin GJ, Taouli B, Choyke PL. Diffusion-weighted magnetic resonance imaging as a cancer biomarker: consensus and recommendations. Neoplasia. 2009 Feb;11(2):102-25.