Clinical CEST MRI: Technical Challenges and Developments

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Chemical exchange saturation transfer (CEST) imaging is a new molecular MRI method that allows detection of low-concentration, endogenous or exogenous chemicals with exchangeable protons through the water signal. In the past years, several CEST imaging types have been designed, and the validation of new applications is progressing rapidly on many fronts. Amide proton transfer (APT) imaging, a specific CEST imaging type, has the potential to introduce into the clinic an entirely new molecular MRI methodology that can detect endogenous cellular protein signals non-invasively. Technically, the APT effect is measured as a reduction in bulk water intensity due to the chemical exchange with saturated backbone amide protons of endogenous mobile proteins. The early pre-clinical and clinical data suggest that APT imaging has unique features by which to detect and characterize strokes and brain tumors. In addition, this technology may be relevant for applications to other cancers and other human diseases. This is particularly meaningful in the era of molecular imaging. Similar to other MRI techniques, the ultimate goal of CEST imaging is to develop methodology suitable for use in the clinical setting, where there are strict radiofrequency (RF) amplifier (duty cycle and pulse length) and specific absorption rate (SAR) limitations. In addition, technical issues, such as long scan time due to the need to acquire multiple saturation images at multiple frequencies, B_0 and B_1 field inhomogeneity, lipid artifacts due to asymmetry anslysis, and data processing methods, have to be addressed. We are now already developing methods for whole-brain 3D CEST MRI for the possible standardized use on clinical instruments. APT imaging is a safe, non-invasive MRI technology that can be implemented relatively readily for clinical applications. The research is of high potential impact since the validation of the results will result in a new sensitive and specific MRI modality with the potential to aid in the molecular diagnosis and treatment assessment of malignancies and other diseases at the protein level.