Asian Forum Session 2: CEST/MT

SY21-1

Basic Physics and Scientific Application of CEST

Hiroyuki Kabasawa

MR collaboration and Development, GE Healthcare, Hino, Tokyo, Japan

Water molecule as well as other species in biological tissue is not static, but dynamically moving and chemically exchanging each other. CEST (chemical exchange dependent saturation transfer) is a method to measure chemical exchange with NMR technique. Chemical exchange measurement using saturation transfer has been used in NMR field long time to understand detail molecular structure and dynamics since early days.

Basic pulse sequence design for CEST imaging is relatively simple. It includes continuous RF irradiation at certain frequency, followed by imaging acquisition. RF irradiation should be long enough (typically seconds) to generate sufficient saturation effect and its transfer by chemical exchange process. The continuous RF pulse saturates spins at its resonance frequency. If the spins have any interaction with free water, spin saturation effect is transferred to free water by spin exchange and that results in decreased water proton signal. This contrast mechanism makes us possible to perform indirect signal measurement of unobservable molecule using conventional MRI. CEST has a large potential to provide molecular dependent contrast mechanism, including amide proton, glucosaminoglycans, glucose and OH-containing molecules. As the Chemical exchange is associated with pH, pH measurement using CEST has been investigated and reported.

MTR asymmetry index is frequently used to measure CEST effect. It is simple index to observe CEST effect and is easy for interpretation. However, the MTR asymmetry is qualitative information and is contaminated with a lot of other information other than chemical exchange. As the actual observed signal change includes not only chemical exchange, but also magnetization transfer, and NOE effect. Z-spectrum includes such spin interaction information. More detail Z-spectrum analysis will provide us various quantitative chemical exchange information. We have developed new CEST spectrum analysis method called CPE-spectrum. It is robust spectrum analysis method that enable us to map out several useful information from CEST measurement.

This presentation will cover the overview physics background of the CEST, engineering requirement for pulse sequence and MRI system, CEST data analysis method and its application to quantitative analysis.

Keywords : CEST, Physics, Engineering

Asian Forum Session 2: CEST/MT

SY21-2

Ultrafast CEST

Jaeseok Park

Biomedical Engineering, Sungkyunkwan University, Suwon, Korea

This talk is to present ultrafast chemical exchange saturation transfer magnetic resonance imaging. We present how to design ultrafast CEST pulse sequence to acquire full z-spectra in the whole brain, how to reconstruct the whole brain CEST images, and how to produce corresponding asymmetric z-spectra. We expect to complete z-spectrum acquisition in clinically acceptable imaging time and asymmetric z-spectra without conventional subtraction.

Keywords : MRI, Ultrafast, CEST

Asian Forum Session 2: CEST/MT

SY21-4

CEST Imaging of Brain Tumor

Takashi Yoshiura, Kiyohisa Kamimura, Masanori Nakajo

Department of Radiology, Graduate School of Medical and Dental Sciences, Kagoshima University, Kagoshima, Japan

Chemical exchange saturation transfer (CEST) is a novel MR contrast mechanism based on the saturation transfer via proton exchange between solutes and the surrounding water molecules. It enables us to detect low concentration molecules with amide, amine and hydroxyl groups. Amide proton transfer (APT) imaging is a specific type of CEST imaging which probes mobile proteins and peptides. APT is considered to be the most feasible CEST imaging, and has been successfully applied to brain tumor imaging. Previous studies have shown that APT can help preoperatively estimate the histological grade of gliomas based on higher APT signal in high grade tumors than in low grade ones. Moreover, it is reportedly useful in discriminating post-treatment tumor recurrence from treatment-related changes. A hypothetical theory of the high APT signal in malignant brain gliomas is higher intracellular protein/peptide content due to higher proliferative activity. However, underlying mechanisms of APT contrast in tumors are not fully understood. It seems obvious that extracellular proteins/peptides can also contribute to APT signals. Indeed, effects of hemorrhage and edema associated with tumors on APT imaging have never been carefully evaluated. In this presentation, I will discuss about the clinical usefulness and the limitations of CEST/APT imaging in evaluating brain tumors.

Keywords : Chemical exchange saturation transfer, Amide proton transfer, Brain tumor

Asian Forum Session 2: CEST/MT

SY21-5

Amide Proton Transfer Imaging in Stroke: Protocol Optimization and Potential Clinical Applications

Ji Eun Park

Radiology, Asan Medical Center, Seoul, Korea

Molecular imaging using endogenous molecules has always generated interest because the methodology does not have the adverse effects of gadolinium (Gd) contrast agents and has clinical benefits for pediatric patients or patients with a contraindication to an exogenous contrast agent. Amide proton transfer (APT) imaging is gaining attention as a relatively new *in vivo* molecular imaging technique that has higher sensitivity and spatial resolution than magnetic resonance spectroscopy imaging. APT imaging is a subset of the chemical exchange saturation transfer (CEST) mechanism, which can offer unique image contrast by selectively saturating protons in target molecules exchanged with protons in bulk water.

APT imaging can reflect tissue physic-chemical properties. In patients with acute stroke, APT produces negative contrast followed by a rather simplified equation (reference 1):

*APTR = k[amide proton]/2[H20]R1w * (1-exponential [-R1w * saturation time])*

So far, first and only clinical study of APT imaging in actual stroke patients was published in 2013 (reference 2). In 10 patients with acute anterior or posterior infarctions, APT imaging on a 3T MRI scanner was performed, and reduced APT asymmetry was noted compared to the contralateral side (P = 0.003). However, the protocol was based on gradient-echo sequence and needed to be further optimized. Recently, a 3-dimensional turbo spin-echo (TSE) imaging was implemented with APT imaging, enabled a long duration for off-resonance saturation RF pulse and resulted in high contrast.

In this lecture, I will introduce steps for optimizing protocol of APT imaging in stroke patients, which was validated in rat stroke model on 3T machine. Also, I will provide illustrative cases of APT imaging in patients with stroke. Also, potential clinical applications of APT imaging as integrated approach for stroke imaging will be discussed.

References:

1. Zhou JY, Payen JF, Wilson DA, Traystman RJ, van Zijl PCM. Using the amide proton signals of intracellular proteins and peptides to detect pH effects in MRI. *Nature Medicine* 2003;9:1085-1090

2. Tietze A, Blicher J, Mikkelsen IK, Ostergaard L, Strother MK, Smith SA, et al. Assessment of ischemic penumbra in patients with hyperacute stroke using amide proton transfer (APT) chemical exchange saturation transfer (CEST) MRI. NMR Biomed 2014;27:163-174

3. Keupp J, Baltes C, Harvey P, J. VdB. Parallel RF transmission based MRI technique for highly sensitive detection of amide proton transfer in the human brain at 3T. In: Proc 19th Annual Meeting ISMRM 2011;Montreal.

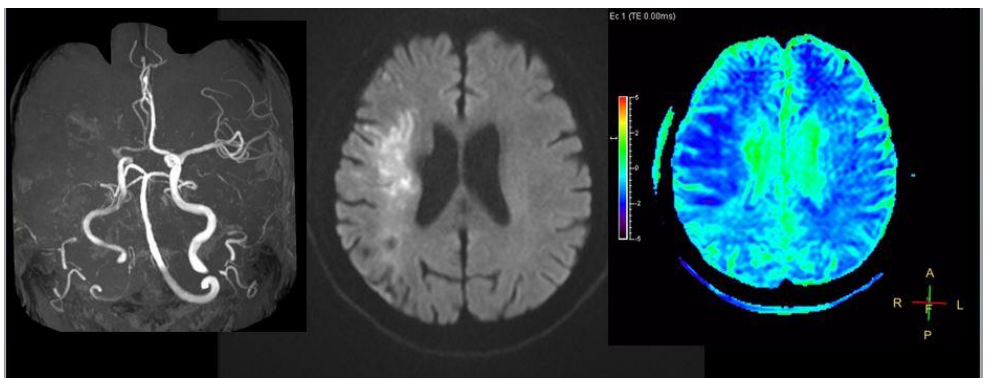

Fig 1.

Legend : A 46 year old patient with acute stroke 4 days ago. MR angiography shows occlusion of right middle cerebral artery (MCA). Note that reduced APT asymmetry is observed in right MCA territory slightly larger than restricted diffusion regions.

Keywords : Amide proton transfer, PH weighted imaging, Stroke