Chemical Exchange Saturation Transfer (CEST) Imaging for Thoracic Oncology: Preliminary Experience for Characterization of Thoracic Nodule and Mass

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Introduction: Differentiation of malignant tumor from benign tumor as well as therapeutic effect evaluation and recurrence assessment is essential for radiological examination in routine clinical practice. Currently, CT and MR imaging have been applied for morphological evaluation, although FDG-PET and PET/CT are currently applicable molecular imaging technique in various clinical and academic interest. In contrast to PET or PET/CT, MR-based molecular imaging has been also proposed by using hyperpolarized noble gas MR imaging, etc. in the last decades. In the last several years, chemical exchange saturation transfer (CEST) imaging is suggested as new technique and one of the MR-based molecular imaging techniques (1, 2). CEST imaging can be performed by proteins, amino acids and DNAs including chemical exchangeable protons such as hydroxyl protons (-OH: ~1ppm), amine protons (-NH2: ~2ppm) and amide protons (R-C(=O)-NH2 or R-C(=O)-NHR1 <R ≠ H>: ~3.5ppm), and has been reported in basics and clinical studies (3-5). However, no major reports have been published for evaluating clinical utility of CEST imaging in thoracic oncology patients.

We hypothesized that newly developed CEST imaging, which demonstrates the exchange between protons of free tissue water and the protons of amide groups (-NH) of endogenous proteins and peptides (i.e. amide proton transfer imaging: APT imaging), is possible to evaluate thoracic nodule and mass, and play as new diagnostic tool in routine clinical practice. The purpose of this study was to determine the capability of CEST imaging for characterization of thoracic nodule and mass, and evaluate a potential as a new MR-based molecular imaging method in thoracic oncology.

Materials and Methods: Twenty consecutive patients (15 men, 5 women; mean age 67 years) with thoracic nodules or masses prospectively underwent CEST imaging at 3T MR system (Vantage Titan 3T, Toshiba Medical Systems Corporation, Otawara, Tochigi, Japan), pathological examinations from specimens obtained by transbronchial or CT-guided biopsies or surgical resection, and/ or follow-up examinations. According to pathological examination results, all lesions were divided as follows: benign (n=9) vs. malignant (n=11) groups, lung cancers (n=8) vs. other thoracic malignancies (n=3), and adenocarcinomas (n=5) vs. squamous cell carcinomas (n=3). To obtain CEST data in each subject, respiratory-synchronized fast advanced spin-echo images were conducted following a series of magnetization transfer (MT) pulses. Then, magnetization transfer ratio asymmetry (MTR_{asym}) was calculated from z-spectra in each pixel, and MTR_{asym} map was computationally generated.

To evaluate the capability for characterization of thoracic lesion, MTR_{asym}s assessed by ROI measurements were compared between benign and malignant lesions, between lung cancers and other thoracic malignancies, and between adenocarcinomas and squamous cell carcinomas by Student's t-test. P value less than 0.05 was considered as significant in this study.

Results: Representative cases are shown in Figure 1, 2 and 3. MTR_{asym} of malignant lesions (3.2±2.6 %) was significantly higher than that of benign lesions (0.4±0.4 %, $p<0.05$). MTR_{asym} of other thoracic malignancies (5.8±3.6 %) showed significantly higher than that of lung cancers (2.3±1.4 %, $p<0.05$). MTR_{asym} of adenocarcinomas (3.3±0.8 %) was significantly higher than that of squamous cell carcinomas (0.7±0.2 %, $p<0.05$).

Conclusion: On 3T MR system, CEST imaging is applicable for characterization of thoracic nodules and masses.. Mean magnetization transfer asymmetry shows significant differences between benign and malignant lesions, between lung cancers and other thoracic malignancies and between adenocarcinomas and squamous cell carcinomas. Therefore, CEST imaging has a potential for differentiation of malignant from benign lesions as well as sub-typing of thoracic malignancies and lung cancers.

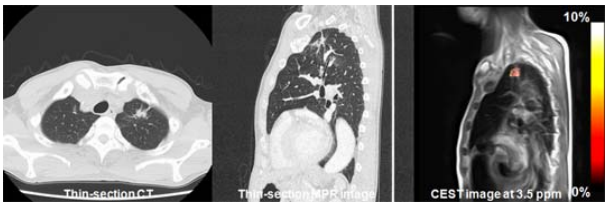

Figure 1. 68-year-old male with organizing pneumonia
Thin-section CT and MPR image demonstrate a nodule with spicula, pleural indentation and notch in the right upper lobe. CEST image shows low MTR_{asym} with the value as 0.7.

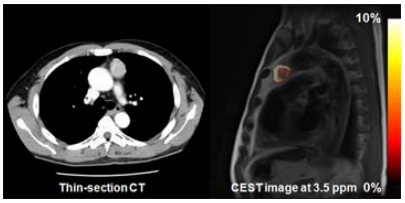

Figure 2. 64-year-old male with thymic cancer
Thin-section CT demonstrate a nodule in the anterior mediastinum. CEST image shows high MTR_{asym} with the value as 4.1.

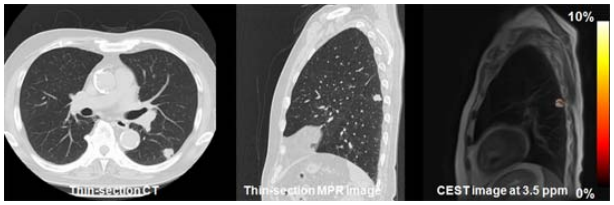

Figure 3. 71-year-old male with adenocarcinoma
Thin-section CT and MPR image demonstrate a nodule with spicula, and notch in the left lower lobe. CEST image shows high MTR_{asym} with the value as 3.7.

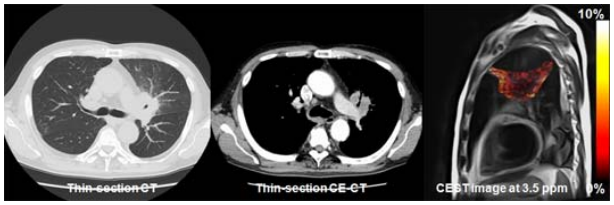

Figure 4. 66-year-old male with squamous cell carcinoma
Thin-section CT and CE-CT demonstrate a mass with spicula and notch in the left upper lobe. CEST image shows low MTR_{asym} with the value as 0.6.

References

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