Applying a length and offset varied saturation (LOVARS) CEST method for Imaging Cerebral Glioma

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Target Audience: Researchers and radiologists interested in CEST imaging.

Purpose: To integrate a length and offset varied saturation (LOVARS) method for improved APT imaging in patients with gliomas[1].

Methods: 10 patients with cerebral glioma confirmed with histopathology were examined using prototype GRE APT and LOVARS CEST on a 3.0T MR scanner (Magnetom Trio Tim, Siemens AG, Erlangen, Germany) with a 12-ch head coil. The basic acquisition parameters are similar for APT and LOVARS: slice thickness = 5 mm, TE/TR = 2.87/1620 ms, FA = 12 degree, FOV = 256 × 256 mm^2, matrix = 128 × 128. For APT, 21 frequency offsets from +5 to -5 ppm with 5 RF pulses (100 ms in length with 100 ms intervals) of 2.0 μT were used for pre-saturation, and images were calculated by B_0 correction and asymmetry analysis of magnetization-transfer-ratio (MTR_{asym})[2]. For LOVARS, only 2 offsets were used for pre-saturation, with either 2 or 5 RF pulses of 2.0 μT. LOVARS phase images were calculated by FFT of the 3 cycles of LOVARS units (12 images in total) with the scheme shown in **Fig. 1**[2]. Additional T1w and T2w images were also collected.

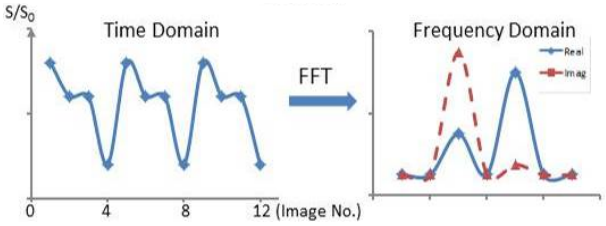

Figure 1. Illustration of the LOVARS scheme[2].

Results: **Fig.2** shows an example in a patient with a high-grade glioma, with APT signal showing hyperintensity, while the LOVARS image showed a phase value> л/4 with improved Contrast-Noise-Ratio (CNR) over the MTR_{asym} map. **Fig.3** shows another example, with the APT signal slightly higher in tumor than in normal tissue, while the LOVARS image showed a clear tumor boundary with better CNR. The signal intensity of tumor on LOVARS phase map in **Fig.3e** is smaller (φ< л/4) than that in **Fig.2e**. This is consistent with the lower APT signals on **Fig.3d** compared to **Fig.2d,** which have been correlated with the tumor grade[3]. LOVARS imaginary maps were also generated (not shown), with signal intensity similar to that for APT. In terms of scan time, LOVARS requires 12 saturation-weighted images, compared to the 21 images in conventional APT by sweeping the frequency. In addition, 6 of the 12 images in LOVARS use 2/5 of the total pre-saturation pulse length, the corresponding SAR effect is also reduced compared to conventional APT using all 5 pulses.

Discussion and Conclusion: Instead of sweeping different frequency offsets as conventional APT imaging, the LOVARS scheme collects only 2 offsets with different pre-saturation time for 3-4 cycles for improving CNR efficiency. In multiple patients, LOVARS phase maps clearly show improved CNR and well-defined tumor boundary, also reducing the total scan time and SAR effect. In addition, as shown in **Figs. 2 & 3**, the phase contrast showed differences between patients, which may allow differentiation of tumor types as APT.

References: [1]Zhou et al. Nat. Med. 9(2003):P1085. [2]Song et al. MRM 2012 68(4): P1074. [3]Wen et al. Neuroimage2011(51): P616

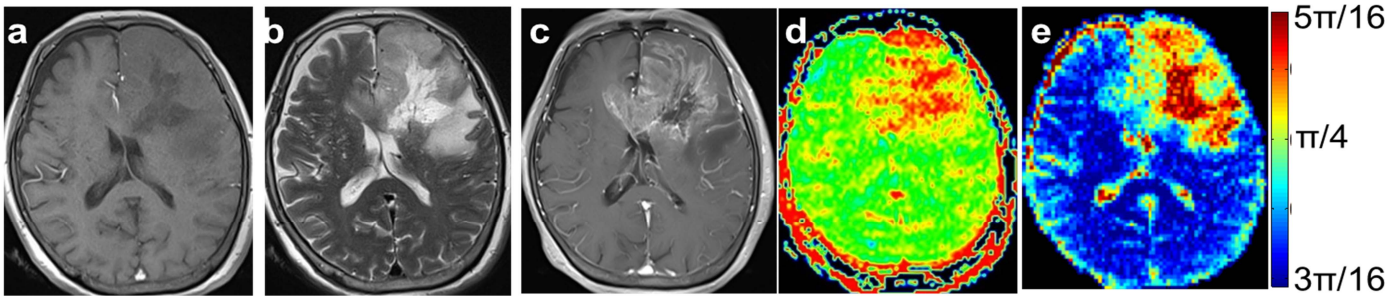

Figure 2. A 57-year-old man with glioblastoma (WHO grade IV) in the left frontal lobe. The tumor shows hypointensity on T1w image (a), heterogeneous hyperintensity on T2w image (b), heterogeneous enhancement on post-contrast T1w image (c), hyperintensity on APT image (d) and heterogeneous hyperintensity on LOVARS phase map (e).

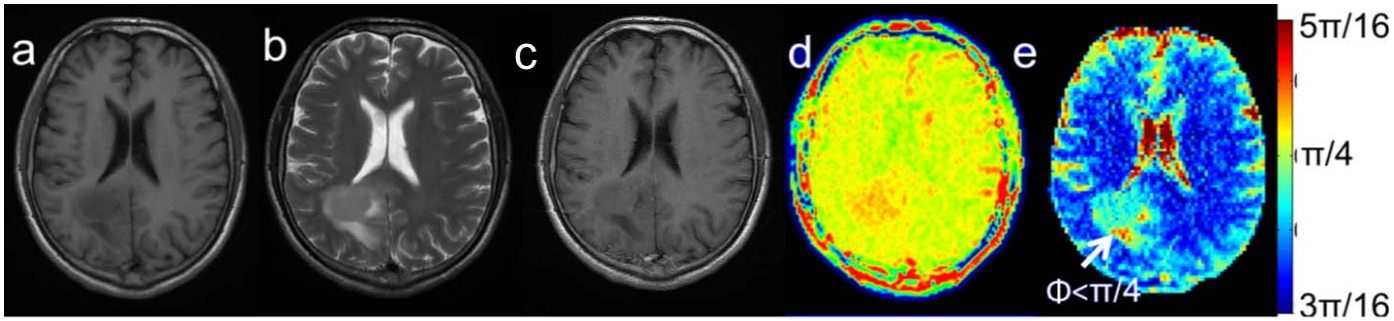

Figure 3. A 57-year-old man with anaplastic astrocytoma (WHO grade III). The tumor shows hypointensity on T1w image (a), isointensity on T2w image (b), mild enhancement on post-contrast T1w(c), slight hyperintensity on APT image (d) and hyperintensity on the LOVARS phase map (e).