R_1- ΔR_2- ΔR_2^* combined MR angiogram with dual contrast SPION

Hoesu Jung[1], Sohyun Han[1], Seokha Jin[1], Dongkyu Lee[1], and Hyungjoon Cho[1]
[1]*Department of Biomedical Engineering, UNIST (Ulsan National Institute of Science & Technology), Ulsan, Gyeongsangnam-do, Korea*

PURPOSE: MR angiogram is a crucial diagnostic tool for vascular malfunction in brain. Various angiogram techniques using contrast agent were investigated to visualize arteries, vein or micro-cerebral vessel in brain [1-3]. R_1-weighted (T_1-weighted) angiogram represents accurate vessel information with positive enhancements, but its sensitivity is low for microvasculature. Transverse relaxation based ΔR_2 and ΔR_2^* angiograms shows improved visibility in microvasculature, while vulnerable to susceptibility artifacts and overestimation of vessel size in the vicinity of air-tissue interface. In this study, we systematically compared the strengths and weaknesses of ΔR_2, ΔR_2^* and R_1-weighted angiograms. Conclusively, R_1- ΔR_2- ΔR_2^* combined angiogram was proposed to synergistically visualize both larger vessels on the cortical surface and microvasculatures in deep brain.

METHODS: *Pulse sequence*: Imaging parameters for UTE3D sequence (R_1-weighted angiogram) were as follows: FA = 20°, TR = 12 ms, TE = 0.012 ms, FOV = 30 × 30 × 60 mm^3, and matrix size = 384 × 384 × 384. Imaging parameters for RARE sequence (ΔR_2 angiogram) were as follows: TR = 2000 ms, effective TE = 15 ms, FOV = 30 × 30 × 33.12 mm^3, and matrix size = 384 × 384 × 212. Imaging parameters for FLASH sequence (ΔR_2^* angiogram) were as follows: FA = 20°, TR = 80 ms, TE = 5.27 ms, FOV = 30 × 30 × 33.12 mm^3, and matrix size = 384 × 384 × 212.

Experiment: All angiograms of Sprague–Dawley (SD) rat brain were acquired on 7-T MR scanner (Bruker, Germany) with 40-mm volume coil. SPION was administered at the dose of 120 μmol/kg for R_1-weighted angiogram, 240 μmol/kg for ΔR_2^* angiogram and 360 μmol/kg for ΔR_2 angiogram, respectively.

R_1- ΔR_2- ΔR_2^* combined angiogram: First, ΔR_2 and ΔR_2^* angiograms were multiplied to improve vessel sensitivity using ΔR_2^* information and acquire accurate vessel size using ΔR_2 information. And then well-delineated vessels of R_1-weighted angiogram on the brain surface were added to multiplied ΔR_2 and ΔR_2^* angiogram.

RESULTS & DISCUSSION: The vasculature on the brain surface of R_1-weighted angiogram with UTE (Fig 1C) was more accurate than ΔR_2 angiogram with RARE (Fig 1A) and ΔR_2^* angiogram with FLASH (Fig 1B). On the other hand, microvasculature in the inner region of the brain of ΔR_2 and ΔR_2^* angiogram (Fig 2A, 2B) was well defined than that of R_1-weighted angiogram with UTE (Fig 2C). Also, low vessel sensitivity of ΔR_2 angiogram and overestimated vessel size of ΔR_2^* angiogram were observed. In comparison with ΔR_2, ΔR_2^* and R_1-weighted angiograms, the R_1- ΔR_2- ΔR_2^* combined angiogram showed better larger vessel structure on the brain surface as shown in Fig 1D and accurate and sensitive smaller vasculature in deep brain as shown in Fig 2D. The R_1- ΔR_2- ΔR_2^* combined angiogram presents the potential tool to visualize a wide range of vasculature with minimized susceptibility artifacts and enhanced sensitivity.

REFERENCE: [1] Lin, C.-Y et al. Neuroimage, 45(3): 824-831 (2009). [2] Huang, C.-H et al. PloS one, 8(11): e78186 (2013). [3] Jung, H et al. Nanomedicine, 10(8): 1679-1689 (2014).

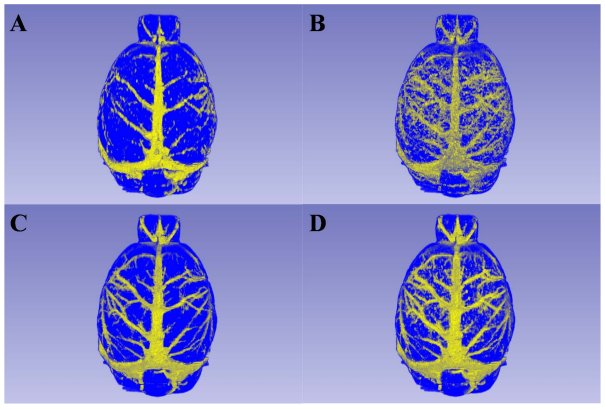

Fig. 1. Dorsal view of rat brain angiograms. ΔR_2 angiogram from RARE (A), ΔR_2^* angiogram from FLASH (B), R_1-weighted angiogram from UTE (C) and R_1- ΔR_2- ΔR_2^* combined angiogram (D).

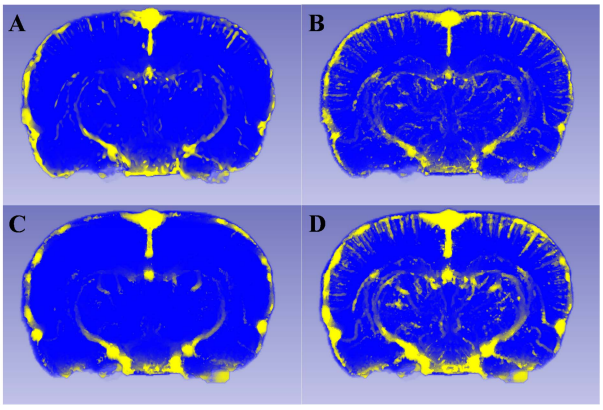

Fig. 2. Axial view of rat brain angiograms. ΔR_2 angiogram from RARE (A), $\Delta R2^*$ angiogram from FLASH(B), R_1-weighted angiogram from UTE (C) and R_1- ΔR_2- ΔR_2^* combined angiogram (D).