DARK BLOOD T2* MAPS IN THE CAROTID ARTERY

R. D. Newbould[1], A. P. Brown[1], D. R. Owen[1], J. Shalhoub[2], and G. Gambarota[1]

[1]GSK Clinical Imaging Centre, Hammersmith Hospital, London, United Kingdom, [2]Department of Vascular Surgery, Imperial College London, London, United Kingdom
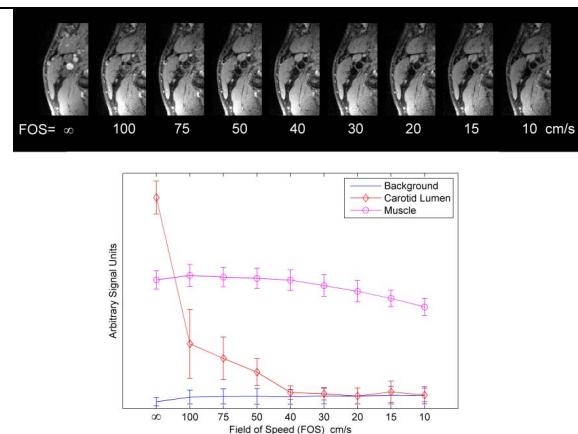
Introduction: Uptake of the ultrasmall super-paramagnetic iron oxide (USPIO) agents in carotid plaques may be a marker of macrophage activity and therefore a measure of inflammation in the plaque[1]. With no innate flow suppression,gradient echo (GRE) sequences have large artifact power from flowing blood spins in the neck vessels. Strong blood suppression is therefore needed to acquire T2* maps of the carotid plaques, which are located near these flowing spins, to model USPIO uptake. Motion-sensitized driven equilibrium (MSDE) preparation[2] rapidly suppresses flowing spins, and here is applied to a multi- echo GRE sequence. Previous work has used MSDE with FSE[3], which has excellent innate through-plane flow suppression[4], or at 1.5T[5]. The effect of the preparation on the image contrast and T2* mapping is here characterized to allow sequence optimization, and is used in six subjects with carotid plaques at 3T.

Materials and Methods: The MSDE preparation consists of non-selective 90° pulse, a pair of gradient lobes around a non-selective 180° pulse, and a -90° driven equilibrium pulse[2]. MSDE and spoiled GRE (SPGR) acquisitions were acquired at the level of the carotid bifurcation in a healthy volunteer and MSDE only in six ultrasound identified subjects with extensive carotid plaques on a Siemens Verio 3T system. [FOV=16x12cm, voxels=0.8x0.8x2mm, TR=300ms, FA=80°, 12slices in 2 concats, 8 echoes every 4.92 ms]. The MSDE preparation gradients were modulated to give a FOS of ∞ , 100, 75, 50, 40, 30, 20, 15, and 10 cm/s resulting in b-values from 0.014 to 0.645 s/mm^2. Strong (75mT *ms/m) gradient spoiling after the preparation removed any residual magnetization. A FOS of ∞ corresponds to a non-MSDE prepared SPGR acquisition. In carotid plaque subjects, a field of speed (FOS, = 2*Venc, where Venc is the velocity encoding value) of 37cm/s was used. In all experiments T2* maps were calculated by fitting the echoes to a three-term exponential decay $S(TE)=\rho_{app}[exp(-TE/T2^*)]+C$, where ρ_{app} is proportional to the spin density and C is a rectified noise floor.

Results: The MSDE-prepared SPGR acquisition has an additional decay over SPGR due to diffusion-weighting and T2 decay during the preparation. Increasing the size of the flow-sensitizing gradients in the preparation reduces the speed at which flowing spins are suppressed, but adds additional T2 weighting to the acquired images, as noted in the plot of muscle signal in Fig 1. The flowing spins in the carotid lumen are rapidly suppressed. A FOS of 37cm/s was chosen as a balance between flow suppression and T2-related signal loss to be used in carotid plaque subjects. One example slice from all six subjects is shown in Fig 2. The top row shows the raw echo images, the middle row the resultant apparent proton density map, and the bottom row the T2* maps. Excellent blood suppression is noted in each, showing the robustness of the technique.

Discussion: In this work an MSDE preparation was investigated to allow robust T2* mapping in carotid plaques. Much stronger sensitizing gradients than previously used[3,5] were found necessary, possibly due to increased flow sensitivity in SPGR. MSDE was found to be more robust than DIR with optimal TI=630ms for 3T (data not shown) in our patient population. Further, MSDE is insensitive to changes in the T1 of blood, such as when the contrast agent is introduced. A QIR preparation[6] can effectively null a wider range of T1 values; however acquisition of multiple slices and SAR deposition may preclude its use here. Previous works characterizing vessel plaques with USPIO used single-echo T2* weighted images[1], and thus relied on relative T2* changes using muscle as a reference; this work demonstrates full T2* mapping with robust blood suppression.

Fig 1. MSDE-prepared SPGR images of the carotid artery and adjacent muscles with increasing flow-sensitizing gradients, resulting in a field of speed (FOS) ranging from ∞ to 10 cm/s. The bright blood signal seen in carotid artery and jugular vein in the unprepared (FOS=∞) image rapidly disappears with increasing blood suppression.
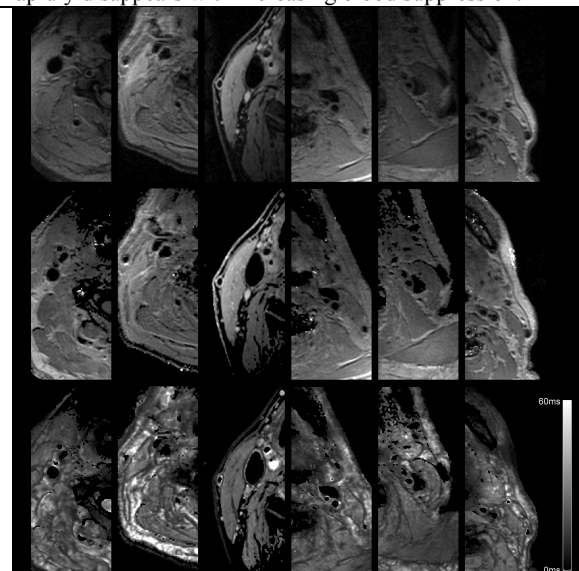
Fig 2. T2* mapping from six subjects with carotid plaques. The first of eight echo images are shown in the top row, which results in an apparent proton density (middle row) and T2* maps (bottom row). Excellent blood suppression and good plaque and vessel wall delineation can been seen in each case.

References: 1. Trivedi, AthThrombVasc Bio,26:1601-1606, 2006. 2. Pell, MRM 49:341-350,2003. 3.Wang,MRM, 58:973-981,2007. 4. Hinks,MRM 32:698-706,1994. 5. Nguyen,JMRI,28:1092-1100,2008. 6. Yarnykh MRM 48:899-905 2002.