**Application of T1-weighted contrast enhancement in EPRI/MRI co-imaging of isolated rat heart**

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**Introduction:** Electron paramagnetic resonance imaging (EPRI) using stable free radical probes is a powerful tool in detecting tissue redox and oxygenation status in vivo and ex vivo (1, 2). However, spatial resolution achievable using the EPRI technique is limited. As a result, EPRI functional images are normally overlaid onto MRI images of high spatial resolution to visualize the distribution of free radical probes within tissue (3). In this approach, however, the only spatial distribution information of free radical probes comes from the low resolution EPRI images, which is not accurate. One possible solution to this problem is to overlay the EPRI images onto $T_1$-weighted MRI images, which are generated using the free radical probes as $T_1$ contrast agents. To date, no such an approach has been reported in the literature. In this study, ex vivo 3D EPRI images of rodent hearts are overlaid onto the corresponding 3D $T_1$-weighted MRI images to depict the free radical probe distribution with improved accuracy.

**Method:** MRI images were collected on a 0.38 T Resonex electromagnet, which was water cooled and equipped with a gradient coil from Tesla Inc. (80 mm ID, slew rate = 1600 mT/m/ms) and a shim coil from Resonex (24 channels), using a home-made EPRI/MRI double-resonance resonator. An isolated beating rat heart (~8 mm long) hang in a glass tube was perfused with St. Thomas solution containing 1.5 mM stable free radical triaryl methyl (TAM, version OX63) at a flow rate of 2 mL/min and was imaged using the double-resonator. A 3D gradient echo (GRE) pulse sequence from MR Solutions Inc. was modified into an IR-GE3D sequence by incorporating a selective AFP pulse into the sequence ($HS_1$, R = 15, $T_p$ = 4 ms, $B_1$(max) = 1.875 kHz, BW = 3.75 kHz) for both inversion and excitation. The slice selection gradient amplitude for the inversion $HS_1$ pulse was scaled to 0.7 of that for the excitation $HS_1$ pulse for nonlinear phase dispersion cancellation (4). $T_1$-weighted images were obtained using AFP-IR-GR3D pulse sequence. Scan parameters: spectrum width (SW) = 10 kHz, matrix size = 128 x 128 x 32, slab thickness = 30 mm, FOV = 40 mm, FOV in slab selection direction (FOV2) = 30 mm, flip-angle (FA) = 90°, TE/TR = 230/14 ms, TI = 200 ms, orientation = transverse, number of averages = 1, scan time = 15 m 58 s. 3D EPRI images were collected at 40 mT on a Bruker system equipped with a Bruker ER023 signal channel and a ER032M field controller. EPRI imaging parameters: frequency = 1.19 GHz, microwave power = 300 mW, modulation amplitude = 0.07 mT, scan width = 2 mT, field gradient = 0.5 mT/cm, FOV = 40 mm, 24 x 24 projections, scan time = 3.9 s. 3D image registration (affine) and overlay (25% transparency) were performed on a Linux computer using FSL (v4.0, University of Oxford) and MRIcro (v1.39), respectively.

**Results:** An axial image from the 3D $T_1$-weighted MRI rat heart image, the corresponding EPRI image, and the overlaid images are shown in Figs.1a, 1b, and 1c, respectively. In Fig.1a, hyper-intense signal were observed in the right-ventricle of the rat heart in contrast to the hypo-intense signal shown in the left-ventricle of the heart. In Fig.1b, the boundary between the left- and right-ventricle is not clear on the EPRI image. In Fig.1c, where EPRI images are registered and overlaid onto the $T_1$-weighted MRI images, greater EPRI signals are observed in the right-ventricle area.

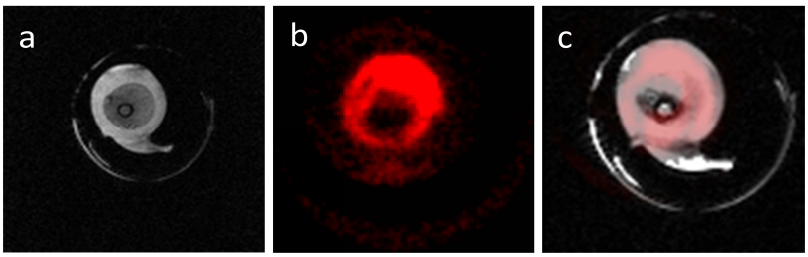


Figure 1. Axial 3D $T_1$-weighted MRI image (a), the corresponding EPRI image (b), and the overlaid images (c).

**Discussion:** Hyper-intense signals in the $T_1$-weighted MRI image (Fig.1a) are ascribed to the higher free radical concentration, which shortens the $T_1$ relaxation time constant. This result is consistent with the free radical distribution in the registered EPRI image in Fig.1c. This study demonstrates that $T_1$-weighted MRI technique is useful for detecting free radical probe distribution within myocardium in EPRI/MRI co-imaging experiments.

**Reference and acknowledgment:** 1. Kuppusamy P, et al. J Magn Reson B 1995;106:122-130. 2. He G, et al. Proc Natl Acad Sci USA 1999;96:4586-4591. 3. He G, et al. Magn Reson Med 2002;47:571-578. 4. Kunz D. Magn Reson Med 1987;4:129-136. This work was supported by NIBIB grants (EB0890 and EB4900).