Sequential imaging of tissue pO2 by Electron Paramagnetic Resonance Imaging and anatomy by MRI at 300 MHz

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Introduction Electron paramagnetic resonance imaging (EPRI) is a sensitive method to map tumor oxygenation which is a crucial prognostic factor for radiotherapy. We recently reported a rapid oxygen mapping procedure using pulsed EPRI. Thus if there are two magnets generating 10.8 mT for EPR and 7 T for MRI, both EPR and NMR imaging of the same sample can be performed with a single resonator assembly operating at 300 MHz without removing the object from the resonator. However, because the electron magnetic moment is ~ 660 times stronger than that of proton, the resonator assembly housing the object must be transferred from the EPR magnet operating at 10. 8 mT to a 7T MRI magnet to co-register the pO_2 images with the proton based anatomic MR images. However, the Q of the resonator for EPR should be switched to a lower value than for MRI to accommodate the larger bandwidth and facilitate fast ring-down. The present study provides a first superimposed imaging of EPRI and MRI of the same animal with a single coil working at 300 MHz and the associated gantry to move the object between the two imaging modalities to ensure reliable co-registration of the two image data sets.

Method Parallel coil resonator (30 mm length, 32 mm i.d.) operating at 300 MHz was constructed to be placed in a 10.8 mT magnet for pO_2 imaging and a 7T magnet for anatomic imaging. The triarylmethyl free radical-based paramagnetic agent agent oxo63 (0.75 mmol/kg body weight) was intravenously injected as an oxygen probe, in anesthetized C3H mice after implantation of squamous cell carcinoma (SCC) into the right hind leg 9 days prior to imaging. A 3D data set of pulsed EPRI with single point imaging (SPI) sequence was obtained, and the oxygen concentration was calculated from the apparent line width ($\propto T_2^{*-1}$) information of oxo63. Then the same mouse in the resonator was transferred to the MRI magnet. T_2 weighted spin echo images were obtained to get the tumor anatomy. Intensity and oxygen concentration maps by EPRI were coregistered on the anatomical image by MRI using external positional markers containing 3 mM oxo63 solution.

Results 3D oxygen mapping by pulsed EPRI clearly shows the hypoxic region in the core region of SCC tumor. Available spatial resolution of EPRI would be ± 2 mm and the resolution of oxygen tension is ± 5 mmHg and the acquisition time is about 5 min. The oxygen distribution is consistent with the anatomical information by MRI. The high field MRI can not only provide anatomical information, but also various functional information including blood flow, blood volume, water diffusion etc. can be obtained by special pulse sequences. Therefore, this feasibility of superimposition of EPRI and MRI would be very useful for better understanding of the relationship among tumor hypoxia, blood flow, blood volume, and treatment response.

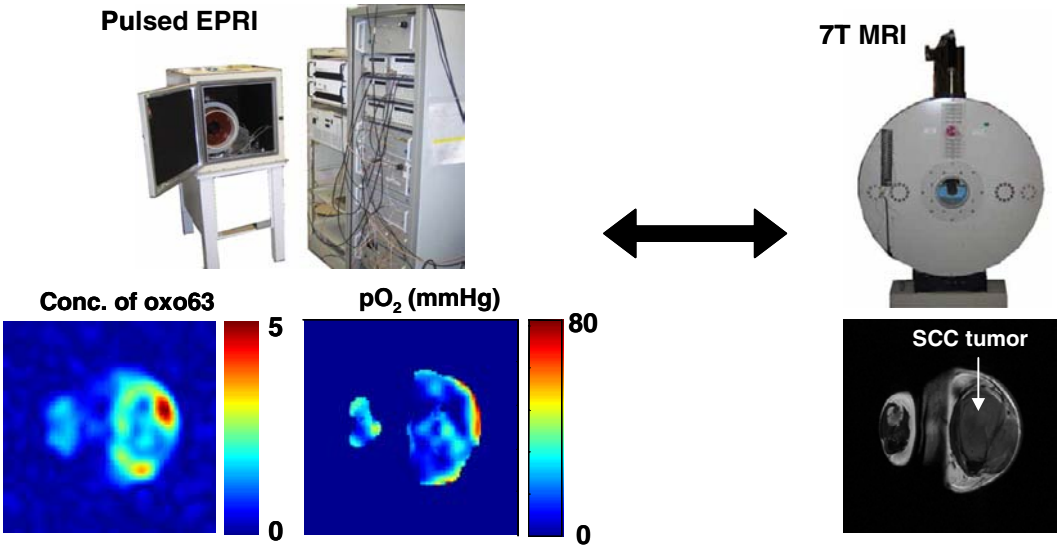

Figure 1. EPRI/MRI superimposition system