NMR Relaxation Time Measurements of 129Xe Dissolved in Tissue and Blood: Toward MR Imaging of Laser-Polarized 129Xe in Tissue

Greg Wilson

Nuclear magnetic resonance relaxation measurements of 129Xe in tissue homogenates and blood were performed to explore the feasibility of magnetic resonance (MR) imaging of laser-polarized (LP) 129Xe in tissues. Laser polarization of 129Xe by optical pumping and spin exchange increases the signal obtained from 129Xe to a sufficient level that, after inhalation of LP 129Xe, it may be detected by MR throughout the body. Image signal-to-noise ratio (SNR) will depend on longitudinal (T1) and transverse (T2) relaxation times of 129Xe in tissues and blood.

129Xe T1 and T2 were measured at 9.4 T and 10 degrees C in rat whole blood and homogenates of rat liver, brain, kidney, and lung at varying oxygenation levels. T1 values ranged from 4.4 +/- 0.4 to 22 +/- 2 s. T2 values ranged from 1.4 +/- 1.0 to 7.00 +/- 0.09 ms. Oxygenation dependence of the relaxation times varied between tissues. The observed oxygen dependence suggests relaxation due to paramagnetic deoxyhemoglobin dominates that due to free oxygen in tissues with sufficiently high fractions of blood. In addition, T1 and T2 of 129Xe in separated blood plasma were measured at both 9.4 and 1.89 T to explore the dependence on field strength. T1 of 129Xe in plasma decreased from 46 +/- 8 to 20 +/- 3 s and T2 increased from 11 +/- 2 to 127 +/- 8 ms when the field strength decreased from 9.4 to 1.89 T.

When an inhalation model of gas delivery to tissue is used, the expected intrinsic SNR for LP 129Xe in gray matter at 9.4 T is approximately 3% of the conventional proton intrinsic SNR at 1.5 T. Short 129Xe T2 values (at 9.4 T) and the finite amount of magnetization available for imaging LP 129Xe further reduce the expected image SNR compared to conventional proton imaging. Several common pulse sequences were modeled to predict their relative effectiveness for imaging LP 129Xe at both 9.4 and 1.89 T. Each modeled sequence predicted higher SNR at 1.89 than at 9.4 T.