# *In vivo* $T_{1\rho}$-weighted MR imaging of rat brain using a surface coil at 11.7 Tesla

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## Introduction

$T_{1\rho}$-weighted MRI is a very useful method for generating tissue contrast. However, it suffers from sensitive to $B_1$ inhomogeneity. Inhomogeneous $B_1$ field causes flip-angle artifacts, especially when using a surface coil at high field strength (11.7 Tesla). In this study, we used a sech-based adiabatic spin-lock spin-echo pulse sequence to overcome the aforementioned complication. To demonstrate the utility of the pulse sequence and to evaluate the tissue contrast characteristics obtained with the technique, high resolution $T_{1\rho}$-weighted MR images of rat brain after focal bicuculline administration *in vivo* were obtained using an 11.7 Tesla spectrometer.

## Methods

All experiments were performed on a Bruker microimaging spectrometer (Bruker Biospin, Billerica, MA) interfaced to an 11.7 Tesla 89-mm bore vertical magnet. A circular $^1$H surface RF coil with an inner diameter 14.9 mm and conductor width of 2.6 mm was used for transmitting and receiving radiofrequency signals at 500.14 MHz. The pulse sequence for $T_{1\rho}$-weighted MRI was shown in Fig. 1. The magnetization vector is tilted by 90$^o$ with the application of the first half of a hyperbolic secant pulse (sech). Then the spin-lock field is applied. The magnetization relaxes along the $B_1$ by the time constant $T_{1\rho}$. The $T_{1\rho}$ relaxation time constant is dependent on the amplitude of the spin lock (SL) field, $B_1$ and typically ranges from zero to a few kilohertz. TSL is the time of spin-lock. Following the SL pulse, the second half of the sech pulse flips the magnetization back to the z axis. This pulse is immediately followed by a strong crusher gradient that destroys any undesired residual transverse magnetization. A spin-echo imaging sequence followed afterward (repetition time/echo time [TR/TE]: 5000 ms/10.13 ms; matrix size: 256 x 256; field of view [FOV]: 2.56 x 2.56 cm$^2$; slice thickness [st]: 1 mm; number of acquisitions [NA]: 2). Male adult Sprague-Dawley rats (body weight: ~200 g) were studied according to the procedures approved by the National Institute of Mental Health Animal Care and Use Committee. All rats were orally intubated and ventilated with a mixture of 70% $N_2O$/30% $O_2$ and 1.5% isoflurane. One femoral artery was cannulated for intermittent sampling of arterial blood for measurement of plasma gases, pH and arterial blood pressure. One femoral vein was also cannulated for administration of 8.4 % sodium bicarbonate, and/or 50% dextrose when necessary for adjusting physiological parameters during the experiment. Bicuculline methiodide (20 mM, 2 µl) was infused in 10 minutes into left dorsal hippocampus (2 mm to the left of middle suture, 4 mm posterior to bregma, and 2.5 mm deep to the surface of cortex) to generate the lesion. Then, the same amount of saline was infused on the opposite of the brain as a control. Images were acquired at 50, 95, 140, 185, 230 and 405 min following the bicuculline infusion. After surgery, anesthesia was maintained using 1.5 % isoflurane.

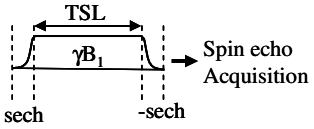


Fig. 1. The spin-lock pulse.

## Results

A representative time course of high resolution (100 µm x 100 µm in-plane and 1 mm slice thickness) on-resonance $T_{1\rho}$-weighted MR images of the bicuculline treated (left) and control (right) hemispheres are showed in Fig. 2. Elevation of signal intensity was first observed at 50 minutes after bicuculline administration in the region of left hippocampus and neocortex. The contrast enhancement spreads out fast until 140 minutes after the bicuculline administration. This spreading became much slower afterwards till the end of experiment at 405 minutes after bicuculline administration. The opposite brain hemisphere, which was the control side, showed a small high signal intensity region in the neocortex, which indicated the needle pathway during the saline administration. However, there were no significant signal intensity changes in the right hippocampus. It was noticed that no significant imaging artifacts were observed in these $T_{1\rho}$-weighted MR images.

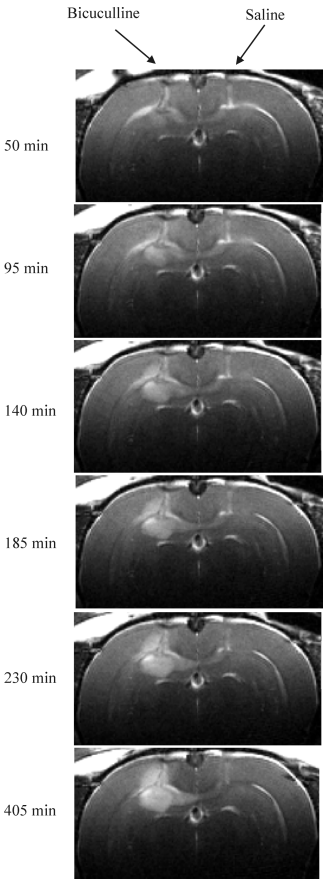


Fig. 2. $T_{1\rho}$-weighted MR images of axial slices of a single rat brain with the focal bicuculline treatment (left) and saline treatment as a control (right).

## Discussion

A sech-based adiabatic spin-lock spin-echo technique was demonstrated here to obtain on-resonance $T_{1\rho}$-weighted MR images using a $^1$H RF surface coil in rat brain at 11.7 T *in vivo*. The technique provided a $T_{1\rho}$ contrast with high spatial resolution, and revealed signal changes after focal bicuculline administration with little imaging artifacts. Similar spin-lock methods have been used in the investigation of $^{15}$N off-resonance rotating frame relaxation rates of macromolecules [1] and acute ischemic stroke using a volume coil in rats [2]. The inherent property of $T_{1\rho}$ is believed to probe processes taking place in protein/water interaction [3, 4, 5, 6]. The measurement of $T_{1\rho}$ values showed that $T_{1\rho}$ remains elevated or increases in tissue destined to neuronal damage in cerebral ischemia [7]. Our results here provided new evidence to the previous investigations in that $T_{1\rho}$ is sensitive to the bicuculline induced ischemia.

## References

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