An 8-Channel Coil Array for Small Animal 13C MR Imaging

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Introduction

Metabolic imaging utilizing hyperpolarized [1-^{13}C]-pyruvate is be a promising technique for investigate cancer metabolism *in vivo* [1]. Due to the short lifetime of the hyperpolarized ^{13}C spins in solution, fast imaging techniques are required. Parallel imaging is an attractive concept for this situation, but requires multi-coil hardware operating at the ^{13}C frequency, and not commonly found on MR scanners. This work presents a multi-channel coil system for small animal ^{13}C MR imaging interfaced with a clinical MRI system.

Methods

We designed and fabricated a coil system consisting of an 8-ch receiving array and a detunable transmit coil (Fig. 1). The array of eight receiving coils was laid out azimuthally around an acrylic cylinder, whose 75mm inner diameter was designed for imaging rodents of up to rat size. Each rectangular receive array element was 75mm long by 50mm azimuthally, and was decoupled with active diodes during RF transmit. Adjacent coils were decoupled by geometrical overlap but due to the small volume, all non-overlapped array elements were heavily coupled (Fig. 2a/b). Therefore, further decoupling was achieved with low-noise low-impedance pre-amplifiers (Fig. 2c) that were housed in a separate package (Fig. 1). This pre-amp box was connectorized to provide the possibility of serving other ^{13}C coil arrays. The transmit coil was a high pass birdcage coil with diameter of 125mm and length 162mm. Each rung was cut and bridged by actively connected diodes to activate the coil only during the transmit phase. The bias power was sent to the transmit coil via a DC bias signal, supplied through a quad hybrid.

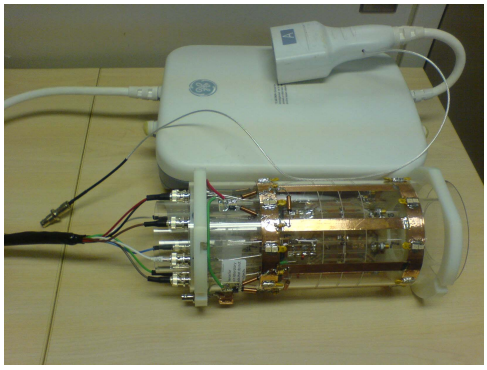

Figure 1, the coil system. 8-ch receive array is inserted into the birdcage transmit coil. Pre-amplifiers are hosted in a separated box.

The coil system was configured for and tested on a GE MR750 3T scanner (GE Healthcare, Waukesha, WI). A large bottle of corn oil (T_1~500ms) was used for RF power / flip angle calibration and used as a phantom for ^{13}C imaging acquisition tests. The calibration was realized by plotting the corn oil ^{13}C resonance peak intensity vs transmit gain (TG). A normal Wistar rat (450 g) was used for *in vivo* imaging. For preliminary *in vivo* experiments gradient echo 2D thick slab projection images (64x64, 18cm FOV, 5 or 10 degree tip angle) were acquired from the torso of the animal following bolus injection of [1-^{13}C] pyruvic acid (CIL, Cambridge MA) that had been hyperpolarized in a DNP polarizer (Oxford Instruments, Abingdon UK) and titrated with a NaOH/Tris/EDTA solution, at a nominal concentration of 80mM pyruvate, and pH ~7.4. The injection volume was 3 ml.

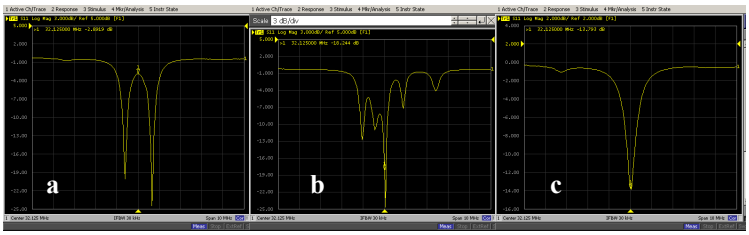

Figure 2, S_{11} of a receive array element; (a) coil 1-3 coupled; (b) all 8 coil coupled; (c) decoupled with low-noise, low-impedance pre-amplifiers.

Results

A perfusion image of the pyruvate in the aorta/inferior vena cava and heart 8s after the start of a 12s bolus of hyperpolarized [1-13C] pyruvate is shown in Fig. 3(a); and in Fig. 3(b), the kidneys were visualized 15s after the start of the injection. Fig. 4 shows the chemical shift images of the corn oil bottle obtained with the 8 separate receive coils. Spatial sensitivity of each coil is clearly distinguishable.

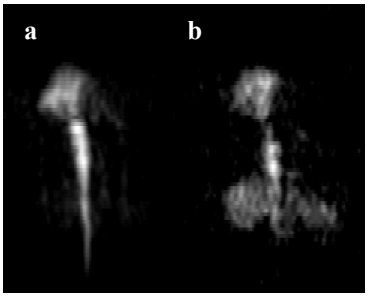

Figure 3, Hyperpolarized ^{13}C 2D MR images of the rat; (a) 8s & (b) 15s after ^{13}C pyruvate injection.

Discussion

An 8-channel ^{13}C receive coil array/preamp system with associated detunable transmit coil system was successfully installed/interfaced onto a clinic MRI scanner without additional hardware. Low impedance pre-amplifiers were used to decouple the heavy coupling between array elements in the extremely small volume. ^{13}C phantom CSI data and *in vivo* images hyperpolarized pyruvate were demonstrated with this coil system. It represents the one of first parallel imaging experiments conducted with hyperpolarized 13C imaging performed with a receive array of 8 elements and parallel imaging.

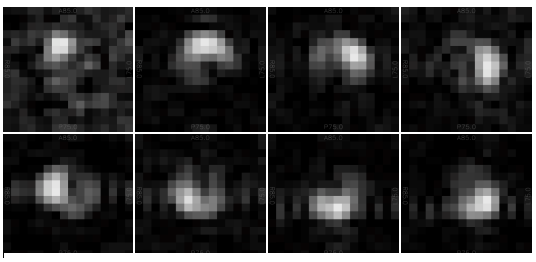

Figure 4, chemical shift images of ^{13}C in corn oil from 8 channels of receiving coil.

References

1. S. Mansson, Eur Radiol (2006) 16 57-67