Tumor Detection in Mice Lung Using Fast Imaging with Steady-State Precession (FISP)

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Introduction

Living lung tissue is one of the most difficult organs to image using conventional MRI techniques [1, 2]. This is mainly due to the low proton spin density in lung parenchyma. Physiologic motions, as well as large variations in magnetic susceptibility associated with air-tissue interfaces, will also lead to significant MR signal loss in proton images. These problems are even more manifest in small rodents because of their much higher cardiac and respiratory rates. The purpose of this study was to implement and evaluate advanced MRI imaging methods for the detection and characterization of small lung tumors in a mouse model [3]. To achieve this, we implemented the fast imaging sequence with steady-state precession (FISP) for the imaging of very small tumor lesions at sub-millimeter resolution, without using gated acquisition.

Materials and Methods

Animal model: A mouse transplacental carcinogenicity lung tumor model [3], developed in Dr. Miller's laboratory, was utilized in this study. In brief, female Balb/c mice were mated with male mice from the same strain, and the pregnant mice were treated with 3-methylcholanthrene (MC) on the 17th day of gestation. The offspring were born and housed for 14 months. Four of the transplacentally-treated offspring were scanned with MRI. At the end of MRI experiments, the animals were sacrificed and the lungs were removed for histology examination.

MR Imaging: All MR imaging was performed using a Bruker 7T Biospec Avance system, equipped with a 12cm actively-shielded gradient set, with a maximum gradient strength of 400mT/m. A 5cm linear birdcage coil was used for both transmitting and receiving. Mice were anesthetized with ketamine/xylazine mixture. Animals were monitored for respiratory rate and temperature during the imaging experiments. However, neither cardiac nor respiratory triggered acquisition was applied in imaging, and the animals respired freely during data collection. Typically, the following MRI parameters were used for image acquisition: FOV 4cm, 0.5-1 mm slice thickness, 128x128 encoding. For the FISP sequence, a TE=1.3ms, TR=2.6ms, flip angle of 60 degree were used for acquisition, with a total acquisition of 16 or 32 averaging.

Results and Discussion

Figure 1 shows six coronal images, from a series of continuous images, acquired using the FISP sequence. Under selected MRI acquisition parameters, the signals from healthy mouse lung parenchyma are very low, while tumor lesions showed up with higher intensities. The size and the location of tumor lesions detected via MR correlated well with histology results. Due to its high SNR nature, the FISP sequence provided the best detectability for very small tumors in murine lungs, down to sub-millimeter sizes. This will allow an accurate detection and characterization of the tumor growth in this model system along the longer term course of longitudinal studies. FISP sequence also offered a fast imaging technique that allowed for a very short echo-time (1.3ms in this study), and it is less sensitive to artifact due to cardiac and respiratory motions, even without using gated data acquisition. Over the period of this study, we have compared several pulse sequences for the detectability of small lung tumors in this model, and found that the FISP sequence produced the best results.

Conclusion

To the best of our knowledge, this is a first study demonstrating the application of FISP sequence in the detection of small lung tumors in a mouse model. Most of the previous studies used fast spin-echo sequences with respiratory or cardiac-gated acquisition. This work showed that high-quality lung tumor imaging in mice is feasible with the FISP sequence.

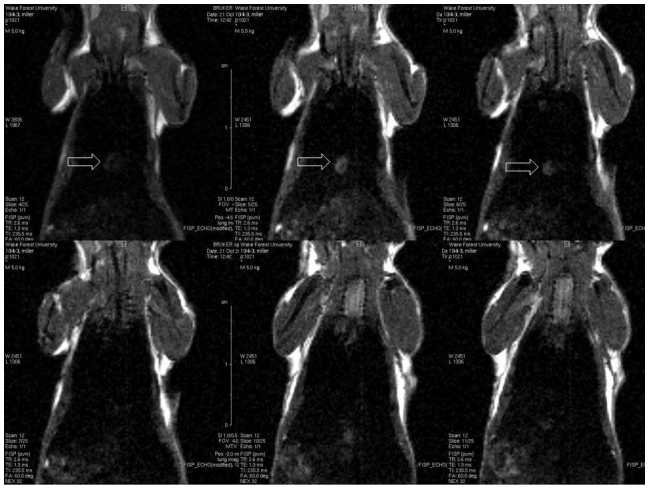

Figure 1:

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References:

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