Feasibility of BOLD Magnetic Resonance Imaging of Lung Tumors at 3T

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Introduction

Significant progress has been made in early detection and therapy for non-small cell lung cancer (NSCLC). However, lung cancer remains the leading cause of cancer death. Better characterization of lung tumors will allow for individualized therapy. There is increasing evidence that hypoxia in tumors predicts poor outcome for many tumor types including lung malignancies, most notably with respect to radiation therapy [1]. Noninvasive assessment of tumor vascular oxygenation using BOLD (Blood Oxygenation Level Dependant) MRI is currently applied in studies of breast, cervix, and head & neck cancers [2]. BOLD imaging of lung tumors is challenging due to artifacts caused by blood flow, respiratory and cardiac motion, and the susceptibility effects of the surrounding lung tissue. In this study, we evaluate the feasibility of applying BOLD MR imaging in untreated NSCLC.

Methods

Five patients with a biopsy proven non-small cell lung cancer were consented to participate in this on-going study. All studies were conducted with a 6-element SENSE cardiac coil on a 3T MR scanner (Achieva, Philips Medical Systems, Cleveland, USA). Patients wore a face mask for delivery of air and oxygen at the beginning of the study. High-resolution T_2-weighted anatomical images were acquired to locate the tumor. T_2*-weighted BOLD images were obtained from the tumor using a multi-echo gradient-echo technique (TE = 2~40 ms, TR = 65 ms) while patients breathed room air, then while breathing100% oxygen at 8 L/min via the mask. Measurement of tumor response to oxygen challenge was performed by calculating T_2* values within an ROI placed in the tumor manually. Fitting the image intensity versus TE curve to a single exponential function was accomplished using IDL program.

Results & Discussion

Different imaging techniques and strategies were tested to optimize BOLD imaging of non-small cell lung cancer. The conventional EPI-based imaging technique did not yield good quality BOLD images of the tumor, due to the artifacts from respiratory and cardiac/blood motion, and susceptibility effects of the surrounding lung tissue. Therefore, a multi-echo gradient-echo sequence was used to measure the BOLD response in this study. Breath-hold imaging was attempted in an effort to immobilize the lung tumor during imaging. However, difficulty was encountered due to variation in diaphragm/lung position during different breath-holds, as well as the fact that most of the lung cancer patients could not tolerate longer breath-hold attempts. Respiratory-gating was thus used throughout the MRI exam to ensure the same anatomy was imaged. Figure 1 shows representative multi-echo T_2*-weighted sagittal images obtained from a lung cancer patient while breathing air and oxygen. In this patient, three T_2* maps were acquired during air-breathing (~3 min), followed by eight T_2* maps acquired during oxygen-breathing (~8 min). Tumor T_2* values from a manually selected ROI are shown in Figure 2.

Conclusion

Our preliminary study has shown the feasibility of using the respiratory-gated multi-echo gradient-echo technique for oxygen-sensitive BOLD MR imaging of lung cancer. Quantitative T_2* measurements demonstrated the tumor vascular oxygenation changes in response to oxygen-breathing. More patient studies are needed to determine if noninvasive BOLD MRI is an effective and robust method to detect tumor hypoxia prior to therapy in order to serve as a prognostic indicator.

References

(1) *Current Oncology Reports* 2008, 10:277-282. (2) *Imaging Med* 2009, 1:11-13.

Figure. 1 Multi-echo T_2*W images of lung tumor with a manually drawn ROI.

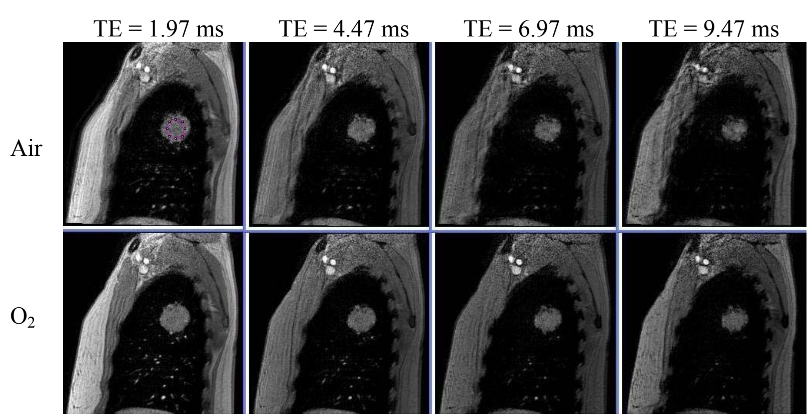

Figure. 2 T_2* measurements from the tumor in Figure 1.