Differentiation of Lung Adenocarcinoma from Normal Tissue Using T_1-weighted FID Projection Imaging

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Introduction: While it is possible to make high quality spin density and T_1-weighted images of lung tissue using FID projection imaging, the aim of this work is to address the issue of whether the available contrast is useful for differentiating lung cancer from normal tissues. Several previous studies have addressed the issue of contrast between normal and diseased tissue in animals with lung cancer (e.g., Ref. 1), but we are aware of only one study (Ref. 2) in which the measurements were performed *in vivo*. In that case, T_1 image contrast was investigated using T_1-weighted and spin density weighted spin echo imaging of human subjects. In this study, we investigate pure T_1 contrast (without T_2-weighting or contrast agents), *in vivo*, in a nude rat with human lung adenocarcinoma.

Methods: The rat of Fig. 1 was irradiated to suppress its immune system and subsequently received an intratracheal instillation of Calu-6 human adenocarcinoma cells. Approximately 6 weeks post-instillation, the 260 g rat was imaged in a 1.9 T magnet under sodium pentobarbital anesthesia, using a mechanical ventilator which holds the lung at constant volume for 0.42 s of each 1 s ventilatory cycle. The imaging pulse sequence (TR=3.5 ms, Nex=4) consists of an excitation pulse (2^o for spin density, 9^o for T_1-weighting) applied in the presence of an imaging gradient (60.5 mT/m), with data collection (512 pts at 1 MHz) commencing ~5 μs after excitation. The sequence is repeated for 53700 different gradient directions. Consecutive gradient directions are roughly perpendicular, so that each imaging gradient also serves as a spoiling gradient. The total imaging time is 30 min. Two FIDs per breath are collected with lowered gradient strength to determine k_0, allowing the 26850 1D projections to be calculated, despite the data missing due to the receiver dead time. The 1D projections are Fourier transformed and gridded onto a Cartesian grid, which is Fourier transformed to yield a 3D image with 0.37 mm isotropic resolution with negligible point spread due to T_2* filtering.

Results: Fig. 1 shows the same coronal plane from the 3D T_1-weighted and spin density images. The image intensities were scaled such that each image has the same average intensity. Regions of interest (ROIs) corresponding to different tissues in the right and left lungs were chosen for analysis. The locations of the ROIs are indicated on the spin density image (P=parenchyma, T=tumor, V=blood vessel, and M=muscle). The mean and standard deviation of the mean was determined for each ROI (see Fig. 2). The spin density of tumor was much higher than that of parenchyma and similar to that of blood vessels and muscle, as expected. The fractional T_1 contrast for each ROI was taken to be the difference in the mean intensities (T_1w minus SD), divided by the mean intensity of the ROI in the spin density image, i.e. $(I_{T1w}-I_{SD})/I_{SD}$. The T_1 contrast displayed by the blood and muscle ROIs is substantially different than that of tumor tissue, allowing these tissues with similar spin densities to be differentiated.

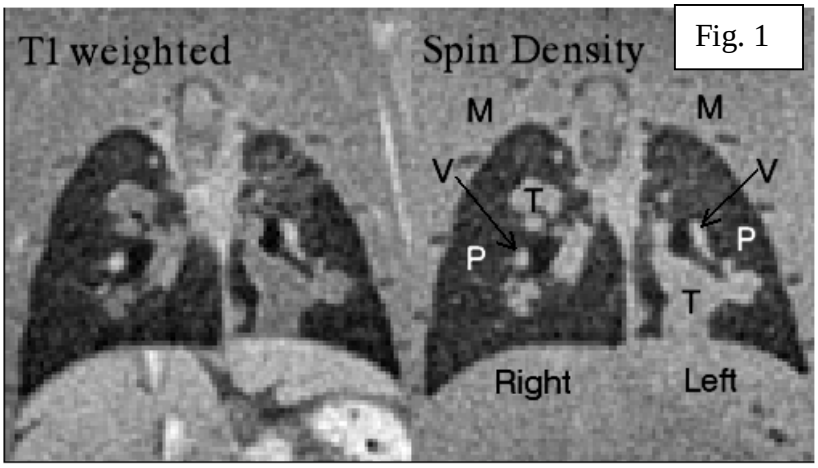

Fig. 1

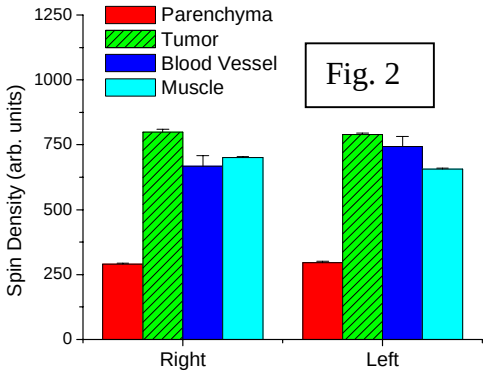

Fig. 2

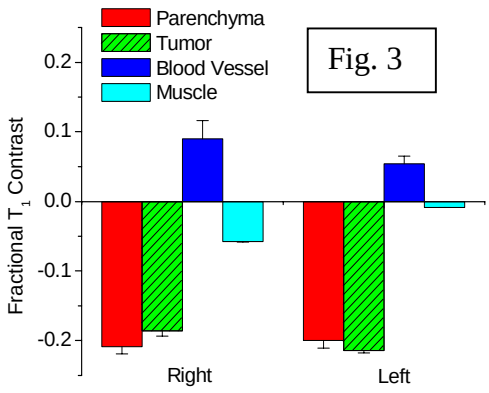

Fig. 3

Conclusion: This preliminary study suggests that endogenous spin density contrast is useful for differentiating tumor tissue from healthy parenchyma in FID projection imaging, and more importantly, that endogenous T_1 contrast allows the differentiation of tumor from normal tissues (blood vessels, muscle) with similar spin densities.

References: 1. Shioya et al, 'Lung Cancer: Differentiation of Tumor, Necrosis, and Atelectasis by Means of T_1 and T_2 Values measured *in vitro*', Radiol. 1988;167:105-9. 2. Falschi et al, 'Usefulness of MR Signal Intensity in Distinguishing Benign from Malignant Pleural Disease,' AJR 1996;166:963-968.