A comparison of T2*decay in normal and abnormal lungs using a 3D Ultrashort TE sequence

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Target Audience: Radiologists, radiographers, physicists and clinicians with an interest in lung imaging.

Purpose: Aeration of the lung and reduced tissue density makes signal return from lung parenchyma virtually nil on conventional T2-W images. Use of an ultrashort TE (UTE) technique offers the opportunity to acquire signal before significant decay and thus measure the apparent T2 relaxation of lung tissue; this is particularly valuable in abnormal, emphysematous lungs where the breakdown of normal structure shortens T2* further and diminishes signal return[1]. The purpose of this study was to implement UTE for lung imaging at 3T and measure the T2* relaxation times of normal lung in volunteers and abnormal lungs in patients with lung cancer post radiation therapy.

Methods: A shortest TE was ensured by minimising the switching time of the receiver coil between detuned and resonant states, without introducing image artefacts. Correction of gradient timings was made for UTE sensitivity to small differences between gradient prescription and execution. Normal volunteers aged 25-40 years (n=6) and patients with lung cancer aged 59-79 years (n=6, 3 post radiotherapy) were scanned on a Philips Achieva 3T system, using a SENSE XL torso coil. All subjects were imaged using a UTE sequence (3D FFE radial acquisition, 192 slices; 3.5mm slice thickness, FOV 350mm, voxel size 3.5x3.5x3.5mm, TR 10ms, 1 NSA, matrix 192x192) in the transverse plane to cover from the dome of the diaphragm to lung apices. The sequence was run seven times using TE values of 0.08, 0.2, 0.3, 0.4, 0.5, 0.75 and 1.0ms during shallow respiration. Morphological imaging was provided by coronal breath-held T1w e-THRIVE and transverse respiratory-triggered T2W TSE sequences. Total imaging time was approximately 40 minutes. T2* estimates were generated from the rate of decay of signal with increased TE from whole lung ROIs at apex, hila (excluding the hilar vessels) and base (immediately above the diaphragm) drawn around both right and left lungs and averaged (**Figure1**). Patients with lung cancer and radiotherapy to the tumour 44±25 months previously were imaged using a similar protocol. ROIs around the whole lung at similar levels to those in the volunteers (apex, hila, base) were used to derive T2* estimates from a monoexponential fit of the signal decay with TE and were averaged between right and left lungs in the same manner. In addition an ROI to encompass the whole lung was done at the level of the radiation therapy in the affected lung (avoiding any residual mass) in the 3 patients who had received treatment (**Figure 2**).

Results: The mean and standard deviation of T2* values of apical, hilar and basal ROIs are compared in **Table 1**. There was a significant difference between normal volunteers and patients at hilar and basal regions, but not at the apices (**Table 1**). In both normal volunteers and patients, estimated T2* was also significantly higher at the hilum than at the apex or base (paired t-test, normal volunteers p= 0.00004 and 0.004 respectively, patients 0.01 and 0.002 respectively). T2* estimates in a segment of lung in the radiation field in the 3 patients (Fig 2b, light blue outline) were 1.32 ms, 1.39 ms, and 1.08 ms. These values were higher than those in non-irradiated lung at that level (1.23ms, 1.27ms and 1.02ms respectively).

Figure 1: ROIs for volunteer at hila

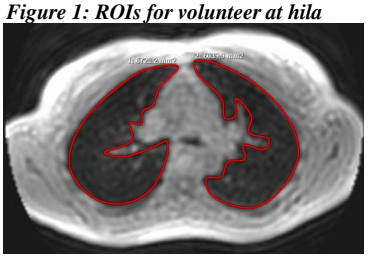

Figure 2a:ROI in "normal" appearing lung at level of radiotherapy

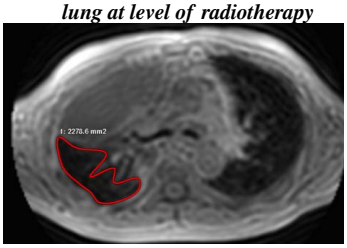

Figure 2b: Radiation therapy field showing dose distributions

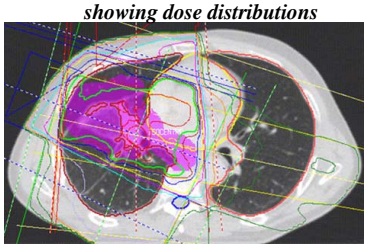

Table 1: Comparison of T2 values from whole lung regions at apical, hilar and basal levels*

	T2* (ms)		p –value (independent samples t-test)
	Normal Volunteers	**Patients**	**Normal Volunteer vs. patients**
Apex	1.17 ± 0.04	1.09 ± 0.09	0.08
Hilar	1.38 ± 0.04	1.20 ± 0.09	**0.001**
Base	1.20 ± 0.04	1.12 ±0.07	**0.04**

References: 1. Takahashi M, JMRI, 2010, 32,326-33.
2. Yu J, et al, MRM 2011, 66, 248-54

Discussion and Conclusions: Our values for normal lung are higher than in other literature at 3T where T2* estimates of <1ms are described[2]. The higher T2* estimates in normal volunteers compared to patients may be due to the emphysematous lungs of patients, where there is more air and less lung parenchyma and fits the data from murine models[1]. The significant difference between the hilar region and base or apex in both volunteers and patients is likely due to the presence of large vessel branches in this region, although care was taken to avoid them. The higher T2* estimates from lung segments being irradiated adjacent to tumor is surprising given the tight dose distributions indicated by the intensity-modulated radiotherapy fields (light blue). However, the number of patients is small and would require a larger number of subjects for assessment, as well as an interrogation of any T2* changes with radiation dose.

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