Influence of lung filling on T2* values in human at 1.5 T with hyperpolarised ^{3}He

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Introduction

Most lung images of hyperpolarised gases are acquired with gradient echo techniques (either FLASH, EPI or spiral), the signal duration of which is given by transverse relaxation time T_2*. Hence, assessment of T_2* is useful not only to settle the best sequence parameters (e.g. readout bandwidth) but also to understand the image contrast. As with proton imaging, T_2*-weighted images might provide a diagnosis tool. Helium-3 T_2* was shown to increase as the voxel size decreases[1]. Indeed, in a large voxel, T_2* may be mainly determined by large-scale magnetic field heterogeneity. Thus, to assess the local characteristics of a given tissue, it is necessary to measure its signal in a small voxel. T_2* also depends on the magnetic field intensity, being roughly inversely proportional to B_0[2,3]. Another parameter, intrinsic to the lungs, is the dependence on alveoli size.
The aim of this work was to determine the influence of lung inflation on T_2* in human, at 1.5 T, with inhaled hyperpolarised ^{3}He.

Material and Methods

Measurements were performed on a normal, non-smoker subject (senior member of the team among the authors) with a 1.5 T imaging unit. Helium-3 was polarised by the metastability exchange technique and doses of about 15 standard cc fully polarised were administered to the subject . For every acquisition, inhaled and exhaled flows were monitored by a MRI-compatible system. Each lung volume was calculated by reference to the functional residual capacity (FRC). The absolute value for FRC was taken from tables for normal subjects [4]. The absolute volume in lungs could thus be continuously monitored. Coronal slices were acquired with the interleaved single-echo, dual echo-time FLASH sequence described on figure 1. This sequence has the advantage over a dual-echo sequence that only T_2* influences the signal decrease between TE_1 and TE_2.

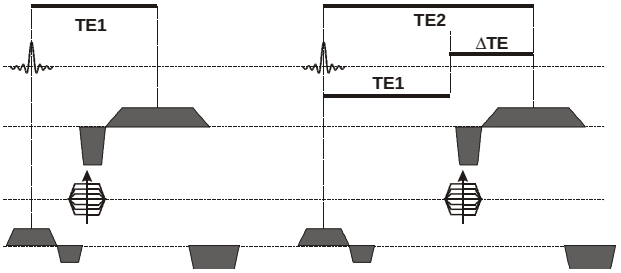


Figure 1 – Interleaved single-echo, dual echo-time, spoiled gradient-echo sequence.
TE_1=3 ms; TE_2=8 ms (TR=7.1 ms/12.1 ms)
40 cm field of view, 64×32 matrix
nine 2-cm thick slices
voxel size: 1560 mm^3
16 kHz readout bandwidth
flip angle ~10° (the TE_2 image was corrected for the longitudinal decay due to flip angle)

To calculate T_2*, for each slice, a mask was taken on the magnitude of the reconstructed image taken at TE_1, using a threshold set at thrice the noise standard deviation. This mask was applied to both TE_1 and TE_2 images and the mean magnitude for each image was calculated. T_2* was derived from the ratio between the two mean magnitudes. This approach had proven more robust than pixel-to-pixel approaches in preliminary simulations, including Rician noise, with a signal-to-noise ratio similar to the experimental one (in the range 7-20).

Results

Figure 2 shows the lung volume-dependence of T_2*, which is highly significant ($p<0.001$), showing an increase in T_2* when lungs inflate.

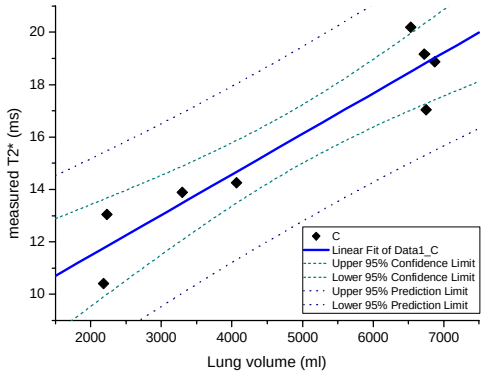
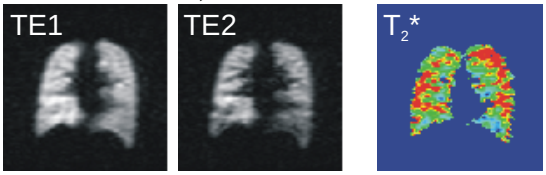


Figure 2 (left) – Measured T_2* as a function of the absolute lung volume at the acquisition time. Each point represents the average of T_2* on every slice in an acquisition, weighted by the inverse of variance. T_2* is around 13 ms at Residual Volume and 19 ms at Total Lung Capacity.

Figure 3 (bottom) – A slice at both TE and parametric T_2* image (from red=25 ms to blue=0 ms)



Intra-slice distribution showed a marked heterogeneity, especially shorter T_2* around hilum (figure 3). Inter-slice analysis showed no significant dependence of anterio-posterior position but only a trend (T_2* slightly longer in anterior i.e. upper parts) at residual volume.

Discussion and Conclusion

These experiments show that, in human, T_2* positively correlates with alveolar size. When performing T_2* measurements, ventilation monitoring is therefore desirable. This correlation is in agreement with the results [1,5] carried on Guinea Pigs at 0.23 and 1.5 T. The alveolar size definitely plays a role in the ^{3}He image contrast in gradient echo sequences. Further studies are needed to determine whether this can be used to diagnose diseases such as emphysema.

References:

1-Olsson *et al.* (ESMRMB 2002) – **2**-Salerno *et al.* (ISMRM 2002) – **3**-Vignaud *et al.* (ESMRMB 2002) – **4**-Quanjer *et al.* (Eur Respir J 1993;6:5) – **5**-Chen *et al.* (Magn Reson Med 1999;42-729)

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