Reduction of ventilated lung volumes in smokers vs non-smokers as measured by Single Shot Fast Spin Echo 1H MRI and Hyperpolarized 3He MRI

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Synopsis: A combination of 3He ventilation MRI and 1H anatomical MRI was used to assess reduction in ventilated lung volumes in age matched groups of healthy non-smokers, healthy smokers and smokers with diagnosed obstructive lung disease. The ventilated volume from the 3He images was subtracted from the thoracic volume calculated from the Single Shot Fast Spin Echo images. A reduction in ventilated volume was observed in all groups, the largest reduction being in the group with diagnosed obstructive disease.

Methods: The lungs of 18 volunteers, 8 non-smokers, 5 healthy smokers and 5 smokers with diagnosed obstructive lung disease, were imaged using 1H MRI and 3He ventilation MRI in the coronal plane. Both MRI examinations were performed on a 1.5 T Edge Eclipse system, (Philips Medical Systems) which was modified to transmit and receive at the 3He frequency. 3He gas was polarized on site to approximately 30% using a spin exchange polarizer (Amersham Health). For the 3He ventilation study, 19 slices were collected during a 14s arrested breath-hold, after inhaling a mixture of 200ml 3He /800 ml N2 from a Tedlar bag from a starting point of functional residual capacity. The sequence was a 2D gradient recalled echo (TR=131ms TE=3.4ms, flip angle=5°, FOV=400mm, Slice thickness=12mm, Matrix=112 views x 128 samples). The 1H MRI images were acquired during a 20s of arrested inspiration after inhaling 1000 ml of room air from an identical Tedlar bag (reproducing the breath-hold procedure of the 3He scan). The sequence used was a single shot fast spin echo (TE eff. = 61.1ms, ETL=140, flip angle=90°, FOV=400mm, Slice thickness=10mm, Matrix=256x256). The ventilated lung volumes[1] for each volunteer were calculated from the 3He images by manual segmentation of signal intensity. Thoracic volumes were calculated from the proton scans by manual segmentation of the signal void [2].

Results: The non-smoking group demonstrated mainly homogenous distributions of 3He throughout the lungs; ventilation defects if present were all minor. The difference in volume between the 1H and the 3He scans for the non-smoking group showed a 10%, 95% C.I. (-7.29, 27.29) mean reduction in ventilated volume. All subjects in both groups of smokers exhibited ventilation defects on the 3He ventilation images, the majority of these defects being classified as either medium or large. The healthy asymptomatic group of smokers was found to have a mean ventilated volume reduction of 24.8%, 95% C.I. (5.95, 43.65). The group of smokers diagnosed with obstructive lung disease demonstrated the largest mean reduction in ventilated lung volume of 34.4%, 95% C.I. (30.05, 38.77).

Conclusions and discussion: The mean volume reduction of 10% in the non-smoking group could be attributable to a combination of minor ventilation defects in some subjects and loss of signal in the 3He images through magnetic susceptibility differences at the lung periphery[3]. The 95% confidence interval stated for this group also indicates non-significance. This signal loss would also apply to the smoking groups. The 95% confidence intervals quoted for the smoking groups indicate statistical significance, especially in the group with diagnosed obstructive lung disease. Combined SSFSE/3He MRI of the lungs is a non-invasive method, using non-ionising radiation, which demonstrates regional ventilation and has potential for calculating both global and regional reductions in ventilated lung volume[4]. Further comparative studies with established pulmonary function tests are planned, as is the development of an automated approach to image segmentation. These preliminary results suggest that this technique could prove useful in assessment of severe COPD patients scheduled for lung volume reduction surgery.

References: