# MRI EQUILIBRIUM SIGNAL MAPPING IS A QUANTITATIVE AND REPRODUCIBLE ALTERNATIVE TO CT FOR THE ESTIMATION OF LUNG DENSITY IN COPD

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**Introduction:** In MRI, the equilibrium tissue magnetisation is proportional to tissue water density. The aim of this study was to explore the feasibility and reproducibility of mapping the signal ($S_0$) associated with the equilibrium magnetisation in the assessment of structural abnormalities in COPD. We compare quantitative $S_0$ ($qS_0$) values with CT measures of lung tissue density.

**Method:** Ethical approval and written informed consent were obtained. MRI: MRI images were acquired in 12 COPD patients (64±7 yrs, GOLD stage 2-3) and 12 healthy volunteers (63±12 yrs) twice within 1 week on a 1.5 tesla Philips Achieva using a coronal 2D inversion recovery half-Fourier single-shot turbo spin-echo sequence for the measurement of $T_1$ and $S_0$ maps via pixelwise fitting [1]. Lung $S_0$ values were normalized by dividing by muscle $S_0$ to provide a quantitative $S_0$ ($qS_0$) value to account for day-to-day scanner settings. Short TE was used to minimise $T_2$ influence on the $qS_0$ values. Scanning parameters: TR/TE 6000 ms/3.2 ms, TI=50, 300, 1100, 2000, 5000 ms, 128 x 128 matrix, 10 mm thickness, pixel size 3.52 mm x 3.52 mm, free breathing, no respiratory or cardiac triggering. All images were registered to the position of end expiration [2]. Quantitative CT: multi-slice CT was performed once on COPD patients only. A single slice which matched the MRI slice was selected for the calculation of the 15th percentile lung density (PD 15) and the relative lung area with attenuation value less than -950 HU (RA -950).

**Result:** All COPD patients showed moderate to severe emphysema in the selected CT slices, with the RA-950 ranging from 8.3% to 41.8%. $qS_0$ maps of the lung were reproducible in both groups (Figure. 1). The Bland-Altman plots (Figure. 2) show a good agreement between the two measurements of the mean $qS_0$ values of the lung, with an intraclass correlation coefficient (ICC) of 89.3% for healthy group and 88.5% for COPD group. The low value areas in $qS_0$ maps of the COPD lungs (blue) had a good consistency with the CT detected emphysema areas (red). The mean lung $qS_0$ value was significantly lower in COPD group than in healthy group, while the inter quartile range of mean lung $qS_0$ values of the two groups were similar (Table. 1). The mean and the 15th, 25th, 50th (median), 75th percentile $qS_0$ values showed strong positive correlations with $PD_{15}$ and negative correlations with RA -950 (Table. 2, Figure. 3).

**Conclusion:** Equilibrium signal maps extracted from MRI correlate strongly with CT density estimates, indicating that $qS_0$ may be a reproducible, non-invasive, non-ionising measure for quantifying lung density abnormalities in COPD.

**References:** 1) Kingsley, P.B. and Gordon Monahan, W., *Magn Reson Imaging*, 2001. 19(2): p. 279-282. 2) Naish, J.H., et al., *Magn Reson Med*, 2005. 54(2): p. 464-469. **Acknowledgement:** This work was supported by the EPSRC and AstraZeneca.

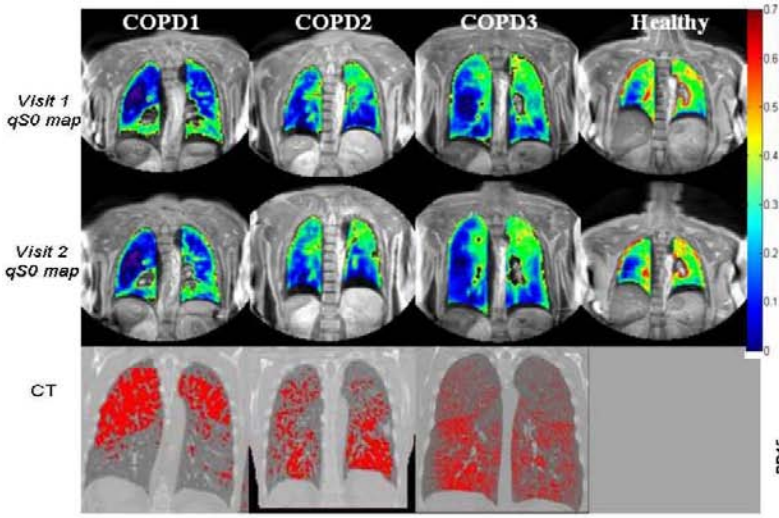


Figure. 1. Example lung $qS_0$ maps and the corresponding CT images with areas of attenuation value below RA -950 HU showing in red.

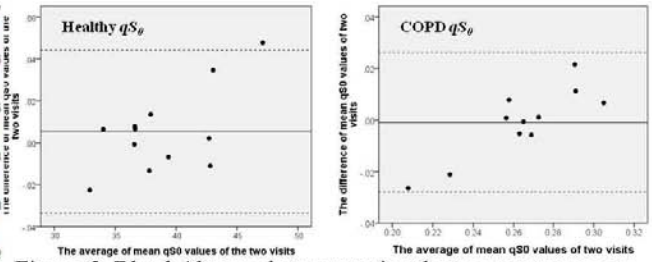


Figure. 2. Bland-Altman plots comparing the two measurements of the mean lung $qS_0$ in healthy group (left) and COPD group (right).

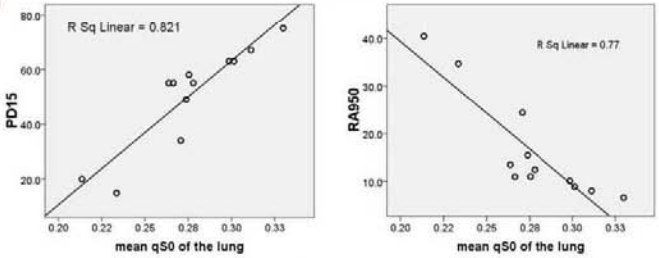


Figure. 3. Scatter plots showing the correlation between lung $qS_0$ values and $PD_{15}$ (left) and $RA_{-950}$ (right) in COPD

Table.2. Pearson correlation between lung $qS_0$ values and CT parameters

| | | Mean $qS_0$ | 15th centile $qS_0$ | 25th centile $qS_0$ | 50th centile $qS_0$ | 75th centile $qS_0$ |
|---|---|---|---|---|---|---|
| PD15 | CC† | 0.906** | 0.837** | 0.866** | 0.919** | 0.887** |
| RA-950 | CC† | -0.878** | -0.820** | -0.823** | -0.877** | -0.875** |

† Correlation coefficient; ** p value < 0.01.

Table.1 The comparison of the lung $qS_0$ between 2 groups

| | Healthy | COPD | p-value |
|---|---|---|---|
| mean $qS_0$ | 0.39±0.05 | 0.28± 0.03 | <0.001 |
| IQR $qS_0$ | 0.13±0.02 | 0.14±0.02 | 0.547 |