

# Navigator triggered oxygen-enhanced MRI in patients with interstitial lung disease

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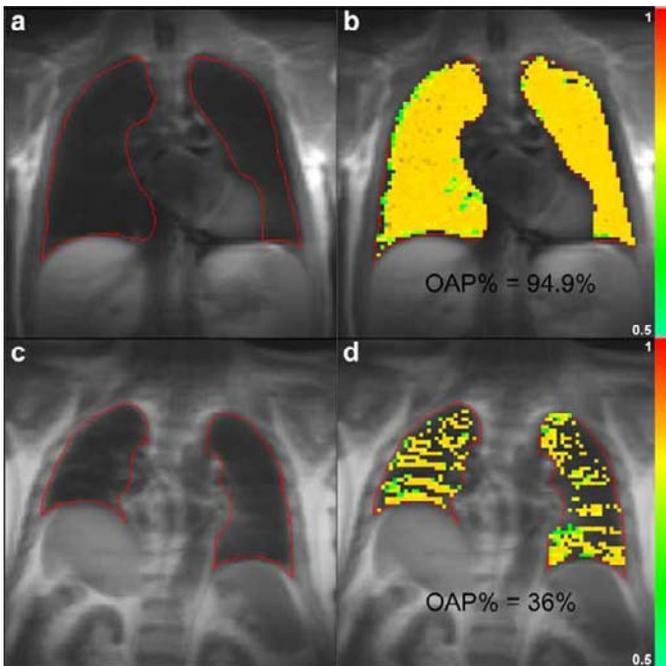
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## Purpose

The assessment of lung function in oxygen-enhanced magnetic resonance (MR) imaging is achieved with an inversion-recovery half-Fourier single-shot turbo spin-echo sequence (IR-HASTE). To minimize the physiological signal variability of the lung<sup>1-3</sup>, which interferes with the detection of oxygen-induced SI changes, ECG<sup>4,5</sup> or respiratory triggering<sup>6,7</sup> are required. The aim of this study was to evaluate an optimized method to perform oxygen-enhanced MRI of the lung, combining ECG and navigator trigger in a double triggering technique, for simultaneous cardiac and respiratory synchronization. The results of navigator-triggered oxygen-enhanced ventilation imaging were compared with the pulmonary functional tests (PFT) used for the assessment of alveolar gas exchange.

## Method and Materials

12 healthy-volunteers (age-range:20-32y) and 10 patients (age-range:37-87y) with interstitial lung disease (ILD) underwent pulmonary function tests (PFTs) and oxygen-enhanced MRI. The transfer lung factor for carbon monoxide (Tlco [mmol/min/kPa]) and the transfer coefficient (Kco; Tlco/Va [mmol/min/kPa/l]) were measured using the single breath (sb) method. The partial pressure of oxygen (pO<sub>2</sub> [mmHg]) and oxygen saturation (O<sub>2</sub>Sat [%]) in peripheral blood were measured with a conventional blood gas analyzer. Oxygen-enhanced MRI was performed on a 1.5T MR-scanner. The paradigm room-air – O<sub>2</sub> – room-air was acquired with a nonselective-IR-HASTE (TE=12msec;TI=1200msec). Set-up parameters for navigator-trigger were adapted to achieve end-expiratory synchronization of images. A 2 mm acceptance window was used as tolerance level for maximal diaphragm mismatch. ECG trigger was used to obtain cardiac synchronization in the diastolic phase. Simultaneous cardiac and respiratory triggering was achieved by assigning triggering capabilities only to those navigator echoes with a fixed delay from a triggering R wave. A double triggering event occurred when those selected navigator echoes matched an acceptance window. In a post-processing phase, inhouse-developed software was used to further reduce respiratory motion artifacts. Cross-correlation analysis was performed in ROIs encompassing both lungs (r-value=0.5; p-value=0.01 as thresholds). The percentage of activated pixels over the total number of pixels in the ROIs (OAP%) was calculated from both lungs (Fig. 1). Mean OAP%s calculated from ILD patients and from volunteers were compared (Mann-Withney test). The correlation between OAP%s and PFTs was assessed with the Spearman test.



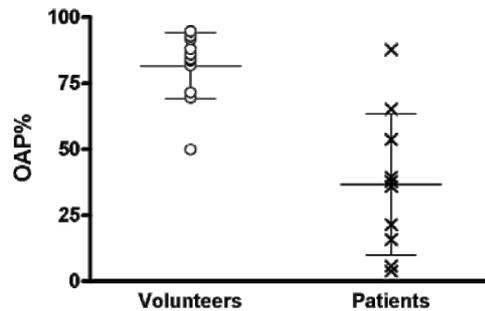
**Fig. 1.** ROIs encompassing both lungs (a – c) and relative cross-correlation maps (b – d): examples from a volunteer (a – b) and a patient (c – d). The percentage of oxygen-activated pixels over the total number of pixels in the ROIs (OAP%) are reported under the correlation maps.

## Results

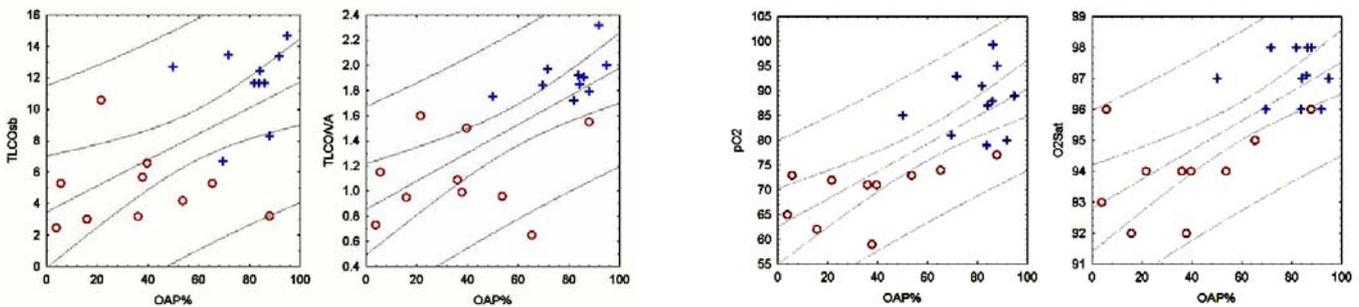
The double triggering method reduced artifacts from cardio-respiratory motion. Free-breathing end-expiratory acquisition was time-effective and not tiring for all subjects. Image post-processing further reduced the signal variability. The mean OAP% of patients was significantly lower than that of volunteers ( $31.7 \pm 16.6$  vs  $81.7 \pm 7.1$ ;  $p = 0.001$ ; Fig. 2). OAP%s correlated significantly with Tlco ( $r = 0.64$ ;  $p = 0.002$ ), with Tlco/Va ( $r = 0.75$ ;  $p < 0.001$ ), with pO<sub>2</sub> ( $r = 0.77$ ;  $p < 0.001$ ), and with O<sub>2</sub>Sat ( $r = 0.70$ ;  $p < 0.001$ ).

## Conclusion

Oxygen-enhanced MRI of the lung using navigator and cardiac triggering is an efficient imaging method and has a potential role in the functional assessment of ILD. Navigator and cardiac trigger combined in a double triggering method can be used for simultaneous control of cardio-respiratory motion.



**Fig. 2.** Comparison of OAP% between volunteers and patients. All dots are aligned according to volunteers or patients group. Horizontal large lines indicate mean values. Error bars indicate standard deviations.



**Fig. 3.** Spearman correlation between OAP%s and PFTs. Red circles represent patients. Blue crosses represent volunteers.

**References:** 1. Mai VM, et al. Magn Reson Med. May 2000;43(5):760-763. 2. Knight-Scott J, et al. J Magn Reson Imaging. Oct 2001;14(4):411-418. 3. Bankier AA, et al. J Magn Reson Imaging. Dec 2004;20(6):961-966. 4. Loffler R, et al. Magn Reson Med. Jun 2000;43(6):860-866. 5. Mai VM, Magn Reson Med. Jun 2000;43(6):913-916. 6. Ohno Y, Magn Reson Med. Jun 2002;47(6):1139-1144. 7. Ohno Y, et al. Eur J Radiol. Nov 2004;52(2):200-205.