Improvement of Multislice Oxygen-Enhanced MRI of the Lung by Fully Automatic Non-Rigid Image Registration.

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Purpose

In oxygen-enhanced MRI of the lung (O2-MRI) [1], inconsistencies of respiratory phase may influence the quality of parametric O2-maps [2-3]. In this study, fully automatic non-rigid image registration was assessed as a postprocessing method to improve the quality of O2-MRI [4-6].

Method and Materials

Twenty healthy subjects (mean age: 49.4y; age range: 41–63y) were investigated on a 1.5-T scanner. O2-MRI was obtained in four coronal planes using a nonselective IR-HASTE sequence (TE/TI=12/1200 ms). In each subject, 30 images per slice location were obtained at O2 and room-air ventilation. Both datasets were aligned spatially using fully automatic non-rigid registration (5–10 sec per slice location). Nonregistered (NR) and registered (R) images were used separately as inputs to two post-processing algorithms that calculated pixelwise coefficient of variation of signal per each ventilation phase (CV-t maps), and relative enhancement ratio between oxygen and room-air ventilation (RERO2 maps, Fig. 1). From those parametric maps, mean CV-t and RERO2 of both lungs were calculated using regions of interest (CV-t-oxygen-NR, CV-t-oxygen-R, CV-t-roomair-NR, CV-t-roomair-R; RERO2-NR, RERO2-R); coefficients of variation expressing spatial heterogeneity of RERO2 maps were also assessed (CV-s-O2-NR; CV-s-O2-R). Within-group, within-subject and within-slice comparisons between NR and R datasets were performed.

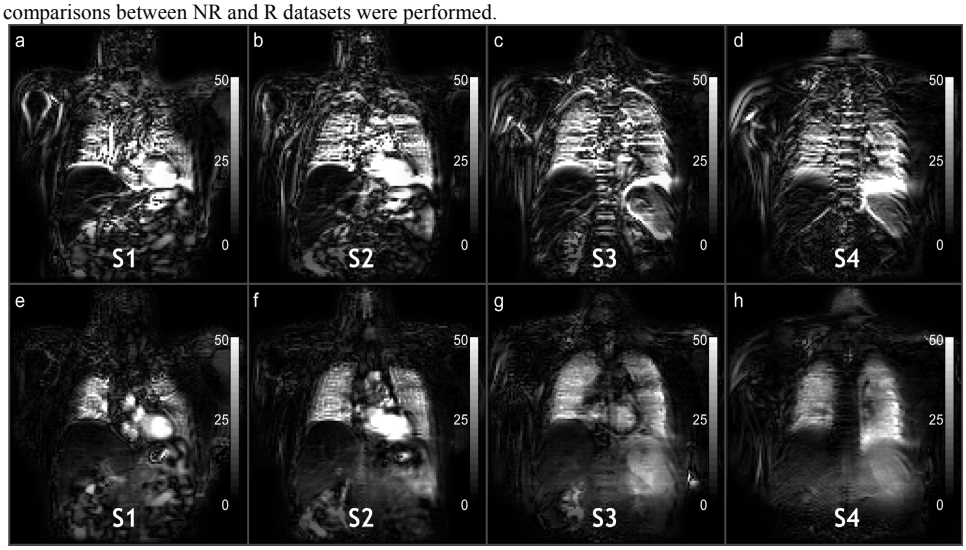

Fig. 1. RERO2 maps computed from one subject; a–d = before image registration; e–h = after image registration.

Results

In registered datasets CV-t was significantly reduced: CV-t-oxygen-NR=6.6% vs. CV-t-oxygen-R=5.5% ($p<0.01$; Fig. 2), CV-t-roomair-NR=7.6% vs. CV-t-roomair-R=6.5 ($p<0.01$; Fig. 3). RERO2-R was similar to RERO2-NR (Fig. 4). Registration reduced spatial heterogeneity of RERO2: CV-sO2-NR=45.3% vs. CV-sO2-R=34.1% ($p<0.01$; Fig. 5).

Discussions

In O2-MRI, lung signal is measured repeatedly during different breathing cycles [1-3]. Inconsistencies of respiratory phase may hamper the quality of the O2-maps [2-3]. In this study, fully automatic non-rigid registration [5-6] reduced spatial misalignment among images and signal variability within the lung. O2-induced signal enhancement was not influenced by image registration, whereas spatial heterogeneity of parametric O2-maps decreased significantly.

Conclusions

Fully automatic non-rigid registration is a rapid and effective postprocessing method to improve the quality of multislice O2-MRI of the lung.

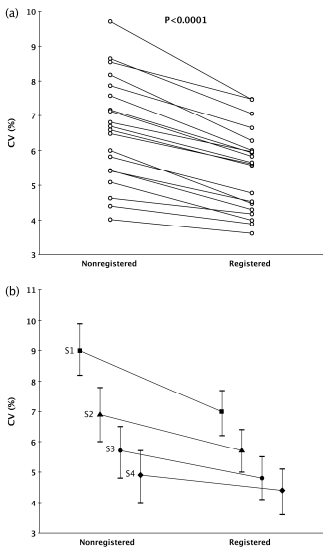

Fig. 2. Temporal variability of MR signal at oxygen ventilation, before and after image registration. Mean coefficients of variation (CV) calculated from each subject (**a**) and slice (**b**). Signal variability in the lung was significantly reduced by image registration.

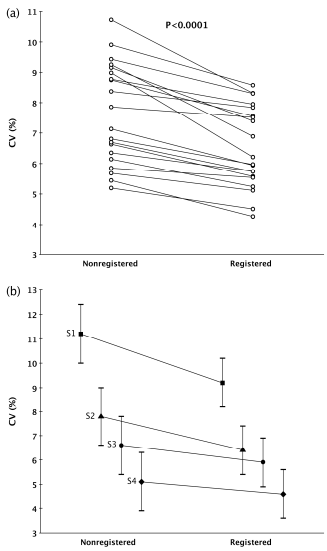

Fig. 3. Temporal variability of MR signal at room-air ventilation, before and after image registration. Mean coefficients of variation (CV) calculated from each subject (**a**) and slice (**b**). Signal variability in the lung was significantly reduced by image registration. The reduction was significant in S1 and S2 ($p<0.05$).

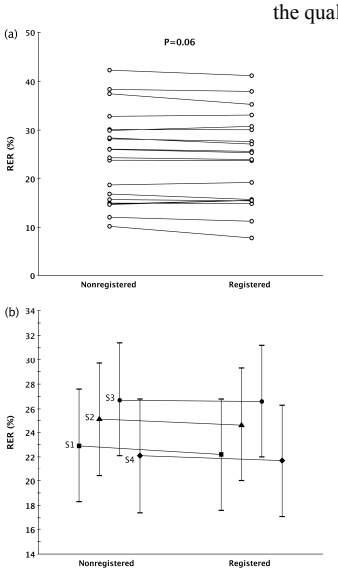

Fig. 4. Relative signal enhancement ratio (RER) calculated from the oxygen-enhanced maps, before and after image registration. RER was calculated from each subject (**a**) and slice (**b**). No significant difference of signal enhancement was observed from the use of image registration.

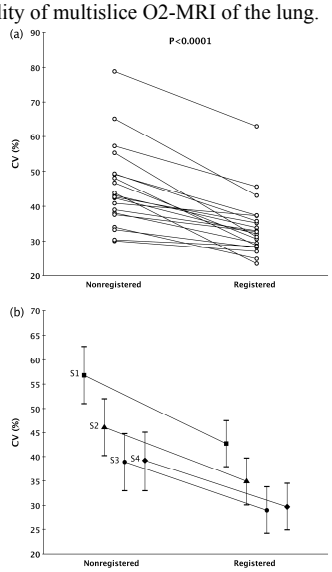

Fig. 5. Spatial variability of relative signal enhancement calculated from the O2 maps, before and after image registration. Mean coefficients of variation (CV) calculated from each subject (**a**) and slice (**b**). Image registration improved significantly the homogeneity of the O2 maps in all subjects and imaging planes.

References: **1**. Ohno Y et al. Am J Respir Crit Care Med 2008:177:1095-1102. **2**. Dietrich O et al. Magn Reson Med 2005:53:1317-1325. **3**. Molinari F et al. J Magn Reson Imaging 2007:26:1523-1529. **4**. Naish JH et al. Magn Reson Med 2005:54:464-469. **5**. Chefd'hotel C et al. ICCV Workshop, Vancouver, BC, Canada. 2001. **6**. Deimling M et al. Proceedings of the International Society for Magnetic Resonance in Medicine (ISMRM), Toronto, Canada 2008.