Title: Pulmonary Ventilation Analysis Using Motion-Resolved Ultrashort Echo (UTE) MRI

Authors: Fei Tan[1], Xucheng Zhu[1], Peder E. Z. Larson[1,2]
[1]UC Berkeley-UCSF Graduate Program in Bioengineering, University of California, Berkeley and University of California, San Francisco
[2]Department of Radiology and Biomedical Imaging, University of California, San Francisco

Highlights: Tissue deformation-based and signal intensity-based ventilation analysis are applied to respiratory motion-resolved UTE MRI for the first time. The ventilation maps derived from both approaches are consistent with each other on a healthy volunteer and a subject with lung abnormality.

Introduction:

^{1}H MRI is gaining more attention on pulmonary imaging because it can provide both structural and functional information (1). The recently developed motion-resolved 3D free-breathing pulmonary MRI enables the separation of several respiratory states between expiration and inspiration (2). By analyzing the lung tissue deformation and intensity variation across the expiratory and inspiratory phases, it is possible to assess local ventilation and improve pulmonary disease diagnosis. In this study, we aim to apply the tissue deformation-based Jacobian determinant method (3), and the intensity-based specific ventilation (SV) method (4) to motion-resolved 3D UTE lung MRI for ventilation assessment.

Methods:

Two subjects were included in this feasibility study, a healthy volunteer and a subject with Bronchiolitis Obliterans. Images were acquired on a 3T MR750 clinical scanner (GE Healthcare, Waukesha, WI) with an 8-channel cardiac phased-array coil. An SNR optimized 3D radial UTE sequence (5) was adopted and the acquisition parameters are as follows: TR/TE = 3.048 ms/ 0.070 ms, flip angle = 4°, number of spokes = 120,000 , bandwidth = ±125 kHz, FOV = 32 cm, pixel size = 1.6 mm isotropic. 6 respiratory phases between full inspiration and full expiration were reconstructed by the recently proposed self-navigating motion-resolved reconstruction for free-breathing pulmonary MRI method (2). The fully expiratory state was registered to the inspiratory state via Demons non-rigid registration (6). The tissue deformation-based approach used Jacobian determinant as the measurement of volume change of each voxel, defined as $\det(Id + \frac{\partial(D_x, D_y, D_z)}{\partial(x,y,z)})$(3,7). The intensity-based approach is quantified by specific ventilation (SV), defined as $SV = \frac{V_{insp} - V_{exp}}{V_{exp}} = \frac{S_{exp} - S_{insp}}{S_{insp}}$, where S_{exp}, S_{insp} are the signal intensity of each voxel in the registered expiratory and inspiratory image (4). Image volumes were smoothed by a 3D Gaussian filter before Jacobian determinant and SV calculation to reduce the variation.

Results:

Figure 1 shows one coronal slice ventilation map from a healthy volunteer and a subject with Bronchiolitis Obliterans, calculated by the Jacobian determinant method and specific ventilation method respectively. For the tissue deformation-based method, areas with Jacobian determinant greater than 1 indicates expansion of lung tissue. While areas with Jacobian determinant smaller than 1 correspond to contraction. As for the specific ventilation, values greater and smaller than 0 are related to expanding and contracting areas. The ventilation maps of the healthy subject are homogeneous with most areas expanding, which suggest the areas are ventilating. However, for the subject with Bronchiolitis Obliterans, the right lung has significant lower values in both ventilation maps, which indicates the right lung is less ventilated than the left lung. This result matches the pathology of the subject.

Conclusions:

Both the tissue deformation-based and intensity-based methods are applicable to motion resolved UTE Lung MRI, providing ventilation information of lung volumes. The correlation and differences between the ventilation maps derived from both methods requires more investigations in the future.

Figures:

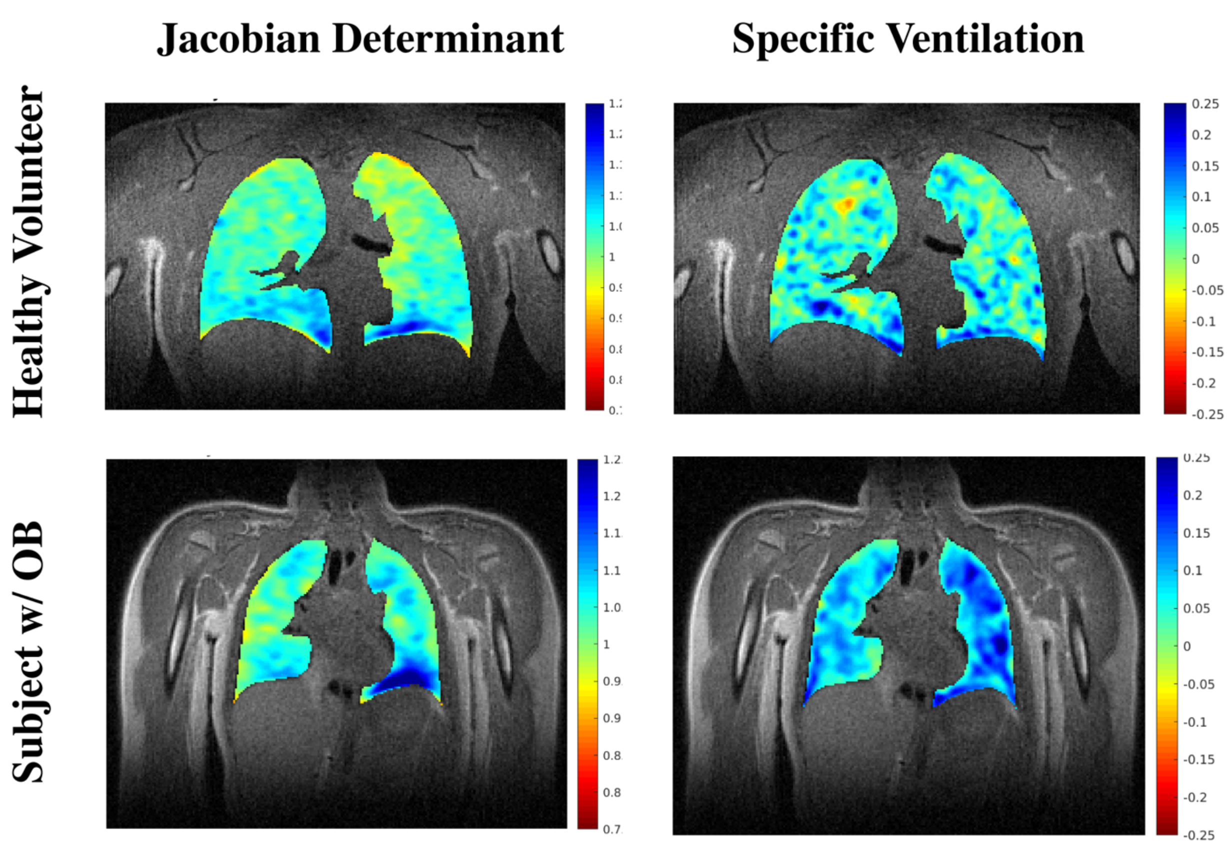

Fig. 1

Reference:

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