

MRI Assessment of Dynamic Lung Volume Changes in Subjects Using a Nasal Expiratory Positive Airway Pressure (nEPAP) Device

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Introduction: A new treatment for obstructive sleep apnea (OSA) that utilizes adhesive resistive valves for producing nasal expiratory positive airway pressure (nEPAP) has become available under the name Provent™ (Ventus Medical Inc) and is now FDA approved due to its early success in a subset of patients with OSA. Nevertheless, the mechanism by which nEPAP treats obstructive apnea is unclear. We propose that the main action of nEPAP is to produce end-expiratory hyperinflation which stiffens the upper airway through increased longitudinal traction on the trachea. It has thus far not been possible to evaluate changes in lung volume with the nEPAP device in place using standard pulmonary function measurement techniques. The purpose of the current study is to demonstrate the capability of a real-time MRI technique for the measurement of changes in lung volume in subjects using a nEPAP device.

Methods: Three normal subjects were tested. The study was IRB approved and all participants provided informed written consent. A time series of lung volumes were obtained from MRI images using a gradient echo sequence with a very short TR/TE that was developed for real-time imaging of the lungs at a frequency of up to 10 images per second without gating [1,2]. Subjects were asked to breathe quietly with normal tidal breaths through the nose and separately through the mouth during which up to 500 images were acquired. Two identical scans were performed, one with and one without the Provent™ nEPAP device (Fig. 1). Custom software was then used to calculate the lung volume (Fig. 2) and generate lung volume vs. time curves from which the functional residual capacity (FRC) was found by inspecting the time series to identify a reproducible end-expiratory volume. All scans were conducted on

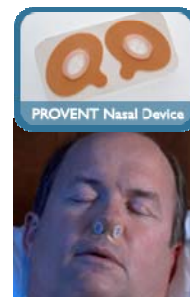


Figure 1

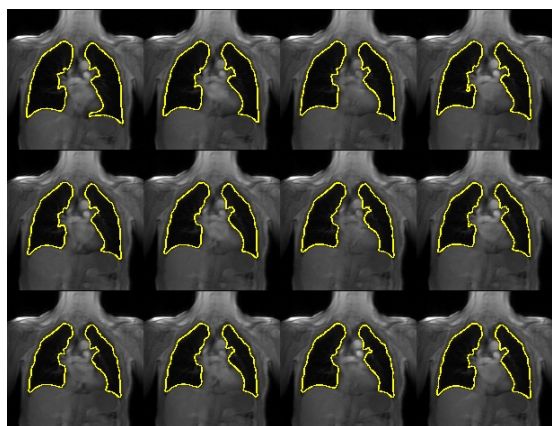


Figure 2. An example of a time series of lung volumes (outlined in yellow) obtained from one subject in the coronal plane using the current technique.

a Siemens 3T whole-body MR scanner (Magnetom TIM Trio) with a maximal gradient strength of 45mT/m and maximal slew rate of 200mT/m/s using the following parameters: TR/TE = 1.6ms/0.7ms, FA = 5°, matrix size = 192x128-192, BW = 965 Hz/pixel, slice thickness = 16mm, with (6/8) partial Fourier and a field of view = 420-460mm. Measurements were made in two sagittal imaging planes and one coronal plane.

Results: Figure 3 shows results from one subject demonstrating two typical lung volume vs. time curves that were obtained from the experiment. While employing the Provent™ device (Fig. 3A) there was a marked change in FRC when subjects switched from breathing through the nose (through the Provent™ valves) to the mouth (bypassing the Provent™ valves). In contrast, without the Provent™ device (Fig. 3B) no change was observed in FRC when subjects switched from breathing through the nose to the mouth.

Conclusions: We have shown the capability of using a real-time MRI technique for the measurement of lung volume (FRC) increase caused by the use of the Provent™ nEPAP device. This increase in lung volume may be a key factor in the observed improvement of OSA in patients using the Provent™ device. Since end-expiratory hyperinflation is likely to produce increased traction on the trachea, we propose that the main action of the expiratory resistors is to stiffen the upper airway through increased longitudinal traction. The magnitude of this change in FRC and its relationship to tracheal traction and successful therapy with nEPAP need to be further investigated.

Acknowledgements: This work was supported in part by NIH grant R01 HL069023.

References:

1. Voorhees A, et al; MRI-Based Pulmonary Function Test Using Forced Breathing Maneuvers. Proc ISMRM 15, 2007.
2. Zhang K, et al. Assessing local lung function: measurement of regional FEV1/FVC using tissue tracking MRI. Proc ISMRM 16, 2008:3787.

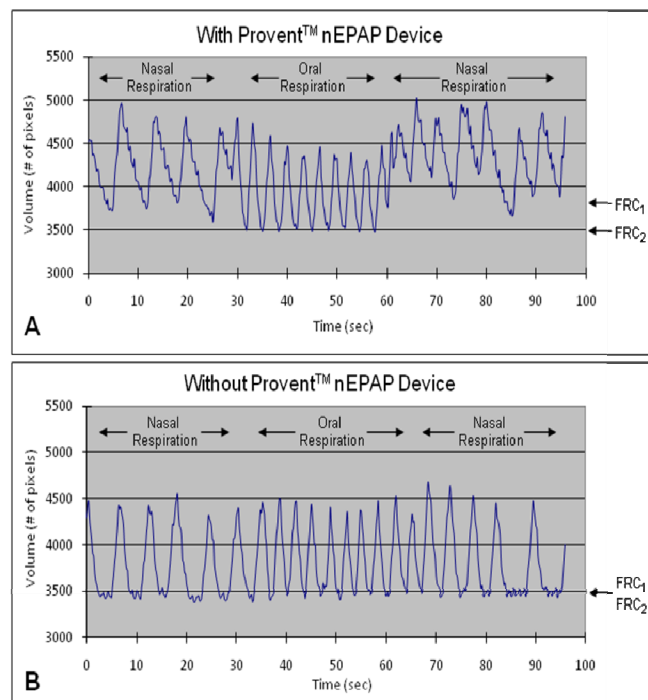


Figure 3. Results from one subject demonstrating typical lung volume vs. time curves obtained with (A) and without (B) the use of the Provent™ nEPAP device; FRC₁ and FRC₂ denote the functional residual capacities associated with nasal and oral respiration respectively.