Hyperpolarized Helium-3 ventilation and ADC MR imaging in the treatment of patients with inoperable lung cancer.

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Introduction: Hyperpolarized helium-3 (hp He-3) MRI has been used for more than 10 years as an investigational tool to study a variety of obstructive lung diseases such as COPD and asthma (1, 2, 3). Non-small cell carcinoma alters the regional anatomy and physiology of the lung. To our knowledge there has only be limited investigation of hp He-3 in assessing the effect of the lung tumors on the regional lung ventilation (4). The purpose of our study was to investigate, using hp He-3, the regional ventilatory and structural pulmonary changes in patients with inoperable lung carcinoma.

Methods and Materials: Four patients (3 females and 1 male; 58-78 YO) with inoperable lung carcinoma were imaged with hp He-3 MRI. At the time of the hp He-3 study, all subjects had at least one chest computed tomography (CT) scan and a lung biopsy which could be used to correlate the findings from the hp He-3 MRI. Two of the patients had also been diagnosed with COPD and one with lung fibrosis. Hp He-3 MRI was used to confirm the previous diagnoses and to perhaps determine lung disease progression.

All subjects were scanned in a 1.5 Tesla clinical MR system (Sonata, Siemens Medical Solution, Malvern, PA) using a He-3 flexible RF coil (Clinical MR Solutions, Brookfield, WI). He-3 was polarized via the optical-pumping spin-exchange method in an IGI-9600He polarizer (MITI, Durham, NC), with final polarization levels between 35-40%. Each subject received two inhalations of a mixture of hp He-3 (400cc-500cc) and medical grade nitrogen (150cc-550cc) for a total volume of 730cc-1050cc, depending on their forced expiratory vital capacity (FVC) obtained immediately before the MRI study using spirometry. Immediately after the first inhalation a set of contiguous coronal He-3 diffusion images with a voxel size of 3.3 x 3.3 x 25 mm (TR/TE, 11/6.7 ms; FA, 7°; matrix, 128 x 80) was obtained during a breath hold, covering the entire lung volume. For this measurement of the apparent diffusion coefficient (ADC), a FLASH-based pulse sequence with bipolar diffusion-sensitization gradients was used with a b-value pair of 0 and 1.6 s/cm^2. Another FLASH sequence (without diffusion sensitization gradients) was used for the second inhalation to acquire ventilation images with higher spatial resolution. For this acquisition the pulse-sequence parameters included: TR/TE, 6.7/2.85 ms; matrix 128 x 80; voxel size, 2.8 x 2.8 x 12 mm; FA, 9°. The means, standard deviations and histograms of the ADC values for each image slice and for the sum of all sections were calculated.

Results: Regional changes in the lung ADC, having the shape of protuberances (Fig. 1E), were observed for one of the COPD patients. Focal regions of decreased ADC were observed in the patient with fibrosis (Fig. 1B), and focal elevations in ADC were seen in all 4 patients. In those patients with a large intrapulmonary tumor, there was a ventilation defect in the region of the tumor. The whole lung mean ADCs of all 4 patients, even the patient with pulmonary fibrosis, was elevated relative to our prior experience in healthy subjects (3), Table 1. We can speculate that this patient may have an undiagnosed combination of emphysema and fibrosis.

Table 1 - Mean overall ADC values

Subject	Secondary Disease	Mean ADC ± SD [cm^2/s]
1	Fibrosis	0.33 ± 0.10
2	COPD	0.40 ± 0.19
3	COPD	0.46 ± 0.15
4	none	0.30 ± 0.15

Discussion: Hp He-3 ventilation and diffusion images did not add new findings to the diagnosis, assessment of progression, or staging of the lung carcinomas, but were nonetheless very useful for the visualization of and determining the severity of the emphysema and fibrotic changes involving the remainder of the lung. The addition of ventilation and ADC hp He-3 imaging in the treatment planning of patients with inoperable lung cancer may be helpful to determine the extent and severity of underlying emphysema and/or lung fibrosis in order to indentify and spare the healthiest lung tissue.

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References: 1) de Lange, et al. Chest 2006; 130: 1055-1062. **2)** Holmes J, et al. J Magn Reson Imaging. 2007, Sep;26(3):630-6. **3)** Wang C, et al. J Magn Reson Imaging. 2008 Jul;28(1):80-8. **4)** Kauczor H, et al. Radiologe 2001 Mar; 41(3):279-87.

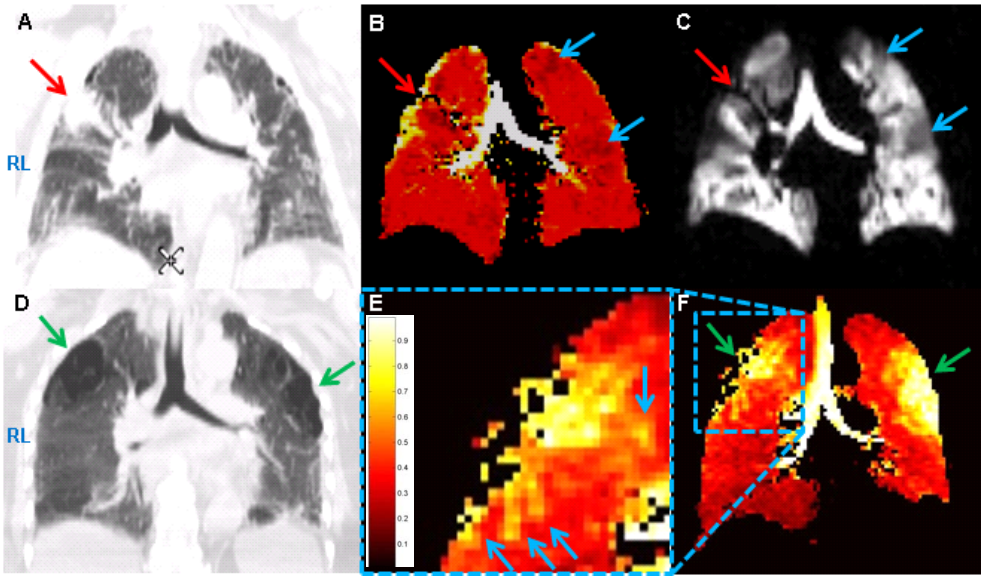

Figure 1: Images in top row belong to subject 1 (pulmonary fibrosis). Images in bottom row belong to subject 3 (COPD). **A:** CT scan showing carcinoma (red arrow), and fibrosis throughout both lungs. **B:** ADC map. Location of carcinoma (red arrow) is surrounded by areas of patchy fibrosis (low ADC) and honeycombing which produces elevated ADC values. Two larger patches of fibrosis are seen in the left lung (blue arrows). **C:** He-3 ventilation image shows a ventilation defect from the carcinoma (red arrow) and the underlying lung disease (e.g., blue arrows). **D:** CT scan showing two large areas of emphysema (green arrows). **E:** Zoom-in of the right lung upper lobe section of the ADC map in image F to show elevations in the form of protuberances (blue arrows). Scale represents ADC and is in cm^2/s. Same ADC scale applies to all ADC maps. **F:** ADC map, showing both lungs and both emphysematous areas (green arrows) as seen in CT image D.