

Long-term reproducibility of apparent diffusion coefficient using hyperpolarized ^3He MRI in healthy volunteers.

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Background:

Hyperpolarized (HP) gases have recently been used in magnetic resonance imaging (MRI) to demonstrate new image-derived pulmonary parameters. One of these is the Apparent Diffusion Coefficient (ADC), which reflects the size of the structures that compartmentalise gas, in this case the size of the lung alveoli. However, if a method is to be used in a clinical setting it must be reproducible. The aim of the study was to examine the long term reproducibility of ^3He ADC MRI in non-smoking healthy volunteers.

Material and methods:

To examine the long-term reproducibility of the ADC of HP ^3He -inhalation, we examined 11 healthy volunteers (6M and 5 F, age range 25- 63) at baseline, at 6 months and at 12 months. Coronal diffusion-sensitised MR images were obtained during 15 seconds breathhold after inhalation of HP ^3He -gas mixed with nitrogen at a net activity between 3.5 to 4.5 mmol. All subjects were examined with hyperpolarized ^3He inhalation (^3He mixed with N_2) in a 1.5-T whole-body imaging system (Siemens Magnetom Sonata, software: Syngo MR 2002 B; Siemens Medical Solutions, Erlangen, Germany). ^3He ADC MRI was performed using a diffusion-weighted 2D gradient echo pulse sequence (TR/TE 9.6/5.9 ms, flip angle 7° , FOV 382 x 470 mm, matrix 80 x 128, slice thickness 15 mm, interslice distance 5 mm, number of slices 10, bandwidth 250 Hz/pixel, time of acquisition 15 sec). The slices were acquired in sequential order. At each slice position, two images were acquired: one without (b0) and one with a bipolar diffusion sensitizing gradient waveform applied in the slice direction (b1). The signal attenuation constant for the bipolar gradient waveform was $b1 = 1.6 \text{ s/cm}^2$. The phase encoding for the b0- and b1-image was interleaved. Coronal slices covered the whole lungs from anterior to posterior. The volume ^3He used was 15% of each subjects total lung capacity (TLC) with a net activity of 3.5 to 4.5 mmol hyperpolarized ^3He . The administration of the He/ N_2 mixture started with the subjects lung at functional residual capacity (FRC). Imaging was done in the coronal plane during a 15 s breathhold. Pixel-by-pixel colour maps of ADC-values and histograms of ADC-values were calculated per slice and per subject. The mean and SD of the ADCs at the different time points were calculated in each subject and between subjects.

Results:

The long-term reproducibility of the mean ADC values was excellent with very small intra-individual variation (table 1). The average mean ADC value for all subjects was 0.216, 0.217 and 0.218 cm^2/sec at baseline, at 6 months and at 12 months respectively (NS). The SD of the mean ADC between the different time points ranged from 0.002 to 0.009 cm^2/sec (mean ADC varied from 0.181 to 0.294 cm^2/sec in the subjects). Expressed in percent this SD corresponds to an intra-individual mean ADC variation of 0.97 to 4.1 %. There was an inter-individual variation which however, seemed to be age dependent with an increase in ADC values with aging (see Fig 1).

Conclusions:

Very good short-term reproducibility and sensitivity of ^3He ADC MRI have been shown previously. This study shows that the method is reproducible also in a long term perspective although a possible age dependency might have to be taken into account. The method seems to be robust enough to be possible to use for the evaluation of emphysema.

Pat	Baseline	6 months	12 months
1	0,295	0,288	0,300
2	0,193	0,197	0,201
3	0,227	0,223	0,227
4	0,182	0,186	0,194
5	0,162	0,155	0,162
6	0,185	0,191	0,184
7	0,242	0,224	0,228
8	0,248	0,254	0,256
9	0,231	0,237	0,238
10	0,183	0,196	0,193
11	0,233	0,232	0,218
Mean	0,216	0,217	0,218

Table 1. Mean ADC all time points, all subjects

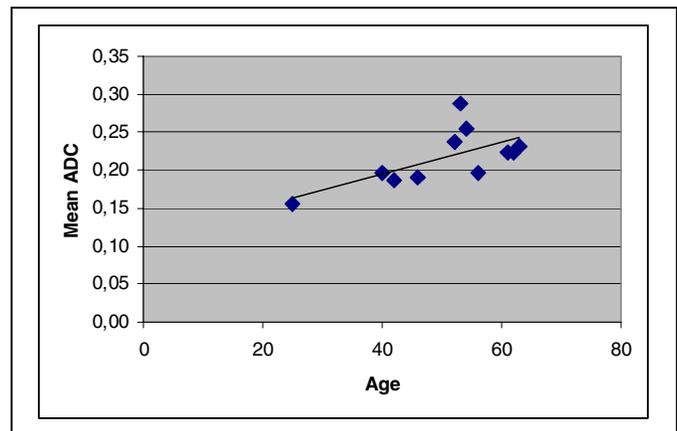


Fig 1. Age dependency (ADC values at 6 months evaluation)