

## Preliminary results on image artifacts in lipid diffusion imaging

Jutta Janke<sup>1</sup>, Andreas Wetscherek<sup>1</sup>, Bram Stieltjes<sup>2</sup>, and Frederik Bernd Laun<sup>1,2</sup>

<sup>1</sup>Dpt. Medical Physics in Radiology, German Cancer Research Center (DKFZ), Heidelberg, Baden-Württemberg, Germany, <sup>2</sup>Quantitative Imaging-Based Disease Characterization, German Cancer Research Center (DKFZ), Heidelberg, Baden-Württemberg, Germany

### Introduction:

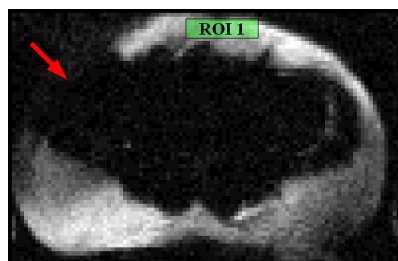
Although most research in the field of diffusion weighted imaging (DWI) focuses on molecular water diffusion, promising first measurements and results of lipid diffusion in human subjects could be obtained recently [1]. The Apparent Diffusion Coefficient (ADC) of lipids may be a valuable biomarker for various diseases, e.g. diabetes [1]. Owing to their larger molecular mass, the Apparent Diffusion Coefficient (ADC) of fat molecules is smaller – by two units of magnitude – than that of water molecules [2, 3]. This low ADC entails the need to apply strong diffusion weightings (b-values > 10,000 s/mm<sup>2</sup>) in order to generate a sufficient signal attenuation. The downside of using such strong diffusion weightings is the resulting long echo time, which results in a low signal-to-noise ratio (SNR). We tried to counter this low SNR by using larger slice thicknesses. In this abstract, we describe some unexpected artifacts we encountered, which usually do not appear in water diffusion measurements.

### Material and Methods:

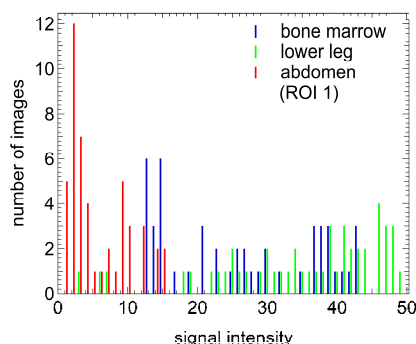
A single refocusing single-shot echo planar imaging (EPI) sequence was used to acquire diffusion weighted images of six healthy volunteers (aged 22 - 27 y). The images of three volunteers covered the lower abdomen and the images of the other three volunteers covered the lower leg. Images of the abdomen were acquired in inhalational breath hold. Acquisition parameters were TR = 2.5 s, TE = 267.4 ms, BW = 1923 Hz/Pixel, matrix 100 x 100, one slice, in plane pixel size 0.4x0.4 cm<sup>2</sup>, an axial slice of 2.0 cm thickness, 6 diffusion gradient directions, 1.5 T, Magnetom Avanto (Siemens Medical Solution, Erlangen, Germany). 48 diffusion weighted images were acquired with a monopolar diffusion weighting for each of these b-values: b = 5,000 s/mm<sup>2</sup>, b = 15,000 s/mm<sup>2</sup> and b = 25,000 s/mm<sup>2</sup>. The averaged signal within several regions of interest (ROIs) was calculated for each image. Moreover, the mean, median, and maximum signal intensity were determined on a voxel by voxel basis for all 48 diffusion weighted images. These signal intensities were averaged in a ROI and the ROI-averaged signal was used to calculate the ADC using all three b-values. The ROIs were placed in subcutaneous abdominal fat, in subcutaneous fat of the lower leg and in the tibial yellow bone marrow.

### Results:

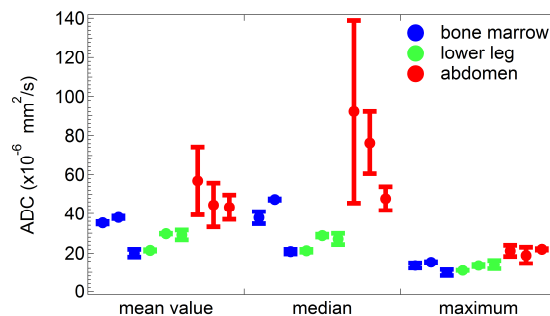
Fig. 1 shows a diffusion weighted image of the abdomen with a large area in which the signal dropped substantially (red arrow). This signal drop was, in general, increased at higher b-values (data not shown). Fig. 2 shows that a large variance of the 48 ROI-averaged signals is present, which is due to the signal drops shown in Fig. 1. The maximum signal intensity yields the lowest standard deviation of obtained ADC values (Fig. 3).



**Fig.1:** Signal drop (red arrow) in a transversal plane of the abdomen (b = 25,000 mm<sup>2</sup>/s), acquired in breath hold.



**Fig.2:** Histogram of ROI-averaged signal intensities of 48 pictures of one subject (per color) with b = 25,000 mm<sup>2</sup>/s. Most signal intensities are attenuated.



**Fig.3:** ADC-values calculated using ROI-averaged signals for three volunteers (three dots). Error bars denote the standard deviation of the linear regression of the logarithmic signal data versus b-values.

### Discussion:

The artifacts observed using our acquisition parameters had a major impact on the obtained quantitative values. We attribute the signal attenuation to two effects. Firstly, the thick slice resulted in small slice selection gradients for the refocusing pulse, making the achieved flip angle possibly susceptible to residual eddy currents caused by the first gradient lobe. Secondly, tissue pulsation results in additional, quasi-random signal drops. As the signal drops in the fatty tissue tended to affect large areas (as in Fig. 1), it seems appropriate to use the signal averaged within a ROI. We consider the ADC calculated from the maximum signal values as most appropriate, since both artefact types only reduce the signal, but do not increase it. The obtained absolute values are roughly in accordance with those obtained by Steidle et al. [1]. In future experiments, we aim at minimizing the observed signal attenuations by adopting sequence parameters and the timing of the sequence.

### References:

- [1] Steidle G. *et al.* Quantitative Imaging of Adipose Tissue in the Human Lower Leg. *MRM*. 2011; 65:1119-1125.
- [2] Ababneh Z.Q. *et al.* In vivo lipid diffusion coefficient measurements in rat bone marrow. *MRI*. 2009; 27:859 – 864.
- [3] Lehnert A. *et al.* Diffusion characteristics of large molecules assessed by proton MRS on a whole-body MR system. *MRI*. 2002; 22 (39 – 46)