Assessment of vendor dependency of apparent diffusion coefficients – a phantom study at 1.5T

S. Feuerlein[1], A. Bornstedt[2], A. Wunderlich[3], S. Boujraf[2], and V. Rasche[2]

[1]Radiology, University of Ulm, Ulm, Germany, Germany, [2]Internal Medicine II, University of Ulm, Ulm, Germany, Germany, [3]Radiology, University of Ulm, Ulm, Germany

Purpose

Diffusion-weighted imaging (DWI) has become an important complementary technique in abdominal MRI. Outside of the brain DWI is usually used to characterize focal lesions by providing information about the water diffusibility on a cellular level. Generally, malignant lesions have lower ADCs, whereas benign lesions have higher ADCs, although variable overlap occurs between both groups. As ADC measurements are increasingly used for lesion characterization, factors like reproducibility and dependence on technical parameters become important (1). Kwee et al. (2) showed that even different respiratory triggering technique (free breathing vs. breathhold vs. respiratory triggering) resulted in significantly different ADC values in healthy volunteers. It is known that due to the "intravoxel incoherent motion" model of LeBihan (3) the lowest b-value used for ADC calculation has a significant impact on the ADC in perfused tissue. Since there are no standards defined for ADC-calculations, almost every published study uses different sequences (EPI vs. PROPELLER), different b values, and different preparation pulses. The aim of this study was to compare the reproducibility and accuracy of ADC measurements on scanners from two different vendors with comparable acquisition protocols.

Materials & Methods

Imaging was performed using 1.5 T MR imaging systems of two different vendors (referred to as vendor a and vendor b). Transverse diffusion-weighted images were obtained using a diffusion multi-shot multi-spin echo PROPELLER technique (periodically rotated overlapping parallel lines with enhanced reconstruction) (4). The following acquisition parameters were chosen: TE(including diffusion preparation)/TR = 124/3000ms, 16 echoes, 0.5x0.5x7mm³ spatial resolution, b-values of 0 and 800 s/mm^2. Pixel-wise ADC maps were generated applying the vendor-specific analysis software. For reference purposes additional data was acquired on the system of vendor a using 13 b-values equally spread from 0 to 1500 s/mm^2. Please note that system a is using a diffusion preparation approach, whereas with system b the diffusion encoding gradient are integral part of the multi-spin echo sequence. The phantom contained 5 circular plastic tubes filled with cyclohexane, butanol, destilled water, n-hexadecane and ethanol. ADC values were measured in a circular-shaped region of interest (ROI). The resulting mean values were compared with the literature data (5) and the 13-b-value reference scan. Diffusion values for the temperature within the scanner were interpolated linearly between the published 20°and 25° values. Scanning temperature was 22.5° for vendor a and 25° for vendor b.

	20.0°C (Ref)	25.0°C (Ref)	22.5°C (interpol.)	V-A (0-1500) 13 b-values	V-A (b=0-800) Mean	V-A (b=0-800) SD	V-B (b=0-800) Mean	V-B (b=0-800) SD
Cyclohexane	1345	1474	1409	1370	1361	66	1460	50
Butanol	397	456	426	396	400	70	445	82
Destilled water	2023	2317	2170	2018	2140	68	2324	100
N-hexadecane	341	384	372	351	365	160	380	235
Ethanol	977	1080	1028	1040	1044	180	1094	242

Table 1: Measured ADC values and literature values (V-A=Vendor a, V-B=Vendor b)

Results

Both systems showed excellent agreement with literature values at the recorded temperatures (see Fig.1). R^2 values above 0.95 could be achieved for both vendors. A slight offset in the order of below 10 cm²/s was observed for both vendors, which were not significant. Please note that the ADC values obtained by two b-measurements agree excellently with the 13 b-measurements for vendor a.

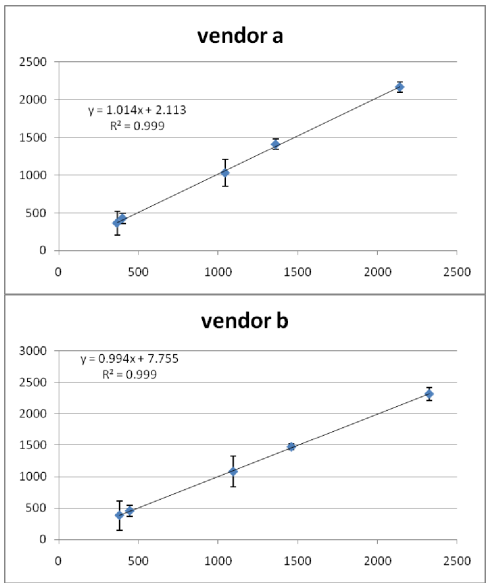

Fig.1 Scatter plots of measured and literature ADC values.

Conclusion

The differences in measured ADC values for a wide range of diffusion coefficients was assessed for clinical whole-body MRI systems by two different vendors. Although both vendors use different approaches for diffusion preparation, the reconstructed ADC value agreed excellently with the values reported in the literature. The outcome of this study indicates that ADC values can be measured accurately independently of the scanner vendor. This further supports the idea of basing lesion characterization and potentially the resulting clinical decision making on ADC values. Vendor-independency also can be seen as one important step toward clinical standards in DWI imaging including the choice of b-values and sequence parameters. However, further work is necessary to assess the reliability and reproducibility of ADC measurements before this technique can be used in clinical routine safely.

References

[1] Yoshikawa T et al. Am J Roentgenol 2006; 187:1521-1530.
[2] Kwee TC et al. J Magn Reson Imaging 2008; 28:1141-1148.
[3] Le Bihan D et al. Radiology 1986; 161:401-407.
[4] Deng J et al. Invest Radiol 2006; 41:769-775.
[5] Tofts PS et al., MRM 2000 Mar;43(3):368-74