Comparison of Breath-Hold and Free-Breathing Diffusion-Weighted Techniques for Liver MR Diffusivity in Healthy Volunteers and Patients

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Introduction: Diffusion-weighted MR imaging (DWI) is a potentially important technique for evaluating diffuse liver disease [1, 2]. However, variability in DWI protocols is a hurdle to establishing apparent diffusion coefficient (ADC) utility for quantitative analysis of liver disease. DWI may be performed with: 1) breath-held (BH) DWI allowing rapid image acquisition with reduced motion artifact but is limited by low signal-to-noise ratio (SNR); 2) free-breathing (FB) DWI allowing greater SNR but may suffer from motion artifact. To date there have been few studies comparing ADC derived from the 2 techniques and those have focused on healthy volunteers. The purpose of our study was to determine the relationship of liver ADC obtained with BH and FB DWI in subjects with diffuse liver disease and in healthy volunteers.

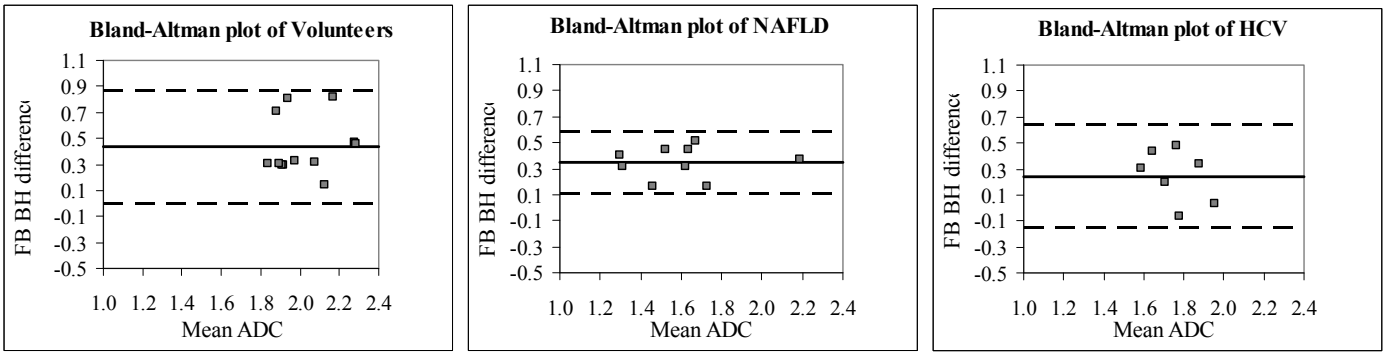
Methods: Twenty-eight subjects (mean age 45 years, range 22-71), including 12 healthy volunteers, and 16 patients (9 nonalcoholic fatty liver disease (NAFLD); 7 chronic active HCV) were included in the study. Single shot echo-planar DWI (b-values, 0, 600 s/mm2; slice/gap 10/2mm; 3 acquisitions; number of slices, 9; FOV, 40-48cm; matrix, 128x128; acceleration factor 2) with BH (24 sec scan; 3 directions averaged, TR/TE, 2000/min;), and FB (5 min scan; TR/TE, 7000/min) techniques at 1.5T was performed on each subject within 90 minutes with interval removal of the subject from the scanner. Average ADC measurements were obtained using a single large ROI occupying most of the right lobe including vessels at 3 axial levels; superior, inferior and at the level of the portal vein. Pearson's correlation coefficient was used to determine correlation between BH and FB ADC, paired t-tests to assess ADC differences, Bland-Altman method to assess bias, and the Brown-Forsythe test to determine significance of ADC variation across disease status.

Results: Liver biopsy was performed on NAFLD patients within 1 month of MRI (range, 1 to 30 days); steatosis grade: 0 to 1, n = 6; grade 2 to 3, n =3; Ishak fibrosis stage: 0 to 1, n = 5; stage 2 or more, n = 4. Liver ADC was significantly higher in healthy volunteers compared to patients with NAFLD and compared to FB DWI in HCV patients, but not BH DWI in HCV patients [Table 1]. Liver ADC was lower on BH compared to FB in all groups with a mean difference of 0.36 $\pm 0.20 \times 10^{-3}$ ($p < 0.01$) [Table 1]. Across all subjects, the correlation coefficient between BH and FB ADC was 0.77, (NAFLD, r=0.90; healthy volunteers, r =0.34; HCV, r =0.24). Bland-Altman plots [Figure 1] did not demonstrate an agreement in mean absolute difference between all groups. The limits of agreement ranged between 0.11 to 0.59 in NAFLD patients, -0.15 to 0.64 in HCV patients, and 0.003 to 0.87 in healthy volunteers but significant differences in variance were not detected (p = 0.58, Brown-Forsythe test).

	BMI± SD	Avg ADC in BH± SD	Avg ADC in FB± SD	ADC decrease ± SD
Healthy [n=12]	22.74± 1.65‡	1.80± 0.18†	2.24± 0.20†	0.43± 0.22*
All Patients [n=16]	28.2± 8.46	1.52± 0.25	1.82± 0.22	0.30± 0.16*
NAFLDs [n=9]	32.22± 9.15‡	1.43± 0.27†	1.78± 0.28†	0.35± 0.12*
HCVs [n=7]	24.17± 5.78‡	1.63± 0.19†	1.88± 0.12	0.24± 0.20*
All subjects [n=28]	25.92± 7.00	1.64± 0.26	2.00± 0.30	0.36± 0.20*

Table 1. Average ADC ($x10^{-3}$ mm/sec) and ADC difference with FB and BH DWI. BMI = body mass index; SD = standard deviation.
‡ denotes significant difference between NAFLD and other 2 groups ($p<0.05$)
† denotes significant difference between healthy volunteers and other groups ($p< 0.01$)
* denotes significant difference between BH and FB ($p<0.01$)

Figure 1. Bland-Altman plots did not demonstrate an agreement in mean absolute difference between all subject groups.



Conclusion: The correlation between BH and FB liver ADC is moderate at best such that BH and FB DWI should not be used interchangeably. The lower variability between FB and BH ADC in the NAFLD group may reflect differences in underlying liver disease pattern relative to HCV or reduced respiratory effort range in NAFLD patients due to a higher BMI [1]. The consistently higher ADC values in FB versus BH DWI should be considered when evaluating and comparing different liver MR diffusion studies.

References:

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