IVIM DWI of the Liver: Inter-platform variability between 1.5T and 3T

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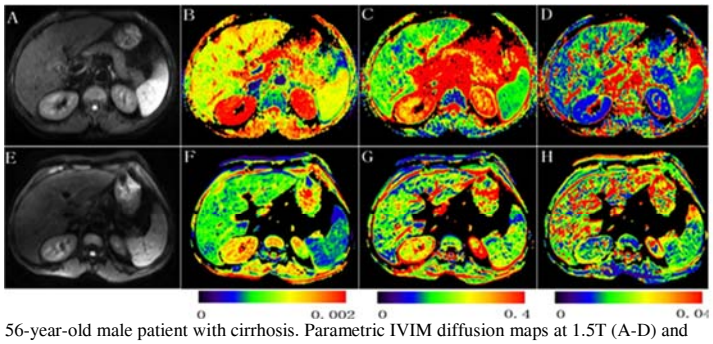
Target Audience: Radiologists and technologists with interest in liver disease.

Purpose: DWI is now fully integrated to routine body imaging and has shown promise for liver lesion detection and characterization and for assessment of response to therapy[1, 2]. By separating the effects of true diffusion from perfusion effects, intravoxel incoherent motion (IVIM) could potentially be more sensitive than conventional DWI in characterizing liver fibrosis and liver lesions[3]. Inter-platform differences in IVIM parameters between 1.5T and 3T have not been evaluated. The purpose of this prospective study is to compare IVIM DWI in the liver at 1.5T and 3 T in terms of image quality, parameter quantification and inter-platform reproducibility obtained in the same subjects.

Methods: In this IRB approved prospective study, 19 subjects (including 17 with chronic liver disease, M/F 12/5, mean age 58 y) and 2 healthy volunteers (2 males, mean age 34y) underwent two repeat scans at 1.5T (Siemens Avanto) and 3T (GE MR 750). Each scan included fat suppressed IVIM DWI using 16b values from 0 to 800 s/mm^2. A respiratory-triggered (RT) acquisition with a navigator echo was used at 1.5T with coronal/axial acquisition in 13/6 subjects, respectively. Sequence parameters were: TR 1 respiratory cycle, TE 74, GRAPPA 2, 2 averages, FOV 350-400mm, slice/interval 8/1.6 mm, 160*128. For 3T, a free breathing axial DWI acquisition was used (TR/TE 2600,TE 59.5ms, ASSET 2, 2 averages, FOV 350-400mm, slice thickness/interval 8/1.6 mm, 128*128. Two independent observers rated subjective image quality and one observer measured IVIM parameters and estimated SNR (eSNR) at b0,200,400,800. ROIs were placed in the right hepatic lobe and mean signal intensity decay was used to estimate true diffusion coefficient (D), perfusion fraction (PF), pseudodiffusion coefficient (D*) and ADC using Bayesian fitting method. Wilcoxon paired tests were used to compare image quality between 1.5T and 3T. Inter-platform reproducibility was assessed by calculating within-subject coefficients of variation (CV).



56-year-old male patient with cirrhosis. Parametric IVIM diffusion maps at 1.5T (A-D) and 3.0T (E-H). A, E, axial SS EPI diffusion images (b200). B, F: D maps. C, G: PF maps. D, H: D* maps. D maps show higher values at 1.5T compared to 3.0T. PF and D* maps show lower values at 1.5T compared to 3.0T. Calculated values were: for D, 1.22 and 0.75×10^{-3} mm^2/s for PF, 13.2 % and 20.4 %, for D*, 14.7 and 19.7 ×10^{-3} mm^2/sec, respectively at 1.5T and 3.0T.

	eSNR			Image quality scores*					
				Observer 1			Observer 2		
	1.5T	3T	p	1.5T	3T	p	1.5T	3T	p
b0	81.7 ± 65.7	93.5 ± 81.0	0.239	4.7 ± 1.2	5.8 ± 1.1	0.013	5.7±1.2	6.4±1.0	0.102
b200	55.6 ± 34.4	83.1 ± 69.9	0.020	4.8 ± 1.4	6.3 ± 1.2	0.006	5.7±0.9	6.3±1.1	0.061
b400	45.0 ± 30.4	69.1 ± 60.4	0.016	4.4 ± 1.2	6.2 ± 1.5	0.002	5.5±0.8	6.3±1.3	0.026
b800	29.5 ± 17.9	49.7 ± 39.8	0.006	3.9 ± 1.1	5.7 ± 1.5	0.002	5.3±1.0	6.0±1.5	0.066

Table 1: Qualitative and quantitative parameters for assessment of image quality evaluated with DWI sequences acquired at 1.5T and 3T. * Maximum score of 9 per b value.

Results (Fig., Tables 1-2): Subjective image quality was significantly better at 3T for liver edge delineation and distortion (p=<0.001-0.009). eSNR was significantly higher at 3T for all b selected values except for b0. IVIM parameters were significantly different between 1.5T and 3T except for ADC. Inter-platform reproducibility of D and ADC was good, with mean CV of 10.9% (range, 0.6%-34.0%) and 11.1% (range, 1.0%-30.5%), respectively. D*and PF showed more limited inter-platform reproducibility for PF: CV 22.6% (range 3.3%-104.5%), for D*; CV 46.9% (range, 8.4%-53.0%).

Discussion: IVIM parameters may potentially represent a quantitative biomarker for liver fibrosis and for assessment of tumor response. Thus, inter-platform reproducibility of IVIM metrics is important. In our study, D and ADC were found to have good reproducibility between 1.5T and 3T, while D* and PF were less reproducible. Large differences in D* may be attributed to fitting errors, as this parameter typically displays the largest fitting uncertainty in IVIM studies. A previous study found no significant difference between 1.5T and 3.0T ADCs for the liver[4]. The current study showed ADC was still the best parameter in terms of reproducibility, likely due to large data points. Future IVIM studies should assess the impact of different platforms on lesion metrics.

Conclusion: IVIM DWI at 3.0T provided better image quality than 1.5T in the liver. ADC and D showed good reproducibility between the two platforms.

Parameter	1.5T	3T	p
D	1.12 ± 0.16	0.99 ± 0.16	0.005
PF	16.0 ± 4.1	19.0 ±5.5	0.033
D*	93.5 ± 64.0	57.2 ± 40.2	0.044
ADC	1.52 ± 0.18	1.48 ± 0.27	0.748

Table 2: Liver IVIM parameters and ADC at 1.5T and 3T. D, D* and ADC: ×10^{-3}mm^2/sec; PF: %.

References:
1) Galea N, et al. JMRI 2013; 37:1260-1276
2) Sandrasegaran K, et al. AJR 2009; 193:1556-1560
3) Patel J, et al. JMRI 2010; 31:589-600
4) Rosenkrantz AB, et al. JMRI 2011; 33:128-135