Evaluation of liver fibrosis with Intravoxel incoherent motion MR imaging: an experimental study in rat model

Caiyuan Zhang[1], Yanfen Cui[1], Yong Zhang[2], and Dengbin Wang[1]

[1]*Department of Radiology, Xinhua Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, Shanghai, China,* [2]*MR Research, GE healthcare, Shanghai, Shanghai, China*

Purposes: To evaluate the feasibility of parameters derived from intavoxel incoherent motion (IVIM) MR imaging for predicting severity of liver fibrosis induced by carbon tetrachloride (CCl_4) in rat model.

Materials and Methods: All experiments received approval from our institutional animal care and use committee. Forty Sprague-Dawley rats (eight week age) were divided into four groups and were intraperitoneally injected with CCl_4 twice per week for 2, 4, 6 and 8 weeks, respectively. The parameters including true diffusion coefficient (D), perfusion fracture (*f*), blood pseudodiffusion coefficient (D*) and apparent diffusion coefficient (ADC) were measured by using 3.0 T MRI unit with thirteen diffusion factors. Pathologic METAVIR scores were used to assess liver fibrosis stage. The relationship between severity of liver fibrosis and all parameters was evaluated by Spearman's ranked correlation. Receiver operation curves (ROC) analysis was performed to assess the performance of all parameters for hepatic fibrosis stage.

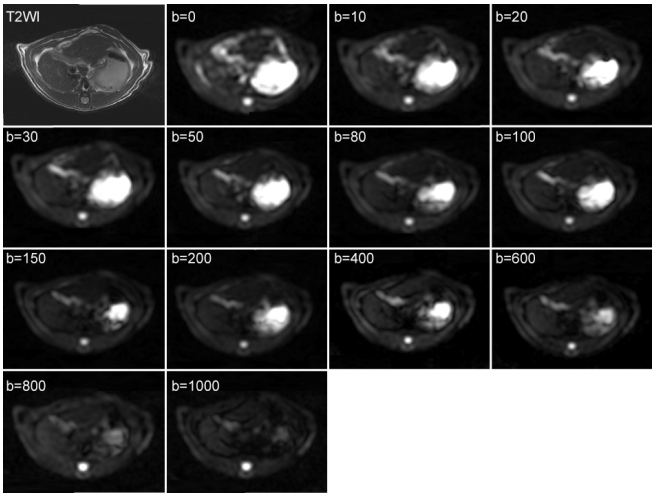

Figure 1. represents diffusion weighted images with b-value of 0, 10, 20, 30, 50, 80, 100, 150, 200, 400, 600, 800 and1000 s/mm^2 from one animal without CCl_4 insult.

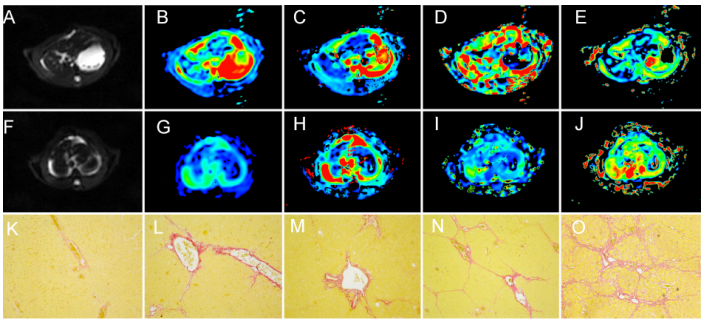

Figure 2. (A-J) IVIM MR images. (A-E). normal liver. (A). DWI image (b=0), (B). ADC. (C). True diffusion coefficient (D). D*. (E). *f* (F-J). Liver fibrosis stage 3. (F). DWI image (b=0), (G). ADC. (H). True diffusion coefficient (I). D* (J). *f*. (K-O) Sirius red staining of liver specimen represents liver fibrosis stage 0 to 4

Results: Diffusion weighted MRI was successfully performed in all experimental rats (Figure 1). All parameters except for *f* were moderately correlated with staging of liver fibrosis (r=-0.503, -0.468, -0.588, respectively, P<0.01) (Figure 2). ROC analysis reveals ADC, D and D* were statistical significant for differentiating nonfibrosis from fibrosis group (P<0.05) with area under the curve (AUC) of 0.871, 0.965 and 0.935, respectively. For differentiating fibrosis stage 1 or lower from stage 2 or greater, ADC, D and D* provided AUC of 0.867, 0.701 and 0.899, respectively (Table 1).

Conclusions: D and D* shows better diagnostic performance than ADC for predicting the presence of liver fibrosis, particularly, D* has potential to differentiate moderate and advanced fibrosis from liver fibrosis.

Table 1. Diagnostic performance of ADC and IVIM derived parameters for normal liver and liver fibrosis

	F0 VS F1-4	F0-1 VS F2-4	F0-2 VS F3-4
ADC cutoff	1.26	1.23	1.205
Sensitivity	70.6%	76.90%	71.40%
Specificity	100.00%	92%	60%
Area under the curve (95%CI)	0.871(0.747,0.994)	0.867(0.754,0.979)	0.660(0.478,0.842)
P	0.013	<0.001	0.051
D cutoff	1.11	0.995	0.985
Sensitivity	91.20%	73.10%	78.60%
Specificity	100%	68.20%	56.00%
Area under the curve (95%CI)	0.965(0,1)	0.701(0.50,0.902)	0.723(0.558,0.887)
P	<0.001	0.025	0.014
D* cutoff	77.45	67.15	66.3
Sensitivity	85.3%	92.3%	92.90%
Specificity	100%	76.90%	48%
Area under the curve (95%CI)	0.935(0, 1)	0.899(0.787,1)	0.709(0.547,0.870)
P	<0.001	<0.001	0.013
f cutoff	43.9	34.65	37.2
Sensitivity	100.00%	61.50%	85.70%
Specificity	20%	61.50%	32.00%
Area under the curve (95%CI)	0.559(0.265,0.853)	0.593(0.397,0.789)	0.574(0.384,0765)
P	0.555	0.247	0.316