Characterize Hepatocellular Carcinoma with IVIM-DWI and DCE-MRI in Combination: Preliminary Experience

Lifen Xie[1,2], Changhong Liang[1], Zaiyi Liu[1], Queenie Chan[3], and Yingjie Mei[4]

[1]*Department of Radiology, Guangdong Academy of Medical Sciences/Guangdong General Hospital, Guangzhou, Guangdong, China,* [2]*Southern Medical University, Guangzhou, Guangdong, China,* [3]*Philips Healthcare, HK, China,* [4]*Philips Healthcare, Guangzhou, Guangdong, China*

Purpose: To quantify diffusion and perfusion characteristics of hepatocellular carcinoma (HCC) with both intravoxel incoherent motion (IVIM) diffusion-weighted imaging (DWI) and dynamic contrast enhanced (DCE) MRI, and to evaluate the correlation between the resulting parameters.

Materials and Methods: This prospective study was approved by the institutional review board and written informed consent was obtained. 35 patients (male-female ratio, 31:4; mean age, 47.6 years old; range, 23～66) with cirrhosis and HCCs underwent IVIM-DWI (respiratory triggered SS-EPI using 12 b values from 0 to 800 sec/mm^2) and DCE-MRI scans at 1.5 T MR scanner (Achieva, Philips Healthcare, Best, Netherlands). DCE-MRI protocol consisted of one pre-contrast scan for T_1 mapping and a dynamic axial 3D-FFE sequence centering on the lesions (TR/TE 11/3, FA 5 and 15°, matrix 204×177, slice thickness 4 mm, 22 slices, temporal resolution 6～8 sec, 36 dynamics for average 10 min) before and after IV bolus of 0.1 mmol/kg of Gd-DTPA (Magnevist). Time-activity curves were converted to gadolinium concentration, then analyzed using a single-input two compartment model and the following DCE-MRI quantitative parameters of HCCs were obtained: volume transfer coefficient (K^{trans}), reverse reflux rate constant (k_{ep}), the fractional volume of extravascular extracellular space (v_e) and the fractional volume of plasma (v_p). ROIs were placed on the IVIM-DWI parametric maps in order to extract the apparent diffusion coefficient (ADC), true diffusion coefficient (D), pseudo-diffusion coefficient (D*) and perfusion fraction (f) of tumors and the liver parenchyma using a bi-exponential model[1]. Pearson or Spearman correlation was computed to assess correlation between IVIM-DWI and DCE-MRI parameters of HCCs. IVIM-DWI parameters were compared between liver parenchyma and tumors using Paired-Samples T Test or Wilcoxon Test.

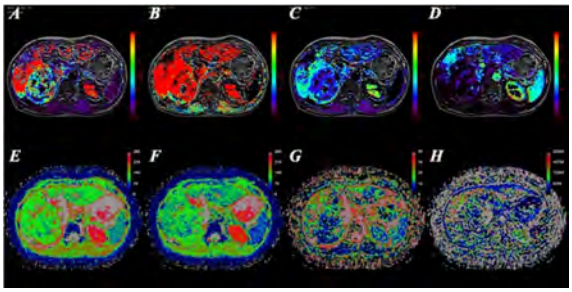

Figure. 1. (A-D) K^{trans}, k_{ep}, v_e, v_p maps and (E-H) ADC, D, f, D*maps in a 59 year old patient with a 94 mm HCC in lower right lobe.

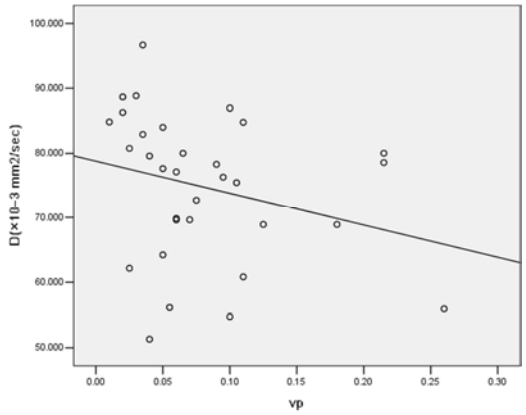

Figure. 2. Graph demonstrating a significantly weak negative correlation between v_p and D (r=-0.391, *P*<0.05).

Results: 35 HCCs were evaluated (mean size 56 mm, range 33～168 mm). v_p was inversely correlated with D in HCCs (r=-0.391, *P*=0.027) (Fig.2); While no significant correlation between the other IVIM-DWI and DCE-MRI parameters was detected (correlation coefficients range -0.278～0.17, *P* > 0.05) (Fig.1). Furthermore, when compared with liver parenchyma, HCCs showed significantly lower ADC, D, f and D* values (*P*＜0.001) (Table, Fig.1).

Parameter	Liver	HCC	*t*/*Z* value	P value
ADC (×10^{-3} mm^2/sec)	1.14 ± 0.07	0.87 ± 0.12	-6.113	＜.001
D (×10^{-3} mm^2/sec)	0.99 ± 0.06	0.76 ± 0.13	-5.822	＜.001
f (%)	19.66 ± 3.46	11.12 ± 3.16	9.692	＜.001
D* (×10^{-3} mm^2/sec)	118.25 ± 20.24	73.62 ± 21.35	8.219	＜.001

Table Comparison of IVIM and DCE-MRI metrics of liver and HCCs.

Discussion: As previously reported, the combination of IVIM-DWI and DCE-MRI can provide an accurate diagnosis of cirrhosis, but without significant correlation between those parameters, since IVIM-DWI and DCE-MRI may reflect different aspects of tissue perfusion [2]. However, our study demonstrated that v_p shows weak negative correlation with D. Because v_p represents the fractional volume of vascular in tissue, higher v_p suggests poor differentiation of tumor, which results in diffusion restriction from decreased extracellular space. ADC value and IVIM-DWI parameters were all decreased in HCCs. Increased cellular density in tumor is believed to impair molecules diffusion, thus leading to reduction in ADC and D values. A lower f value in HCCs compared to liver may be explained by blood flow derivation into small, leaky and poorly efficient tumor capillaries, resulting in a decrease of the fast moving blood pool[3]. The distortion, small diameter and thus slow blood flow of generated vessels in HCCs can explain the lower D* value.

Conclusion: This study indicates that perfusion parameter v_p derived from DCE-MRI shows a weak negative correlation with diffusion coefficient D from IVIM-DWI in HCC. IVIM-DWI provides parameters that are significantly different in HCC compared to liver parenchyma, and could potentially be used for characterization of HCC.

References: [1] Le Bihan, D., et al., Radiology, 1988. [2] Patel J, et al. J MRI, 2010. [3] Lewin M, et al. Eur Radiol, 2011.