Diffusion-weighted MRI for the zonal characterization of liver tumors

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Introduction

Several studies have shown that diffusion-weighted MRI (DW-MRI) is helpful for liver tumor characterization, mainly by showing higher apparent diffusion coefficients (ADC) in fluid-containing lesions such as cysts or hemangiomas than in solid lesions (1, 2). These studies were based on whole tumor ADC measurements and did not permit separate analysis of different components within the tumors such as viable tumor zones and fibrotic or necrotic areas. The aim of this study was to assess if DW-MRI with separate measurements of the apparent diffusion coefficient (ADC mono), the pure diffusion coefficient (ADC slow), the perfusion-related diffusion coefficient (ADC fast) and the fraction of diffusion related to microcirculation (f) (3) could be used to differentiate between viable, fibrotic and necrotic regions within liver tumors.

Material and methods

The study was IRB approved and informed consent was obtained. Eighty-eight patients programmed for MRI to assess their liver tumor between May 2009 and August 2010 were prospectively included. Liver cysts and tumors < 1cm were excluded from the study. The examinations were performed on a 1.5T MRI scanner (Philips Medical Systems, The Netherlands). Unenhanced FSE T2-weighted MR images, DW images and 3D GRE T1-weighted images of the liver were obtained. The 3D GRE sequence was repeated during the arterial, portal venous, and delayed phases after bolus injection of 0.1 mmol/kg of gadoterate. The DW-MR echo-planar images were obtained with slice thickness of 4 mm, in-plane resolution of 4 x 4 mm and 11 b-factors (0, 10, 20, 30, 40, 50, 75, 100, 150, 300, 500 s/mm^2). Parametric images of enhancement and of diffusion parameters were obtained (including ADC slow, ADC fast, and f calculated with a biexponential model, and ADC mono with a monoexponential model). According to their degree of enhancement, the tumors were subdivided into viable regions when their enhancement was maximal during the arterial or portal venous phase, fibrotic regions when their enhancement was maximal during the delayed phase, and necrotic regions when there was no enhancement. The regions of interest were copied on the DW-MR images.
Results are presented as mean +/- SD. Data were analyzed by ANOVA for repeated measurements and Student's t-test for differences between groups. $P < 0.05$ was considered statistically significant.

Results

ADC slow differed significantly ($p < 0.05$) between the three tumor regions of viable tissue, fibrosis and necrosis (viable regions: 1.25 +/- 0.31 x 10^3 mm^2/sec, versus fibrotic regions: 1.47 +/- 0.29 x 10^3 mm^2/sec, and necrotic regions: 1.85 +/- 0.61 x 10^3 mm^2/sec) (Fig. 1). There was a significantly lower f value in the necrotic regions (13 +/- 5%) than in the viable tumor regions (22 +/- 9%, $p < 0.05$), but f of the fibrotic regions (18 +/- 7%) did not differ significantly from that of the viable or the necrotic regions. ADC mono and ADC fast did not differ significantly between the three groups (viable regions: 1.78 +/- 0.54 x 10^3 mm^2/sec and 46.81 +/- 39.60 x 10^3 mm^2/sec respectively, versus fibrotic regions: 1.85 +/- 0.45 x 10^3 mm^2/sec and 42.19 +/- 32.43 x 10^3 mm^2/sec, and necrotic regions: 2.16 +/- 0.75 x 10^3 mm^2/sec and 31.49 +/- 15.78 x 10^3 mm^2/sec).

Discussion and conclusion

This study shows that viable regions in liver tumors can be differentiated from fibrotic and necrotic regions by ADC slow measurements, but not by simple ADC mono measurements. These results suggest that when using DW-MRI for the characterization and follow-up during treatment of liver tumors, ADC slow rather than ADC mono should be used, as recommended by the NCI consensus conference on DW-MRI (4).

References

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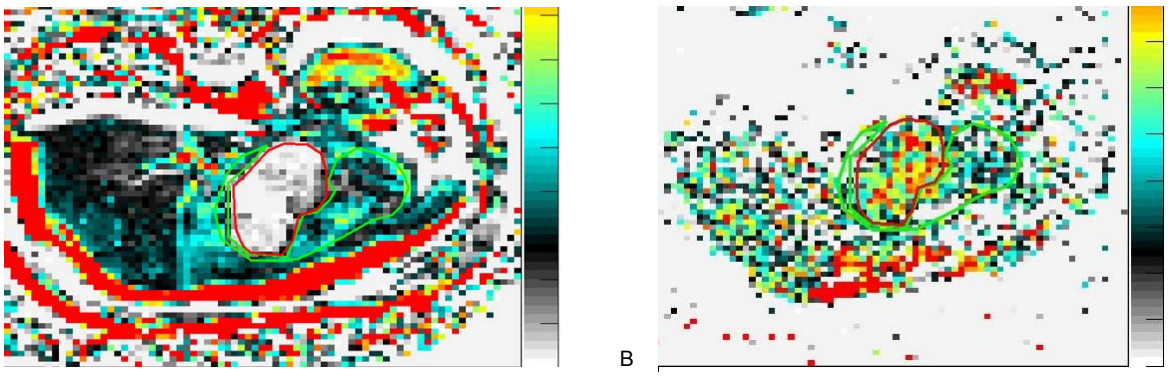

Fig. 1: Patient with hepatocarcinoma. Red ROI: necrotic region. Green ROI: viable tumor region. The viable tumor region shows higher enhancement than the necrotic region on the portal venous enhancement map (A) and lower ADC slow on the diffusion map (B).