SPIO-enhanced MR Evaluation of Regional Hepatic Blood Flow

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PURPOSE: To establish the methods of semi-quantification of regional hepatic blood flow using paramagnetic iron oxide (SPIO)-enhanced dynamic MR imaging and two-input, one-compartment model in phantom and clinical studies.

METHOD AND MATERIALS: The phantom study was conducted using a 1.5-T MR scanner (Achieva, Philips Medical Systems) and SPIO (Resovist, Bayer Healthcare)-agarose phantom. 2D-GRE (TE: 2.3/4.6), 3D-GRE, 2D-GRE-EPI, 2D-GRE (TE: 6.9), and T2W/PDW fast SE sequences were evaluated.

In clinical study, 37 patients (25 men and 12 women, mean: 62.1 years, Child-Pugh A:30, B: 7) who were suspected to have hepatic tumors (hepatic metastasis; 18 (colorectal: 13, carcinoid: 2, gastric: 1, pancreas: 1, islet cell tumor: 1), HCC: 11, FNH: 1, hyperplastic nodule: 1, hemangioma: 1, abscess: 1, simple cyst: 1, portal aneurysm: 1), underwent hepatic MR perfusion study. Dynamic scans (3D-GRE, TR: 0.76, TE: 1.97, FA: 10, Matrix: 128 x 128, Acquisition: 1, fat-suppression, 10mm x 10 slices, parallel imaging factor: 3) were conducted using the same MR scanner 0 - 90 sec after bolus injection of SPIO (0.016 ml/kg, diluted to 20ml, 3ml/sec). The center of scan volume was set at the hepatic hilum.

A software for semi-quantification of regional hepatic blood flow by two-input and one-compartment model was developed on MATLAB ver. 6 (The MathWorks, Inc.). Input functions were generated from the ROIs on abdominal aorta and main portal vein (Fig.1.). Arterial and portal perfusion maps were created (Fig.2 & 3.) and ROIs were placed on normal hepatic parenchyma as large as possible avoiding large vessels, tumors, and affected hepatic parenchyma. Mean hepatic arterial and portal blood flows (ml/min/100ml) (AHBF and PHBF), and hepatic arterial perfusion ratio (arterial blood flow / total blood flow x 100 %) (HAPR) were estimated and compared with Child-Pugh class (n = 37) and ICG_{R15} (n = 18).

RESULTS: In phantom study, 3D-GRE sequences showed the best linear relation between SPIO concentration and signal intensity over the range of 0.01 - 2mM (Fig.4.). Dilution ratio and injection rate of SPIO in clinical study were set considering the dilution ratio during passing through the heart.

In clinical study, the mean AHBF, PHBF, and HAPR were 30.2 ± 11.6, 62.3 ± 26.5, and 33.4 ± 9.6, respectively. AHBF was significantly greater ($p < 0.05$), and HAPR and PHBF tended to be greater in Child-Pugh B group than A. Weak negative correlation was found between HAPR and ICG_{R15} (γ: -0.28).

CONCLUSION: Regional hepatic blood flow can be estimated by SPIO-enhanced dynamic MR imaging and two-input, one-compartment model. The estimated values have the potential to be used for evaluation of regional hepatic function.
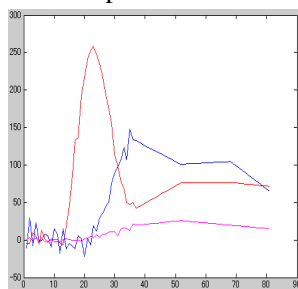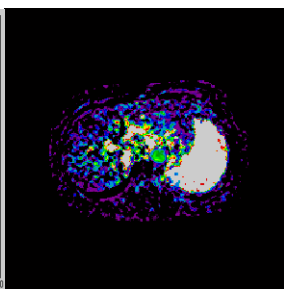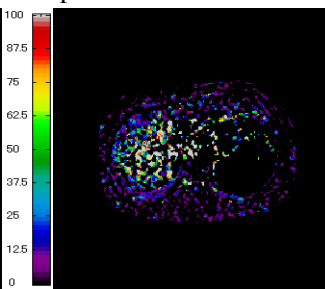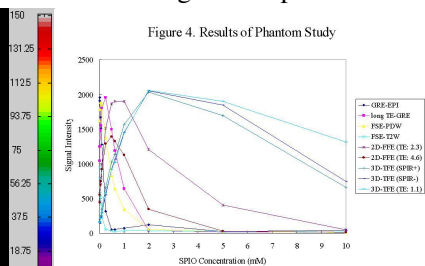

Figure 1. Input Curve   Figure 2. AHBF image   Figure 3. PHBF image   Figure 4. Results of Phantom Study