Quantification of liver perfusion MRI with a time-signal curve fitting method

Lei Wang[1], Sheng Xie[2], YongLiang Sun[2], ZhiYing Yang[2], Jia Ning[3], and HuiJun Chen[3]

[1]China-Japan Friendship Hospital, BeiJing, BeiJing, China, [2]China-Japan Friendship Hospital, BeiJing, China, [3]QingHua University, BeiJing, China

Background and purpose:

Evaluation of liver fibrosis stage and liver function has significant clinical implications in making treatment decisions. It has been published that liver perfusion is altered in patients with chronic liver disease, where perfusion MRI has been proved to have the potential to assess those vascular alterations associated with collagen deposition. Gadolinium ethoxybenzyl diethylenetriamine pentaacetic acid (Gd-EOB-DTPA) is a hepatocyte-specific MRI contrast agent, which may be applied to obtain a direct measurement of liver function. Several previous mathematic models have been developed to measure liver function using Gd-EOB-DTPA. However, those methods are not designed to be convenient enough for clinical use. In this study, a simple method was proposed to analyze the perfusion measurements and to investigate the correlation of clinical results with parameters.

Methods and materials:

A total of 33 patients with various levels of fibrosis were recruited, and they all underwent standard perfusion MRI. Twenty-six patients were operated within two weeks after the MRI examinations and the stages of liver fibrosis were determined with Batts-Ludwig classification system. The other 7 patients with operation or biopsies confirmed liver cirrhosis were defined as stage 3 or 4.

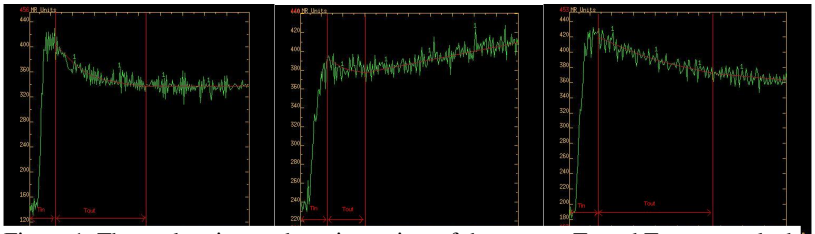

Figure 1: The peak points and turning points of the curves. T_{in} and T_{out} are marked. From the left to the right, the curve shows a flat form, a rising type and a decline type respectively.

Dynamic contrast enhanced MR acquisition was performed on a 3.0 T scanner (GE Discovery MR750, Mikauwee). 3D LAVA（liver acceleration volume acquisition）sequence was applied to scan the liver. Scan parameters were set as follows: TR/TE 2.084/0.82ms, flip angle 12°, FOV 400*400mm², spatial resolution 3*3mm², slice thickness 5.0 mm with no gap. The contrast-enhanced acquisition started at the same time with injection. 8-10 mL of injection solution (0.025mmol Gd-EOB per kilogram of body weights) was injected intravenously at 2 mL/sec, followed by 15 mL of saline flush administered with same injection rate. A total number of 200 phases were acquired which lasted for 6min55s. On workstation, the time-intensity curves of MR signal from the perfusion MRI were analyzed by linear fitting in segments, where the curves were separated into three segments. The first segment was a sharp rise, which was caused by the arterial and portal infusion of the liver. The interval from the start of scanning to the peak point of the intensity was recorded as T_{in}. Then the signal decreased, after a period of time, it would increase again, or continue to decline but at a different rate. There was a turning point which divided the curve after the peak into two segments according to different gradients. The interval between the peak point and the turning point was recorded as T_{out}. The slope of the third segment was measured as K_{up}, which reflected the uptake of the contrast. The ratio of the signal intensity of the peak to the last phase was estimated.

According to the stages of liver fibrosis, patients were divided into two groups (23 patients with S0-2; 10 patients with S3-4). Parameters of perfusion MRI were compared between two groups using Mann-Whitney U test. Correlations were tested among the parameters and serum prealbumin level, where pre-albumin was a sensitive index for damaged liver function.

Table 1 Mean and standard deviation for the estimated Tin, Tout, Kup and Ratio between the S0-2 group and S3-4 group.

	S0-2 group	S3-4 group	*P* value
T_{in}	42.24±13.51	60.82±28.44	0.270
T_{ou}	76.10±30.39	146.73±58.03	0.006
K_{up}	0.21±0.14	0.03±0.19	0.001
Ratio	0.97±0.08	0.93±0.13	0.001

Results

A significant difference of each parameter (T_{in}, T_{out}, K_{up} and Ratio) between two groups was detected (Table 1). There were significant correlations between serum pre-albumin level and K_{up} or Ratio (r=0.691 and 0.700 respectively, P<0.05), whereas serum pre-albumin level was negatively correlated to T_{out} (r=-0.591, P<0.05). The figure shows different types of time-intensity curves among the patients.

Conclusion

The new procedure for quantifying the hepatocyte-specific uptake of T1-enhancing contrast agent was capable to demonstrate that the impaired hepatobiliary function severely influenced the hepatic uptake of Gd-EOB-DTPA. Therefore, the interval of blood inflow from perfusion MRI data has shown a potential to predict advanced fibrosis.