T1ρ relaxation of the liver; Comparison of the continuous wave and stretched type adiabatic hyperbolic scant (HS) pulses for the assessment of liver function

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Target Audience: Researchers and clinicians interested in body/liver imaging and disease

Introduction

T1ρ relaxation has potential as a biomarker of liver function in patients with chronic liver disease (CLD) because T1ρ values of the liver were significantly prolonged related to the worsening of liver function [1,2]. A continuous wave (CW) pulse was used for the assessment of liver function, but this method is sensitive to B0 and B1 inhomogeneity and subject to a limitation of specific absorption ratio. An amplitude and frequency modulated adiabatic hyperbolic scant (HS) pulse train has been introduced to overcome these problems [3,4]. Therefore, this technique has a potential to improve the assessment of the severity of liver function. The purpose of the present study was to compare the adiabatic HS pulse with the CW pulse regarding the visual image quality and diagnostic capability of T1ρ map in patients with or without CLD.

Materials and Methods

Forty-four patients with metastatic liver tumor or CLD (F:M = 20:24, age range = 45-81 years, mean = 69.3 years) were scanned liver MRI on a 3.0 Tesla MR system (Achieva TX, 3.0T, Philips Healthcare, Best, The Netherland) using a 32-channel torso-cardiac phased-array coil. The T1ρ relaxation of the liver was calculated using three different methods [3]: 1) the CW, 2) the stretched type adiabatic hyperbolic scant 8 (HS8) pulse with a pulse duration of 5ms (adiabatic-HS8-5) and 3) the stretched type adiabatic HS8 pulse with a pulse duration of 10ms (adiabatic-HS8-10). The spin lock (SL) frequency offset of CW was 500Hz and the time of SL (TSL) were 1, 20 and 40 ms. A maximum amplitude of the adiabatic-HS8-5 and -HS8-10 were 13.48μT and 6.73μT, respectively. The SL frequency sweeps of the adiabatic-HS8-5 and HS8-10 were 1273.2Hz and 636.62Hz, respectively. TSL were 0, 20 and 40ms. Scan parameters of readout sequence were: 3D-TFE, TE/TR=0.98/2.1ms, 2.25×2.22×10mm, FA=10, number of slice=3, shot interval=5sec, SENSE factor=2, scan time was 15sec for each TSL, with one breath hold. The T1ρ map was generated on a pixel-by-pixel basis on Philips Research Integrated Development Environment (PRIDE) software written in Interactive Data Language using a mono-exponential decay model: M(TSL) = M0*exp(-TSL/T1ρ). Homogeneity of each T1ρ map was visually scored by two readers using 3-point scoring; 1: Poor, 2: Fair, 3: Good. In addition, T1ρ values of the liver were calculated after a total of 15 regions of interest (ROIs) were drawn on each map referring to source images of T1ρ map by one radiologist. The ROIs were made as large as possible on the liver parenchyma while still avoiding major vessels, tumors and artifacts. Patients' blood serum parameters, including the indocyanine green (ICG) clearance tests, were recorded not more than 1 week before or after MRI. The ICG clearance tests were performed using 0.5 mg/kg body weight Diagnogreen (Daiichi Pharmaceutical, Tokyo, Japan). Blood samples were collected before and 15 minutes after the Diagnogreen administration, and the retention rates at 15 minutes after the injection (ICG-R15s) were measured (normal range, <15%). Visual scores were compared using the Wilcoxon signed-rank test. Pearson's correlation coefficients (r = simple correlation) were calculated between T1ρ value of the liver and ICG-R15. A $p < 0.05$ was considered significant.

Results

Figure 1 shows the results of visual score of T1ρ maps and correlation between T1ρ value of the liver and ICG-R15 of three different methods. Mean±SDs of visual scores were: CW, 1.9±0.8; adiabatic-HS8-5, 2.6±0.6; and adiabatic-HS-10, 2.6±0.6, respectively. The adiabatic-HS8-5 and adiabatic-HS8-10 showed significantly higher visual scores ($p<0.05$). There was no significant difference in visual scores between adiabatic-HS8-5 and adiabatic-HS8-10. Pearson's correlation coefficients were: CW, r=0.34 ($p<0.05$): adiabatic-HS8-5, r=0.27 (p=0.10); and adiabatic-HS8-5, r=0.18 (p=0.28), respectively. T1ρ values of the liver were prolonged relating to the increase of ICG-R15, in other words, a worsening of liver function. However, the CW only showed significant positive correlations between T1ρ of the liver and ICG-R15. **Figure 2** is example colored T1ρ maps of three different methods.

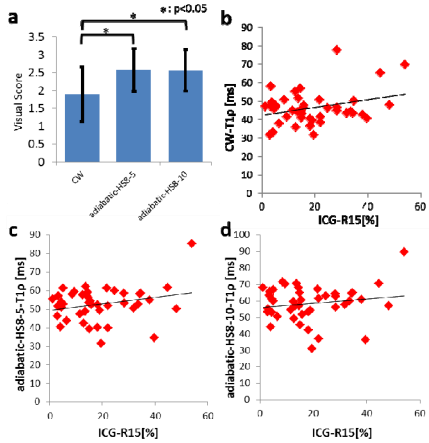

Figure 1. a) Graph (mean±SDs) of visual scores of three different methods. Scatter graphs of b) CW-T1ρ, c) adiabatic-HS8-5-T1ρ and d) adiabatic-HS8-10-T1ρ regarding the correlation between T1ρ values of the liver and ICG-R15.

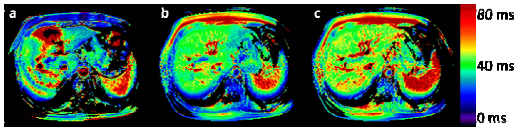

Figure 2. Colored T1ρ maps of the liver of a) CW-T1ρ, b) adiabatic-HS8-5-T1ρ and c) adiabatic-HS8-10-T1ρ. Visual score were: CW-T1ρ, 1.0; adiabatic-HS8-5-T1ρ, 3.0 and adiabatic-HS8-10-T1ρ, 2.0, respectively.

Discussion and Conclusion

The stretched type adiabatic HS8 pulse provides homogeneous T1ρ maps at 3T, but this technique might not have enough diagnostic capability of T1ρ relaxation for the assessment of liver function. Speculated reasons might be related to the selection of TSL or inadequate T1ρ contrast of the stretched type adiabatic HS8 pulse. The CW was advantageous for the assessment of liver function using T1ρ relaxation although the modification was necessary to minimize inhomogeneous T1ρ map.

References

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