Fast T1 mapping for liver function estimation using Gd-EOB-DTPA

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Introduction: It has been shown that quantitative measurement of liver T1 value after administrating Gd-EOB-DTPA provided liver functional information [1]. In the previous work, T1 map was obtained two dimensionally. Three dimensional (3D) T1 measurement may provide more detailed diagnostic information, however, it is challenging especially in abdominal region because scan time is dramatically increased. In this work, we demonstrated a novel approach to measure T1 value of liver with multiple breath-holding 3D acquisitions. The purpose of this study is to develop and establish a method to acquire 3D T1 map from the liver with clinically acceptable scan time.

Methods: In this study, IR-prep 3D fast SPGR (3D IR-fSPGR) pulse sequence was developed. This sequence allowed rapid 3D data acquisition following non-selective IR pulse and was designed such that the respective TI data sets are acquired in separated breath-hold scans. First, phantom study was conducted in order to verify the accuracy of T1 value. T1 value of the phantom that consists of various concentrations of Gd-EOB-DTPA diluted by saline solution was compared between the developed sequence and 2D IR-FSE as gold standard on 1.5T clinical scanner (GE Healthcare, Signa HDxt, WI, USA). Acquisition parameters for 3D IR-fSPGR were: TR/TE=2.4/1.0ms, FA=4deg, FOV=36*36cm^2, matrix=128*128 (reconstructed to 256*256), THK=4mm*32 slices, and scan time for each TI data was approximately TI+4s. Acquisition parameters for 2D IR-FSE were: TR/TE=12000/36.9ms, ETL=4, FOV=36*25cm^2, matrix=128*128 (reconstructed to 256*256), THK=6mm *1 slice, and scan time for each TI data was 4m48s. In both sequence, 5 different TIs were set to be 75, 100, 600, 1600 and 4000 ms, respectively. T1 map was obtained by prototype software using non-linear least squares fitting based on Levenberg-Marquardt algorithm [2]. In addition to the phantom validation, volunteer study was conducted. Following a volunteer study protocol at the authors' institution, T1map were obtained from six healthy volunteers using 3D IR-fSPGR sequence. Acquisition parameters of the volunteer study were the same as those of the phantom study except for THK=7mm and TI=41, 250, 500, 1000 and 4000 ms.

Results and Discussion: A plot of T1 values of Gd-EOB-DTPA phantom acquired by 3D IR-fSPGR and 2D IR-FSE is shown in Fig.1 (a). It shows good correlation between 3D IR-fSPGR and 2D IR-FSE in a wide range of T1 from 200 to 3000ms. Compared with 2D IR-FSE, 3D IR-fSPGR could provide T1 map with dramatically less scan time and larger volume coverage. In the volunteer study, 3D T1 map was successfully from all volunteers. A typical result of 3D T1map acquired from healthy volunteer is shown in Fig.1(b). By ROI-based analysis, T1 value was uniform in the liver parenchyma and was consistent with the previously reported T1 value using 2D acquisition [1].

Conclusion: We demonstrated that 3D IR-fSPGR pulse sequence can be useful for rapid acquisition of 3D T1map of the liver with acceptable accuracy of T1. This approach can be expected to evaluate T1 of the liver with large volume coverage with clinically acceptable scan time.

Reference: [1] Katsube T, Okada M, Kumano S, et al. Invest Radiol. 2011 Apr;46 (4):277-83. [2] Press WH et al. Numerical Recipes in C Second Edition (1992)

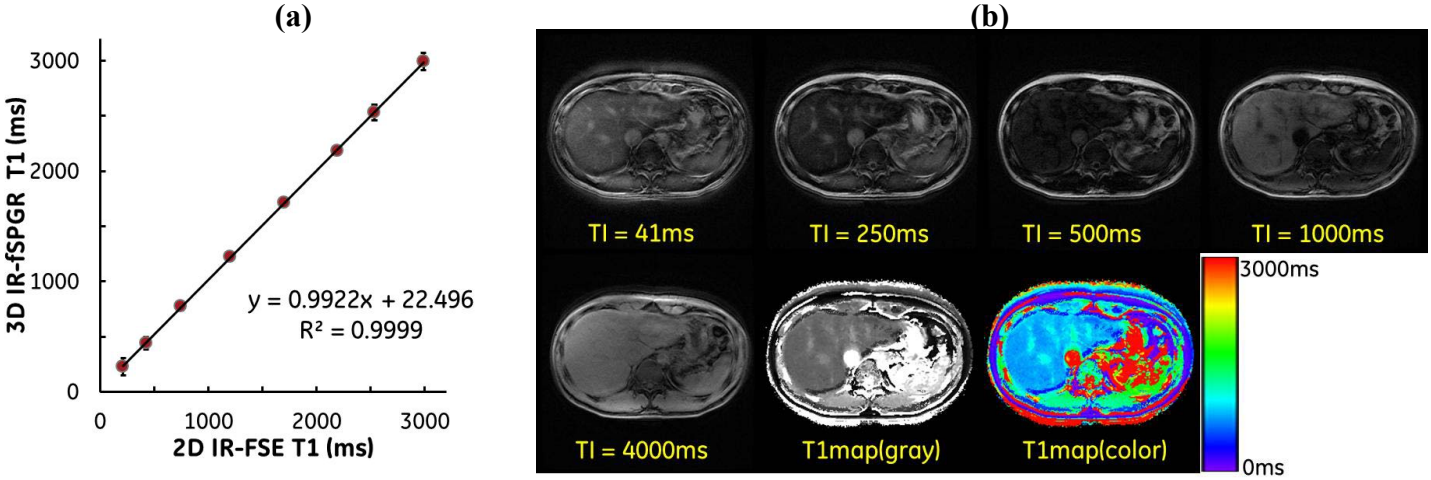

Fig.1 (a): A plot of T1 values of Gd-EOB-DTPA phantom acquired by 3D IR-fSPGR and 2D IR-FSE sequences. T1 values showed good correlation between them. (b): A typical result of 3D T1map acquired from a healthy volunteer.