The optimal curve-fitting models for liver T2´ measurements iron overload in β-thalassemia major patients

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Introduction

MRI T2 and T2* have been widely used for liver iron assessment and show strong correlations with liver iron concentrations (LIC) [1, 2]. The T2* is more sensitive to iron-induced field inhomogeneity than T2 [3]. However, fibrosis and cirrhosis in liver affected to the T2 could be a confounding factor for the accuracy of T2* iron measurement [4]. T2´ is another MRI parameter that reflects solely to the magnetic field inhomogeneity and shows high correlations to LIC, T2 and T2* [5, 6]. Two major analysis methods have been used to calculate for liver T2 or T2*, region of interest (ROI) based and pixel based methods. ROI based method is derived from an exponential curve fitting of mean signal intensity in a selected ROI of liver parenchyma at the region of regular biopsy [7]. Pixel based method is obtained from median T2 or T2*of all pixels of the whole liver parenchyma excluding great vessels [7-9]. Data analysis of pixel based method requires more works and time compared to that of the ROI based method. To our knowledge, T2´ with ROI based has never been documented. Therefore, we aims to find the correlations between T2´ obtained from pixel based method and ROI based method in 3 different curve fitting models, mono-exponential, offset, and truncation.

Purpose

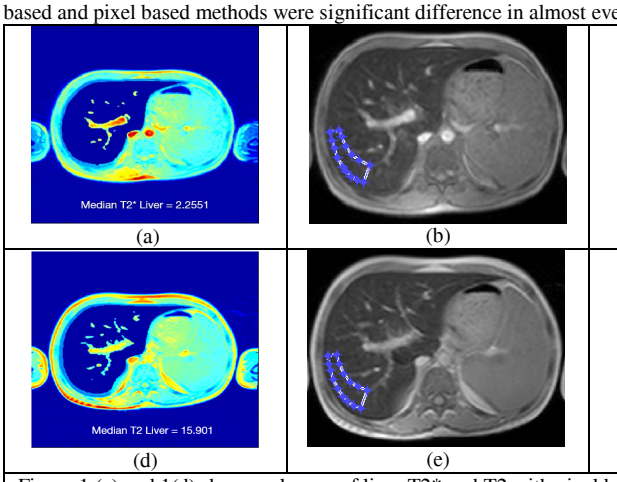
The purpose of this study was to compare the liver T2´obtained from ROI based and pixel based method in three different curve fitting models.

Materials and methods

Fifteen β-thalassemia major patients (7 males and 8 females, mean age 13.59±2.48) who have received blood transfusion and chelation therapy were involved to this study. The study was reviewed and approved by a local institutional review board. Images were acquired on a 1.5 Tesla, Achieva, Philips, Netherland, MRI scanner with a SENSE torso 16 elements coil. The T2´ in each voxel was calculated from the relationship between T2 and T2* (1/T2*=1/T2+1/T2´) by 2 acquisitions, multi-echo spin echo and multi-echo gradient echo pulse sequences of axial liver images through the center with slice thickness 10 mm. Scanning parameters were TEs4.35-130.50 ms at 4.35 ms increment, and TR 2000 ms for T2 acquisition, and TEs 1.179-28.323 ms at 0.936 ms increment, TR 100 ms, and flip angle 30degree for T2* acquisition. Matrix size was adjusted in accordance with patient size and feasible scan time. ROI based method was performed by selecting a ROI near the posterior border of liver in homogenous area avoiding great vessels. Average signal intensity in the ROIs of 30 TEs was plotted against TEs and fitted for decay curves in three models, mono-exponential, offset, and truncation model (signal from late echo times were excluded). For the pixel-based method, each pixel excluding great vessels in a selected ROI was fitted for T2´ with the 3 curve fitting models. Median T2´was represented liver T2´.Segmentation to eliminate great vessels was done by fuzzy clustering algorithm (FCM). All analysis was performed on a PC using MATLAB R2014b (Mathworks, Natick, MA, USA), and SPSS software V. 17. Inter and Intra-observers variations in each curve fitting model were evaluated by Intra-class correlation coefficient (ICC), percent coefficient of variation (% CV), and Bland-Altman plots were used to demonstrate the variations. Pearson correlation was applied to assess the correlation between T2´ obtained from ROI based and that of pixel based methods. The differences between T2´values of ROI based and pixel based were evaluated by paired samples t-test at 95 % Confidence Interval (CI).

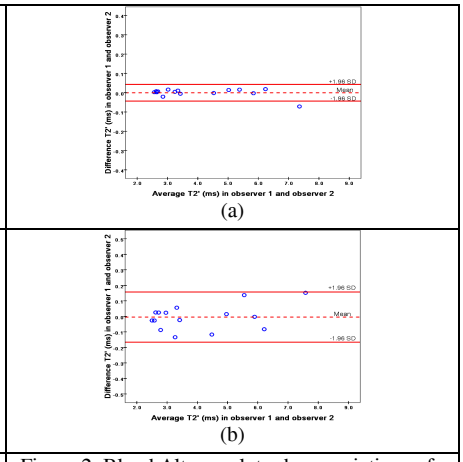
Results

The ICC demonstrated good agreement among T2´ values estimated by two observers in both ROI based and pixel based methods (correlation coefficient=0.992-1).Based on %CV, pixel based method provided less intra and inter-observers variation than those of the ROI based method in all curve fitting models, 0.27% to 1.83%, and 1.15% to4.68% respectively.The offset fitting model offered minimal %CVs of intra-observers and truncation model offered minimal %CVs of inter-observers variation in pixel based method. Likewise, the minimal %CV of inter-observers with ROI based method was from offset fitting model. Figure 1(a) and 1(d) shows an example of median liver T2* (2.2551 ms) and T2 (15.901 ms) obtained by pixel based method. Figure 1(b) and 1(e) shows a selected ROI of identical image data set for T2* and T2 ROI based analysis, and the fitting result with offset model, T2*=2.2346 ms and T2=15.8789 ms, in Figure 1(c) and 1(f). Bland Altman plots show less variation of T2´s fitted by offset model from pixel based method in Fig. 2(a) compared to that of the ROI based method in Fig. 2(b).ROI based method shows remarkably greater variation. Pearson correlation between the 2 methods showed strong correlations in all fitting models ($0.993<r<0.996$) (p=0.01). The offset curve fitting model showed higher correlation between ROI based and pixel based methods. The T2´s obtained from ROI based and pixel based methods were significant difference in almost every model except that of the offset model.



(a) (b) (c) (d) (e) (f)

Figure 1 (a) and 1(d) shows colormapof liver T2* and T2 with pixel based method fitted by offset model (medianT2*=2.2551 ms, median T2=15.901 ms). Figure 1(b) and 1(e) a selected ROI in homogenous area of liver. Figure 1(c) and 1(f) shows result of offset curve fitting model from ROI based method, T2*=2.2346 ms, and T2=15.8789 ms.



(a) (b)

Figure 2. Bland Altman plots show variations of T2´s fitted by offset model from pixel based method 2(a) and ROI based method 2(b).

Discussion and Conclusion

The liver T2´s measured by ROI based method showed greater variations than those of the pixel based method. This may be due to inhomogeneous deposition of the iron in liver or smaller sampling numbers of data. However, there was no significant difference of the T2´s between the ROI based and pixel based methods when they were fitted with the offset model (p=0.893), because the offset term may absorb the effects from noise and artifact.

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