SWI-based method for emphasizing susceptivity changes on liver T2* multi-echo gradient-echo MRI

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Introduction

It is well known that the susceptibility difference between tissues, such as venous blood and surrounding tissue, causes a different bulk magnetization that can be observed both in magnitude and phase images: as a signal amplitude loss due to a reduced T2*, and as a local frequency variation of the protons inside the vessel that results in a phase angle Φ of the venous blood signal, respectively. So, these two types of information can be combined for obtaining an image with susceptibility related contrast (susceptibility weighted imaging - SWI) [1].
In the clinical MRI practice, it is common to assess liver iron overload by T2* multi-echo gradient-echo images. The currently used methods involve manual drawing of a region of interest (ROI) within liver parenchyma carefully excluding vessels; then, evaluation of a representative liver T2* value is done by fitting an appropriate model to the signal decay within the ROIs vs. the echo time. Such ROI-based methods may suffer from sampling errors due to user-dependent placement of the ROI and erroneous inclusion in the ROI of regions close to liver vessels. Arterial vessel in T2*-weighted images appear as bright pixels with a quite good contrast with the parenchyma, but venous vessels often are not visible in T2*weighted images, so an erroneous inclusion of venous vessels in the ROI can occur.
In the present work we suggest a method, based on a SWI approach, that increases the contrast between tissues of different susceptivity, in liver T2* multi-echo gradient-echo images.

Materials and methods

Liver MRI were acquired by using a 1.5-T MR scanner (GE Excite, Milwaukee, WI, USA) with an eight-element cardiac phased array coil. Fast gradient-echo multi-echo sequence (flip angle 25°, matrix 192×256 pixels, field of view 40×40 cm, bandwidth 62.5 kHz, slice thickness 8.0 mm, number of excitations 1, repetition time 25 ms) was used and both amplitude and phase images were memorized. A single transverse slice through the liver was obtained at 10 different TEs (2.0–21.8 ms, increasing in 2.2-ms increments) in a single end-expiratory breath-hold; the total acquisition time was about 5 s [2].
Magnitude and phase images stored during acquisition, for each TE, were processed offline using Matlab (The Mathworks, Natick, MA, USA). Postprocessing operation included the following steps [1, 3]:

1. high-pass filtering of the phase image, for background fields inhomogeneities removal; the filter was performed with a 2D circular low-pass Hamming window with kernel *k* and then transformed in high-pass filter by a complex division;
2. phase mask definition, in order to suppress the signal of the pixels having specific phase values, due to the presence of high local susceptibility;
3. product of the amplitude image and *m*-times the mask, in order to obtain a SWI-like image from T2* multi-echo gradient-echo images.

Results

In figure 1a, amplitude image with two selected ROIs is shown; it includes also a zoom of a region including the ROIs. The relevant mean-intensity vs.TE curves are shown in fig 1b; figures show that selecting two ROIs in regions apparently similar, the mean intensity-TE curves are different. It is due to the presence of a different susceptivity variation in the ROI_1, as it appears in figure 1e. Figure 1c shows the phase image, while figure 1d is relevant to the resulting mask, obtained with filter kernel k=64 and multiplying factor m=7, to be applied on the amplitude image; in figure 1e the final SWI-like image is shown, where the dark regions, with higher susceptivity variations, are emphasized (see also the zoomed region).

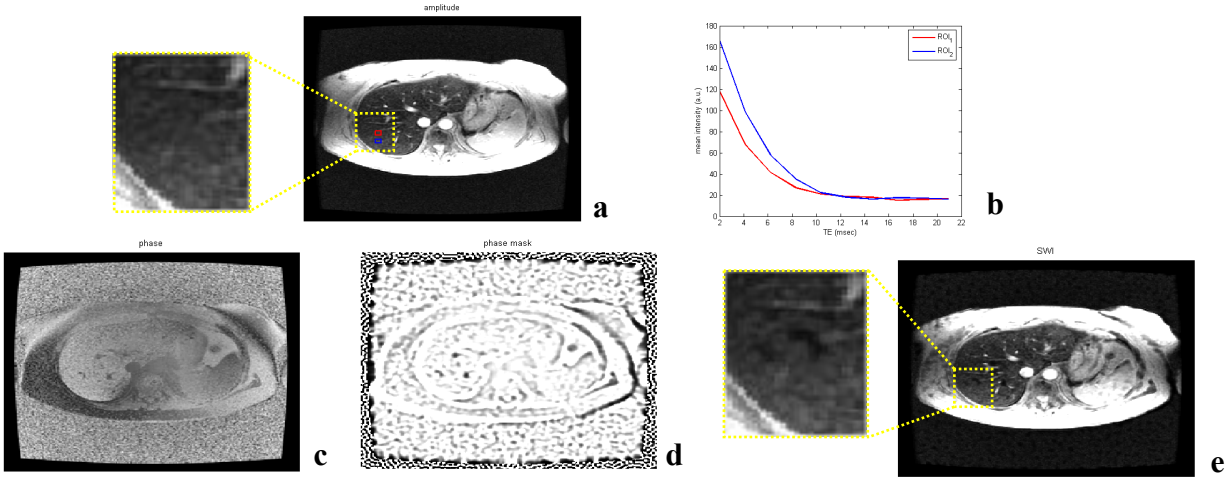

Figure 1

Discussion and Conclusions

SWI technique is largely used in brain imaging studies for visualizing susceptivity variations in the brain. In the present work, we suggest to exploit such method for enhancing susceptivity variations in liver T2* multi-echo gradient-echo images, without increasing the examination time. The resulting images can be used to better define the ROI for a more accurate evaluation of liver T2*.

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