Quantitative texture analysis of the fibrotic liver on double-contrast enhanced gradient recalled echo images: A first step in non-invasive diagnosis of liver fibrosis using MR imaging

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Introduction

Cirrhosis is an important cause of morbidity, mortality, and health care costs worldwide. Currently, diagnosis of cirrhosis requires biopsy. A reliable non-invasive method to detect liver fibrosis would: 1) reduce or eliminate biopsy complications; 2) save costs; 3) eliminate sampling errors; and 4) provide global assessment of the entire liver. SPIOs are 35-227 nm synthetic iron-oxide particles that are phagocytosed by liver Kuppfer cells. These particles gradually accumulate in normal liver and regenerating nodules after intravenous infusion. Accumulation causes signal loss on GRE images because of T2* shortening. Fibrotic tissue lacks Kuppfer cells, does not accumulate SPIOs, and does not lose signal. On delayed images after Gd administration, fibrotic tissue enhances, further increasing its conspicuity. Thus, the cirrhotic liver has a heterogeneous appearance on double-contrast enhanced GRE sequences: hyperintense reticulations of fibrosis surround hypointense regenerating nodules. The aim of this retrospective study was to identify image texture features that reliably differentiate fibrotic from normal from liver on double-enhanced GRE images.

Methods:

12 patients, 6 with pathology proven fibrosis and 6 normals, underwent combined SPIO and Gd enhanced MR imaging at 1.5T. Double-contrast enhanced, chemically fat saturated, spoiled 2D GRE images ($160/4.5/70^{o}$) were retrospectively evaluated. Images were 8 mm thick without gaps and had 32-40 mm field of view (88x256 matrix). Two MR radiologists without knowledge of pathology or clinical data reviewed the images and placed comparably-sized regions of interest (ROIs) in representative areas of the liver on each of the twelve cases, avoiding blood vessels. Twenty-nine feature detection operators useful in quantifying image heterogeneity were applied to the ROIs with Matlab software. Statistical comparisons were performed (unpaired Student t-tests assuming unequal variances). A two-tailed alpha level of 0.05 was chosen for statistical significance. We did not correct for multiple comparisons.

Results:

Twenty-six of 29 (90%) quantitative measurements of heterogeneity were higher in fibrotic compared to normal liver, including 11/29 (38%) that were statistically significant.

The variable that showed the most significant difference was coefficient of variation ($P<0.0001$). Also statistically significant were:

- two image information variables: inverse of angular momentum ($P<0.0001$) and entropy ($P<0.02$);
- two measures of pixel intensity distribution: kurtosis ($P<0.003$) and skewness ($P<0.02$);
- three difference operators ($P<0.02$ for all);
- three measures of image gradient ($P<0.05$ for all).

In contrast, 3/29 (10%) quantitative measurements were higher in normal liver, none of which were significant (P-values from 0.34 to 0.91).

Conclusions:

Internal liver architecture can be assessed with quantitative texture measurements on double-contrast enhanced 2D GRE images. This capability shows promise for noninvasive scoring of liver fibrosis. Multi-variate image texture analysis in conjunction with pulse sequence optimization is being developed to detect and score fibrosis in a larger cohort of patients. Further development of non-invasive MR assessment of liver fibrosis is warranted.