Quantitative Ultrasound Spectroscopy Tissue Characterization of Nonalcoholic Fatty Liver Disease in Patients

Amir M. Pirmoazen, Aman Khurana, Isabelle Durot, Aya Kamaya, Ahmed El Kaffas,
Department of Radiology, School of Medicine, Stanford University, Stanford, California

Background, Motivation and Objective

Early detection, characterization and monitoring of Nonalcoholic fatty liver disease (NAFLD) is critically needed to facilitate disease management and minimize end-stage complications. Ultrasound is ideal for rapid bedside screening applications, tissue characterization and repeated liver imaging, and may be an ideal tool to guide NAFLD patient management if further developed. Here, we assessed Quantitative Ultrasound Spectroscopy (QUS) as a tissue characterization tool for hepatic steatosis in patients with or suspected of NAFLD.

Statement of Contribution/Methods

A total of 24 patients (sex: 12 men, 12 women; age: 53 ± 14.9; bmi: 30.2 ± 6.5) with or suspected of NAFLD, and without history of chronic liver disease, were prospectively recruited and consented for this IRB-approved study. All patients had a proton density fat fraction (PDFF) measured by MRI, which served as a reference standard. Steatosis was categorized as S0, <5%; S1, 5-10%; S2, 10%-20% or S3 >20% based on the PDFF. A minimum of 3 ultrasound liver acquisitions with RF data, obtained in the right lobe (sectors 5 and 6), were acquired for each patient using a Philips EPIQ 7 coupled to a C5-1 transducer. Imaging parameters were not varied, except for the focus and depth. Corresponding phantom images were acquired for each patient with matching imaging parameters. An ROI was drawn by one observer within 2 cm of the focus in the liver parenchyma. The average normalized (using tissue phantom) power spectrum for each ROI was extracted and a linear regression was fit within the -6 dB bandwidth window of the power spectrum, from which the mid-band fit (MBF), spectral intercept (SI) and spectral slope (SS) were extracted. The correlation of single or combined QUS parameters to PDFF grading were assessed using the Spearman correlation coefficient (r). The diagnostic performance of the QUS parameters was evaluated with receiver operator curves.

Results/Discussion

Our n=24 patient population consisted of 25% S0, 13% S1, 29% S2 and 33% S3. All three QUS parameters correlated significantly with the MRI-based PDFF fat fraction. Preliminary analysis indicated that the SS had the best correlation with a $r = 0.91$ ($p < 0.0001$), followed by the MBF with and $r = 0.84$ ($p < 0.0001$). The SI also had a good inverse correlation with PDFF fat fraction, with and $r = -0.82$ ($p < 0.0001$). The area under the ROC to correctly identify S3 steatosis was found to be 0.89, 0.91, and 0.97, for the MBF, SS and SS, respectively. Our results indicate that QUS parameters are good indicators of fatty liver content, and that these could be used alone or with other quantitative measures to characterize different subtypes of NAFLD.