Ultrasound parametric imaging of pediatric nonalcoholic fatty liver disease using the Nakagami statistical distribution and the information theoretical entropy

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Background, Motivation and Objective

Nonalcoholic fatty liver disease (NAFLD) is now common in children and adolescents. Ultrasound has been widely used to screen NAFLD. Hepatic steatosis alters the properties of scatterers in the tissue, which result in different behaviors of backscattering and the corresponding backscattered statistics. The model-based statistical distributions and non-model-based information theoretical entropy are currently the two major analysis methods for backscattered statistics analysis. However, histological characteristics of pediatric NAFLD differ from those of adult NAFLD. Thus, the usefulness of model- and non-model-based statistical approaches in characterizing pediatric NAFLD remains unanswered. This study investigated the performances of using the Nakagami distribution (an approximation model of ultrasound backscattered statistics) and the information entropy (a typical non-model-based measure) in pediatric NAFLD examinations.

Statement of Contribution/Methods

A total of 53 subjects were enrolled in this study (age: 3 – 18 years-old). For each patient, blood examinations were performed to calculate the hepatic steatosis index (HSI), and hepatic steatosis was identified when HSI > 36. Subsequently, an ultrasound scanner equipped with a 3.5 MHz convex transducer was used to scan the liver by intercostal approach and acquire the image raw data for ultrasound Nakagami and entropy imaging. The Nakagami parameters and entropy values corresponding to the control and steatosis groups were compared to evaluate the diagnostic performances by the receiver operating characteristic (ROC) curve, and those as a function of HSI were also used for correlation analysis.

Results/Discussion

The Nakagami parameters were 0.47±0.08 and 0.77±0.06 for the control and steatosis groups, respectively. The entropy value of the normal control was 5.08±0.02, and that of the steatosis group was 5.14±0.01. The accuracies for using the Nakagami and entropy values in diagnosing hepatic steatosis were 96% and 90%, respectively. The Nakagami parameter significantly correlated with the HSI (the correlation coefficient $r = 0.76$) compared with the entropy ($r = 67$). According to the above results, we summarized two critical findings: (i) pediatric NAFLD alters the backscattered statistics to be closer to the Rayleigh distribution; the signal uncertainty also becomes higher; (ii) ultrasound entropy imaging was reported previously to improve diagnosis of adult NAFLD compared with Nakagami imaging. However, the Nakagami parameter diagnoses pediatric NAFLD with a higher accuracy, and it also correlates with the HSI more significantly, as supported by the current results. The mechanisms are under investigation; but importantly, the model-based statistical distributions may be more applicable to accurate tissue characterization of pediatric NAFLD.