Mechanical Modeling and Ultrasound Elasticity Imaging for Quantification of Hepatic Fibrosis

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Abstract—To evaluate quantitatively the stage of chronic hepatitis with respect to fibrosis on the basis of ultrasound tissue elasticity imaging, we introduced a mechanical model of fibrosis progression and simulated the process by which hepatic fibrosis affects elasticity images and compared the results with those clinical data analysis. As a result, it was confirmed that even in diffuse diseases like chronic hepatitis, the patterns of elasticity images are related to fibrous structural changes caused by hepatic disease and can be used to derive features for quantitative evaluation of fibrosis stage.

I. INTRODUCTION

Ultrasound tissue elasticity imaging is a new modality for the visual assessment of tissue elasticity especially for cancer diagnosis. The first practical system was developed by us in 2003 and referred to as the Real-Time Tissue Elastography® (RTE). This technology has already been proved to be diagnostically valuable in detecting tumor of the breast, prostate and other organs.[1] We found that texture of elasticity image (strain) of chronic hepatitis becomes patchy pattern as liver fibrosis progress and could be categorized into the four stages. The purpose of this study is to evaluate fibrosis progression quantitatively using ultrasound tissue elasticity image with the aim of constituting a system for computer-aided diagnosis of chronic hepatitis. Then, we introduced a mechanical model of fibrosis progression and simulated the process that hepatic fibrosis affects elasticity images and compared clinical data analysis.

II. METHODS

Chronic hepatitis causes the fine liver lobule structure to change to a coarse nodular structure stage by stage. Then, it is expected that fibrosis cause the inhomogeneous distribution of tissue hardiness, which produces non-uniform texture pattern of strain images. To increase objectivity, we extract nine morphological and stochastic features from strain images. Pixel data in the colored strain image was transformed into a histogram, then stochastic features such as mean and standard deviation are calculated from strain histogram. The strain image is transformed into binary image, then morphological features such as complexity of the shape of an extracted low strain area are extracted. Finally, we performed multiple regression analysis to derive the index of liver fibrosis (LF index) as to nine features.

In order to clarify how fibrosis progression affects the elasticity image of chronic hepatitis, we analysed the relation by simulating the process with the following mechanical models which represent tissue structure change and tissue deformation due to hepatic fibrosis as shown in Fig. 1.

![Figure 1](image1.png)

**Figure 1. Analysis of liver fibrosis progression and its influence on strain imaging using mechanical model**

III. RESULTS

From the strain distribution, we could see that the area of low strain increases, and the strain distribution becomes more and more complex as fibrosis progresses. Extracted features of strain and derived Liver Fibrosis Index showed definite tendency as a fibrosis progression and coincided with result of clinical data analysis as shown in Fig. 2.

![Figure 2](image2.png)

**Figure 2. Relation of Liver Fibrosis Index and fibrosis stage**

IV. CONCLUSION

We proposed a mechanical model of fibrosis progression. Results of simulation indicate that even in diffuse diseases like chronic hepatitis, pattern of strain image is related with fibrous structure change caused by hepatic disease and can be used to derive features for quantitative evaluation of fibrosis stage.

REFERENCES