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Characterization of rat liver tissue by measuring the acoustic characteristics in high frequency
高周波領域におけるラット肝音響特性計測による組織性状解析

Kenta INOUE[1‡], Jonathan MAMOU[2], Kazuto KOBAYASHI[3], Yoshifumi SAIJO[4], Tadashi YAMAGUCHI[5]
([1]Faculty of Engineering, Chiba Univ.; [2]F. L. Lizzi Center for Biomedical Engineering, Riverside Research Resarch; [3]Honda Electronics Co. Ltd.; [4]Graduate School of Biomedical Engineering, Tohoku Univ.; [5]Research Center for Frontier Medical Engineering, Chiba Univ.)
井上 健太[1‡], Jonathan MAMOU[2], 小林 和人[3], 西條 芳文[4], 山口 匡[5] ([1]千葉大 工学部; [2] F. L. Lizzi Center for Biomedical Engineering, Riverside Research; [3]本多電子株式会社; [4]東北大大学院医工学研究科; [5]千葉大 CFME)

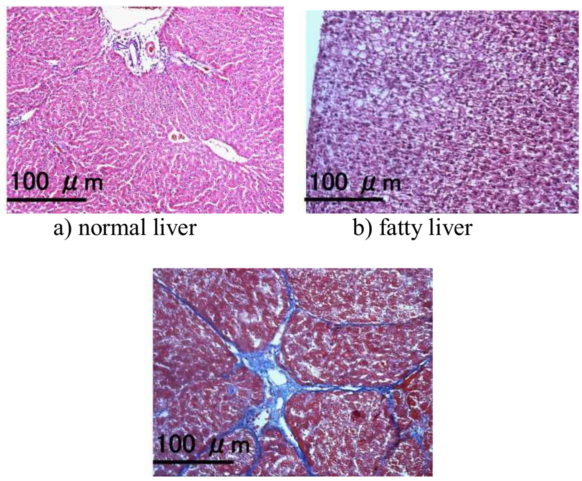
1. Introduction

Hepatitis is a growing health concern and early disease detection is critical. Ultrasound is ideally suited for real-time imaging of tissues, but typical ultrasound images do not display quantitative tissue information because it is first necessary to understand the complex interaction between ultrasound and tissue and scattering models based on tissue properties must be devised. Towards this aim, acoustic characteristics of tissues (speed of sound, attenuation and acoustic impedance) from three types of rat livers (normal, fatty, and fibrosis) were measured with a scanning acoustic microscope using transducers with center frequencies 80 MHz. The measureed results of acoustic characteristics were verified compared with the stained pathological images.

2. Measurement of target and device

Three kinds of rat liver models were used as measurement objects. Normal liver bred with normal food, fatty liver bred with high calorie food and fibrosis liver injected medicine, are made in our laboratory. After euthanasia, livers were extracted from their body immediately.

The acoustic impedance of cross-sections made from each liver was measured by acoustic microscope system (modified AMS-50SI; Honda Elec. Co.). Distilled water was used for the coupling medium between the measurement object and a ultrasonic transducer. Two-dimensional profile of acoustic impedance was obtained by mechanically scanning the transducer. Each liver was measured on ninety thousand points within size of 4.8 mm × 4.8 mm using an ultrasonic transducer that has a central frequency of 80 MHz, and a lateral resolution of 20 µm. For the measurement of the speed of sound and the attenuation, each liver was sliced about 10 µm after formalin fixation, and putted on a slide glass. The measurement was performed by using the same microscope system, and the measurement size was 2.4 mm × 2.4 mm. Additionally, The pathological specimens (HE stained) on the very near slice from the slice of the liver which measured the acoustic characteristics were created. **Fig. 1** shows an example of pathological image of three types of rat livers. In normal liver, liver tissues are observed thickly and homogeneously. Many fat droplets less than 20 µm in diameter can be observed in fatty liver. The net-like fiber structures can be observed in fibrosis liver.



a) normal liver b) fatty liver c) fibrosis liver

Fig. 1 Pathological images of three kinds of rat livers.

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z8t0804@students.chiba-u.jp

3. Measurement result of acoustic characteristics

In each liver status, three area of interests are chosen from the two-dimensional distribution of measurement results. In the fatty liver and the fibrosis liver, the area where fat droplet or fiber was observed in pathological image were chosen, respectively.

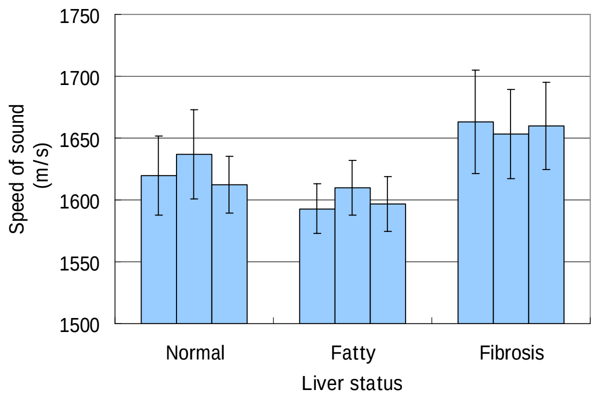

Fig. 2 Speed of sound of three types of rat liver

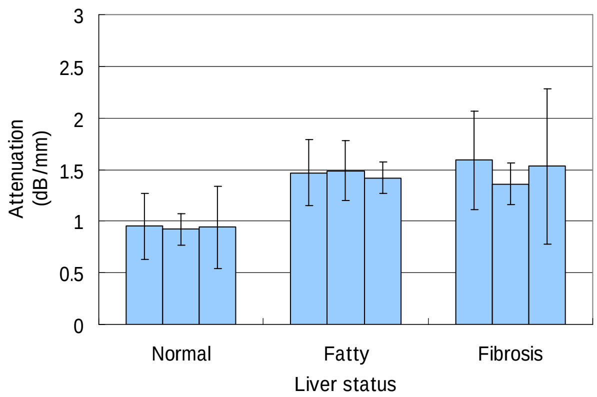

Fig. 3 Attenuation of three types of rat liver

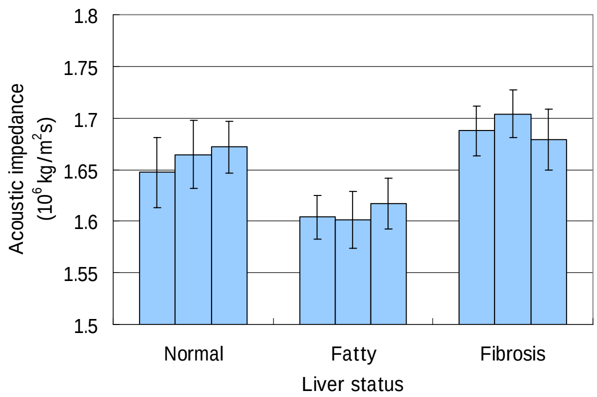

Fig. 4 Acoustic impedance of three types of rat liver

The speed of sound of fatty liver is slower than normal liver, but is faster in than normal liver in fibrosis liver (**Fig. 2**). The attenuation of fatty liver and fibrosis liver are larger than normal liver, respectively (**Fig. 3**). The acoustic impedance of fatty liver is smaller than normal liver, but it is larger than normal liver in fibrosis liver (**Fig. 4**). These results are in agreement with the acoustical characteristics of the tissues well known from previous studies measuring separately about each acoustic property[1-6].

The acoustic impedance is known as the parameter that correlated with the tissue stiffness, and represented by the relation of density and speed of sound. The high relation was confirmed in acoustic characteristics measurement of the fixed points in rat livers [7-8]. Additionally, it has high relation of the mechanical properties of the elasticity in each liver that measured using a general-purpose testing machine (EZ Test; Shimzu Co.).

4. Conclusion

In this paper, the relationship between tissue physical properties and acoustic characteristics of rat livers was examined. Correlation between the ultrasound wavelength and the distribution and size of fat or fiber deposits in the liver was investigated using the corresponding stained histology photomicrograph in one by one matching. To detect this relationship in more detail, we try to measure and analyze more tissue samples and to make a three dimensional acoustic characteristics distribution mapping.

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