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Acoustic characteristics measurement of rat liver by multi-frequency ultrasound

複数周波数によるラット肝組織の音響特性計測

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1. Introduction

In the ultrasonic diagnosis, it is difficult to obtain tissue information from only the echo signal quantitatively, since the relation between information of the receiving signal and properties of the biological tissue have not been clarified enough. In this reserch, to understand the relation between acoustic characteristics of tissues and physical properties (or structures) of the tissue in detail, some of biological tissues were measured by multi-frequency in two dimensions. The result of the acoustic characteristics measurement of the rat liver is presented in this paper.

2. Measurement and analysis of acoustic characteristics with 1-50 MHz transducer

In order to examine change of the acoustic characteristics according to the degeneration of tissues in detail, rat liver was selected as a measurement object. In this study, we used three kinds of rat livers (normal, fatty and fibrosis). Fatty livers and fibrosis livers were made with administration of high-calorie meal and carbon tetrachloride, respectively.

Each exenterate rat liver was sliced to about 3 mm thickness to make measurement samples. They were observed by our ultrasonic 2-D scannning system, with some kind of ultrasonic transducers. Attenuation and speed of sound were calculated from the measurement result.

Figure 1 is the analysing result of the reration between attenuation and speed of sound with 25 MHz transducer. The acoustic characteristics of normal livers have stable value, and it is nealy to well-known value. On the other hand, speed of sound was slow and attenuation was a large in fatty liver. This is in agreement with the feature of fat known well. One of the great factor of the acoustic characteristics change is the density of fatty tissue is smaller than normal liver tissue. Moreover, speed of sound was low and attenuation is a large value in fibrosis liver. Both values of fibrosis liver is the middle of a normal liver and fatty liver. It is thought that this is an influence by coexistence of fiber tissue and fatty tissue.

The measurement result that uses the high-frequency ultrasound has high resolution. However, strength of the echo signal received is weak because the frequency depended attenuation is large when the ultrasound is propagated in tissue. This is similar in the frequency band used for a general ultrasonic diagnosis. Therefore, same liver samples were measured by using low frequency such as 1 MHz and 5 MHz.

In the measurement and the analysys results that uses 1 MHz and 5 MHz, it was confirmed that the relation between attenuation and speed of sound in normal liver, fatty liver and fibrosis liver were similar to the result in 25 MHz. However, the dispersion of attenuation and speed of sound in fibrosis liver showed the increasing tendency especially in 1 MHz. This is because it becomes impossible to judge minute fiber tissue as an discrete scatterer.

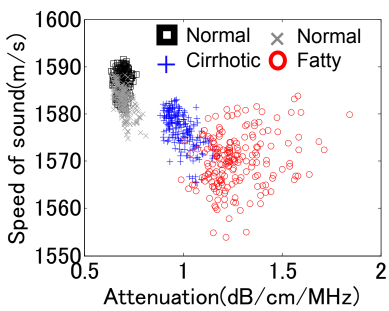

Fig.1 Correlation of attenuation and speed of sound in rat liver (25 MHz)

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3. Measurement and analysis of acoustic characteristics with 120 MHz transducer

In the measurement of the tissue by using the ultrasound of 1-50 MHz, it becomes possible to examine the tissue near the situation observed by ultrasonic diagnosis. On the other hand, it is important for achieving the tissue characterization to know specific acoustic characteristics such as liver parenchyma, fatty tissue and fiber tissue. Then, a more detailed measurement was done by using 120 MHz ultrasonic microscope system (Fig.2). This system can measure the speed of sound, attenuation and thickness of tissue.

The measurement object in this system is 10 μm thickness specimen. The specimen was made by placing the tissue that cut it in the thickness of 10 μm and 4 μm on the glass slide. The undyed 10 μm pathology specimen is measured by the ultrasonic microscope system. To examine the measurement result, the 4 μm pathology specimen were stained with the hematoxylin-eosin stain and the Azan stain.

10 μm specimens were made from tissues that measured with 1-50 MHz ultrasound. The acoustic characteristics were calculated by using this system. As a result, a different feature of the acoustic characteristics were confirmed in each liver. Moreover, the stained specimens of measurement tissues were made to examine the relation of those acoustic characteristics and tissue composition (Fig.3).

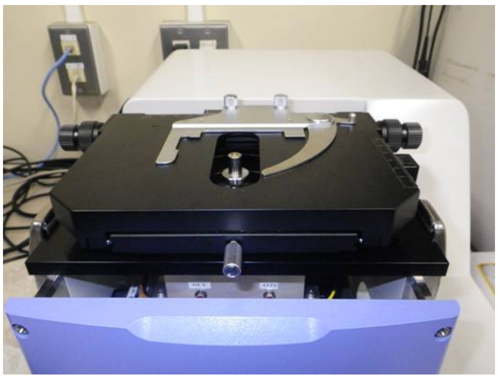
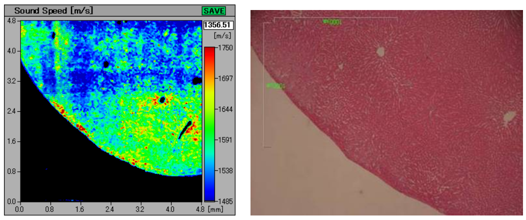
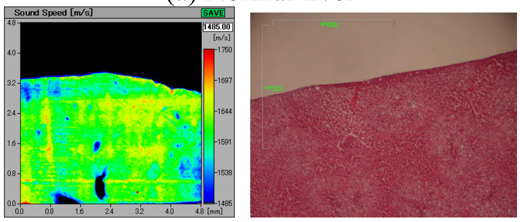


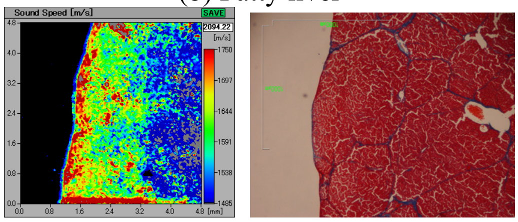
Fig.2 Ultrasonic microscope (AMS 50SI, Honda Electronics, Toyohashi, Japan)



(a) Normal liver



(b) Fatty liver



(c) Fibrosis liver

Fig.3 Speed of sound distribution image and pathological tissue

4. Conclusion

In this study, the acoustic characteristics of the normal, the fatty and the fibrosis rat livers were measured by using multi-frequency ultrasound. In using 1-50 MHz frequency, tissues that has some structures exist together were measured. In using 120 MHz frequency, specific acoustic characteristics of these tissue were measured. Moreover, to examine the relation between these measurement results and the tissue composition, the stained specimen was made. As a result, it was able to be confirmed to have changed the acoustic characteristics in the place where fatty tissue and fiber tissue existed.

In the future, the measurement of the many kinds tissues will be executed.

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