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Measurement of tissue physical properties of rat liver using multi-modality measurement system
複数モダリティを用いたラット肝組織の生体物性計測

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1. Introduction

The change of composition of living tissue that caused by some disease appears to not only the structure but also stiffness. Medical doctors are evaluating the functional lesion based on the change of stiffness by the manipulation (examination by touch). This shows that the elasticity of tissue is important information as diagnosis index. In recent years, some of tissue characterization methods which are displayed tissue physical properties including stiffness are widely used in ultrasound diagnosis and are help of earlier detection. However the quantitative diagnosis is difficult, because relations between tissue physical properties and changes of tissue characteristics are not clarified. In this paper, the aim of this study is comprehending of the relations between tissue physical properties and changes of tissue characteristics in detail. The acoustic impedance of tissue was measured by acoustic microscope, and the elasticity of tissue was measured by mechanical measurement system. The rat liver was measurement object.

2. Measurement of acoustic impedance

Rat liver was chosen for target object, because changes of tissue physical property with tissue degeneration should be examined after the measurement. The breeding of rats begins breeding from the age of four weeks. Three kinds of model, which are normal liver bred with normal food, fatty liver bred with high calorie food and fibrosis liver injected medicine, are made in our laboratory.

Rat livers were removed from their body immediately after euthanasia. The acoustic impedance measurement can be done by acoustic microscope system (Honda Electronics Co. AMS-50SI). Distilled water was used for the coupling medium between the substrate and transducer. The acoustic wave, being focused on the interface between the substrate and tissue, was transmitted and received by the same transducer. Two-dimensional profile of acoustic impedance was obtained by mechanically scanning the transducer. Each rat liver was measured on ninety thousand points within size of 4.8 mm x 4.8 mm using a transducer that had a central frequency of 120 MHz. This measurement system was calibrated by measuring well-known distilled water of acoustic impedance in advance and acoustic impedance of a measurement target was calculated.

Three kinds of normal liver of different ages were measured in this measurement. **Fig. 1** shows an example of impedance map of rat liver. The difference of physical properties of tissue surface could be observed without dyeing.

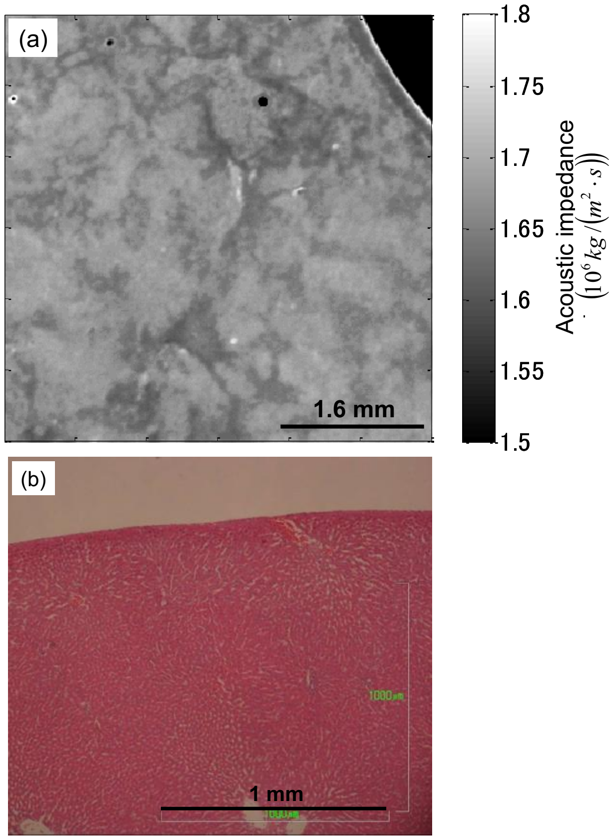

Fig. 1 Two-dimensional profiles of acoustic impedance of normal liver (a) and optical microscopy (b).

Fig. 2 shows the average value of the acoustic

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impedance in three kind of rat liver. They were calculated from ten thousand points of area estimated tissue. Acoustic impedance of liver is known as 1.65 x 10^6 kg/m^{2}s. The results of normal liver and fibrosis liver were close to this value. On the other hand, the result of fatty liver was lower than this value. We considered that it is mixed with minute fat droplets which have low acoustic impedance in whole liver tissue. It was verified with H-E stained pathological samples which made from measured liver.

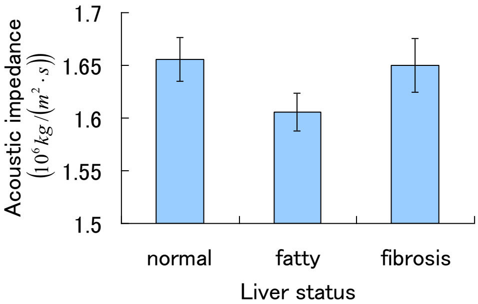

Fig. 2 Acoustic impedance of three kinds of rat livers

3. Measurement of mechanical properties

One of the most important tissue physical property is the mechanical properties including stiffness (elasticity). Mechanical properties were measured using a general-purpose testing machine (SHIMADZU EZ Test). Compressive test was performed using the flat plate and the pin of different diameter of 3 mm and 6mm. **Fig. 3** shows appearance of compressive test of specimen which cut from a lobe of rat liver. Tensile test was performed using the same machine.

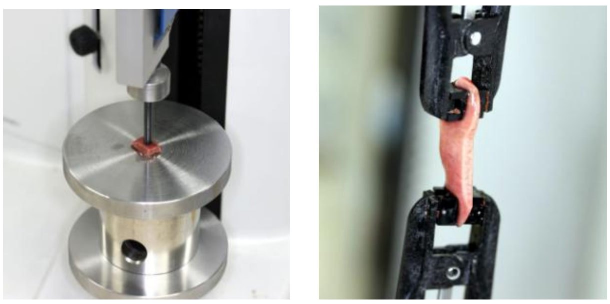

Fig. 3 Compressive test (left) and tensile test (right) of the rat liver

Fig. 4 shows a example of stress-strain curve under the compressive test of normal liver. In this mechanical measurement, the stress of the appearance was the load divided by the area of the specimen. The strain of the appearance was the crossing head displacement divided by the height of the specimen. The Young's modules of the appearance was the inclination of linear part to yield point obtained in this measurement. **Table I** shows Young's modules calculated in each mechanical measurements. In stress-strain curve of all measurements, the change from peculiar nonlinear behavior to soft tssue into linear behavior was confirmed. On the other hand, in Young's modules, the dispersion of the results growed in compressive test by the pin. And the results of tensile test were lower than of compressive test totally. We considered that the force was not applied uniformly by compressive with the pin and by method of fixing specimen in tensile test. However, Young's modules of fibrosis liver was higher than others as same as generally known.

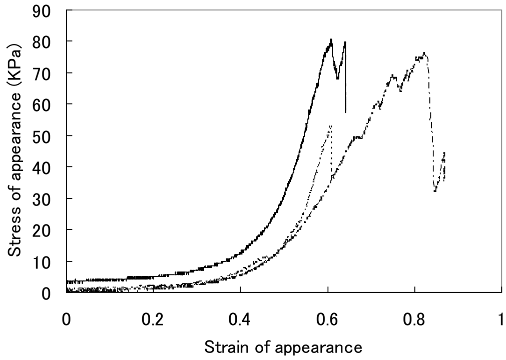

Fig. 4 Stress–strain curve under the compressive test

Table I Young's modules of rat liver in each mechanical measurements

Liver status	Measurement method	Young's modules (KPa)	Number of test
normal	compressive(φ3.0)	245±92	2
normal	compressive(φ6.0)	403±140	3
normal	compressive	322±59	3
fatty	compressive(φ3.0)	248±64	3
fibrosis	compressive(φ3.0)	355±9	3
normal	tensile	31±25	3
fatty	tensile	28±9	4
fibrosis	tensile	55±14	4

φ : diameter of the pin

4. Conclusion

In this paper, tissue physical properties of the rat livers were measured using multi-modality measurement system. The changes of tissue physical properties could be confirmed with the changes of tissue characteristic on a micro scale and on macro scale. In the future, the specimen with different stage of change of tissue characteristic will be measured and the relation between the changes of tissue characteristic and tissue physical properties will be examined in detail.

References

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