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Basic Study for Tissue Characterization of Carotid Artery Plaque using Ultrasonic Velocity-Change Imaging Ⅱ

超音波速度変化イメージング法の血管プラークの性状診断への応用に関する基礎研究　Ⅱ

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1. Introduction

The detachment of carotid artery plaque leads to the brain infarction and the cardiac infarction. It has been thought that the instability of the vessel plaque relates to the size and the distribution of lipid core. If lipid-rich plaques are found out in early stage, we will be able to protect the plaque rupture by the lifestyle modification or the drug treatment.

We have applied the ultrasonic velocity-change imaging method [1] to the characterization of carotid artery plaque composition. Ultrasonic velocity -change images constructed by ultrasonic warming showed clearly the lipid-rich area in the blood vessel phantom.[2]

In this study, we apply the light from the diode laser to warm the vessel phantom and obtained the ultrasonic velocity-change images of lipid area in the vessel phantom. The wavelemgth of the light from the diode laser is adjusted to the absorption peak of fat. Ideal vessel phantoms using sheep intestines are prepared to apply to the experiment under simulated beat of heart.

2. Experiment system

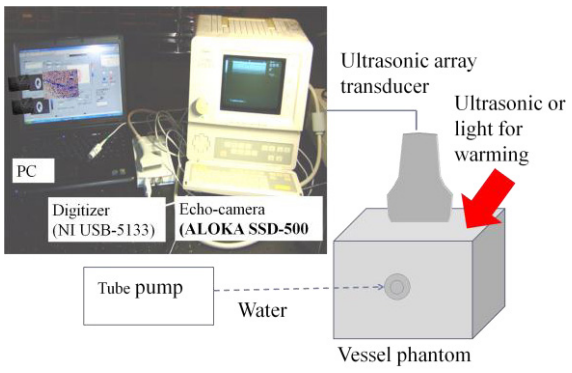

Fig.1 Experimental set-up for constructing the ultrasonic velocity-change image of vessel phantom

Figure 1 shows the experimental set-up to get ultrasonic velocity-change images of blood vessel phantoms including model plaque. The portable ultrasonic velocity-change imaging equipment was consisted of the analog diagnostic ultrasound equipment (SSD-500, 128ch, 7.5MHz), the high-speed AD converter and the personal computer. The echo waveform data were detected by this ultrasound equipment and were digitized by AD converter. The personal computer was used to compensate the moving of the vesssel phantom during the echo acquisition and construct the ultrasonic velocity-change images.

3. Ultrasonic velocity-change imaging of vessel phantom by light warming

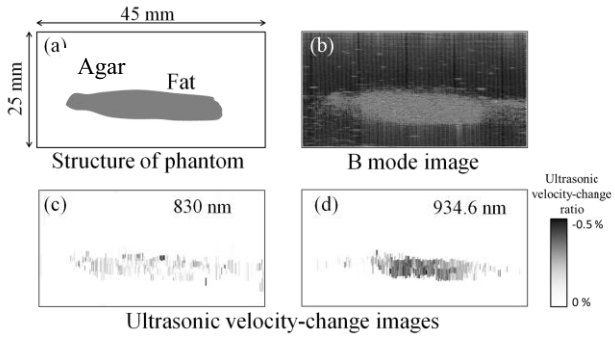

Fig.2　Phantom structure for preliminary experiment and ultrasonic images obtained by light irradiation with 0.830nm and 0.935nm.

It has been known that the living tissue shows the low optical absorption between　0.7μm and 1.2μm. The optical absorption spectrum of fat has the small absorption peak around 0.935μm.[3] We tried to apply the high power diode laser (0.935μm) to warm selectively the lipid core of vessel phantom.

We obtained the ultrasonic velocity-change images of the fat piece in the agar under the illumination of diode lasers of 0.830mm and 0.935nm. Figures 2 (a) and (b) show the structure of the phantom and the B mode image of the phantom, respectively. Both lasers were set to be 0.3W/cm^2. The fat distribution is clearly shown in Fig.2 (d) but

it is not clearly observed in Fig.2 (c). It was shown that the fat area was selectively warmed by the light from the diode laser with 0.935nm.

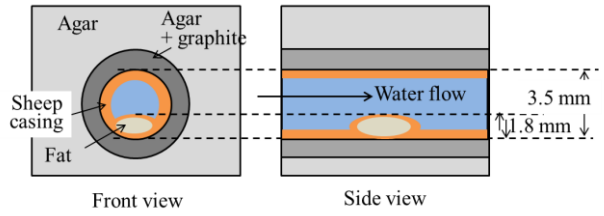

Fig.3 Structure of vessel phantom made of sheep intestines and agar

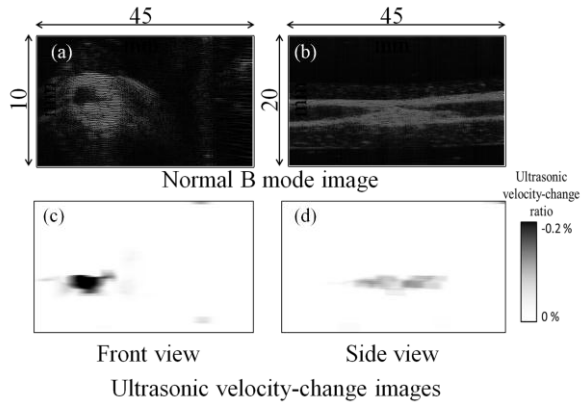

Fig.4 B mode images and ultrasonic velocity-change images obtained by diode laser warming

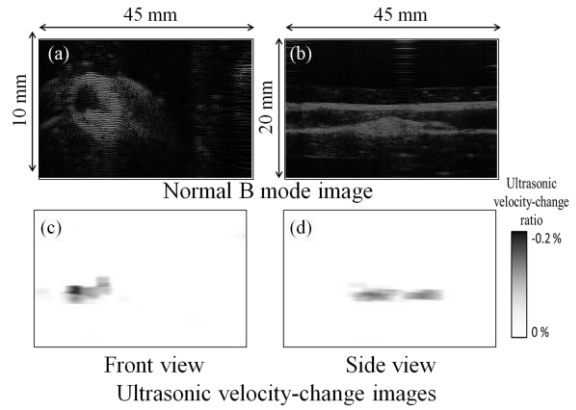

Fig.5 B mode images and ultrasonic velocity-change images obtained by ultrasonic warming

We made the ideal phantom using sheep intestines. As shown in Fig.3, a piece of fat was inserted into double sheep intestines as a lipid core of the plaque. As this vessel phantom is elastic, it is suitable for the experiment under simulated beat of heart.

In the experimental set-up of Fig.1, the diode laser with 0.935nm instead of the ultrasonic transducer was used in order to warm the vessel phantom in Fig.3.

Water was streamed in the blood vessel phantom by using a tube pump. The current velocity was 80ml/min. After warming for 120 sec, echo pulse waveforms were received by the linear array ultrasonic transducer in temperature relaxation process. The B mode images and the ultrasonic velocity-change images are shown in Fig.4.

The ultrasonic velocity-change images obtained by using the laser diode warming show the distribution of the fat in the vessel phantom.

For comparison, the ultrasonic velocity-change images of the same phantom were obtained under the ultrasonic warming. The current velocity of water and the warming time were the same as the experimental condition of the light warming. The ultrasonic velocity-change images were shown in Fig.5. Similar ultrasonic velocity-change images were obtained by using both methods of the light warming and the ultrasonic warming.

4. Conclusion

We applied the light from the diode laser to warm the phantom and obtained the ultrasonic velocity-change images of the lipid-rich area in the blood vessel phantom under the similar situation to the blood flow and the beat of the real carotid artery.

The ultrasonic velocity-change imaging method has the possibility of application to characterization of carotid artery plaque composition.

Acknowledgment

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References

1) H.Horinaka, T. Matsunaka, et al.:"Optically Assisted Ultrasonic Velocity-Change Images of Visceral Fat in a Living Animal", 2010 IEEE International Ultrasonics Symposium Proceedings, pp.1416-1419,2010
2) K.Mano, T. Matsunaka, H.Horinaka, et al.:"Basic Study for Tissue Characterization of Carotid Artery Plaque using Ultrasonic Velocity-Change Imaging", The 33rd Symposium on Ultrasonic Electronics (USE2012) Proceeding, pp.373-375
3) J.M.Conway, K.H.Norris, C.E.Bodwell: "A new approach for the estimation of body composition: infrared interactance", Am J Clin Nut 40, pp. 1123-1130, 1984