3Pb5-6

Proceedings of Symposium on Ultrasonic Electronics, Vol. 32 (2011) pp. 541-542
8-10 November, 2011

Simulated B-mode image from acoustic impedance map of HIFU-exposed specimen

音響インピーダンス・マップを用いた HIFU 照射試料の B-mode 像シミュレーション

Takashi Shishitani‡, Ryo Matsuzawa, Shin Yoshizawa and Shin-ichiro Umemura (Tohoku Univ.)
獅子谷卓‡，松澤亮，吉澤晋，梅村晋一郎 (東北大)

1. Introduction

Ultrasound echography is known well as a non-invasive and real-time monitoring method. It has advantages to be a non-invasive monitoring method of non- or less-invasive treatments such as high-intensity-focused ultrasound (HIFU) and radiofrequency (RF) ablation, in its real-time monitoring capability and its availability at low cost. An ultrasound echopraph shows basically the distribution of acoustic impedance mismatches, and indirectly those of ultrasonic attenuation and sound speed.

The relationship between the state of the tissue and its acoustic properties must be known well enough to interpret an ultrasound echograph for monitoring the state. If an ultrasound echograph is related to an acoustic property map, an optical micrograph, or other maps, which have been proved to reflect the state of the tissue, it will become more dependable monitoring method.

A map of acoustic properties, especially acoustic impedance, of a cross-sectional specimen can be easily obtained using a scanning ultrasound microscope, which has a planar resolution in order of the time-of-flight resolution of high-frequency ultrasound echography.

Previously, we reported that both B-mode image and acoustic impedance map of chicken breast muscle changed by HIFU exposure due to its heating effect [1]. The change in acoustic impedance occurred mainly due to the change in sound speed. However, the relationship between changes in the B-mode image and the acoustic impedance map was not clarified.

In this preliminary study, ultrasound B-mode images and acoustic impedance maps were obtained from non-treated and boiled porcine liver tissues. The actual B-mode image was compared with the simulated B-mode image, synthesized from the corresponding acoustic impedance map.

2. Experimental Setup

A freshly excised porcine liver was perfused with degassed saline and used as the specimen. It was cut into pieces with a length of about 3 cm. Some pieces were boiled at 80°C for about 5 min to be prepared as thermally denatured specimens.

Ultrasound B-mode images of the specimens in a water bath at room temperature were obtained using an ultrasound echography system (SSD-α10, ALOKA) with a linear imaging probe at 7.5 MHz.

The acoustic impedance of the specimens was mapped with an ultrasonic microscope (HUM-1000, Honda Electronics) [2], using a focused transducer, driven with a nanosecond pulse. It had a central frequency of 80 MHz, a focal length of 1.5 mm, and an aperture diameter of 1.2 mm. Its planar resolution was about 60 μm.

The produced acoustic impedance map of the specimen had the area of about a 6.0 mm square with a pixel pitch of 40 μm. The HIFU-exposed specimen was sliced on the focal plane to map the acoustic impedance distribution.

Simulated B-mode images were obtained by convolving the acoustic impedance map with the point spread function (PSF) of the ultrasound echography. In this study, the PSF is assumed to have azimuth and horizontal width of about 5 and 5/2 wavelengths at 7.5 MHz, respectively, with hanning windows.

3. Results

Figure 1 shows the actual B-mode image of non-denatured (left) and boiled (right) specimens. Brightness of the non-denatured specimen looks higher than that of the non-denatured specimen, indicating that some of the acoustic properties seem to have changed due to denaturation by the HIFU exposure.

Figure 2 shows the acoustic impedance maps of the same non-denatured and boiled specimen. Hepatic lobules as hexagonal-shaped tissues and central veins are clearly appeared in both images.

Figure 3 shows simulated B-mode images synthesized from these acoustic impedance maps.

4. Discussion

To compare the change in brightness, mean

‡sisitani@ecei.tohoku.ac.jp

brightness of these specimens were calculated for a region of interest (ROI) of a 5 mm square in each of the actual and simulated B-mode images. These results were summarized in **Table I**. In the simulated images, brightness in boiled specimen is slightly, about 5%, higher than that of the non-denatured image. However, it is inconsistent with the results of the actual images.

Bush *et al.* reported [3] that the attenuation coefficient and backscatter coefficient of the degassed porcine liver was significantly increased and slightly decreased, respectively, after HIFU exposure. It is consistent with our result of actually images.

In this simulation study, distributions of backscatter coefficient were estimated from the obtained acoustic impedance map but that of the attenuation coefficient was not considered. Considering the attenuation coefficient may be needed for comparing the actual and simulated images.

5. Conclusion

Simulated ultrasound B-mode images were synthesized from the acoustic impedance maps of the non-denatured and boiled porcine liver specimens and compared with their actual B-mode images taken by an ultrasound echography system. The changes in brightness of the simulated and actual B-mode images were inconsistent. This was probably because the possible changes in the attenuation coefficient were neglected in the simulation.

Acknowledgment

The authors would like to express their sincere thanks to Prof. Y. Saijo of Tohoku Univ., to Dr. K. Kobayashi of Honda electronics, and to Mr. T. Okuyama of Taga electric.

The presented work is partly supported by Tohoku University Global COE Program "Global Nano-Biomedical Engineering Education and Research Network Centre", MEXT, Japan.

References

1. T. Shishitani, S. Yoshizawa and S. Umemura, *IEEE Ultrasonic Symp.*, 1384-1387, 2010.
2. N. Hozumi, A. Kimura, S. Terauchi, M. Naga, S. Yoshida, K. Kobayashi, and Y. Saijo, *IEEE Ultrasonic Symp.,* 170-173, 2005.
3. N. L. Bush, I. Rivens, G. R. ter Haar, and J. C. Bamber, Ultrasound Med. Biol., **19**, 789-801 (1993).

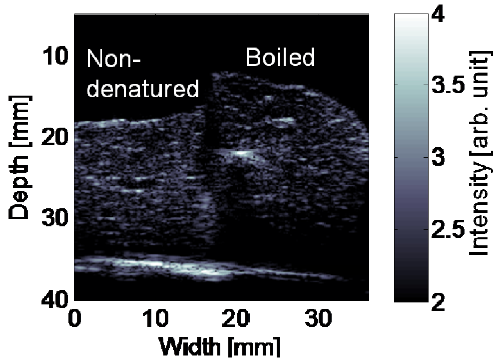
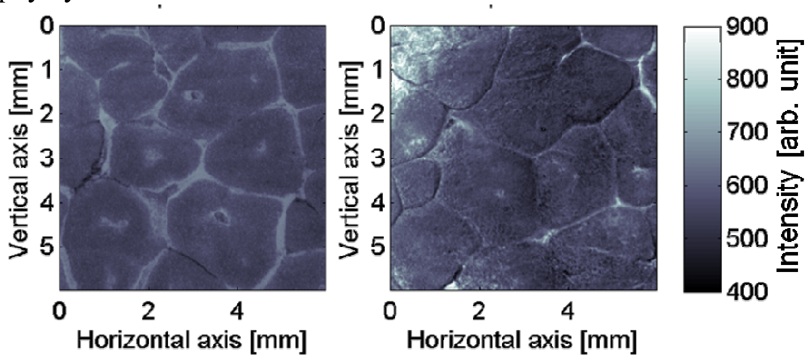


Figure 1. Acutual B-mode image.

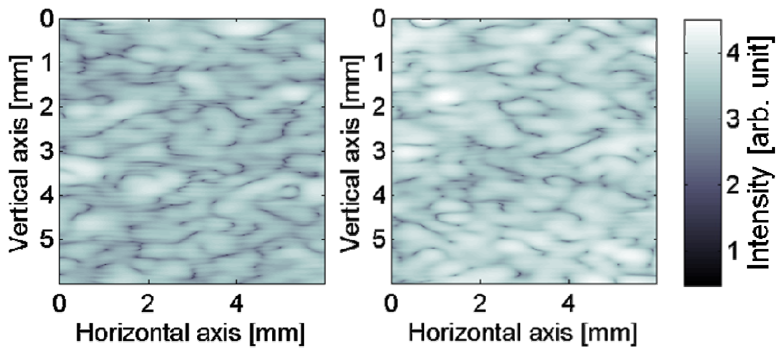
Table I. Summary of mean brightness in B-mode images

-	Non-denatured [arb. unit]	Boiled [arb. unit]	Relative Index [-]
Actual image	2.03	1.95	0.96
Simulated image	3.34	3.64	1.09



(a) Non-denatured specimen. (b) Denatured specimen.

Figure 2. Observed acoustic impedance map.



(a) Non-denatured specimen. (b) Denatured specimen.

Figure 3. Simulated B-mode images.