1P5-4

Reduction of Potential Side Effects Outside Focal Region by Suppressing Standing Waves in Cavitation Enhanced High-Intensity Focused Ultrasound Treatment

気泡援用 HIFU 治療における定在波抑制照射法による焦点領域外副作用リスクの低減

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1. Introduction

HIFU (High-Intensity Focused Ultrasound) is a non-invasive treatment method to heat and coagulate tissue by focusing ultrasound from the outside of the body without incising it[1)]. The physical burden on patients can be smaller than anticancer drug therapy and radiotherapy. Using cavitation to improve the efficiency of this treatment has been proposed. However, cavitation outside the tissue to be treated can cause side effects such as skin burns. In this paper, we propose an irradiation method reducing such unwanted cavitation and confirm its usefulness.

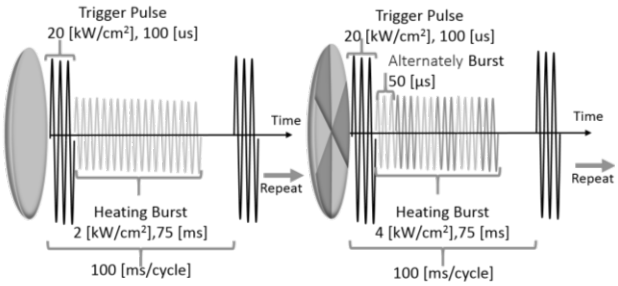
2. Material and Method

2.1 Trigger HIFU

"Tiggerer HIFU" is consisiting of high-intensity short "Trigger Pulse" generating acoustic cavitation bubbles and low-intensity long "Heating Burst" vibrating them to heat the tisssue to be treated. The heating efficiency is thereby improved efficiently[2)]. However, the standing wave caused by the difference in acoustic impedance between water and living body, has the charactor to collect microbubbles and bubble nuclei to its anitnode, and air bubbles tend to be formed on the body surface. Such bubbles may lead to skin burns during the Heating Burst.

2.2 Irradiation Method to Suppress Standing Waves

In order to reduce the possiblity to produce bubbles on the surface of living body, it is necessary to reduce the standing wave. The proposed method as shown in Fig.1, can theoretically suppress the occurrence of the standing wave by alternating two different ultrasonic paths of the Heating Burst through dividing the transducer into six segments. It was alternately switched every 50 µs. The total input energy was kept the same when the effect was compared with the conventional Trigger HIFU exposure.



(a) (b)

Fig. 1 Irradiation method.
(a) Trigger HIFU exposure, (b) Proposed method.

2.4 Experimental setup

Fig.2 shows the experimental system. A BSA (Bovine Serum Albnmin) containing gel[3)] (15%) or excised chicken breast tissue was placed in degassed water (DO:20-30%) in a tank as the sample to be exposed. During exposure with the transducer with an opening diameter of 120 mm and an F number of 0.85, the temperature of the sample surface in contact with the water bag was measured and ultrasonic images during irradiation were acquired. The gel was irradiated for 3 seconds. The chicken breast sample was irradiated for 10 seconds to check the potential thermal damage of the surface. B-mode ultrasonic images were also obtained during exposure. The focal position was set 10 mm deep from the surface.

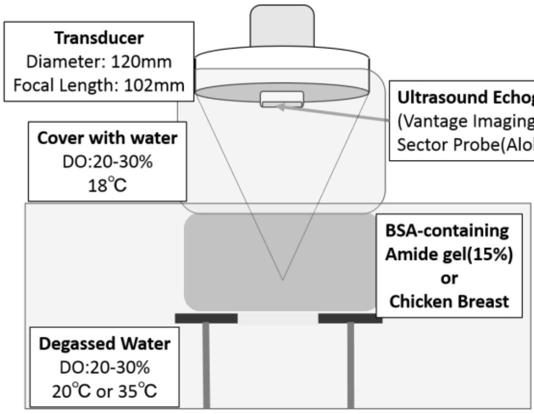


Fig. 2 Schematic of Experimental Setup.

3. Result and Discussion

Fig.3 shows the temperature at the surface of the sample (gel) during irradiation. Fig.4 shows the average rising temperature when irradiated for three times. The temperature rise was reduced from 5.6 ℃ to 4.4 ℃ on average by the proposed method. Although the reduction is slight, no thermal damage near the surface was seen with the proposed method while it was seen with the conventional method. Fig. 6 shows fluctuation in the ultrasonic images. On the sample surface, it is significantly higher in the conventional method than the proposed method. This suggests that the occurrence of bubbles such as seen on the sample surface with the conventinal method, was suppressed by the proposed method.

4. Conclusion

In this study, we investigated the potential side effect at the acoustic interface by Trigger HIFU exposure of a biomimetic gel and an excised chicken breast tissue sample. The temperature rise and thermal damage at the interface were reduced by the proposed method alternating two different ultrasonic paths.

References

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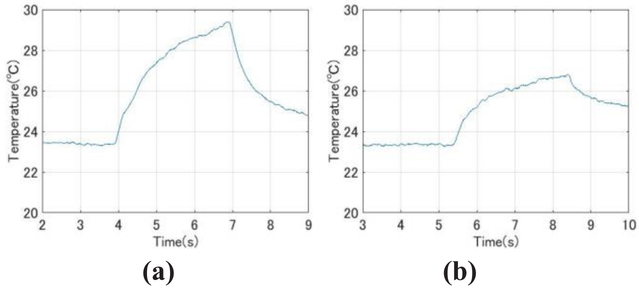

Fig. 3 Temperature rise on surface.
(a) Trigger HIFU exposure, (b) Proposed method.

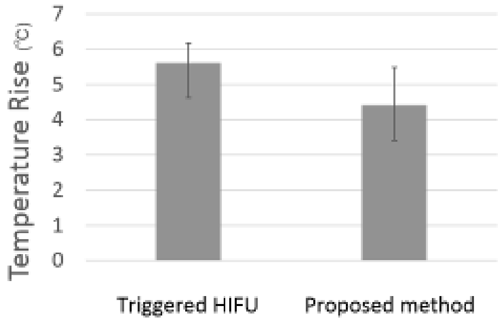

Fig. 4 Average temperature rise.

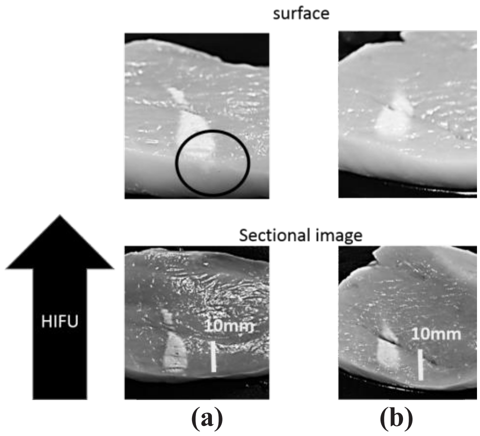

Fig. 5 Coagulation area.
(a) Trigger HIFU exposure, (b) Proposed method.

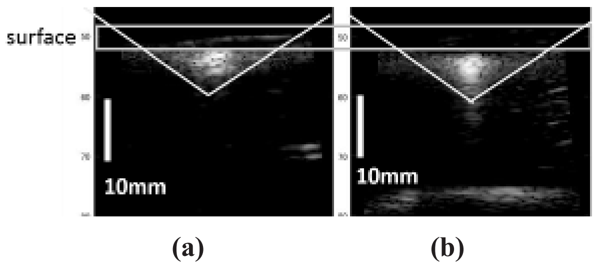

Fig. 6 B-mode images of cavitation bubbles.
(a) Trigger HIFU exposure, (b) Proposed method.