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Real Time HIFU Beam Imaging
集束超音波ビームをリアルタイムに可視化する技術

Keisuke Fujiwara[1†], Hideki Takeuchi[1], Kazunori Itani[1], Kiyoshi Yoshinaka[2], Akira Sasaki[3], Takashi Azuma[3], Ichiro Sakuma[3], and Yoichiro Matsumoto[3]
([1]Hitachi Aloka Medical, Ltd.; [2]AIST; [3] School of Eng. Univ of Tokyo.)
藤原 圭祐 [1†], 竹内 秀樹 [1], 射谷 和徳 [1], 葭仲 潔 [2], 佐々木 明 [3], 東 隆 [3] , 佐久間 一郎 [3],
松本 洋一郎 [3] ([1] 日立アロカメディカル, [2] 産総研 , [3] 東大 工学系)

1. Introduction

The High Intensity Focused Ultrasound (HIFU) has yielded practical applications such as a noninvasive treatment method for fibroid and prostate diseases[1]. Accurate irradiation of the therapeutic targets by HIFU is necessary for the ablation treatment of malignant tumor. However, an HIFU focal point and cavitation occurrence are changed because of inhomogeneity of sound speed and attenuation in the targets. Previously, B mode images can only visulaize scatter distribution, but can not visulaize HIFU beam.

Therefore, the technique is developed to visualize the target and HIFU beam and its surrounding focal area in situ and in real time under an ultrasound image guided HIFU device.

2. Methods

A pulse transmitted from a HIFU transducer was used as an imaging pulse for our proposed method. In this method, while a reception beam obtained by an imaging array was scanned in its imaging area, the transmission beam was not scanned. Using this method, an echo distribution acquired by receiving beam scan reflects a special distribution of HIFU beam.

3. Experimental setup

A HIFU transducer of 56 elements (Imasonic, France), which had a central frequency of 2 MHz a focal length of 100 mm and an f-number of 1, was used in this study. To put an imaging array coaxially in the HIFU transducer, the center section of the HIFU transducer was made of a hollow structure of a 35 mm diameter. A small prototype linear array was made to perform ultrasonic imaging (Fig.1). It was made of 128 elements with a 6.5 MHz central frequency and a 0.2 mm pitch. An ultrasound diagnostic system (Model SSD-α10, Hitachi Aloka Medical, Japan) was used. A homogeneous 3 % agar phantom and a two layer agar phantom which upper layer was 3% agar and lower layer was graphite mixing agar were used as targets of HIFU exposure.

fuji5108@hitachi-aloka.co.jp

Synchronizing with the transmit trigger of the diagnostic system, 2MHz 2-cycle burst waves and 7.5 MHz half-cycle arbitrary waves were simultaneously transmitted from the HIFU transducer and the linear array, respectively. Ultrasound was transmitted in a conventional linear scan mode from the small linear array while HIFU was transmitted at the same position and an HIFU beam was formed. The small linear array simultaneously received the scattered echo signals from HIFU transmit and the linear array's transmit using a conventional beamforming algorithm. Fig.2 schematically shows an experimental setup used in this study.

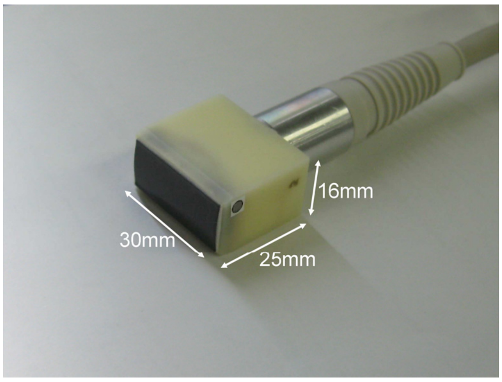

Fig. 1 Small prototype linear array

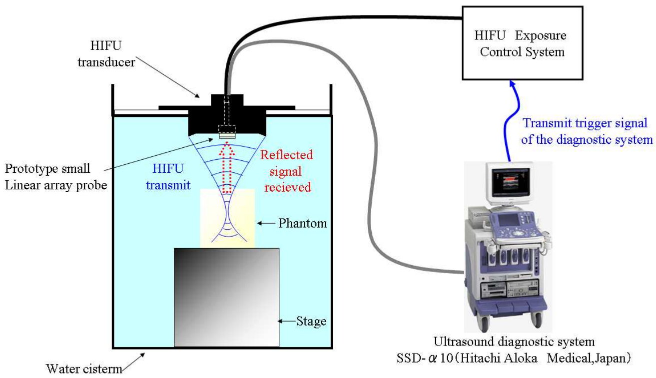

Fig. 2 Schematic of experimental setup in this study

4. Results and Discussions

Fig.3 shows ultrasound images of each phantom before HIFU transmit. Fig.4 shows ultrasound images of each phantom when transmit power of linear array was turned off and HIFU was transmitted. The linear array received the scattered echo signals from only the HIFU exposure. Then HIFU beam shape and its surrounding focal point were visualized in real time in the ultrasound image.

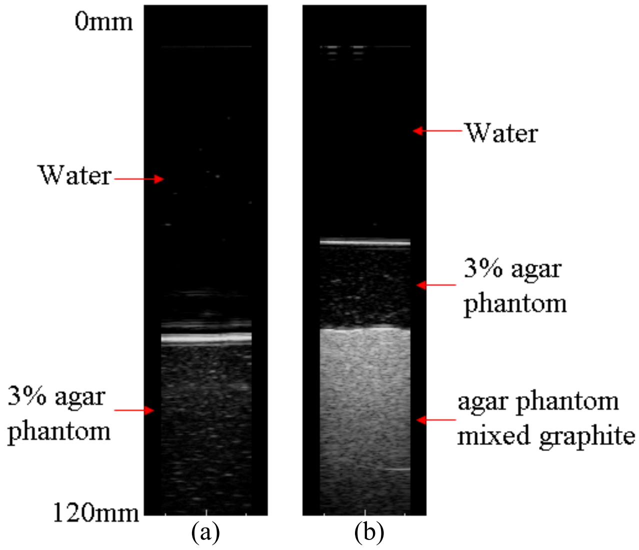

Fig. 3 Ultrasound images of the phantom;
(a)3% agar phantom, (b)two layer agar phantom

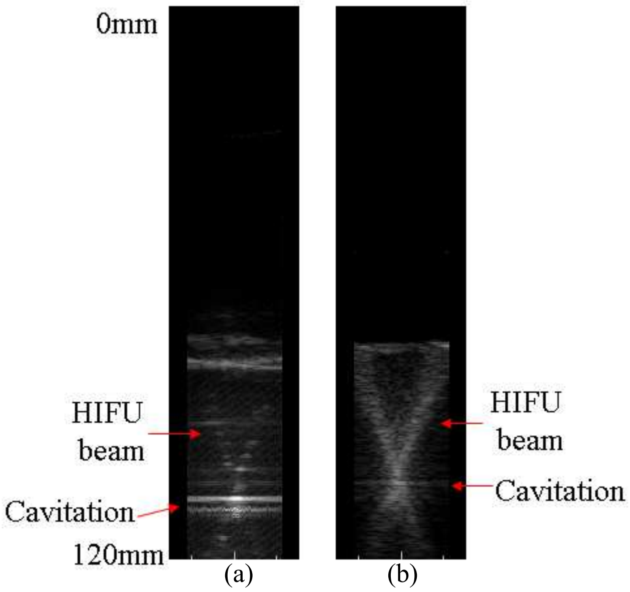

Fig. 4 Ultrasound images of the HIFU beam within the phantom;(a)3% agar phantom, (b)two layer agar phantom

When transmit power of linear array was increased, the ultrasound image overlapped HIFU beam shape and the tissue could be obtained as Fig.5.

Next, when the transmit power of HIFU transducer was increased, the high brightness spot appeared at the HIFU focal point in the ultrasound image as Fig.4. This phenomenon suggested the cavitation occurrence. These imaging results could be confirmed both the phantoms. However, the homogeneous 3% agar phantom was obtained more obscure ultrasound image of HIFU beam than the two layer agar phantom. Additionally, differences in threshold of cavitation occurrence were observed each phantom.

Visibility of HIFU beam was depended on a concentration of scatters at the focal area. This means that high scattering materials are easy to visualize HIFU beam. Whether the technique can apply both high echo signals and low echo signals like body tissues, we will need to evaluate in vitro and in vivo experiments.

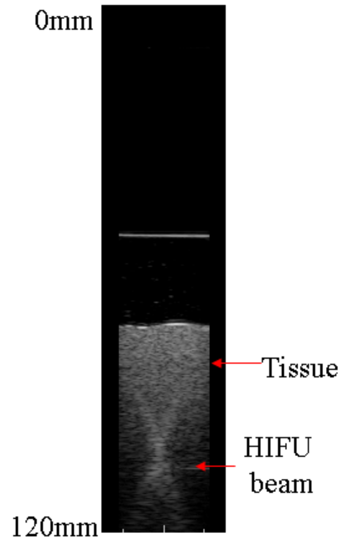

Fig. 5 Ultrasound image overlapped HIFU beam shape and the tissue for the two layer agar phantom

5. Conclusions

In this study, we developed the technique visualized the HIFU beam and its surrounding focal area in situ and in real time under an ultrasound image guided HIFU device. We have named this technique Real Time HIFU Beam Imaging.

Acknowledgment

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References

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