3J3-1

Proceedings of Symposium on Ultrasonic Electronics, Vol. 35 (2014) pp. 391-392
3-5 December, 2014

Characteristic of Ultrasound Beam for Fetal Surgery
胎児治療用超音波ビームの特徴

Tomoo Sato[1†], Shunsuke Osawa[2], Hiromasa Yamashita[1], Ubaidus Sobhan[1], Rie Ishii[2], Takashi Mochizuki[3], and Toshio Chiba[1] ([1]National Center for Child Health and Development; [2]Showa Univ. School of Medicine; [3]Medical Ultrasound Lab.)
佐藤智夫[1†], 大澤俊亮[2], 山下紘正[1], ソブハン ウバイダス[1], 石井理絵[2], 望月剛[3], 千葉敏雄[1]
([1]国立成育医療研究センター, [2]昭和大 医, [3]MU 研究所)

1. Introduction

High intensity focused ultrasound (HIFU) treatment is one of the non-invasive treatments. Congenital diaphragmatic hernia (CDH) is a severe fetal disease[1)]. Most popular treatments for CDH is fetal endoscopic tracheal occlusion (FETO). For this treatment, a small balloon is placed in the trachea for several weeks. However the balloon must be removed before birth to prevent the newborn's suffocation. The state of the art for the balloon removal is the needling with the endoscope or the ultrasound guide. We aim to increase non-invasively balloon rupture by HIFU and show its feasibility using animal model [2)]. **Fig. 1** shows the schema of our animal experiment. A sacrificed rabbit is the model for the fetus, and was placed supine with the water tank filled with the degassed water, which simulates the uterine cavity and the amniotic fluid. The balloon was placed in the trachea, between vocal cords and sternum, filled up with the mixture fluid of nanodroplets (PCND-US-100LG, HITACHI, Japan) and microbubbles (Sonazoid®). The nanodroplets are gasified by HIFU irradiation[3,4)]. The HIFU transducer (IMASONIC, France) is doughnut type and specially designed. An imaging probe was mounted at the center of HIFU transducer. The measured beam diameter at the focus is 2mm. The focus range is 15mm. The focal length is 120 mm. Intensity (I_{SATA}) is 3kW/cm^2 (CW). Operating frequency is 1MHz. The irradiation time of HIFU is 5 to 30 seconds. The inflated balloon and ruptured balloon are shown in **Fig. 2**. The inflated balloon was about 6 mm in diameter, and 20 to 30 mm in length. Because we give the first priority to the balloon rupture and HIFU irradiation was continued until skin burn, which often occurred. In **Fig.3(a)**, the skin burn is the same size as the spot size of HIFU beam, which is acceptable. However, there is larger damage compared with the spot size of HIFU in **Fig.3(b)**. In this report, we consider the mechanism of the large skin damage using the beam profile of HIFU.

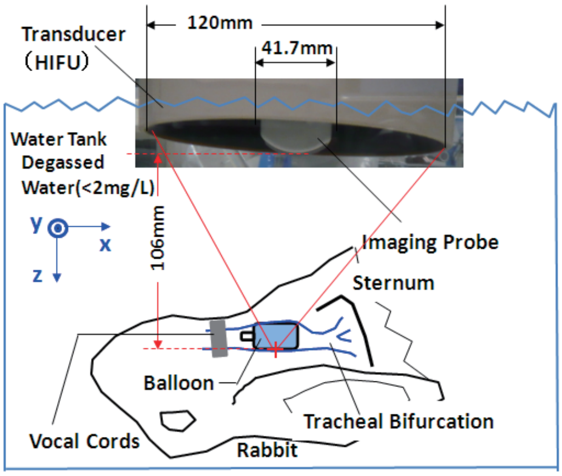

Fig.1 Schema of animal experiment

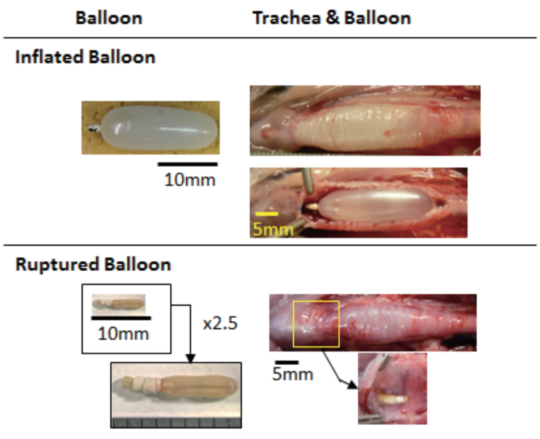

Fig.2 Photo of balloon and trachea (Not same sample)

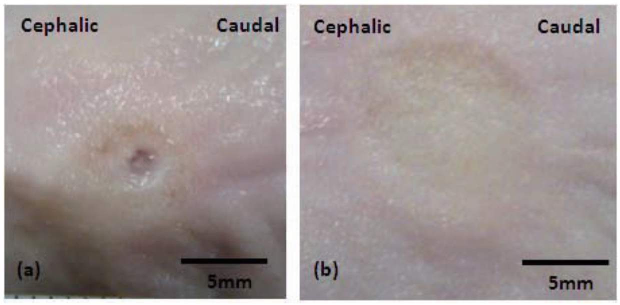

Fig.3 Photo of skin burn

2. Method

The profile of acoustic pressure was superimposed on the photo of skin burn (Fig.3(b)). The profile was calculated with the following assumptions. (1) The transducer of HIFU was approximated with point sources. (2) The HIFU transducer transmitted CW, and we evaluated the acoustic pressure during the steady state. (3) The non- linearity of water was not considered.

The distance between the focus of HIFU and the skin was measured from the ultrasound image.

3. Results / Discussion

The simulation result of the HIFU beam is shown in **Fig. 4.** The beam diameter at the focus is 3mm. The focus range is 15mm. These values are acceptable to compare with the measured values. **Fig. 5** shows ultrasound image of the treatment area. The balloon and HIFU beam are overlaid. The distance between the skin surface and HIFU focus is 13.8mm. The acoustic pressure at the skin is about one tenth of the peak pressure of HIFU beam. The beam profile at the skin surface is shown in Fig. 4 (a: blue line). **Fig. 6** shows the beam profile at the skin which is superimposed on the photo of skin burn. We can understand that the area of the skin burn is related with the profile of HIFU beam.

4. Conclusion

It is effective to consider the beam profile of HIFU for better understanding of HIFU treatment results. The evaluation with HIFU irradiation time is one of our future works.

Acknowledgment

A part of this work was supported by Health and Labour Sciences Research Grants (H22-MIS–Norm -001) and JSPS Grants-in-Aid for Scientific Research (26282150).

References

1. D Miniati: <http://emedicine.medscape.com/article/2109500-overview> [accessed on Aug. 29, 2014].
2. S Osawa, H Yamashita, T Sato, T Mochizuki, G Kitazumi, A Toki, T Chiba: presented at 13th World Congress in Fetal Medicine (2014).
3. S Umemura, S Yoshizawa, R Takagi, Y Inaba, J Yasuda: Jpn. J. Appl. Phys. **52** (2013) 07HA02.
4. K Kawabata, R Asami, T Azuma, S Umemura : Jpn. J. Appl. Phys. , **49** (2010) 07HF18.

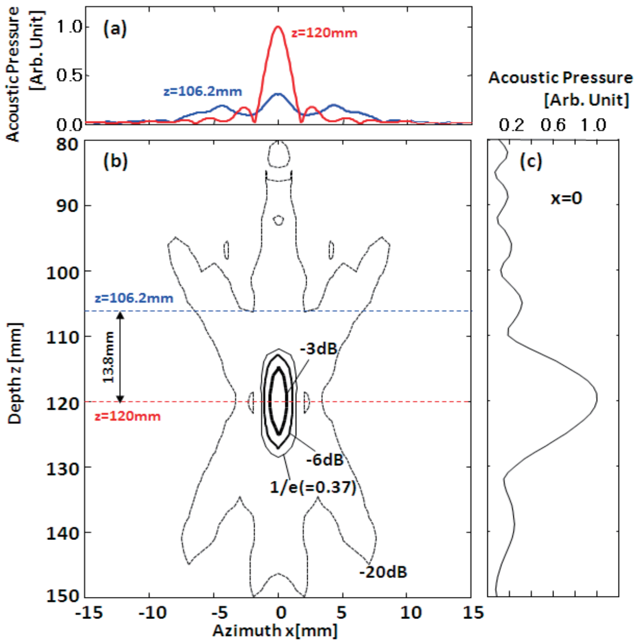

Fig.4 Profile of HIFU beam. (a) Azimuth direction. (b) Contour plot (c) On acoustic axis.

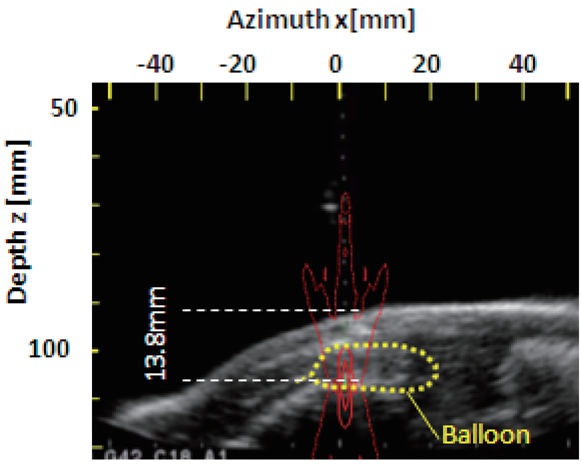

Fig.5 Ultrasound image with superimposition of balloon (yellow line) and profile of HIFU beam (red line).

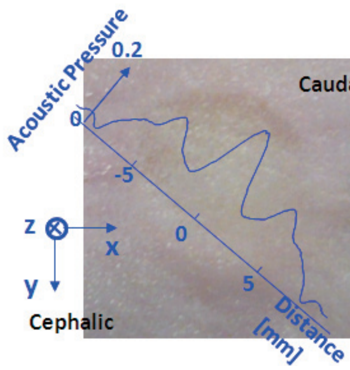

Fig.6 Photo of skin burn and beam profile of HIFU beam. Acoustic pressure is normalized by peak pressure of HIFU beam.