1P5-10

Development of Backscatter Coefficient Evaluation Method on Conventional Ultrasound Scanner – Comparison with Single-Element Transducer

汎用超音波診断装置による後方散乱係数評価法の開発 - 凹面単一振動子との比較

Takuma Oguri[1, 2†], Masaaki Omura[2], Takeru Mizoguchi[2], Kazuya Ito[2], Atsuko Yamada[2] and Tadashi Yamaguchi[3] ([1]Ultrasound General Imaging, GE Healthcare; [2]Grad. School Sci. Eng., Chiba Univ.; [3]Center for Frontier Medical Engineering, Chiba Univ.)
大栗　拓真[1,2†]，大村　眞朗[2]，溝口　岳[2]，伊藤　和也[2]，山田　敦子[2]，山口　匡[3] ([1]GE ヘルスケア・ジャパン　超音波製品開発部, [2]千葉大院　融合理工, [3]千葉大 CFME）

1. Introduction

In previous works, sevral studies for evaluation of various tissues, e.g. fatty liver, breast tumor and lymph node etc., by measuring backscatter coefficient (BSC) with single-element transducer have been reported [1]. And also, several in vivo experiments to evaluate BSC on conventional ultrasound (US) scanner have been reported [2]. However, the method to quantify BSC by conventional US scanners hasn't been established.

The aim of this study is to develop a new clinical application for US scanner to quantify BSC. In this report, BSC has been measured on two kinds of homogenous tissue-mimicking phantom, which atenuation coefficient (AC) and BSC are different, by low and high frequency phased liner array transducers with US scanner. To examine BSC measurement accuracy, BSC measured by phased liner array transducers was compared with single-element transducers which the frequency is corresponding with each phased liner array transducer.

2. Materials and Method

2.1 Tissue-Mimicking Phantoms

Two kinds of homogenous tissue-mimicking phantoms (Target No. 1 and No. 2) which have different scatterer diameter (SD) and concentration (SC) were created. The solution was mainly composed of 2 wt% agar (A1296, Sigma-Aldrich, MO, USA) and degassed purified water. Each phantom also contained spherical scatterers with the mean diameter of 20 μm and or 30 μm (MX-2000 and MX-3000, Soken, Aichi, Japan), prepared at the concentration of 0.5 wt% or 5.0 wt%, respectively. A reference phantom was also created with 10 μm spherical scatterers (MX-1000, Soken, Aichi, Japan) at the concentration of 0.5 wt%.

The speed of sound (SoS) and AC of each phantom were measured by the time of flight and insertion method with 5.0 MHz single-element transducer (Table I). Theoretical BSC value of each phantom was calculated in theoretically by Faran model [3].

2.2 Data Acquisition

RF signals for each phantom were acquired by low and high frequency phased linear array transducers and single-element transducers. 9L-D and ML6-15-D (GE Healthcare, Tokyo, Japan), and V309 and V327 (Olympus, Tokyo, Japan) were used for phased linear array transducers and single-element transducers, respectively (Table II). A clinical US scanner LOGIQ S8 (GE Healthcare, Tokyo, Japan) and a laboratory-made scanner were used to data acquisition with array transducers and single-element transducers, respectively. Total scan area in lateral direction on both single-element transducer was 20 mm. On each transducer, scan lines were overlapped a half of PSF in lateral at focus depth, and field of view was 40 mm. The sampling frequency was 50 MHz. All phantoms were set in the degassed water at 23 °C during data acquisition, and focus depth was placed around 20 mm from the phantom surface on each transducer.

2.3 Backscatter Coefficient Measurement

Reference phantom method [4], using a homogenous phantom which AC and BSC are known, for BSC measurement. BSC was measured as

$$BSC(f) = \log_{10}\left\{\frac{S(f,d)}{S_{ref}(f,d)}\right\} + A(f,d) + BSC_{ref}(f)$$

where $S(f)$ and $S_{\mathrm{ref}}(f)$ are power spectrum of the measured from target and reference phantom at the frequency f and the depth of region of interest (ROI)

Table I Properties of each phantom

Phantom	SD [μm]	SC [%]	SoS [m/s]	AC [dB/cm/MHz]
Reference	10	0.5	1494.3	0.13
Target No. 1	20	0.5	1494.0	0.08
Target No. 2	30	5.0	1505.4	0.65

Table II Properties of each transducer

Transducer	Band width (-6dB) [MHz]	Focus depth [cm]	PSF lateral [mm]	PSF axial [mm]
9L-D	5.5±2.0	2.0	0.30	0.50
ML6-15-D	9.5±3.0	2.0	0.20	0.40
V309	4.6±2.5	1.8	0.50	0.33
V327	9.5±5.0	2.0	0.34	0.16

d, respectively. *A*(*f*, *d*) are attenuation compensation function for target and reference phantom [5].

Five times of the PSF in lateral and axial direction were used for the sizes of ROI in each direction. ROI was scanned in lateral and depth direction with overlapping a half of PSF in lateral and axial in 10 mm ~ 35 mm depth. The BSC was measured in -6 dB bandwidth, root mean square error (RMSE) between measured and theoretical BSC values was calculated, and the BSC value at center frequency was measured.

3. Results

Figure 1(a) and 1(b) show mean of RMSE in each depth on Target No. 1 and No. 2, respectively. On target No. 1, significant depth dependency wasn't confirmed on all transducers. On target No. 2, significant depth dependency in RMSE wasn't confirmed also on 9L-4 and ML6-15, on the other hand, RMSE in deeper than around 30 mm and 25 mm area was higher than shallower area on V309 and V327, respectively, due to degradation of signal to noise ratio (SNR).

Figure 2(a) and 2(b) show mean of measured BSC value at center frequency in each depth and theoretical BSC value at 5.0 MHz and 9.5 MHz on Target No.1 and No. 2, respectively. Except low SNR depth on V309 and V327, significant depth dependency wasn't confirmed, measured BSC values were close to theoretical values on all transducers and phantoms.

4. Conclusion

There weren't significant differences between low and high frequency linear phased array transducers and single-element transducers in RMSE and BSC values at center frequency. It was confirmed that BSC measured by linear phased array transducers and single-element transducers were comparable.

Reference

1. M. L. Oelze et al.: IEEE Trans. Ultrason. Ferroeletr. Freq. Control 63 (2016)
2. S. C. Chen et al.: Clin. Gastroenterol. Hepatol. 13 (2016)
3. M. F. Insana et al.: J. Acoust. Soc. Am. 87 (1990)
4. L. X. Yao et al.: Ultrasonic Imaging 12 (1990)
5. M. L. Oelze et al.: J. Acoust. Soc. Am. 111 (2002)

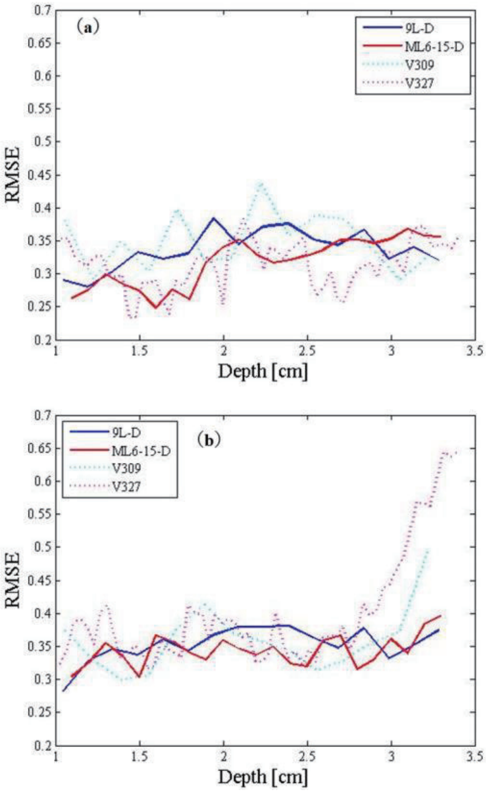

Fig. 1 RMSE in each depth. (a) is Target No. 1, (b) is Target No. 2.

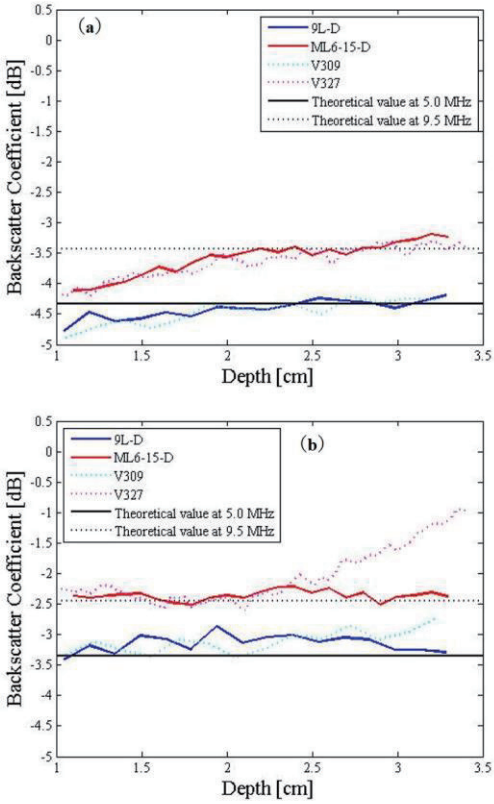

Fig. 2 BCS at center frequency in each depth. (a) is Target No. 1, (b) is Target No. 2.