3P5-14

Verification of influence of tissue structure on shear wave velocity evaluation
生体組織構造がせん断波伝搬速度評価に与える影響の検証

Daiki Ito[1†], Atsuko yamada[1], Takuma Oguri[1,2], Kenji Yoshida[3] and Tadashi Yamaguchi[3*] ([1]Grad.School Sci. and Eng., Chiba Univ; [2]Ultrasound General Imaging, GE Healthcare; [3] Center for Frontier Medical Engineering, Chiba Univ.)
伊藤 大貴 [1†], 山田 敦子 [1], 大栗 拓真 [1,2], 吉田 憲司 [3], 山口 匡 [3*] ([1] 千葉大院 融合理工学府, [2]GE ヘルスケア・ジャパン 超音波製品開発部, [3] 千葉大 CFME)

1. Introdaction

Shear wave elastography (SWE), which utilizes the shear wave velocity (SWV) generated in tissue by acoustic radiation force, has been used in clinical practice as a method for evaluating the stiffness of tissues by ultrasound. However, SWV calculation dramatically depends on the diagnosis equipment because of the difference of the algorithms of pre and post signal processing, and the calculated SWV is also unstable in some observation targets to the physical properties and the structure of the tissue [1].

In this report, the calculated SWV was investigated by means of simulated shear wave propagation in tissue with the elastic finite-difference time-domain (FDTD) method [2]. The propagation of the shear wave in any biological tissues were simulated under the transmission condition which mimicked the acoustic radiation force (ARF) distribution of actual diagnosis equipment, and SWV of each tissue was evaluated with the cross-correlation method. In addition, the influence of tissue structure on the shear wave velocity evaluation was verified.

2. Method

2.1 Simulation

Propagation for X-direction of shear wave simulated in two dimensions with elastic FDTD by ARF excitations in the left of simulated space. In this study, the propagated shear wave was calculated by temporal change of particle velocity for Y-direction. Uniform simulated space (SWV; 2 m/s) of 300 pixels × 300 pixels (30 mm × 30 mm, 1 pixel = 100 μm) which was included 2.5 mm diameter circular tissue (SWV = 1 m/s) was used. ARF was mimicked acoustic field of push pulse of abdominal linear array probe (9L-D, GE Healthcare) of ultrasonic diagnosis equipment (LOGIQ S8, GE Healthcare). The simulation scheme is shown in **Fig. 1**.

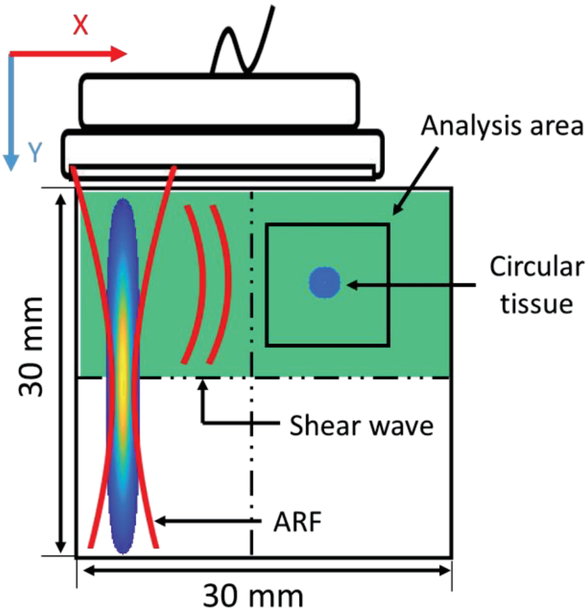

Fig. 1 Schematic of simulation space

2.2 Analysis of SWV

Temporal change of shear wave was calculated by simulated particle velocity distribution and SWV was analyzed. First, particle velocity distribution was processed to remove wave which propagated in the opposite direction (the negative direction for X-direction) of shear wave. Second, the time difference for propagation of shear wave between two points was found with timewave of two spatial grids continuous in the X-direction with cross-correlation, and SWV between two points was calculated [3]. This process was performed for each spatial grid in the analysis area of **Fig. 1**, and SWV distribution was estimated.

2.3 Vector of shear wave propagation direction

Propagation of shear wave was shown from 7 to 10.5 ms after ARF excitations in vector. Shear wave in the image of the frame was surrounded by ROI, the distance and direction the ROI moved several frames later, and vector was calculated. This process was performed every 350 μs, and the trajectory of shear wave was shown in vector.

3. Result

Fig.2(a) shows SWV distribution set in the analysis area, and **Fig.2(b)** shows SWV distribution calculated in the analysis area. Compared with the set spatial model, calculated SWV distribution was different from set SWV by the circular tissue.

As this factor, it is difficult to detect the waveform of shear wave at the boundary between tissue with different stiffness, and the propagation direction of shear wave propagating was complicated by the circular structure.**Fig.3** shows spatial waveform of shear wave for X direction from 9.5 to 10 ms after ARF excitations. This figure also shows the propagation of shear wave from low stiffness tissue to high stiffness tissue. In the waveform 9.8 ms after pushing ARF, SWV evaluation accuracy decrease due to be distorted shear waveform because the amplitude was lager and the wavelength was shorter in the low stiffness tissue than in the high stiffness tissue. Therefore, it is important how to process propagation of shear wave in various directions in the case of more complicated tissue.

Fig.4 shows the propagation direction of shear wave in vector. Shear wave was propagated along the boundaries of the circular tissue. In the report, SWV evaluation accuracy was decreased due to be evaluated considering only the X direction without considering the Y direction.

4. Conclusion

The Propagation of shear wave was simulated in uniform simulated space which was included the low stiffness circular tissue with elastic FDTD, and the factors that circular tissue was given to SWV distribution was verified　As a result, SWV evaluation accuracy was decreased due to be difficult to detect the waveform of shear wave at the boundary between different tissues and be complicated by circular tissue. Currently, we are investigating the factor that affect shear wave evaluation by more complicated tissue, SWV calculated method that corrects these factors will be developed, and we want to use to formulate SWV standardization indicators.

Acknowledgment
This work was conducted as part of the activities of the JSUM SWE Standardization Subcommittee and JRS J-QIBA.

†d.ito@chiba-u.jp, *yamaguchi@faculty.chiba-u.jp

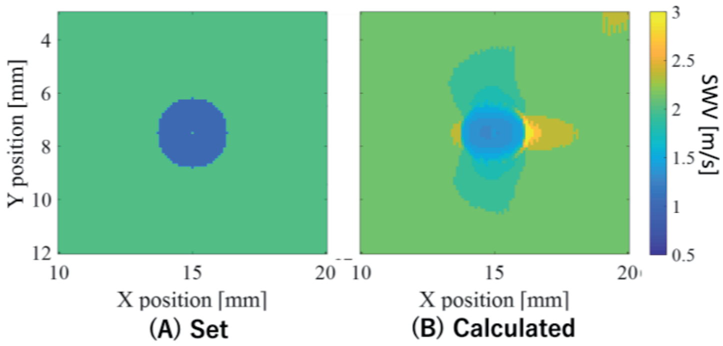

Fig. 2　SWV distribution in analysis area

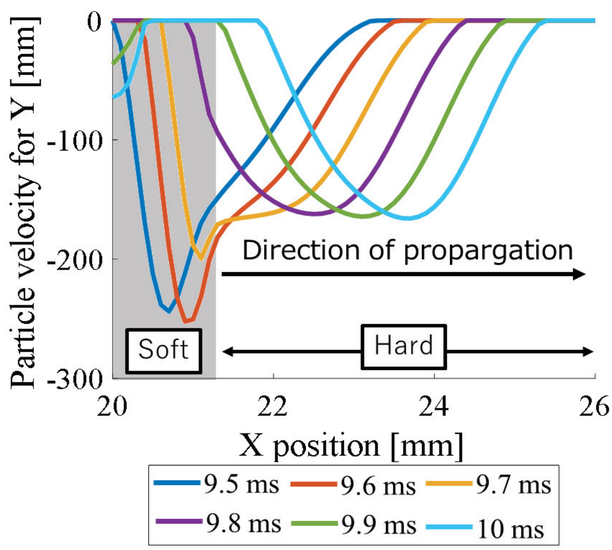

Fig. 3　Spatial waveform of shear wave after ARF excitations

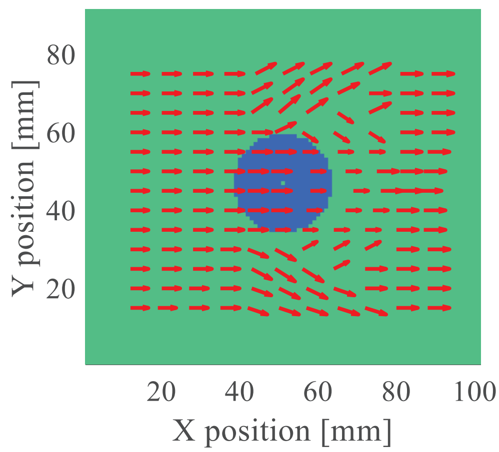

Fig. 4　Propagation direction of shear wave in vector

References
1.Mark L. Palmeri , et al; IEEE T. Ultrason, 64(2017),
2. S. masahiro, ASJ, .64(2008),
3. Y makoto, Med. Image. Tech. 32(2014)