2P5-2

Estimation of Pulsation Component to Improve Accuracy in Ultrasonic Measurement of Luminal Surface Roughness of Carotid Artery

ヒト頸動脈内膜側粗さの超音波による計測高精度化のための拍動成分推定

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1. Introduction

Stroke and heart attack are the main cause of death of Japanese. The internal elastic layer and endothelial cells are damaged in the early stage of atherosclerosis[1)]. It is necessary for ultrasonic evaluation of the surface roughness to measure displacement of the wall on the order of microns because the thickness of internal elastic layer is 10-20 μm. Since the wavelength along the beam direction in the conventional ultrasonic diagnostic apparatus is about 150 μm, the spatial resolution is insufficient for measuring the surface roughness. We realized the measurement of the luminal surface roughness on the order of microns utilizing the displacement of the carotid artery wall along the longitudinal direction during for one cardiac cycle and measuring the radial displacements of the same ultrasonic beams.[2)] The radial displacement was estimated by the phased-tracking method,[3)] and the longitudinal displacement was estimated by the block matching method.[4)]

In the present study, by properly restricting the region of interest (ROI) in block matching method, the estimation accuracy of longitudinal displacement was improved

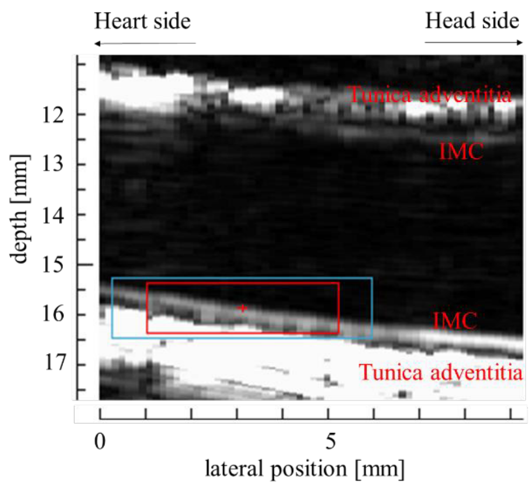
2. Methods

We acquired RF data using an ultrasound diagnostic equipment (ProSound F75, Hitachi Aloka Medical Ltd.) with a linear array probe of the center frequency 7.5 MHz. The sampling frequency was 40 MHz, the beam interval was 150 μm, the frame rate was 187 Hz, and the number of beams was 62. RF signals were measured from the right carotid artery of a 23-year-old healthy male.

2.1. Introduction of restrict in ROI area

Figure 1(a) shows the B-mode image of the carotid artery. The ROI and the search area were shown by the red frame and the blue frame, respectively. The size of ROI was 4.2×1.0 mm^2 and that of the search area was 5.7×1.2 mm^2. *In vivo* measurement, the carotid artery wall frequently has a slope in the B-mode image. Thus, the high brightness part, which corresponds to the tunica adventitia, was included in the ROI if the slope is steep as shown in Fig. 1(a). In this case, the displacement of the internal elastic layer cannot be correctly traced by the block matching procedure because the results highly depend on the

(a)



(b)

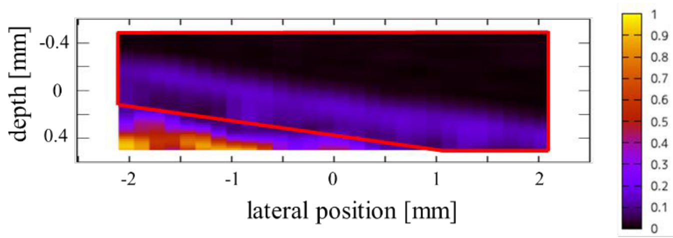


Fig. 1. (a) The B-mode image of the carotid artery. (b) The value of the envelope signal of the acquired RF signal in the ROI for the first frame of the block matching process. Each value was normalized by the maximum value of the received signal in the ROI.

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displacement of the high brightness parts. Therefore, as shown in **Fig. 1(b)**, a ROI was set so that the reflection components from the tunica adventitia were excluded and it was employed for the calculation of the correlation values in the block matching process.

2.2. Display of longitudinal direction motion

It has been reported that the intima–media complex (IMC) moves along both the longitudinal direction and the radial direction during one cardiac cycle.[5, 6] For each RF signal, we detected the reflected signal from the surface of the IMC. By repeatedly applying the process in one cardiac cycle for all beams, IMC was detected in each beam and then the movement of the IMC along the longitudinal direction was visualized, which is similar to the conventional M-mode.

3. Results

The detected longitudinal motion of the IMC was shown in **Fig. 2**. The intensity of the envelope of the RF signal was converted into brightness. The trajectory of equal brightness shows the longitudinal motion of the IMC. The red lines in Figs. 2(b) and 2(c) show the estimates of the longitudinal displacement obtained by the block matching method. The measurement range was one cardiac cycle from the R-wave to the R-wave in the succeeding heartbeat in electrocardiogram (ECG).

The red line in Fig. 2(b) shows the estimated result of the longitudinal displacement using a rectangular ROI. Compared with longitudinal direction motion, the estimation accuracy was low. In particular, it was significantly separated from the trajectory in the range from 0 to 0.20 s, which was caused by that the high brightness part was included in the ROI in the calculation of the correlation values.

On the other hand, the red line in Fig. 2(c) shows the estimated result when the region of the ROI was restricted as shown in Fig. 1(b). The estimated results coincided with the longitudinal direction motion except for 0.31 s. From the results, it was confirmed that estimation accuracy of longitudinal displacement in the block matching method was improved by restricting the ROI so that the unnecessary part was excluded.

4. Conclusion

The estimation accuracy of the longitudinal displacement on the block matching method was compared between the conventional rectangular ROI and the newly introduced restricted ROI. Introducing of the ROI excluding high brightness part was confirmed to be useful for the proper estimation of the longitudinal displacement. In the future, we will apply the results obtained in the present study to increase the accuracy in the estimation of the luminal surface roughness.

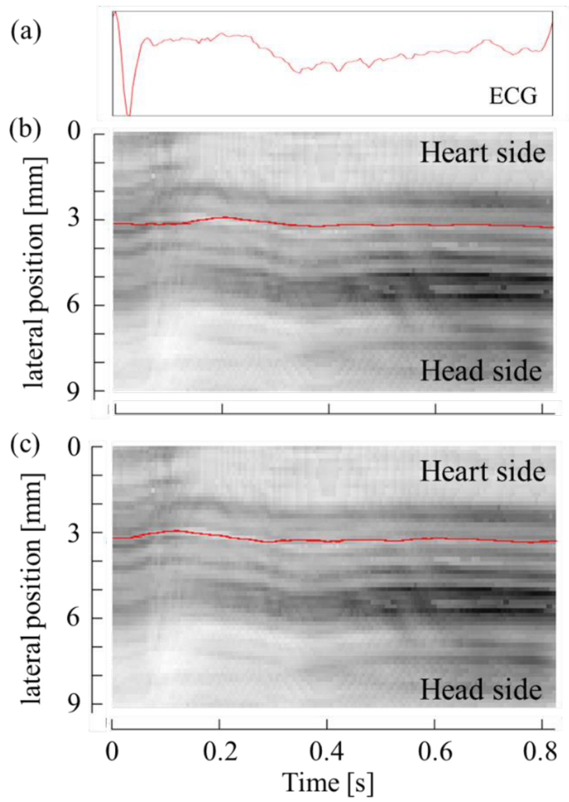

Fig. 2 The motion of the IMC along the longitudinal direction and the estimated results of the longitudinal displacement by the block matching method. (a) ECG. (b) Rectangular ROI shown in Fig. 1(a). (c) Restricted ROI shown in Fig. 1(b).

References

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