Examination of stable evaluation method of the degree of red blood cell aggregation by measuring short axis view of vein using ultrasound

超音波を用いた静脈短軸計測による赤血球集合度の安定な評価法の検討

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1. Introduction

The reversible adhesion between red blood cells (RBCs) is called RBC aggregation. With ultrasound imaging, the progression of the RBC aggregation can be confirmed as an increase in the brightness of the B-mode image.[1)] Our previous studies have shown a positive correlation between the degree of RBC aggregation and the blood glucose level,[2)] a useful parameter for the evaluation of the degree of RBC aggregation in diabetics,[3)] and the intravascular attenuation calculation method that is important for more accurate estimation of the RBC aggregation size[4)].

However, there is a problem that the measurement reproducibility of the degree of RBC aggregation is too low to apply the method to evaluation of the degree of RBC aggregation in the clinic. To address this problem, we are working on reducing the four main factors: a) slight deviation of the measurement target (vein), b) control of the blood flow, c) analysis condition of the acquired signals, and d) protocol for the measurements. a) is the item mainly examined in the present study. We investigated the influence of the elevational deviation on the measurements in the long-axis view of the vein by the measurements in the short-axis view.

2. Method

Ultrasound diagnostic apparatus (UD-8000; Tomey Corp., Nagoya, Japan) was used with a mechanical sector ultrasound probe (IP210; Tomey Corp., Nagoya, Japan) operating at the center frequency of 40 MHz and whose focal length was 9 mm. Ultrasound data were acquired in the dorsal vein of one person's hand.

The effect by the elevational deviation in the measurements in the long-axis view of the blood vessel can be examined through the lateral variations in the measurements of the short-axis view by confirming the brightness distribution in the blood vessel.

Acquired RF echoes were subjected to the envelope processing, then averaged in the depth direction near the focal point and the intima-media complex (IMC).

The reproducibility of the data was also examined by measuring in the short-axis view with another protocol. Ultrasound data for a frame were acquired 10 times at every 3-second intervals. Acquired RF signals were enveloped and averaged within the area near the center of the vessel in each frame.

3. Results

Figures 1(A) and **(B)** show a B-mode image for the dorsal vein and the average of the brightness along the depth direction in the red and blue frames in (A), respectively. The brightness was 8 dB near the vessel wall and it became brighter up to 20 dB around the center at the area indicated by the red frame. IMC is clearly visible only when the ultrasound beam is incident normal to the vessel wall. From the brightness distribution in the lateral position, it can be seen that there is a brightness gradient even in the range where the IMC can be identified (the region between yellow lines).

Figure 2 shows the average brightness around the center of the blood vessel for each frame. For each of the three measurements, the variation was within 2 dB. Also, for all measurements, the variation was within 2.5 dB.

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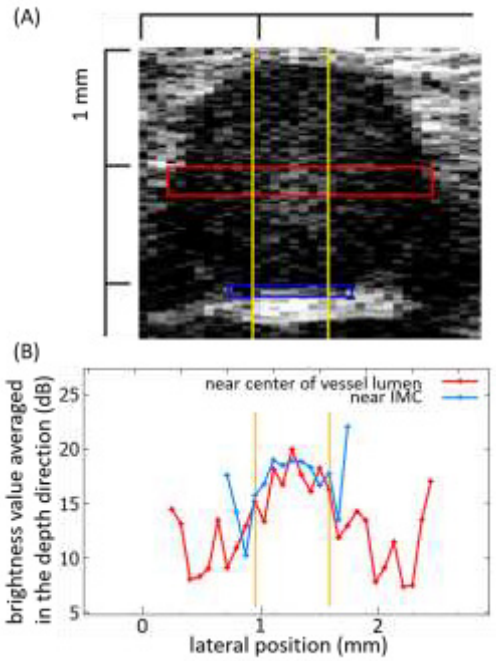

Fig. 1. Brightness averaged in the depth direction within each square frame. (A) B-mode image of the short-axis view of the vein. (B) Brightness values along with the lateral position.

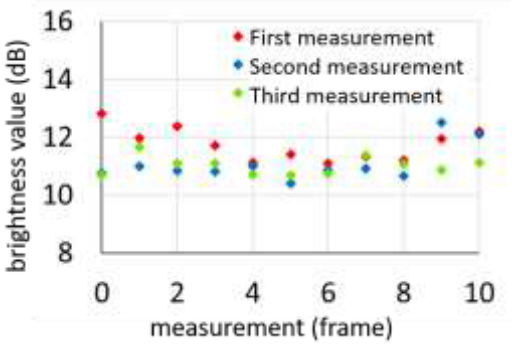

Fig. 2. Average brightness value for each frame.

4. Discussion

In our past experiments, we had measured scattered signals in the long-axis view and used the data in the range where IMC can be confirmed for the analysis. As shown in Fig. 1(B), even if the data in the IMC-visible slice is acquired, the results changed greatly due to the slight difference in the position of the vein. Therefore, the long-axis view measurements cause large variations in the measured brightness values.

Data with small variations were obtained by the measurements in the short-axis view as shown in Fig. 2. Persistent blood flow may be the main cause of these small variations. Additionally, **Fig. 3** shows the acoustic field characteristics along the depth direction of the probe. It is necessary to fit the focal point of the ultrasonic beam to the center of the blood vessel for the stable measurement of the amplitude of the scattered signals. However, it is impossible to set the position without any deviation. If we temporally allow up to 1 dB for the decrease in power due to the deviation of the measurement position from the focal point along the beam direction, the measurement position should be set within ±0.2 mm. The tolerance in the variation can be determined by considering the magnitude of changes in the degree of RBC aggregation associated with changes in blood glucose levels.

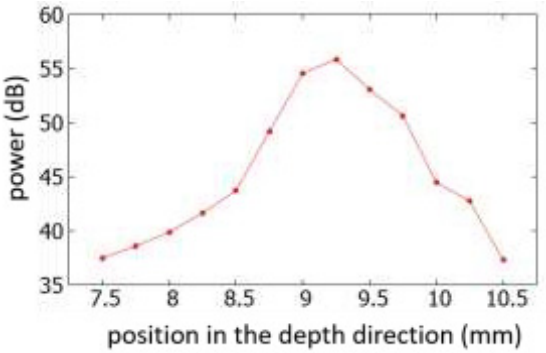

Fig. 3. Acoustic field along the beam axis of the probe.

5. Conclusion

In the present study, it was shown that the stability of the measurements is not guaranteed even when using IMC visible data in the long-axis view. This variation affects the estimated results of RBC aggregation. Based on the above results, we need to make stable measurements in the short-axis view of the vein.

It is ncessessary to correct the acquired data with the sound field characteristics. This is one of our research tasks to investigate the relationship between the degree of RBC aggregation and blood glucose level.

References

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