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Accurate Ultrasound Tissue Vector Measurement Based on 2D Autocorrelation with High-frame-rate Imaging System for Detecting Vascular Diseases

H. Yoshikawa[1], T. Ishii[2], A. J. Y. Chee[2], B. Y. S. Yiu[2], and A. C. H. Yu[2]
1 Hitachi, Ltd. (Tokyo, JAPAN), 2 University of Waterloo (Waterloo, CANADA)

Background, Motivation and Objective

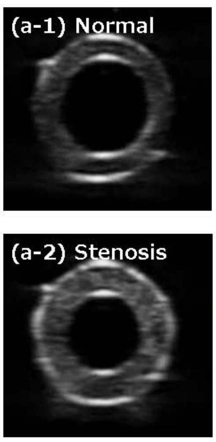
Long-term monitoring of vascular stiffness is important to prevent serious cardiovascular diseases. Vector projectile imaging (VPI) is a promising technique for measuring complex blood flow patterns by using a high-frame-rate data acquisition system. Improving the accuracy of motion tracking is crucial for clinical applications of VPI because the tissue displacement to be measured is much smaller than that of blood flow. In this study, accurate tissue vector measurement (TVM) has been developed to detect small changes in vascular stiffness for early diagnosis utilizing VPI.

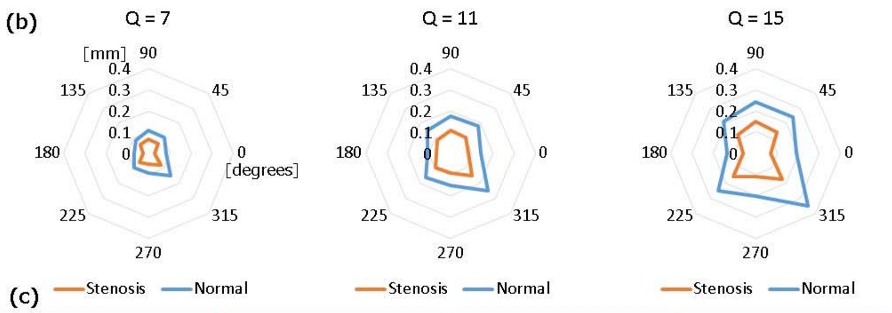
Statement of Contribution/Methods

Local motion vectors were acquired through a multi-angle, least-squares vector estimation methodology utilized in VPI. 2D autocorrelation was applied to the motion measurement in TVM instead of 1D autocorrelation originally used in VPI. Vessel wall phantoms mimicking normal vessels and stenosis were modeled with poly-vinyl alcohol to mimic artery-like elasticity and high acoustic compatibility. The thickness and elasticity of each model were 1.0 mm and 134 kPa, and 1.5 mm and 217 kPa, respectively. The phantoms were set inside an agar container, and a flow circuit was constructed. The wall motions generated by a carotid pulse waveform fluid were measured, and compared at whole angles. The flow quantity (Q) values used were 15 mL/s, which are similar to a healthy adult, and smaller values of 7 and 11 mL/s to generate small displacements.

Results/Discussion

Fig. 1 shows B-mode images of the normal and stenosis models and motion measurement results from the TVM. The wall displacements of stenosis are significantly smaller than those of normal model in whole angles at all of flow conditions. In the case of stenosis, at minimum flow (Q = 7), the measured displacement was 0.05±0.02 mm, which equals a 3% strain. Regarding normal model, the measured displacement and strain were 0.10±0.03 mm and 10%, respectively. These results suggest that TVM is effective to accurately monitor vascular diseases like stenosis and plaques. In conclusion, tissue vector measurement (TVM) based on 2D autocorrelation can effectively work to measure small displacements. Disease progression of vascular diseases can be accurately detected, and medical treatment can start before serious events can occur.





(c)

	Q7	Q11	Q15
Stenosis	0.05±0.02	0.10±0.03	0.12±0.04
Normal	0.10±0.03	0.17±0.04	0.23±0.06

Fig. 1 (a): B-mode images of normal and stenosis PVA models.
(b): Displacement results of TVM in whole angles at every flow conditions.
(c): Average and standard deviation of measured displacement.