A 20/40 MHz Dual Element Transducer for Morphological and Flow Imaging of Coronary Artery

Ruilin Cai[1], Min Su[1], Jiehan Hong[1], Yanyan Yu[1], Zhiqiang Zhang[1], Rong Liu[1], Yaocai Huang[1], Peitian Mu[1], Hairong Zheng[1], and Weibao Qiu[1]
[1]Paul C. Lauterbur Research Center for Biomedical Imaging, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, China

Background, Motivation and Objective

Both morphological anatomy and functional parameters including flow, pressure, and resistance of the vessel are valuable information for the evaluation of vulnerable plaques. Advances in imaging modalities permit direct measurement of properties of the arterial wall, atherosclerotic plaque, and arterial blood flow. Intravascular ultrasound has generally been used for cardiovascular diagnosis, but there is no flow information acquired during the imaging procedure. Fractional flow reserve (FFR) is a method to evaluate coronary artery stenosis, however it requires a special FFR wire for the measurement, which needs more cost and time for the diagnosis. This work proposes a novel dual element transducer to acquire high resolution structural and functional flow information in the coronary artery.

Statement of Contribution/Methods

The dual element transducer integrates a 20 MHz forward-looking element and a 40 MHz side-looking element in one 18-gauge catheter (Fig. A). The forward-looking element acquires flow information using pulse-wave Doppler imaging method, and the side-looking element collects structural data of the artery wall. PZT-5H ceramic is used in the transducer fabrication. Silver epoxy is cured as the first matching layer, and parylene is vapor-deposited to be the second matching layer. Epo-TEK 301 and E-solder are chosen as the backing layer. A blood vessel phantom is fabricated to evaluate the imaging performance. The acquired morphological and flow imaging data are compared with the measurements using a commercial ultrasound scanner (Visualsonics, Vevo 2100).

Results/Discussion

The resonant frequencies and bandwidth at -6 dB of the forward-looking element and side-looking element are 24.9 MHz, 47.8% and 39.1 MHz, 55%, respectively. The stenotic area in the tissue phantom is obtained by the side-looking element. (Fig. B). The frequency shifts caused by the moving fluid around the plaque are collected (Figs. D, E, and F). The corresponding blood speed (325.8 mm/s, 498.2 mm/s and 327.1 mm/s) and the volumetric blood flow of the plaque (2422.9 uL/s) can be acquired by combining sectional images and flow data, which provides insights into the pathophysiological part of the coronary artery.

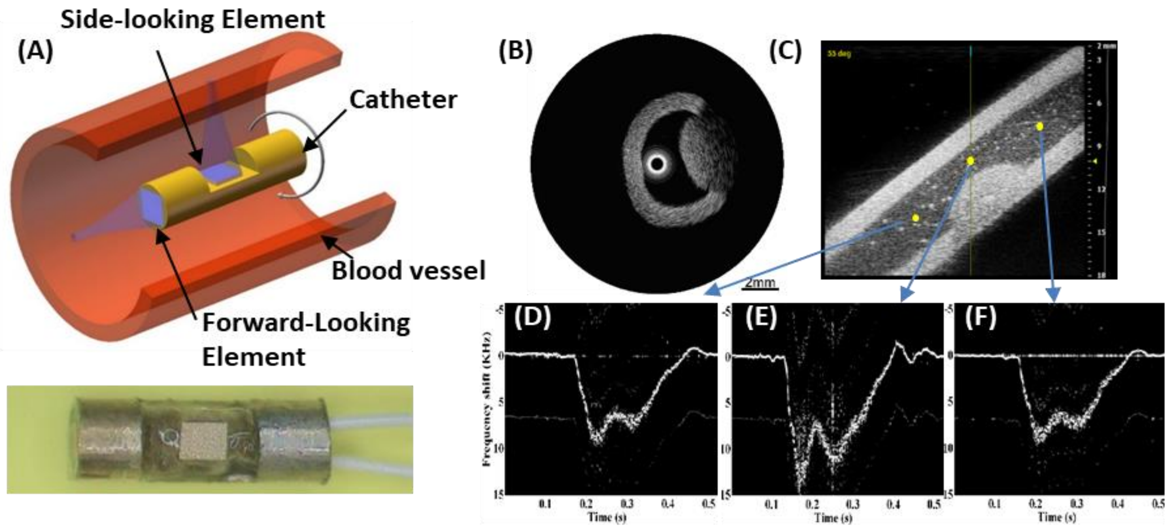

Fig. (A) The diagram of the proposed transducer, and the fabricated transducer; (B) Sectional image of the phantom acquired by the side-looking element; (C) The image acquired by a commercial scanner for comparison; (D-F) The flow images acquired by the forward-looking element.