

Implementation and validation of a new ultrasound probe for continuous radial arterial measurements in an in vitro biomimetic cardiovascular setup

A.B. Amado-Rey¹, Marc Fournelle², T. Stieglitz¹, ¹Albert-Ludwigs-University, Freiburg, Germany.
²Fraunhofer IBMT, Saarbruecken, Germany

Background, Motivation and Objective

Prevention of cardiovascular diseases can be done by continuously monitoring the variations in arterial parameters such as blood flow, arterial thickness, and blood pressure. The realization of a compact, wearable ultrasound (US) system to measure arterial fluctuations in the radial artery involves challenges in terms of accuracy and compactness. In this work, a new compact ultrasound probe is presented and tested on an in vitro cardiovascular setup, which includes a new ultrasound phantom for the underarm and a self-fabricated blood mimicking fluid with 9 $\mu\text{m-Al}_2\text{O}_3$ particles for the erythrocytes. Results of the blood flow velocity and arterial thickness in the phantom demonstrate the usability and high performance of this US-Sensor to be used for a future wearable ultrasound system.

Statement of Contribution/Methods

The US-sensor (Fraunhofer IBMT) is an array of 3 rectangular Lead Zirconate Titanate (PZT) piezo elements with a dimension of $10 \times 5 \text{ mm}^2$. It is hermetically packaged with polyurethane (Obomodulan 500) for its better use in the cardiovascular setup (see Fig. 1 A).

The lateral elements function as sender and receiver and measure the frequency variations of the input signal (a 5 MHz burst signal) as a result of the movement of the erythrocytes particles. Simultaneously, the PZT US-Sensor in the middle measures the artery thickness by calculating the time difference between the emitted signal and the received echo.

The setup (Fig. 1B) includes a calibrated peristaltic pump (Gampt GmbH, Germany), that pumps in a continuous wave (CW) mode a blood mimicking fluid through a silicon tube (radial artery). This silicone tube is inserted in a homogeneous, transparent, long-last acoustic arm Phantom.

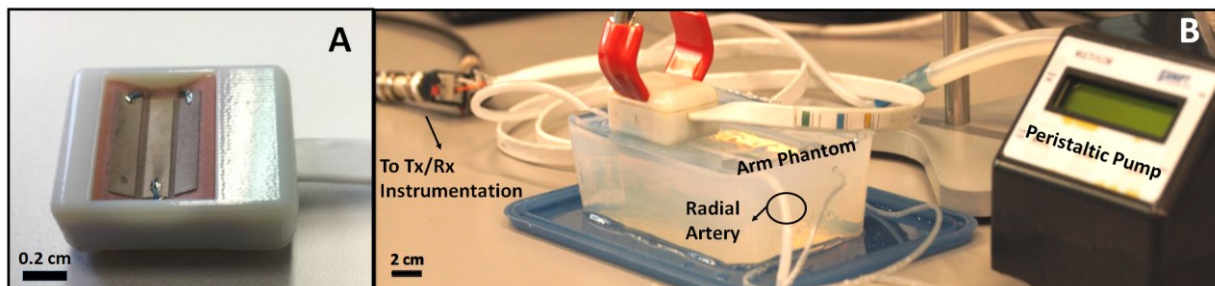


Figure 1. Photos of the US-Probe and the cardiovascular setup A. The fabricated US-Probe is composed of 3 linear rectangular piezo elements with a 6 mm lateral extension, B. The Probe is placed longitudinally to the radial artery of the phantom to realize continuous A-mode arterial measurements.

Results/Discussion

Measurements of the velocity of the mimicked blood and silicon thickness in the phantom were realized simultaneously for various heart rates, applied through different pump rates. When increasing the pump rate from 3000 rpm to 4000 rpm, an increment from 8.29 to 11.6 cm/s in the blood flow, and from 3.51 to 3.57 mm in the arterial thickness was appreciated. These values represent the hemodynamics of human blood. The measurement of these rather small differences was possible due to the high accuracy and performance of the wrist ultrasound probe.