Towards in-vivo photoacoustic imaging of atherosclerotic plaques

Towards in-vivo photoacoustic imaging of atherosclerotic plaques

M.U. Arabul, M.C.M Rutten, F. N. van de Vosse, R.G.P. Lopata

cardiovascular biomechanics

Technische Universiteit Eindhoven University of Technology

Introduction

Cardiovascular disease related deaths are at the top of mortality statistics in developed countries. The large portion of deaths occurs abruptly, without expressing symptoms a priori. This urges the need for reliable and inexpensive diagnostic technologies in cardiovascular clinical practice.

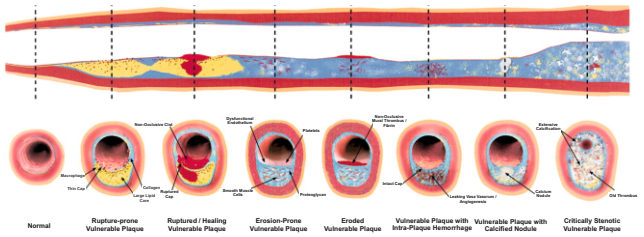

Figure 1: Plaques varies in structure and composition [1].

Atherosclerosis is a disease that resultes excessive accumulation of lipids, fibers and macrophages in the arterial wall. Plaque formation in the arterial wall intrinsically causes stenosis in the vessel and disturbs the blood flow. However, vulnerable plaques that are prone to rupture are a major cause of sudden cardiovascular deaths due to blood cloth formation [1].

Motivation

Retrospective autopsy studies have stated the need for a diagnostic method that is able to reveal the composition of the plaque as well as its structure for the assessment of plaque vulnerability.

Methods

Medical ultrasound provides structural and mechanical information of plaques. Although mechanical contrast between the plaque and arterial wall is low, a significant optical contrast exists. Photoacoustic imaging measures the optical absorption distribution acoustically. Combining optical contrast with acoustic resolution makes photoacoustic imaging (PAI) a promising diagnostic tool for cardiovascular applications.

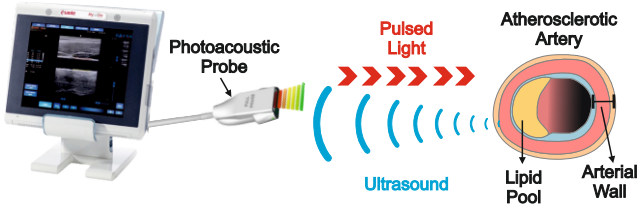

Figure 2: Wavelength dependent optical absorption of fat and arterial wall generates significant ultrasound signal.

Pre-clinical validation

The validation of feasibility of PAI will be done in three steps:

- Polyvinyl alcohol cryogen (PVA-C) phantom studies to quantify sensitivity and specifity

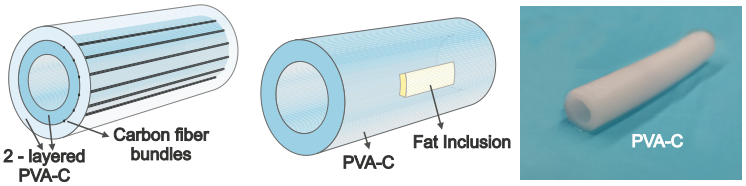

Figure 3: (A) Phantom is consisted of two layer of PVA-C with different mechanical properties and carbon fibers as optical absorbers between the layers. The phantom is designed to investigate lateral resolution, (B) Fat injected PVA-C is designed to investigate lipid sensitivity, and (C) simple PVA phantom to use pulse-echo examination.

- Porcine carotid and human carotid endarterectomy samples as intermediate step for preclinical validation of in-vivo imaging

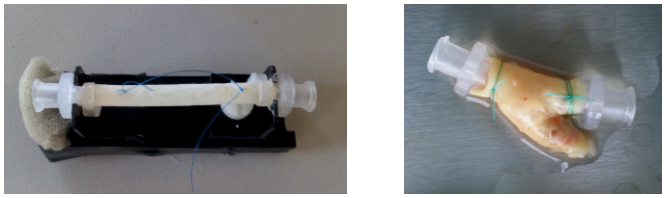

Figure 4: (A) Healthy porcine corotid artery and (B) atherosclerotic human carotid.

- Clinical studies with human subjects

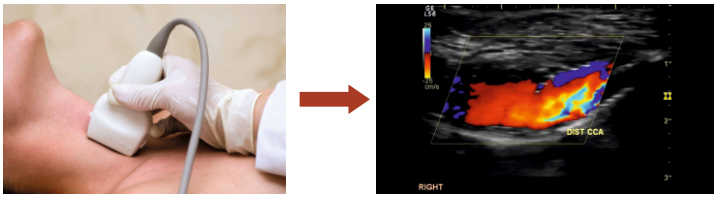

Figure 5: Ultimate goal is to achieve a reliable clinical tool for atherosclerotic carotid artery diagnosis.

Acknowledgement

This project is funded by EU (FP7 FULLPHASE) project.

Reference

[1] M. Naghavi, *et al.*, “From vulnerable plaque to vulnerable patient: a call for new definitions and risk assessment strategies: Part I.,” Circulation, vol. 108, no. 14, pp. 1664–72, Oct. 2003.

/Department of Biomedical Engineering

M.U.Arabul@tue.nl