Assessment of local blood pressure and flow in arteries using ultrasound

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C.A.D Leguy[1,2], E.M.H Bosboom[2], A.P.G Hoeks[3], R.N Planken[4], F.N van de Vosse[1]
[1]Biomedical Engineering, TU/e, [2]Biomedical Engineering, AZM, [3]Cardiovascular Research Institute Maastricht, [4]Surgery & Radiology, AZM (The Netherlands)

Introduction

Cardiovascular disease (CVD) reveals itself in changes in mechanical properties of the arterial tree and thus in blood pressure as well as pulse wave propagation. Therefore, we hypothesize that the local arterial modification can be related to cardiovascular system state, so it can be used to assess CVD risk in an early stage. To develop a diagnostic tool using this relation, the local blood pulse pressure as well as local pulse flow are essential parameters to be assessed. Currently ultrasound seems the most suitable technique, since it can be used to assess locally the vessel geometry and blood velocity non-invasively.

Aim

Develop a method to determine the local pulse pressure and local pulse flow in arteries using ultrasound.

Research approach

The local pressure wave form can be determined by the local vessel compliance and dynamic distension of the arterial wall. The vessel distension can be directly assessed by ultrasound, whereas an assumed mechanical model is required to derive the compliance from the assessed wave propagation velocity. Compliance can be obtained from local pulse wave velocity assessed by an array of ultrasound probes.

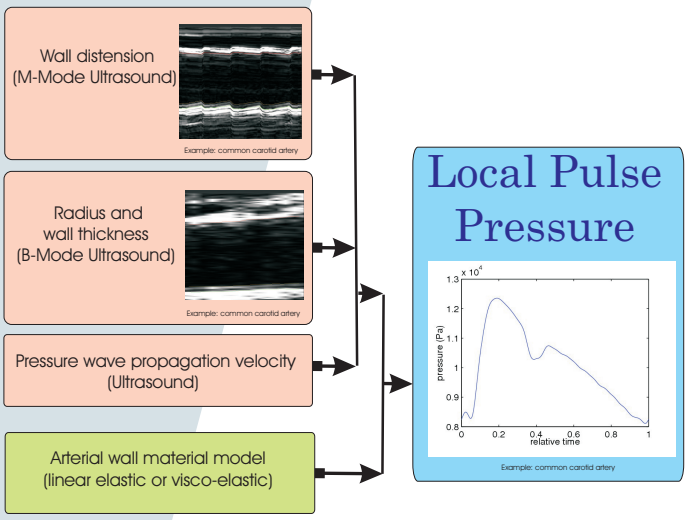

Figure 1: Pulse pressure assessment method

The local flow wave form can be obtained from ultrasound measurements assuming a simple relation with the measured velocity. For complex geometries this relation will be determined by finite element computational fluid dynamics (CFD) simulations.

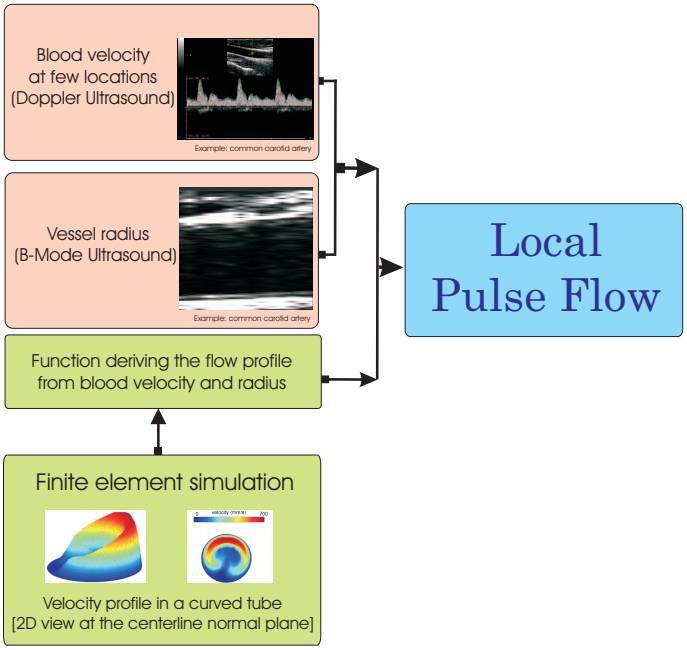

Figure 2: Pulse flow assessment method

The first feasibility studies point out that the arteries of the arm are suitable, because:

- segmentations of the brachial artery from MRA images supply physiological curvature that can be used for the finite element model
- ultrasound assessments can be performed accurately and pressure waves can be studied.

Figure 3: Arterial segmentation from MRA

Future work

As a first step the influence of vessel geometry on the local velocity profile will be studied by means of a finite element analysis.