A wave propagation model to estimate arterial stiffness

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MARIE CURIE ACTIONS

Introduction

Arterial stiffness, S, is an independent predictor of cardio-vascular risk at an early stage. S is defined as:

$$S = h * E,$$

with h the wall thickness and E the Young modulus.

Objective

The goal of this study is to investigate the feasibility of a new non-invasive method that estimates S, using a patient-specific wave propagation model of the upper limb.

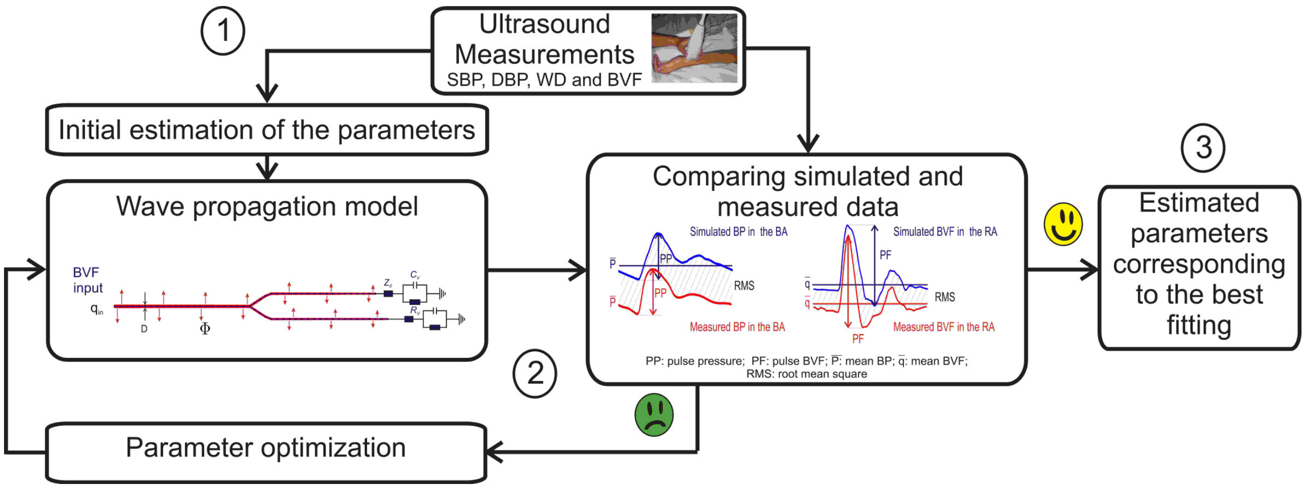

Figure 1: Iterative reverse method based on a patient specific wave propagation model

Methods

Clinical measurements

- Systolic/ diastolic blood pressure (BP) in the brachial artery (BA)
- Diameter (D), wall distension (WD) and blood volume flow (BVF) in the BA, radial (RA) and ulnar (UA) artery

Model parameters estimation

- Linear elastic model with increasing S and exponential decay of D,

$$S = S_0 \exp(x/L_S), \qquad D = D_0 \exp(-x/L_D),$$

with x the axial coordinate, D_0 and S_0 the initial value, L_D and L_S the characteristic decay lengths estimated from the measurements
- q_{in} : input BVF measured in the BA
- Winkessel parameters Z_0, R_v and C_v obtained from a fitting of the BVF and WD waveform at the RA and UA
- BVF distributed outflow estimated from the measured time average BVF

The reverse method

- Optimized model parameters are obtained using an iterative method, see Fig 1.

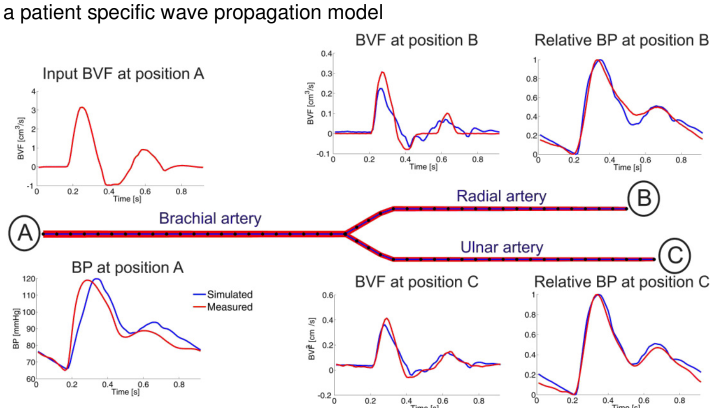

Figure 2: Comparison between the simulated and measured waveforms

Results

- Simulated BVF and BP waveform resulting from the iterative method fit the in-vivo estimates at the BA, RA and UA, see Fig 2.
- Pulse pressure and pulse BVF are the most sensitive to the S and C_v respectively.
- S in the BA, obtained with the model, equals 0.34±0.08 kPa.m. It is 40% lower than the in-vivo estimated S (0.57±1.3kPa.m) from the BA distensibility.

Conclusion

Patient specific wave propagation models can be used to improve the estimation of in-vivo arterial stiffness.