LUMPED-PARAMETER MODEL TO ASSESS CORONARY BLOOD FLOW IN AAOCA: A FOCUS ON THE IMPACT OF BOUNDARY CONDITIONS

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Introduction

Anomalous aortic origin of the coronary artery (AAOCA) is a rare congenital disease that can cause sudden cardiac death (SCD). Starting from our encouraging result [1] we aim to develop a non-invasive patient-specific (PS) computational tool to simulate coronary blood flow (CBF) using multi-patient clinical data to understand how intramural coronary artery (CA) compression affects myocardial perfusion. In this paper we present the model setup and a sensitivity study focalized on the impact of input data on the accuracy of the results. The final aim is to define an accurate tool with a limited use of invasive data.

Methods

Each arterial segment is described as an electrical circuit (Fig. 1A) whose components depend on the geometry of the vessel, its material, and blood properties [2]. A PS pressure waveform is used as inlet condition (Fig. 1B). The aorta's outlet is modeled with a Windkessel circuit (Fig 1C), whereas the CAs' outlet is defined by a 6-elements circuit (Fig. 1D) with an intramyocardial pressure source (Fig. 1E). The total resistance of each outlet is split among circuit resistive parameters [3].

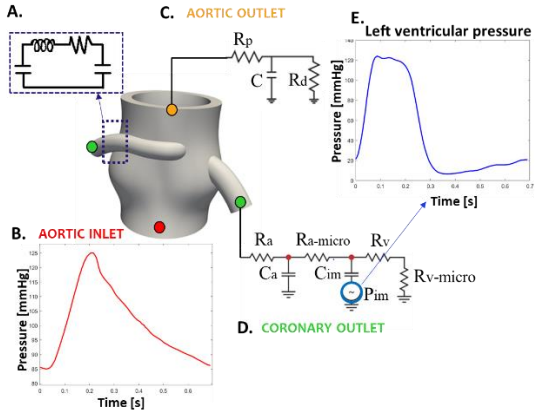

Figure 1: Schematic representation of the model.

Based on preliminary analysis we calibrate the model using geometrical data from CT images. To define a PS boundary conditions (BCs) we compute the total aortic resistance with the patient's cardiac output and mean arterial pressure [3]. The left ventricular pressure (LVP) waveform is rescaled based on the PS data, the right one is evaluated as 20% of LVP [3]. The definition of coronary resistance (Rc), allow us to differentiate two models: **PS Model** and **Literature approach**.

In PS Model we use Rc acquired in-vivo during catheterization exam under resting condition.

In Literature approach we estimated Rc using the analytical procedure proposed in the literature [3] to reduce the using of invasive data.

First, we run the model using PS in-vivo measured Rc. Then, we use Rc analytically computed with the aim to study the impact of BCs on accuracy of CBF assessment.

Results

Fig. 2 shows results considering the two ways of defining Rc. Simulated CBF are compared with in-vivo CBF. The mean square error (MSE) is evaluated and highlights a reduction in accuracy with the removal of Rc invasive information: 0.01 vs 0.57 and 0.02 vs 3.72 for RCA and LCA, respectively.

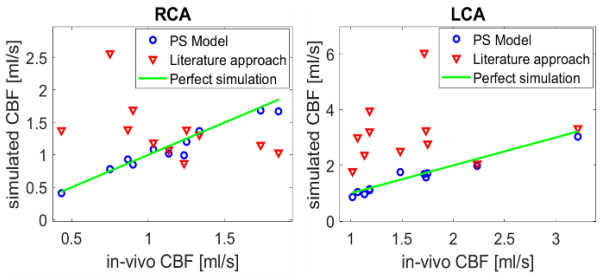

Figure 2: 0D model vs in-vivo CBF. Blue circles: in-vivo PS Rc. Red triangles: literature approach.

Discussion

Our results suggest that invasive Rc plays a key role in CBF assessment. The accuracy is dramatically reduced by using an analytical standard approach that does not consider the presence of AAOCA and the characteristics of the population. A future approach should consider specific population information in defining analytical Rc.

References

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