HUMAN CORONARY ARTERY HEMODYNAMICS IS AFFECTD BY DEGREE OF FREEDOM OF THE ARTERY

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Introduction

The issue with much of previous literature is a way to account for all the physiological characteristics of an artery, and include them in a computational simulation [Lorenzini, 2008 & Siogkas, 2011]. This study explores the best way to achieve this by investigating three different fluid structure interaction (FSI) models with different degree of rigidity.

Geometry and Material

13 patients with stenosis in the left anterior descending artery were reconstructed using three-dimensional quantitative coronary angiography. In order to mimic the compliance motion of the coronary arteries, three different fluid structure interaction (FSI) models (Figure 1 (a-c)) were investigated. Model (I) restricts movement at the inlet and outlet in all degrees of freedom. Model (II) allows movement of the artery in all places except the inlet. For Model (III), all movement is allowed at inlet, outlet, inner wall and outer wall.

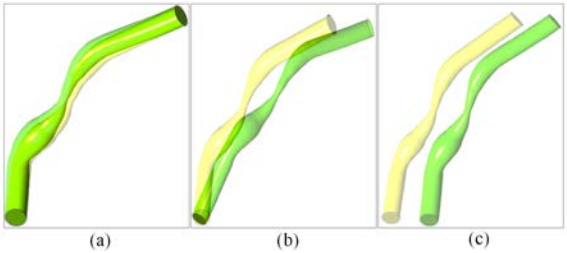

Figure 1. (a) Model I, (b) Model II, (c) Model III.

Results and Discussion

Analysing the motion of the left anterior descending (LAD) coronary artery using the coronary angiography revealed that the motion of the LAD is close to the motion of the Model (II) as the proximal part of the LAD is connected to the left main coronary artery (LM) and the motion of the proximal part is much less than that of the distal part. Figure 2 shows a linear regression analysis of the time averaged wall shear stress (WSS) between the Models (I), (II) and (III) for a patient with %50 stenosis severity. As seen, correlation coefficients (r^2) between the Models are generally high; however, the gradients of the regression lines (a) show that WSS of the Model (II) is about 25 and %2.5 higher than the WSS of the Models (I) and (III) respectively. Figure 3 shows that as the stenosis severity increases, the difference between the WSS of the Model (II) and the Models (I) and (III) decreases. However, for the patients with moderate stenosis severity (%50 to %60), the Model (I) and Model (III) underestimate the magnitude of the WSS significantly in compare to the Model (II).

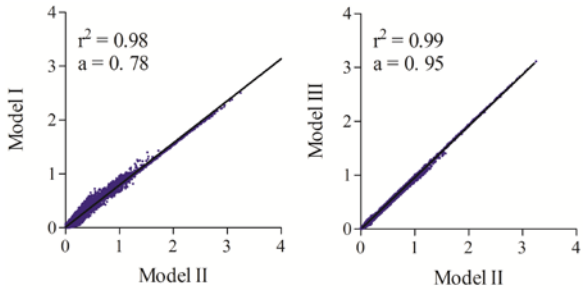

Figure 2. Correlations of time-averaged wall shear stress (WSS) between the models.

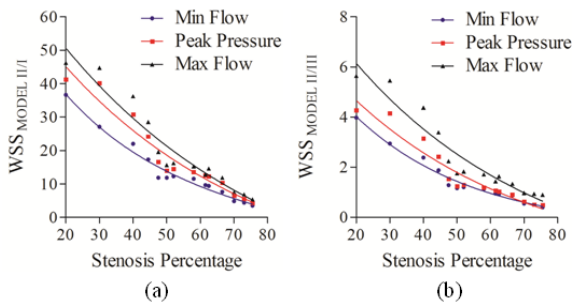

Figure 3. The relationship between stenosis severity and the ratio of the WSS of Model (II) to (a) Model I, (b) Model III.

References

[1] Giulio Lorenzini, E. C., J Biomech, 41: 1862–1870, 2008.

[2] Siogkas, S. A., *et al*, JSSCM, 5: 69-77, 2011.