MODELING OF STENOSIS IN ILIAC ARTERY BIFURCATION USING NUMERICAL METHOD

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INTRODUCTION

Cardiovascular disease is very common in patient with iliac bifurcation stenosis. Accelerated arterial stiffening and a high prevalence of atherosclerotic lesions contribute to high cardiovascular mortality rates in the world. Iliac bifurcation stenosis occurs when the flow of blood from abdominal aorta leading to iliac is constricted by tissue or artherosclerotic plaque. This narrowing of the arteries diminishes the blood supply to the legs. In this study, we have investigated the flow analysis in the bifurcation area and compared the flow patterns for different section areas of stenosis. The hemodynamic parameters of blood have been studied and velocity vectors as well as pressure drops due to stenosis have been calculated.

METHODS

The geometry of iliac artery was made based on the MRI data from a 42-year-old healthy man. Using a novel segmentation method, we could reconstruct the 3D mesh of iliac artery's internal wall. This was done by marching cubes algorithm. The initial mesh was post-processed to enable us to obtain the final surface mesh. Finally, using a frontal method, we constructed a tetrahedral mesh from the main surface. The mesh , with 2179 nodes and 8952 elements, is shown in Figure1. The applied boundary conditions on the fluid domain are:

- Steady uniform velocity at the inlet, the mean blood flow in the iliac bifurcation is 195 ml/min as reported in [1] for healthy human cases. The time-averaged Reynolds number is 422 which is lower than 2300, therefore the inflow can be considered as laminar flow.
- Physiological pressure of 115 mmHg for the outlets.

The boundary conditions that were used for the solid domain are:

- Fixed zero displacement for the face adjacent to the inflow and outflow sections
- External pressure of 400 mmHg suggested by [1].

The boundary conditions on the FSI interfaces state that:

- Displacements of the fluid and solid domain must be compatible.
- Tractions at these boundaries must be at equilibrium.
- The fluid obeys no-slip condition.

The fully coupled fluid and structure models were solved by a commercial finite element package ADINA 8.2. The finite element method (FEM) for the solid domain and finite volume method for the fluid domain is used to solve the governing equations.

RESULTS AND DISCUSSION

The pressure, wall shear stress, effective stress and deformation contours of healthy iliac bifurcation has been compared with stenosis cases. The stenosis results were obtained based on 30,50 and 80 percent reduction in cross section area of the vessel. It is evident that creation of a stenosis on the lateral side of a branching will guide the stream lines and velocity vectors. This in turn results in a wall shear stress spatial distribution of more irregular patterns and the possibility of further activation of the endothelial cell function.

The wall pressure is maximum around the stagnation point in the healthy bifurcation. The flow in the stenosis does not have stagnation point, and therefore it exists a more extended region in the stenosis dome with high pressure compared with the pressure distribution in the healthy bifurcation

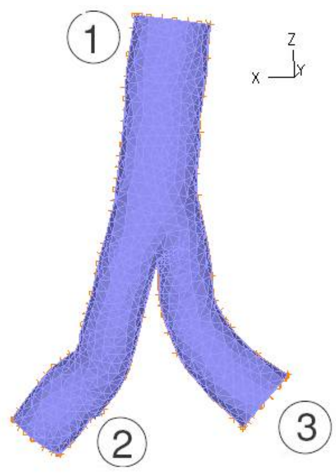

Figure 1: Final mesh of iliac artery bifurcation using 2179 nodes and 8952 elements

REFERENCES

1. A. Valencia and F. Solis, “Blood flow dynamics and arterial wall interaction in a saccular aneurysm model of the basilar artery”, J. Computers & Structures, No. 84, pp. 1326-1337, 2006Noakes TD, et al., *Eur J Appl Physiol.* **104**:757-759, 2008.