2008-01-25

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Funder: Department of Mechanical Engineering, Technological University Dublin (DIT)and the Irish Research Council for Science Engineering and Technology (IRCSET).

Registered Research Student? - Yes Date of first research registration: 01/10/05

EVOLUTION OF A COMPUTATIONAL DOMAIN FOR NUMERICAL ANALYSIS OF FLUID MECHANICAL DISTURBANCE INDUCED BY CORONARY STENT DEPLOYMENT

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INTRODUCTION

Coronary stent implantation can improve blood flow in an artery that has been narrowed by the build up of arterial plaque. However, the haemodynamic effect of stent placement is unclear and flow induced factors such as low wall shear stress (WSS) may influence arterial restenosis (re-blockage). Computational fluid dynamics (CFD) has been used extensively to predict areas of low WSS in stented arteries [1]. However, the unrealistic assumption that the stented segment retains a perfectly circular cross section after stent implantation is implicit to these investigations. The degree of tissue prolapse between stent struts may be an important factor in predicting the restenosis rate of a stent due to the haemodynamic influence of the protruding tissue.

MATERIALS AND METHODS

Automated construction algorithms are designed for creation of the Palmaz-Schatz (PS) slotted tube stent (Johnson & Johnson, USA) and Gianturco-Roubin II (GR-II) coil stent. The algorithms are written in Jscript and input to the ANSYS Workbench Version 11 (Canonsburg, PA) software using the scripting application program interface. The algorithms allow for the models to be generated with a user defined diameter.

Two idealised cylindrical arteries implanted with either 3.0mm stent model are constructed using ANSYS Workbench.

Stents are typically implanted with a stent-to-artery diameter ratio range of 1.1–1.2:1 to achieve maximum luminal patency. A second pair of computational domains is created to represent the arteries implanted with stent models with 3.5mm diameters. The diameters of the unstented sections are the same as in the idealised implanted stent models.

A third pair of models is created with realistic tissue prolapse between the stent struts predicted from the prolapse equation which is written

$$\frac{R}{R_o} = 1 - \frac{XCL}{2R_o}\left\{1 + \cos\frac{2\pi}{L}\left(z - \frac{L}{2}\right)\right\} \qquad (1.1)$$

where L is the distance between two stent wires, C is the coefficient of prolapse based on finite element data [2]. X is a geometrical coefficient dependant on proximity to more than two scaffolding stent wires. R_o is the inner radius of the healthy artery and z and R are co-ordinate variables

The commercial software code ANSYS CFX Version 11 (Canonsburg, PA) is used to solve the governing equations of fluid mechanics for non-Newtonian blood flow in the computational domains using a vertex-centred finite volume scheme.

RESULTS

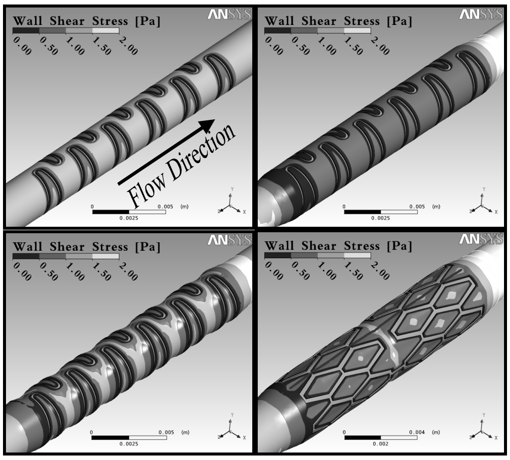

Figure 1:(a) Simple; (b) Oversized; (c) Prolapse computational models of an artery implanted with a GR-II coronary stent; (d) Prolapse model of an artery implanted with a PS coronary stent

DISCUSSION

The results clearly show a difference in WSS distributions between the simple, oversized and oversized with prolapse models for the GR-II stent. Similar differences are found with the PS stent models. In light of the fact that WSS distributions play a crucial role in dictating the arteries response to the stenting procedure, future CFD models must include the important factors presented in this paper to predict accurate and realistic results.

REFERENCES

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[2] P. J. Prendergast(*et al*), Journal Of Biomechanical Engineering, Volume:125, pp 692-699, 2003.