# BLOOD FLOW SIMULATION IN A 3D REALISTIC MODEL OF LEFT DESCENDING CORONARY ARTERY WITH IMPLANTED STENT – WALL SHEAR STRESS ANALYSIS

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## INTRODUCTION

Nowadays, cardiac disease is one of the most common cause of death. Each year almost one million of angioplasty interventions and stents implantations are made all over the world. Unfortunately, in 20-30% of cases neointimal proliferations leads to restenosis occurring within the following period of 3-6 months. This phenomenon often begins and develops mostly at the ends of an implanted stent (edge restenosis, “candy wrapper” effect). Three major factors are believed to contribute mostly to the edge restenosis: (a) mechanical damage of the artery’s wall caused by the stent implantation, (b) interaction between the stent and the blood constituents and (c) endothelial growth stimulation by small (lower that 1.5 Pa) and oscillating wall shear stress (WSS) [1]. The aim of the current research is to analyse how geometrical changes inflicted by the stent implantation affect the WSS distribution, and show that dangerous WSS values can be sustained in the vicinity of the stent’s edges during large fraction of the cardiac cycle (if not permanently).

## COMPUTATIONAL MODEL

Based on coronarography results, a 3D realistic model of the left main coronary artery, including the LAD and LCX branches, has been made. The presence of the implanted stent is modelled by the artery’s wall deformation (Figure 1).

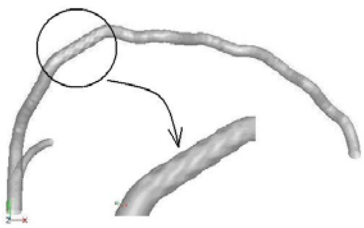

**Figure 1:** Model of coronary artery with stent

Blood is considered a newtonian fluid with a viscosity of $3.5 \times 10^{-3}$ Pa.s, and with a density of 1060 kg/m$^3$. Blood flow at the inlet has a realistic time variation (Figure 2) and a constant split between LAD (70%) and LCX (30%) branches. The diameter at the inlet of the left main coronary artery is 5mm, LAD diameter is 4mm, and LCX – 3mm.

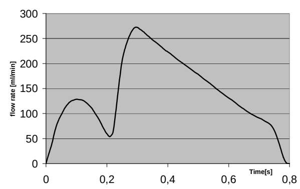


**Figure 2:** Inlet flow rate to the left main coronary artery.

The modelled stent is 15mm long and its diameter exceeds the LAD’s diameter by 5%. The presence of stent is simulated by two-directional deformation (waviness) of the arterial wall. The flow is determined by means of the commercial CFD solver Fluent 6.4.11, using the grid of about 1 milion tetrahedral finite volumes.

## RESULTS AND DISCUSSION

During this research, the regions were sought where the WSS remains in the dangerous range during the whole cardiac cycle. Such state appears near the stent edges due to sharp changes of curvature of the artery related to the increased rigidity of the artery segment with implanted stent [2]. This geometric feature, together with the strong flow pulsations, is responsible for existence of large regions of separated flow with permanently low WSS values. The numerical simulations confirm, that regions of low WSS persist during whole cardiac cycle at the ends of the stent (Figure 3).

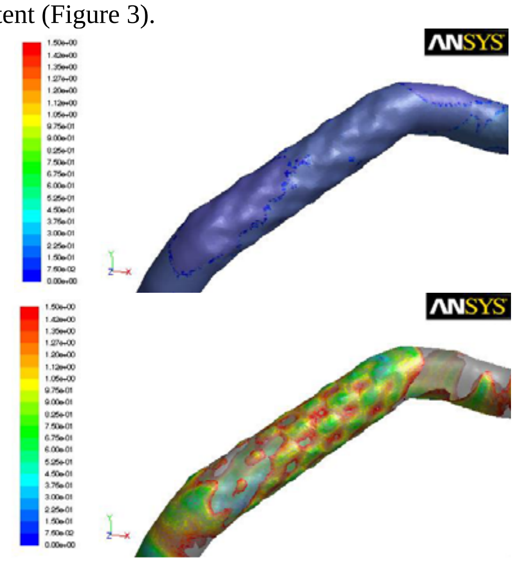


**Figure 3:** WSS < 1.5Pa in stent at min. and max. flow

## CONCLUSIONS

Applying CFD methods, the flow simulations in stented LAD have been performed. Regions of permanently low WSS and thus especially prone to intimal proliferation have been localized. These observations may be helpful in selection of optimally shaped coronary implants, which would minimize risk of restenosis.

## REFERENCES

1. Benard N, et al.: Experimental study of laminar blood flow through an artery treated by a stent implantation: characterisation of intra-stent wall shear stress, *Journal of Biomechanics* **36** (2003) 991-998,
2. Wentzel J, et al.: Coronary stent implantation changes 3-D vessel geometry and 3-D shear stress distribution, *Journal of Biomechanics* **33** (2000) 1287-1295.