Hemodynamic investigation of aortic aneurysm after stent graft with slits treatment

ChiWei Ong[1], Fei Xiong[1], Foad Kabinejadian[2], YenNgoc Nguyen[1], Gideon Praveen Kumar[3], FangSen Cui[3], Gongfa Chen[4], Pei Ho[5], HwaLiang Leo[*†]

[1]Department of Biomedical Engineering, National University of Singapore, Singapore

[2]Department of Biomedical Engineering, Tulane University, New Orleans, LA, USA

[3]Institute of High Performance Computing, A*STAR, Singapore 138632, Singapore

[4]Center of Computational Mechanics, Guangdong University of Technology, China

[5]Department of Cardiac, Thoracic & Vascular Surgery, National University Health System, Singapore

*Presenting author: bielhl@nus.edu.sg
†Corresponding author: bielhl@nus.edu.sg

Abstract

Thoracic endovascular aortic repair (TEVAR) always considered as an alternative to open surgery to treat an aortic arch aneurysm. However, the effectiveness of TEVAR in the aortic arch aneurysm is always difficult due to the complex anatomy of the aortic arch. Flow preservation at the superior branches at the aortic arch makes it an even more challenging task to treat the aneurysm. We proposed a novel stent graft design with slits at the upper side of the stent graft to alter the hemodynamics at the aortic arch while maintaining blood flow to supra-aortic branches. A computational fluid dynamic (CFD) analysis has been carried out to assess flow characteristics near stented aortic arch in simplified aortic arch models, followed by in-vitro experiments using particle image velocimetry (PIV) in a mock loop. The hemodynamics result was evaluated in terms of time-averaged wall shear stress (TAWSS), oscillating shear index (OSI), and endothelial cell action potential (ECAP). The results showed that the stent graft with slits can effectively smooth the flow pattern in the aneurysm considerably. Furthermore, the effect of the slits on flow preservation to the supra-aortic branches was simulated and compared with experimental results. We observed good flow preservation at the supra-aortic branches in the simulation which is supported by in-vitro experiment observation. Low TAWSS and elevated ECAP were observed in the aortic arch aneurysm after the placement of the stent graft with slits, implying the potential of thrombus formation in the aneurysm. The present analysis indicated that not only could the stent graft with slits shield the aneurysm from rupture but also it creates a thrombus friendly environment that can contribute to the shrinkage of the aneurysm.