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Numerical Investigation of the Hemodynamics Characteristics in Coronary Bifurcation Region with Different Dual Stent Implantation Techniques

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1 Introduction

The prevalence of coronary bifurcation lesions (CBL) in the percutaneous coronary intervention (PCI) was reported to be approximately 15-20% [Steigen (2006)]. The complex surgical techniques and the high incidence of restenosis make the treatment of CBL is still one of the most challenging fields in PCI. Even the single stent technique showed prognosis in most CBL treatment, dual stenting technique is still required in some cases. Our clinical follow-ups of dual stent implantation showed that the optimized provisional T-stenting (OPT) technique in CBL treatment has a lower restenosis rate compare with the Culotte stenting technique and T-stenting and small protrusion (TAP) technique. Though the local hemodynamic characteristics have been suggested as a key factor of the restenosis post PCI, the detailed hemodynamics features of the different dual stent implantation configurations are yet to be explored. In this study, the numerical simulations were performed to investigate the flow characteristics in coronary bifurcations with different dual stenting techniques.

2 Methods

In the modeling stage, the stents were firstly *in-vitro* deployed into artificial coronary bifurcations with OPT, PAT and Culotte techniques by the physicians of our team, respectively. Secondly, the geometry data of artery and deployed stents were acquired from micro-computed tomography (micro-CT) scanning (SkyScan 1176, Kontich, Belgium) with a spatial resolution of 18 μm [Tu (2017)]. Then one three-dimensional (3D) model including stents and artery of each stenting techniques were reconstructed by the combined use of self-developed Matlab code and the commercial software MIMICS (Materialise Inc., Leuven, Belgium).

In the CFD simulations, blood was assumed as a Newtonian fluid with a density of a density of 1055 kg/m^3 and a viscosity of 3.5 mPa·s. For simplicity and to reduce the computation costs, the elasticity of the arterial wall was neglected as well, a non-slip boundary condition was specified on all the walls and interfaces. The mean coronary flow velocity of 0.5 m/s was applied at the proximal end of the coronary bifurcation, and zero

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relative static pressures were assigned at the distal ends of the bifurcations as outlet boundary condition.

3 Results

Due to the presence of lumen narrow caused by overlapped stent at the bifurcation site of Culotte model, a reduction of blood flow velocity was observed in the MB. Moreover, the overlapped stent in Culotte model caused stagnation flow near the wall of bifurcation and subsequently leads to a large area of low wall shear stress (WSS) (<0.4 Pa), which coincides with the prone region of restenosis plaques. In the TAP model, small protrusion of side branch (SB) stent ring into the main branch (MB) caused a reduction of velocity in MB whereas a higher average WSS (1.09 Pa) and a smaller low WSS area at the polygon of confluence (POC) site can be observed. The OPT model showed the highest average WSS (1.4 Pa) and the smallest low WSS area at the POC site among the three models, and the WSS at the carina of vessel branch (CVB) region, another prone site of restenosis plaques in coronary bifurcation, is higher than that of Culotte and TAP model. The improvement of overall WSS level in the OPT model might be mainly attributed to the optimized stenting technique, in which the flow in MB and SB was not interfered by the protrudent stent structures.

4 Conclusions

In this study, the hemodynamic characteristics in the coronary bifurcation with three different dual stent implantation techniques were investigated and compared. The results showed that the small protrusion and overlapping of stent structure would greatly affect the local hemodynamic features, and the adoption of OPT technique would result in improved the overall WSS and most likely decreased the risk of post-operative restenosis.

References

Steigen, T. K. (2006): Randomized study on simple versus complex stenting of coronary artery bifurcation lesions: the Nordic bifurcation study. *Circulation*, vol. 114, no. 18, pp. 1955-1961.

Tu, S. (2017): Visualizing polymeric bioresorbable scaffolds with three-dimensional image reconstruction using contrast-enhanced micro-computed tomography. *International Journal of Cardiovascular Imaging*, vol. 33, no. 5, pp. 731-737.