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COMPUTATIONAL FLUID DYNAMIC APPROACH TO MIMIC CHANGES OF BLOOD HEMODYNAMIC IN PATIENTS WITH ACUTE TYPE IIIB AORTIC DISSECTION TREATED WITH TEVAR

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Introduction: We aimed to verify the accuracy of computational fluid dynamics (CFD) algorithm for blood flow reconstruction for type IIIb aortic dissection (TBAD) before and after thoracic endovascular aortic repair (TEVAR).

Methods: 3D models of the aorta with adjacent arteries were prepared using pre- and post-operative CT data from five patients treated for TBAD. The displacement forces acting on the aortic wall in the areas of endograft, mass flow rate/velocity and wall shear stress (WSS) was calculated with CFD technique. Results were verified with ultrasonography (USG) data.

Results: CFD results indicated that TEVAR procedure caused 7-fold improvement in overall blood flow through the aorta (p=0.0001). The accuracy of CFD calculations for pre-TEVAR vs. post-TEVAR were 90% and 96%, respectively. Results from CFD also indicated a significant increase in flow rate for thoracic trunk and renal arteries, which was in accordance with USG data (accuracy 90% and 99.9%). Additionally, a significant decrease in wall shear stress (WSS) values within the whole aorta after TEVAR compared to pre-TEVAR was showed (1.34±0.20 Pa vs. 3.80±0.59 Pa, respectively, p=0.0001). This decrease was provided by a significant reduction in WSS and WSS contours in the thoracic aorta and renal arteries.

Conclusions: CFD technique confirmed that post-operative remodeling of the aorta after TEVAR for TBAD improved hemodynamic patterns reflected by flow, velocity and WSS with accuracy of 99%.

Recent Publications

1. Polanczyk A, Podyma M, Trebinski L, Chrzastek J, Zbicinski I and Stefanczyk L (2016) A novel attempt to standardize results of CFD simulations basing on spatial configuration of aortic stent-grafts. PLoS One 11:e0153332.
2. Polanczyk A, Podyma M, Stefanczyk L, Szubert W and Zbicinski I (2015) A 3D model of thrombus formation in a stent-graft after implantation in the abdominal aorta. J Biomech. 48:425-431.
3. Duvernois V, Marsden A L and Shadden S C (2013) Lagrangian analysis of hemodynamics data from FSI simulation. Int J Numer Method Biomed Eng. 29:445-461.
4. Cheng Z, Juli C, Wood N B, Gibbs R G and Xu X Y (2014) Predicting flow in aortic dissection: comparison of computational model with PC-MRI velocity measurements. Med Eng Phys. 36:1176-1184.5.
5. Yu S C, Liu W, Wong R H, Underwood M and Wang D (2016) The potential of computational fluid dynamics simulation on serial monitoring of hemodynamic change in type B aortic dissection. Cardiovasc Intervent Radiol. 39(8):1090-1098.

Biography

Andrzej Polanczyk is a Researcher and a Team Leader at the Lodz University of Technology (Poland). He earned a PhD in Medical Engineering in 2013. He participated in scientific grants in which he build the installation to simulate the blood flow through the abdominal section of the aorta. Recently he received a grant funded by the National Centre for Research and Development. His research areas comprise biomedical, chemical and environmental engineering.

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