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EFFECTS OF PARENT ARTERY SEGMENTATION AND ANEURISMAL-WALL ELASTICITY ON PATIENT-SPECIFIC HEMODYNAMIC SIMULATIONS*

CHEN Jia-liang, DING Guang-hong
Department of Mechanics and Engineering Science, Fudan University, Shanghai 200433, China,
E-mail: 051029010@fudan.edu.cn
YANG Xin-jian
Beijing Institute of Neurosurgery, Beijing 100050, China
LI Hai-yun
Department of Biomedical Engineering, Capital Medical University, Beijing 100050, China

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Abstract: It is well known that hemodynamics and wall tension play an important role in the formation, growth and rupture of aneurysms. In the present study, the authors investigated the influence of parent artery segmentation and aneurismal-wall elasticity on patient-specific hemodynamic simulations with two patient-specific cases of cerebral aneurysms. Realistic models of the aneurysms were constructed from 3-D angiography images and blood flow dynamics was studied under physiologically representative waveform of inflow. For each aneurysm three computational models were constructed: Model 1 with more extensive upstream parent artery with the rigid arterial and aneurismal wall, Model 2 with the partial upstream parent artery with the elastic arterial and aneurismal wall, Model 3 with more extensive upstream parent artery with the rigid wall for arterial wall far from the aneurysm and the elastic wall for arterial wall near the aneurysm. The results show that Model 1 could predict complex intra-aneurismal flow patterns and wall shear stress distribution in the aneurysm, but is unable to give aneurismal wall deformation and tension, Model 2 demonstrates aneurismal wall deformation and tension, but fails to properly model inflow pattern contributed by the upstream parent artery, resulting in local misunderstanding Wall Shear Stress (WSS) distribution, Model 3 can overcome limitations of the former two models, and give an overall and accurate analysis on intra-aneurismal flow patterns, wall shear stress distribution, aneurismal-wall deformation and tension. Therefore we suggest that the proper length of extensive upstream parent artery and aneurismal-wall elasticity should be considered carefully in establishing computational model to predict the intra-aneurismal hemodynamic and wall tension.

Key words: cerebral aneurysm, fluid-structure interaction, upstream parent artery, wall tension, hemodynamics

Introduction

Cerebral aneurysms are pathological dilatations of the cerebral artery wall, generally found in the anterior and posterior circulation region in the circle of Willis[1]. With the development of noninvasive cerebrovascular imaging diagnoses, more cerebral aneurysms have been identified because the incidence of these aneurysms in the general population is thought to be from two to five percent[2]. Fortunately, most aneurysms are small and an estimated 50% to 80 % of all aneurysms do not rupture through a life time, but some unruptured aneurysm may enlarge and grow, resulting in high rate of rupture[3]. Therefore determining accurate criteria for predicting aneurysm growth and rupture would be important for making better-informed decisions and avoiding unnecessary surgical operations. In this context, there are many numerical studies based on image-based Computational Fluid

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Biography: CHEN Jia-liang (1982-), Male, Ph. D.
Corresponding author: DING Guang-hong,
E-mail: ghding@fudan.edu.cn