Virtual Stent-Graft Deployment in Patient-Specific Abdominal Aortic Aneurysm

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ABSTRACT

Endovascular aneurysm repair (EVAR) is a widely used and well established technique to intervene before rupture of abdominal aortic aneurysms (AAA) occurs. However, EVAR can involve some unfavorable complications such as endoleaks or stent-graft (SG) migration. Such complications, resulting from the complex mechanical interaction of vascular tissue, SG and blood flow or incompatibility of SG design and AAA geometry, are difficult to predict. Finite element simulations can be a predictive tool for the selection, sizing and placement process of SGs depending on the patient-specific AAA geometry and hence reduce the risk of potential complications after EVAR [1].

In this contribution, we present a new virtual SG deployment methodology to reproduce the final state of the deployed SG after intervention. We aim to find the final SG position in a patient-specific AAA geometry and evaluate the mechanical state of AAA and SG, such as contact forces or wall stresses. Three different constituents of the aneurysmatic tissue are considered: diseased aneurysmatic wall, intraluminal thrombus and calcifications [4]. Furthermore, the anisotropic mechanical behavior [2] of the aortic wall in the proximal and distal fixation zones of the SG are taken into account. The simulation process consists of two main steps. In a first step the SG is crimped, bent and moved by a tailor-made morphing algorithm to position the SG inside the AAA. Afterwards, the SG is released inside the AAA where it unfolds and makes contact with the luminal surface of the patient-specific vascular model. We consider mortar based frictional contact [3] between a sophisticated, finite deformation AAA and a SG composed of a parameterized, product specific (Cook Zenith Flex®) graft shell and stent wire frame that can undergo finite deformations. The simulation results of three patient-specific cases are compared to the geometry of the deployed SG taken from postinterventional CT scans.

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