

IDENTIFICATION OF REGIONAL STIFFNESS DISTRIBUTION ACROSS ASCENDING THORACIC AORTIC ANEURYSMS USING CT IMAGES: AN INVERSE METHOD

Solmaz Farzaneh, Olfa Trabelsi, Stéphane Avril

Mines Saint-Étienne, CIS-EMSE, France

Solmaz.Farzaneh@emse.fr, Olfa.trabelsi@emse.fr, Avril@emse.fr

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Summary: Ascending thoracic aortic aneurysms (ATAAs) are abnormal bulge or ballooning of the aorta. ATAA without any symptoms may undergo dissection or rupture of the aneurysm and may end with instantaneous death. Type A dissection is often associated with an ATAA. The treatment of ATAA is a timely surgical repair by replacement of the bulged aortic segment with synthetic grafts. Elective surgical intervention of ATAA is recommended when its diameter is larger than 5.5 cm or when it is considered as a fast growing aneurysms (growth >1 cm per year) [1]. However, it is extensively proved that the risk of type A dissection cannot be predicted simply by measuring the ATAA diameter and there is an urgent need for more reliable risk factors. According to the results of the previous studies we know that there is a significant correlation between a rupture criterion based on the ultimate stretch of the ATAA and the local membrane stiffness of the aorta [2]. Therefore, reconstructing local variations of the membrane stiffness across the aorta seems very important. In this research, we propose a novel non–invasive inverse method to identify the patient–specific local membrane stiffness of aortic walls based on preoperative gated CT scans. Using these images, a structural mesh is generated across the aorta with a group of nodes attached to the same material points at different time steps throughout the cardiac cycle. Fourier series is used to analyze time variations of the position of each node, providing the reconstruction of the local strain distribution (fundamental term). Afterwards, obtained strains are related to tensions with the membrane stiffness, and writing the local equilibrium satisfied by the tensions, the local membrane stiffness is eventually obtained at every position. The methodology is applied onto the ascending and descending aorta of three patients. Interestingly, the regional distribution of identified stiffness properties appears heterogeneous across the ATAA, including hot spots in bulging regions. Averagely, the identified stiffness is also compared with the values obtained from other methodologies. The results support the possible non-invasive prediction of stretch-based rupture criteria in clinical practice using local stiffness reconstruction.