Modelling post EVAR vascular adaptations (G&R) and validation

Sathish Kumar Marimuthu, Prof Robert Geelkerken(UofTwente), Dr Robbie Brodie(Terumo Aortic Ltd, UK), Dr Craig Maclean(Terumo Aortic Ltd, UK), Dr Sean McGinty(Uni. o fGlasgow, UK), Prof Nicholas A Hill(Uni.of Glasgow, UK)
University of Glasgow, James Watt School of Engineering

Abstract:
All biological tissues and organs constantly remodel due to stress or changes in the homeostatic conditions. Following endovascular aortic repair, the aorta could grow and remodel over time to reduce the excessive stresses caused by the less compliant and oversized stent grafts (compared to the aorta). The most proximal rings of the Anaconda device (TerumoAortic, UK) are designed with high stiffness and diameter bigger than the aorta to obtain better fixation. These influence the increase in the diameter of the aorta and the reduction in the contact force between the stent graft and the aorta wall. Hence, it is necessary to understand and predict this adaption to minimise complications such as device migration and endoleaks.
This study aimed to understand the growth and remodelling (G&R) following stent graft implantation using a volumetric growth model with growth along the fibre direction. The framework was divided into pre and post-growth phases, and the aorta geometry was assumed to be a simple cylinder with only the medial layer. The modified GOH model was used to model the aortaâ€™s hyperelastic anisotropic behaviour. To validate the framework, finite element simulation results were compared with abdominal aortic aneurysm patient data acquired at pre-operative discharge stages. Then, the growth parameters were estimated using follow-up (up to 2 years) CT scan data. The dilation of the two proximal rings was captured, which closely matches the CT scan data, and the results from this study clearly show the reduction in aorta wall stresses due to vascular adaptation. Also, the peak maximum principal stresses on the Nitinol stent struts were reduced.
This framework could be expanded to using full patient-specific aorta geometries obtained by segmenting the CT scan to design efficient patient-specific stent grafts with reduced unfavourable arterial remodelling and other post-surgery complications.