Analysis of the mechanical response of an aneurysmatic ascending aorta

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ABSTRACT

This work presents experiments, modelling and simulation aimed at describing the mechanical behaviour of a human ascending aorta with aneurysmal dilation subjected to in-vivo conditions with pressure levels within the normal and hypertension physiological ranges. To this end, an experimental procedure considering pathological samples corresponding to Marfan patients was firstly performed. The pathological tissues were obtained from patients undergoing ascending aorta surgery with or without aortic valve replacement at the Hospital Puerta de Hierro of Madrid. According to the protocol approved by the Hospital Ethics Committee, informed consent from the patients was obtained before the procedure. All the in-vitro mechanical tests described in this work have been performed in the same day using samples obtained immediately after their excision.

Tensile tests were performed to characterize the passive mechanical behaviour of the aneurysmatic aortic wall. The tests were carried out with the specimens permanently submerged in physiological serum at a temperature of 37 ±0.5 ºC. Axial load and axial jaws displacement were recorded during the whole test. From these data, the stress-stretch curve was obtained. These tensile test measurements were used to calibrate the material parameters of the Demiray constitutive model [1]. This model was chosen on the basis that it was found to properly capture the material response in pathological arteries with aneurysms.

Ring opening tests were also carried out on the same pathological tissue. The resulting opening angle was used to estimate, via the previously characterized Demiray model, the residual stresses present in the aorta.

Finally, the material parameters and the residual stresses obtained from the tests described before are assessed in the modelling of the mechanical response of the aneurysmatic ascending aorta under physiological conditions. In-vivo measurements on healthy patients during their cardiac cycle reported in [2] are adopted here in order to define appropriate boundary conditions. Numerical results and experimental measurements of the distensibility and incremental modulus are compared and discussed.

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