BIO
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MECHANICS AND DYNAMICS OF HUMAN DESCENDING AORTA AND WOVEN DACRON AORTIC GRAFTS: MODELS AND EXPERIMENTS
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ABSTRACT
An innovative biomechanical model of the human aorta as an anisotropic hyperelastic and viscoelastic multilayer structure with residual stresses is presented. The aorta is modelled as an incompressible shell with three layers (tunica intima, media and adventitia) by using an advanced nonlinear shell theory retaining thickness deformation, which is necessary since the aorta undergoes large deformations. The numerical model is suitable to investigate the dynamic response of the human aorta and Dacron aorta grafts, to compare their dynamics and assess potential problems of the aorta replacement. Dynamics of human aorta and aortic grafts have not been previously investigated at all. The problem is challenging since it involves fluid-structure interaction in presence of large strains of the wall and highly nonlinear material properties. The study deeply involves hyperelasticity and viscoelasticity, together with an accurate modelling of the residual stresses locked in the human aorta. The models are validated against experimental results on human aortas and commercial Dacron prostheses tested in a specifically designed mock circulatory loop that simulates pressure and velocity pulsations in the physiological regime. The viscoelastic material properties of commercial Dacron aortic grafts and human aorta (layer by layer) have never been investigated in the literature. For this reason, the modelling activity has been preceded by a deep experimental investigation of the hyperelastic and viscoelastic material properties of Dacron grafts and human aortas. Healthy aortas have been retrieved under an agreement with Transplant Québec that supplies aortas of transplant quality through its program. The experimental activity has made use of the most advanced experimental techniques with four laser Doppler vibrometers as sensors. A mock circulatory loop has been developed for testing human aortas and woven Dacron aortic prostheses. Experimental and numerical results will be presented.