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Presentation Abstract

Session:	17-7-New frontiers in 1-D cardiovascular modeling
Presentation:	**A 1-D Model of Murine Hemodynamics**
Location:	300
Presentation Time:	Thursday, Jul 10, 2014, 3:24 PM - 3:42 PM
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Abstract: Many cardiovascular diseases, such as aneurysms and atherosclerotic plaques, are predominantly studied at a pre-clinical stage using dedicated mouse models. This requires a cautious translation of murine data to human systems, but the striking similarities of (amongst others) aortic flow waveforms and arterial pulse wave velocity between humans and mice, as well as the resemblance of the human and murine cardiovascular anatomy, have long been ascertained in literature. However, (non-)invasive measurements in the murine cardiovascular system are difficult to obtain, limited to a restricted number of aortic locations, and need to be justified from an ethical perspective. In this work, a one-dimensional human model of the systemic circulation previously developed by Reymond et al. [1] has been adapted to mice. Murine arterial tree dimensions have been acquired and averaged from the segmentation of Micro-Computed Tomography (μ-CT) scans of 5 wild-type C57Bl/6 mice (12-15 weeks old). The resulting model consists of 73 arterial segments, including all major aortic branches as well as the tail and the cerebral tree. Apart from the aortic geometry, all input to the model has been obtained from a wide range of literature data. An empirical relationship has been fitted between local pulse wave velocity and local arterial diameter and subsequently used to estimate the local arterial wall distensibility in all segments. Peripheral vessels are terminated with three-element windkessel models to account for the resistance and compliance of the distal vasculature. A nonlinear viscoelastic constitutive law is implemented for the arterial wall. The arterial tree is coupled to a model of the left ventricle based on a varying elastance model. The rheological properties of blood flowing in microvessels, including the Fahraeus-Lindqvist effect, have been taken into account. Finally the integrated form of the momentum and continuity equations is solved numerically to yield pressures and flows throughout the arterial network. The resulting model predictions have then been validated against in vivo measurements performed on the same set of animals that were used to determine the aortic geometry. The model predicts pressure and velocity waveforms in good qualitative and semi-quantitative agreement with invasive pressure measurements as well as high-frequency ultrasound Pulsed-Wave Doppler aortic velocity and M-mode aortic distensibility measurements. In conclusion, a well-tuned and appropriately validated 1-D model for the murine cardiovascular system has been developed, which is ready to serve as a versatile study tool in the field of pre-clinical cardiovascular research.