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A probability measure for aortic vessel wall overload based on fluid-structure interaction simulations

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For aneurysms of the aorta, the conditions for the dilation of the vessel and for an increased risk of rupture are an ongoing subject of research. Numerical simulations can be used as a tool to assess aneurysm growth from a biomechanical point of view [1]. For example the stress load within the vessel wall can be a factor for aneurysm development. However, the stress load is not measurable in a direct way and the modelling of aortic vessel wall and blood flow dynamics leads to complex fluid-structure interaction (FSI) problems. Additionally, the model parameters can be highly uncertain for a specific patient.

We present a numerical framework to compute the probability that a threshold for the stress load within a vessel wall is exceeded. It is based on an FSI model of a blood vessel. The model is configured in a patient-specific way by 4D flow magnetic resonance imaging (MRI). The propagation of uncertainties relies on a stochastical collocation method [3]. Each collocation point is given by a finite element simulation using HiFlow^3 [2].

As a result, the probability that a critical threshold of the stress load in the aortic vessel wall is exceeded can be visualised over the vessel wall geometry. The presented work shows the feasibility of the proposed approach, which opens new perspectives for clinical studies.

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