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TOWARDS INDIRECT IN VIVO MEASUREMENT OF MATERIAL PROPERTIES OF AORTIC ANEURYSMS - DETERMINING THE DISPLACEMENT FIELD

Róbert Nagy[1], Csaba Csobay-Novák[2], Attila Lovas[3], Péter Sótonyi[4] and Imre Bojtár[1]

[1] Department of Structural Mechanics, Faculty of Civil Engineering, Budapest University of Technology and Economics, Budapest, Hungary, robert.nagy@mail.bme.hu
[2] Heart Center, Faculty of Medicine, Semmelweis University, Budapest, Hungary
[3] Department of Geometry, Faculty of Natural Sciences, Budapest University of Technology and Economics, Hungary
[4] Department of Vascular Surgery, Faculty of Medicine, Semmelweis University, Budapest, Hungary

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MOTIVATION

In clinical practice, the decision on the management of aortic aneurysms is predominantly based on the diameter of the enlarged lumen [1] and its rate of expansion. Although a good correlation is observed between these factors and the probability of rupture [2], there is no exact causality between them. The possible rupture of untreated small aneurysms [3] raised the demand towards an improved decision strategy based on the stresses in the wall calculated by patient specific numerical modelling. One of the greatest disadvantages of these methods is the lack of individual calibration of the material parameters of the wall.

PURPOSE

We introduce a novel method to measure the material parameters in vivo, thus, not only justifying the eligibility of the wall stresses, but also amending the analysis of the aneurysm by assessing the state of the material in the degradation process.

METHOD

Using ECG-gated CTA images it becomes possible to follow the shape of the arterial wall through a complete cardiac cycle. The displacement of each material point is then approximated based on numerical modelling observations. Simulation of the blood flow, supported by the measurement of the blood pressure, provides the load field acting on

the wall. The material model, connecting the known displacement and load fields, is established based on the wall microstructure [4] and on biaxial macroscopic measurements. Finally, after developing a finite element model, without inverting the stiffness matrix, the material model parameters are calibrated locally by minimizing the nodal force error.

RESULTS

As a result, a more profound, computer aided decision strategy is developed, and a software is provided, with which the practicing clinician can quickly make thorough decisions relying on real, patient specific, local material parameters describing the state of degradation and validating the calculated stresses.

OUTLOOK

The method enables us to adjust the existing material models to better describe the in vivo behaviour of the vessel wall and to understand the pathogenetic process itself. Although, it still involves several open problems to elaborate, such as the most appropriate measure of the degraded state, or the rupture criteria – for which our in vitro measurements are still in process – or the behaviour of the surrounding tissues and constraints.

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