Proteolytical degradation of the aortal elastin and collagen determines aneurysm disease, and to date no proven therapeutic strategies are available, either to limit aneurysm growth or to prevent them from rupture. Hence, evaluating rupture risk is critically important in reducing aneurysm-related mortality without unnecessarily increasing the rate of elective repair. Clinical methods are somehow limited, and according to the current practice, rupture risk is (mainly) estimated from the aneurysm's maximum diameter and/or expansion rate; an approach motivated from statistics but known to fail often in individuals.

In contrast, recent research has demonstrated that patient-specific biomechanical simulations can provide more precise rupture parameter estimates than non-invasive treatment planning and follow-up. In fact, improvements in computer simulation and scientific computing.

**Methods**

A structural analysis of the aneurysm relies on detailed numerical (anatomical) models and their generation currently involves a number of different software products. A new analysis is time consuming and requires expert knowledge from different disciplines. In contrast, A4clinics facilitates fast processing by integrating the latest concepts of medical image processing, vascular biomechanics and scientific computing.

**Image reconstruction**

Specially developed active contour ( deformable) models support an artifice-insensitive segmentation of image data, which is a fundamental requirement to provide computational grids for a meaningful biomechanical analysis (Fig. 1). Based on the derived segmentation data a novel mesh generation algorithm splits the aneurysm tissue, i.e. wall and thrombus into a finite number of hexahedral-dominated volumes (finite) elements, which supports an accurate structural analysis while limiting the computational effort.

**Finite Element Model**

Finally, the model (discretized) aneurysm is enriched by patient-specific information to render a Finite Element problem and hence, facilitating a structural analysis by providing detailed information about biomechanical field variables like stress and strain (Fig. 2). In details, mean arterial pressure is prescribed and constitutive models for aneurysm wall and thrombus are used as proposed in the literature. Likewise, the patient's age, gender and family history are used to estimate spatially varying wall strength, again according to results from in-vivo experiments reported in the literature. Hence, the applied assumptions enrich known biomechanical aneurysms models in several aspects and more reliable conclusions are expected.

**Validation**

In cooperation with the Department of Vascular Surgery at Karolinska Institute, Sweden, the proposed software tool was used to investigate the reliability of the biomechanical rupture risk hypothesis by comparing ruptured (n=10) and diameter-matched non-ruptured (n=10) aneurysms. The study revealed that peak wall stress and peak wall rupture risk (stress related to strength) were respectively 1.18 times (p=0.091) and 1.73 times (p=0.022) higher in ruptured than non-ruptured aneurysms. Most interestingly, all non-ruptured aneurysms exhibited a peak wall rupture risk below 1.0, tough to be the theoretical limit of rupture. Peak wall rupture risks of seven ruptured aneurysms were clearly elevated with respect to the non-ruptured group, whereas in three formations this was not the case. Assuming intact thrombus of these aneurysms could not explain aneurysm rupture and by relaxing that, i.e. considering thrombus perforation, (as partly indicated by the image data) final rupture could be predicted.

**Conclusions**

A novel procedure to develop structural Finite Element models of aortic aneurysms was implemented in A4clinics; a stand-alone software tool to be operated without engineering skills. The computer programme is highly automated and facilitates the extraction of various geometrical and biomechanical determinants from routinely taken clinical data. The software is entirely feasible for analysis of realistic patient-specific models on standard personal computers, and hence can be easily be integrated into routine clinical dataflow. First validation studies underlines the device's suitability to estimate the rupture risk of abdominal aortic aneurysms and to enhance current diagnostic methods; it might be a promising enrichment in aneurysm screening programmes, (potentially) capable of identifying rupture-prone aneurysms. Likewise, the software facilitates in-depth investigation of aneurysm biomechanics and might provide useful data from a purely scientific perspective to enrich today's knowledge of aneurysm pathology.

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1. The Finite Element Method is a widely applied numerical concept to solve problems in engineering and applied sciences.