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### **Development of an in silico-model to investigate the dynamic loads of a transcatheter aortic valve**

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Aortic stenosis, with a prevalence of 2–5% in the over 65 year old patients and 5-10% in patients over 80 is the third most common cardiovascular disease. According to the German *Herzbericht*, in 2015, more than 15,500 catheter-supported aortic valve implantations reach a new high. This can be attributed to the expansion of the indication profile to patients with medium to low risk. As a result of relatively long use evaluation of the dynamic loading, such that on the seam between the valve ring and leaflet is increasingly important.

Using reverse engineering a 3-D model of transcatheter valve was modelled. To improve reproducibility a simplified model of the aorta was generated. The in silico model combined both models using the bi-directional fluid structure interaction method. In terms for physiological inlet limits, a hyperelastic constitutive formulation for bovine pericardial valve leaflet was used. The seam between the leaflet and valve frame was realized by a contact junction condition. Both solvers from ANSYS® (Fluent®, Mechanical®) were used for the computation.

There are significant differences valve leaflet distortion and the forces generated in the leaflet-frame interface that depended on the structure of the leaflet and its fastening. In addition, the more realistic, asymmetric valve leaflet led to a disparate distribution of forces. Within every cardiac cycle there is at least one load change during the opening process, which is the main reason for weakening of or damage to the leaflet. Flutter in the leaflet or single rupture of the leaflet results in increased frequency of load changes within a single cardiac cycle and subsequently greater damage.

The results were validated by comparison with other work using FE-simulation and tensile studies. Tensile testing showed the maximum load to significantly higher. For a more precise prediction of functional life further simulations, computations and experiments are required.

All in all, it can be concluded that simulations offer a useful insight into the dynamic load experienced by transcatheter aortic valves and the factors that influence functional life.

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### Heart rhythm model and simulation of electrophysiological studies and high-frequency ablations

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**Background:** Target of the study was to create an accurate anatomic CAD heart rhythm model, and to show its usefulness for cardiac electrophysiological studies and high-frequency ablations. The method is more careful for the patients' health and has the potential to replace clinical studies due to its high efficiency regarding time and costs

**Methods:** All natural heart components of the new HRM were based on MRI records, which guaranteed electronic functionality. The software CST was used for the construction, while CST's material library assured genuine tissue properties. It should be applicable to simulate different heart rhythm diseases as well as various diffusions of electromagnetic fields, caused by electrophysiological conduction, inside the heart tissue.

**Results:** It was achievable to simulate sinus rhythm and fourteen different heart rhythm disturbance with different atrial and ventricular conduction delays. The simulated biological excitation of healthy and sick HRM were plotted by simulated electrodes of four polar right atrial catheter, six polar His bundle catheter, ten polar coronary sinus catheter, four polar ablation catheter and eight polar transesophageal left cardiac catheter. Accordingly, six variables were rebuilt and inserted into the anatomic HRM in order to establish heart catheters for ECG monitoring and HF ablation. The HF ablation catheters made it possible to simulate various types of heart rhythm disturbance ablations with different HF ablation catheters and also showed a functional visualisation of tissue heating. The use of tetrahedral meshing HRM made it attainable to store the results faster accompanied by a higher degree of space saving. The smart meshing function reduced unnecessary high resolutions for coarse structures.

**Conclusions:** The new HRM for EPS simulation may be additional useful for simulation of heart rhythm disturbance, cardiac pacing, HF ablation and for locating and identification of complex fractionated signals within the atrium during atrial fibrillation HF ablation.

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### **Diffusion simulation of low molecular MRI contrast agents in micronecrotic tumor tissue for DCE-MRI**

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Pharmacokinetic compartment models are used to estimate physiological tissue parameters in the evaluation of dynamic contrast-enhanced magnetic resonance imaging. The typically used low-molecular-weight contrast agents (LMCA) extravasate from the capillaries and distribute in the interstitial space by diffusion. The fractional interstitial volume is increased in micronecrotic and necrotictumor tissue. Tumor vessels can only supply oxygen to the tissue over a limited radius, leading to necrotic tissue outside the radius. Therefore, the interstitial volume may vary within a tumor. Compartment models assume homogeneous tracer distribution within each compartment, neglecting diffusion effects. The present study investigates three compartment models in terms of how accurately they estimate the interstitial volume in inhomogeneous micronecrotic tumor tissue.

To model extravasation and diffusion of LMCA in the interstitial space of a heterogeneous tissue, iterative simulation was performed using macroscopic tissue discretization. The assessment of increased interstitial volume by the compartment models was determined by fitting the models to the simulated concentration-time curves. The extended Tofts model, a parallel 3-compartment model, and a sequential 3-compartment model were investigated.

For mean vessel distances of 100 and 150  $\mu\text{m}$ , interstitial volume is overestimated by 6.9% and 10.0% using the extended Tofts model and by 8.6% and 15.5% using the parallel 3-compartment model. Conversely, the sequential 3-compartment model overestimates interstitial volume by 0.2% (100  $\mu\text{m}$ ) and underestimates it by 18.8% (150  $\mu\text{m}$ ). Overall, our results suggest that the interstitial volumes predicted by the sequential model deviate least from the interstitial volumes predefined in the simulation compared with the Tofts model and parallel model.