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Validation of a Synthetic Cohort of Aortic Stenosis Patients

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1. Introduction

Image-based modelling for diagnosis and treatment planning for aortic stenosis became increasingly relevant in cardiovascular research. In theory, the method allows non-invasive calculation of diagnostic parameters. Furthermore, prediction of hemodynamic outcome after different treatment strategies is feasible. This approach might help to identify optimal treatment strategies for a patient as well as support development of novel implantable devices.

A relevant problem for translation into clinical or industrial application is the lack of available data sets due to data privacy regulations. A promising approach to mitigate this problem is the generation of synthetic data. This type of data can be shared freely, supporting reproducibility studies and comparison of different in-silico approaches.

However, synthetic data must be validated by demonstrating, that the data matches the cohort it is intended to mimic. In this study, we generated synthetic data of aortic stenosis patients. The data set includes general demographics, functional parameters, and geometries of the aorta and the aortic valve. Peak-systolic hemodynamics of the real patients as well as the synthetic data set was calculated and compared against each other.

2. Materials and Methods

A sample of 101 patients with moderate to severe aortic stenosis was investigated in this study. Using computed tomography image data, the anatomy of the aortic root and ascending aorta was reconstructed. Different geometric parameters as for example AVA, the diameters of the aortic annulus and the sinotubular junction were evaluated.

Using copulas [1], multivariate joint distributions for several demographic, functional and anatomic parameters were identified. Then, a randomized sample of synthetic patients mimicking these distributions was generated. Using a parameterized model, synthetic geometries matching the randomized parameters were generated.

Using computational fluid dynamics, the peak-systolic hemodynamics were calculated. Different parameters as for example pressure gradients, the peak-systolic velocity, and the wall shear stresses in the ascending aorta were calculated for the real and synthetic patients. Agreement between real and synthetic data will be evaluated using descriptive statistics, equivalency tests, and visual inspection of generated surface geometries.

3. Results

Deviations between the randomized parameter values and the synthetic surface geometries were observed. Generated surface geometries matched the parameter distributions of the real patient data. Surface geometries were considered to be plausible by experts. Evaluation of the peak-systolic hemodynamics is still ongoing. If final validation of the synthetic cohorts is successful, the generated data set will be made available.

4. References

1. *Nelsen RB. An Introduction to Copulas. Springer, New York (1999)*

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