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VALIDATION OF A NUMERICAL APPROACH TO SIMULATE COLOR DOPPLER IMAGING OF MITRAL REGURGITATION JETS

Simon J. Sonntag[1]; Wei Li[2]; Michael Becker[3]; Wiebke Kaestner[3]; Martin R. Büsen[1]; Nikolaus Marx[3]; Dorit Merhof[2] and Ulrich Steinseifer[1]

[1] Department of Cardiovascular Engineering, Institute of Applied Medical Engineering, RWTH Aachen University and University Hospital Aachen, Pauwelsstr. 20, 52074 Aachen, Germany, sonntag@hia.rwth-aachen.de, buesen@hia.rwth-aachen.de, steinseifer@hia.rwth-aachen.de

[2] Institute of Imaging & Computer Vision, RWTH Aachen University, Sommerfeldstraße 24, 52074 Aachen, wei.li@lfb.rwth-aachen.de, dorit.merhof@lfb.rwth-aachen.de

[3] Department for Cardiology, Pneumology, Angiology and internistic Intensive-care Medicine, University Hospital Aachen, Pauwelsstr. 30, 52074 Aachen, Becker, mibecker@ukaachen.de, wkaestner@ukaachen.de, nmarx@ukaachen.de

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Objectives

Mitral regurgitation (MR) is one of the most frequent valvular heart diseases. To assess MR severity, color Doppler imaging (CDI) is the clinical standard. However, inadequate reliability, poor reproducibility and heavy user-dependency are known weaknesses. A novel approach combining computational and experimental methods is currently under development aiming to improve MR severity quantification.

Methods & Materials

A custom flow chamber for a circulatory flow loop was developed. Three different pinhole diaphragms (circular, rectangular, cross-shaped) were used to mimic variations of MR. The flow field was recorded simultaneously by a 2D ultrasound transducer and Particle Image Velocimetry (PIV).

Large-Eddy simulations were conducted using the same geometry and boundary conditions. The resulting computed velocity field was subsequently used to simulate synthetic Doppler signals. The specified transducer position and characteristics corresponded to the experiments. A graphical user interface enables visualization of virtual color Doppler images as well as configuration of all imaging and measurement parameters.

Results

The numerical CDI simulation exhibits the same characteristics (jet, vena contracta, PISA) as the recorded color Doppler images. Based on the experimental results, the computational algorithms could be further refined. After validation, all different flow visualization modalities will be correlated to give a better understanding of the technical backround of CDI and the complex haemodynamics.

Conclusions

The feasibility of the proposed combination of experimental and computational methods for the investigation of MR is shown and the numerical methods are successfully validated against the experiments. The proposed combination of experimental and computational methods can be used to confirm and refine existing echocardiographic approaches to assess MR severity. The results also support the development of new imaging tools. Furthermore, this approach can be used in the future as a learning platform for medical practitioners and to assist surgical mitral valve repair.