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Characterization of cardiac flow in heart disease patients by computational fluid dynamics and 4D flow MRI[1] JONAS LANTZ, VIKAS GUPTA, LILIAN HENRIKSSON, MATTS KARLSSON, ANDER PERSSON, CARLJOHAN CARHALL, TINO EBBERS, Linkoping University — In this study, cardiac blood flow was simulated using Computational Fluid Dynamics and compared to in vivo flow measurements by 4D Flow MRI. In total, nine patients with various heart diseases were studied. Geometry and heart wall motion for the simulations were obtained from clinical CT measurements, with 0.3x0.3x0.3 mm spatial resolution and 20 time frames covering one heartbeat. The CFD simulations included pulmonary veins, left atrium and ventricle, mitral and aortic valve, and ascending aorta. Mesh sizes were on the order of 6-16 million cells, depending on the size of the heart, in order to resolve both papillary muscles and trabeculae. The computed flow field agreed visually very well with 4D Flow MRI, with characteristic vortices and flow structures seen in both techniques. Regression analysis showed that peak flow rate as well as stroke volume had an excellent agreement for the two techniques. We demonstrated the feasibility, and more importantly, fidelity of cardiac flow simulations by comparing CFD results to in vivo measurements. Both qualitative and quantitative results agreed well with the 4D Flow MRI measurements. Also, the developed simulation methodology enables what if scenarios, such as optimization of valve replacement and other surgical procedures.

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