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An image-based modeling approach for patient-specific blood flow simulations of aortic dissection.

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Introduction and objectives

Aortic dissection (AD) is a vascular condition with high morbidity and mortality rates. Computational fluid dynamics (CFD) can provide detailed information on the complex intra-aortic hemodynamics and thus assist the clinical decision-making. However, oversimplified modelling assumptions and high computational cost compromise the accuracy of the simulations and impede clinical translation. To overcome these limitations, we present a novel patient-specific CFD approach coupled to Windkessel boundary conditions and accounting for wall compliance. The method is used to study a patient with a chronic type-B AD. Simulation results are compared against patient-specific clinical data from different modalities.

Methods

The 3D geometry of the dissected aorta was extracted from CT-scans using ScanIP (Synopsys, USA). Lumen cross-sectional area variation and flow-waves were obtained at several aortic sections from cine 2D-MRI and PC-MRI, and used to inform the model. The 3D aorta was coupled to 0D Windkessel models at the outlet branches to account for peripheral circulation. A new and efficient moving-boundary technique was employed to model the compliance of the aorta. The CFD model was implemented in CFX (ANSYS, USA).

Results

Comparisons between *in silico* and *in vivo* data showed that the proposed approach successfully captures flow and pressure waves for the patient-specific AD and can predict the pressure in the false lumen (FL). Results showed regions of low and oscillatory wall shear stress which, together with higher diastolic pressures predicted in the FL, may indicate risk of expansion.

Conclusion

This study demonstrates a relatively simple and computationally efficient approach (compared to traditional fluid-structure interaction methods requiring more than 50% of the simulation time) to account for arterial deformation in a 3D CFD model of AD, representing a step forward in the use of CFD as potential tool for AD management and clinical support.