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Computational analysis of aortic haemodynamics in the presence of ascending aortic aneurysm

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ABSTRACT

BACKGROUND: The usefulness of numerical modelling of a patient's cardiovascular system is growing in clinical treatment. Understanding blood flow mechanics can be crucial in identifying connections between haemodynamic factors and aortic wall pathologies.

OBJECTIVE: This work investigates the haemodynamic parameters of an ascending aortic aneurysm in humans.

METHODS: Two aortic models (aorta with aneurysm and healthy aorta) were constructed from medical images using the SimVascular software. Finite element method (FEM) blood flow modelling of one cardiac cycle was performed at different vascular wall parameters.

RESULTS: Graphic presentations were formulated, showing the distributions of blood flow velocities, pressure, wall displacements and wall shear stresses (WSS). The results showed that the highest blood velocity was 1.18 m/s in the aorta with the aneurysm and 1.9 m/s in the healthy aorta model. The largest displacements ware in the aorta with the aneurysm (0.73 mm). In the aorta with an aneurysm, time-averaged WSS values throughout the artery range from 0 Pa to 1 Pa. In the healthy aorta, the distribution of WSS values changes from 0.3 Pa to 0.6 Pa.

CONCLUSIONS: In the case of an ascending aortic aneurysm, the maximum blood velocity was found to be 1.6 times lower than in a healthy aorta. The aneurysm-based model was characterised by large changes in wall shear stresses and wall displacement, while the oscillatory shear index decreased compared to healthy aortic results.

KEYWORDS: ascending aortic aneurysm, blood flow, computational fluid dynamics (CFD), finite element method (FEM), SimVascular.