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Blood flow and vessel mechanics in a physiologically realistic model of a human carotid arterial bifurcation

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Abstract

The pulsatile flow in an anatomically realistic compliant human carotid bifurcation was simulated numerically. Pressure and mass flow waveforms in the carotid arteries were obtained from an individual subject using non-invasive techniques. The geometry of the computational model was reconstructed from magnetic resonance angiograms. Maps of time-average wall shear stress, contours of velocity in the flow field as well as wall movement and tensile stress on the arterial wall are all presented. Inconsistent with previous findings from idealised geometry models, flow in the carotid sinus is dominated by a strong helical flow accompanied by a single secondary vortex motion. This type of flow is induced primarily by the asymmetry and curvature of the in vivo geometry. Flow simulations have been carried out under the rigid wall assumption and for the compliant wall, respectively. Comparison of the results demonstrates the quantitative influence of the vessel wall motion. Generally there is a reduction in the magnitude of wall shear stress, with its degree depending on location and phase of the cardiac cycle. The region of slow or reversed flow was greater, in both spatial and temporal terms in the compliant model, but the global characteristics of the flow and stress patterns remain unchanged. The analysis of mechanical stresses on the vessel surface shows a complicated stress field. Stress concentration occurs at both the anterior and posterior aspects of the proximal internal bulb. These are also regions of low wall shear stress. The comparison of computed and measured wall movement generally shows good agreement.

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Keywords

Carotid bifurcation; Coupled fluid/solid model; In vivo data

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