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Experimental and numerical methodology to analyze flows in a coronary bifurcation

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Abstract

Atherosclerosis is frequently associated to disturbed flow patterns in regions of the arteries with geometrical complexity. To understand atherosclerosis development, the hydrodynamic characteristics of the blood flow in arteries, such as the velocity and wall shear stress, must be studied and quantified. To investigate the local hemodynamics in the Left Coronary Artery (LCA) bifurcation, a methodology combining numerical (CFD) and experimental methods (μPIV and streak photography) was designed. A whole volume μPIV experimental method was developed and applied to a simplified 3D phantom of the LCA bifurcation. The experimental and numerical results prove to be in a good agreement. Implications of a deviation from Murray's law and the effect of different Reynolds numbers in flow behaviour were also explored. A streak line photography method was used to complement the methodology and analyse the flow patterns. When the deviation from Murray's law is evident, secondary flows are observed and they intensify as the Reynolds number increases. The secondary flows are visible in regions of low wall shear stresses (WSS). The present work reinforces, with numerical and experimental support, the importance of flow patterns that are relevant for prevention and treatment of atherosclerosis.

Keywords: left coronary artery; computational fluid dynamics; hemodynamics; in vitro studies; helical flow; atherosclerosis