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COMPUTATIONAL MODEL OF THE FLUID DYNAMICS IN ABDOMINAL AORTA AND RENAL BRANCHES

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ABSTRACT

Because heart pumps blood in a cyclic way, blood flow in arteries can be firstly characterized for its unsteady and variable nature. Blood flow is normally laminar but its pulsatile nature and the presence of branches and curves in the cardiovascular system result in a highly tridimensional flow. As a result, blood flow is characterized by asymmetries in velocity patterns, complicated secondary motions and flow separation. These hemodynamic characteristics have long been shown to play an important role in the pathogenesis of atherosclerosis. Actually, *in vitro*, *in vivo* and computational data supports the idea that associated with low wall shear stress is the accumulation of lipids in the arterial walls, frequently in branches and junctions (Ku, 1997).

The application of Computational Fluid Dynamics (CFD) methods has become an important strategy in the investigation of blood flow in arteries and the development of cardiovascular diseases. Distinct from experimental techniques, CFD methods have the ability to simulate velocity and pressure fields in virtual models of the cardiovascular system. Moreover, the computational data can be use to predict interventions, and improve treatment strategies (Taylor and Draney, 2004).

The purpose of the present work is to develop a three-dimensional computational model of the abdominal aorta and renal branches, able to characterize the unsteady flow patterns. The clinical interest in this location is related to its elevated predisposition to the development of atherosclerosis. This pathology usually occurs primarily along the posterior wall of the abdominal aorta downstream of the renal arteries and also in the renal arteries (Ku, 1997).

The geometrical domain was modeled based on previous literature. The results were obtained for a smooth and refined grid in order to detect significant changes in velocity gradients. Numerical simulations were carried out for a Newtonian and incompressible fluid, for which the viscosity assumed was 0.0035 *kg/m s* and the density 1056 kg/m^3. The inlet velocity was set as a pulse cycle according to a representative suprarenal blood flow waveform.

The axial velocity profiles, secondary motion and recirculation in abdominal aorta and renal branches were obtained and are shown in Figure 1. Results on the flow at renal branches proved the occurrence of flow separation since flow divides into two streams: maximum velocity at the distal wall of the bifurcations and slower moving fluid on the proximal wall. The occurrence of recirculation is coincident with low WSS. Results also showed that the flow in the abdominal aorta is greatly affected by the renal branches. These blood flow patterns may be related to the development of atherosclerosis plaque at this location.

Two different configurations on the inlet velocity boundary condition were studied, either a uniform velocity or a fully developed velocity profile. The effect of the inflow configuration is more noticeable in the beginning of the domain and tends to be minimized along the vessel. A closer analysis of the recirculation zone shows that the recirculation length is approximately the same for both cases. This suggests that the occurrence of this phenomenon is a direct consequence of the geometric configuration.

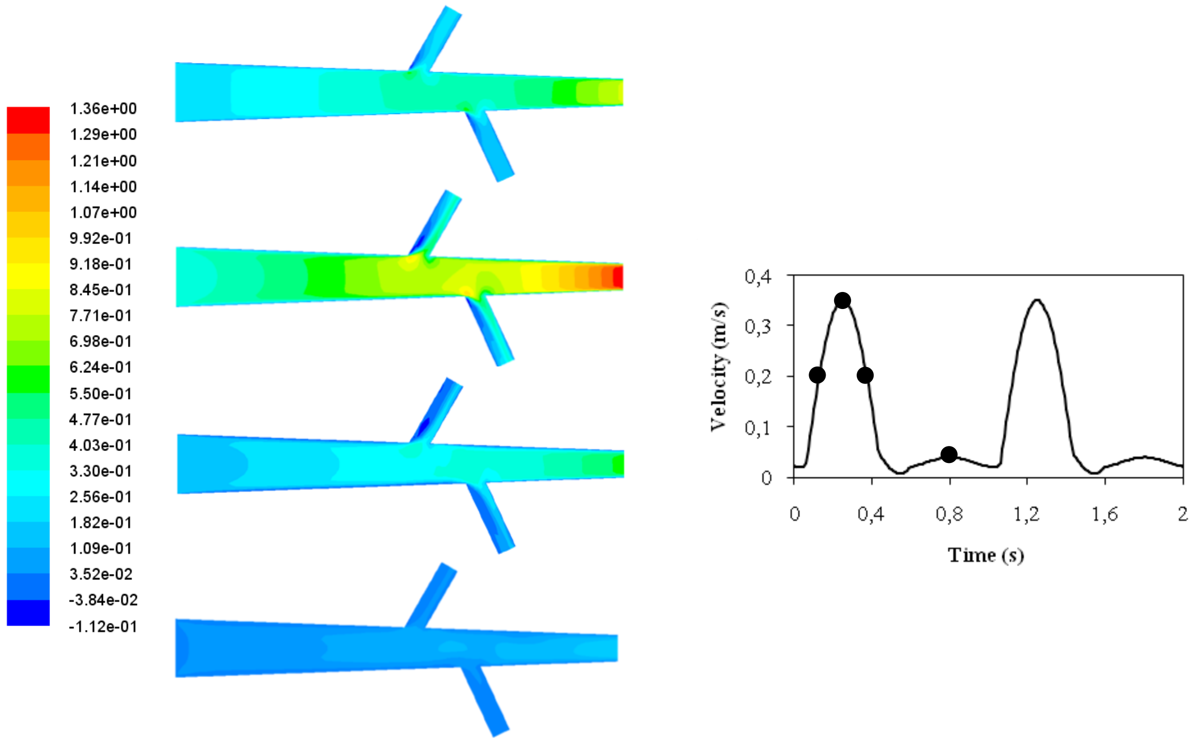

Figure 1 Axial flow velocity profiles at the mid-frontal plane at (from top to bottom) 0.13 s, 0.25 s, 0.4 s, 0.8 s.

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