# A 1000-tube model of human systemic arterial vasculature

N.Kizilova[a]

The first model of systemic arterial tree was based on the data of the large 55 arteries obtained by measurements on corpses[1]. The initial database has been later updated to the 87 arteries[2] and the geometrical parameters have been used for the computations of the pressure and flow profiles using the 1D nonlinear Euler model[3], 2D linearized axisymmetric model and some combinations of the 2D and 0D models[4]. In this paper a virtual model of human systemic arterial tree that includes the database on geometry of the systemic arterial vasculature, the software for numerical computations and visualization of the blood flow and pulse wave propagation, diagnostic analysis of the pulse wave parameters and planning the cardiovascular surgery and treatment is presented. The parameters of the systemic arteries have been measured during the post-mortem examination on five corpses[5]. The parameters of the intraorgan arterial beds have been measured on the plastic casts of the intraorgan and intramuscle vasculatures. The ultrasound measurements on five healthy volunteers have been carried out across and the geometric data as well as the flow curves have been obtained. Some organ-specific relationships between the diameters of the arteries in the bifurcations, the diameter of the parent artery and the length of the longest downstream arterial pathway and between the diameters and branching angles have been obtained by statistical analysis of the measured data. Basing on the regularities an algorithm for generation of the intraorgan vasculatures has been proposed and validated by a comparative study of the blood flow profiles in the real vasculatures and in their models. The 'minimal' 880-tube model composed of the systemic arteries found in all of the five datasets and a 'maximal' 1080-tube model containing all the systemic arteries found at least in one of the personal dataset have been built. The tubes have been terminated by the generated models of the corresponding intraorgan and muscle vasculatures.

The blood flow in the system has been modeled as a sum of the Windkessel and pulsatile components. Pulse wave propagation and reflection at the bifurcations have been considered as axisymmetric waves in the fluid filled thick wall viscoelastic tubes. The corresponding software has been elaborated. The results of the numerical computations of the pressure and flow wave evolution along aorta, simulations of the blood vessel occlusion, stenosis, aneurism and the flow in the collateral pathways as a model of arterial and venous grafts are reported. The model may be very helpful in the normal and pathological blood flow computations, surgery planning, tumor modeling, and estimation of treatment and rehabilitation procedures.

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[a]DptMech, Kharkov National University, Svobody sq., 4, 61077 Kharkov, Ukraine

[1] Westerhof, Bosman, DeVries and Noordegraaf, *J. Biomech.*, **2**,121 (1969).
[2] Segers, Stergiopulos, Verdonk and Verhoeven, *Med.&Biol. Eng.&Comput.*, **35**, 729 (1997).
[3] Olufsen, *Amer. J. Physiol.*, **276**, H257 (1999).
[4] Kumar, Quateroni, Formaggia and Lamponi, *Computing,* **71**, 321 (2003)
[5] Zenin, Kizilova and Philippova, *Biophysics*, **52**, 499 (2007).