Numerical solutions for blood flow in elastic vessels

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We consider the differential–algebraic system

$$\begin{cases} \dfrac{\partial q}{\partial t} + \dfrac{\partial}{\partial x}\left(\dfrac{q^2}{A}\right) + \dfrac{A}{\rho}\dfrac{\partial p}{\partial x} = -\dfrac{8\pi\mu}{\rho}\dfrac{q}{A}, \\ \dfrac{\partial q}{\partial x} + \dfrac{\partial A}{\partial t} = 0, \\ p = f(A_0, A), \end{cases} \tag{1}$$

where $A = A(t,x)$ is the area of the cross section with a prescribed initial value $A_0 = A_0(x)$, interpreted as a cross-sectional area of the vessel for the pressure p_0; $p = p(t,x)$ - the internal pressure over the cross section, ρ - the blood density and μ - the blood viscosity. By the operator splitting method we transform (1) into the system of four equations, introduce the bicharacteristics and perform the time-space non-uniform discretization, obtaining the new leap-frog scheme. Our results are illustrated with numerical experiments.

REFERENCE

[1] Olufsen, M. S., Peskin, C. S., Kim, W. Y., Pedersen, E. M., Nadim, A. and Larsen, J., Numerical simulation and experimental validation of blood flow in arteries with structured-tree outflow conditions. Ann Biomed Eng 28, 1281–1299 (2000).