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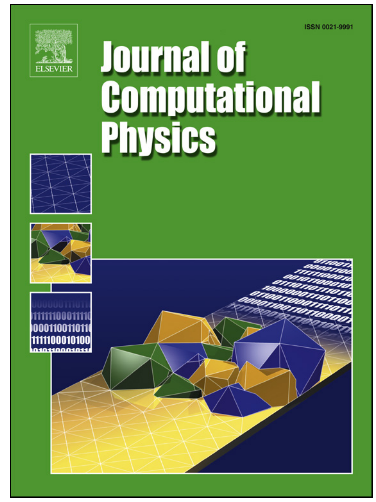

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A fast algorithm for the simulation of arterial pulse waves

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Abstract

One-dimensional models have been widely used in studies of the propagation of blood pulse waves in large arterial trees. Under a periodic driving of the heartbeat, traditional numerical methods, such as the Lax-Wendroff method, are employed to obtain asymptotic periodic solutions at large times. However, these methods are severely constrained by the CFL condition due to large pulse wave speed. In this work, we develop a new numerical algorithm to overcome this constraint. First, we reformulate the model system of pulse wave propagation using a set of Riemann variables and derive a new form of boundary conditions at the inlet, the outlets, and the bifurcation points of the arterial tree. The new form of the boundary conditions enables us to design a convergent iterative method to enforce the boundary conditions. Then, after exchanging the spatial and temporal coordinates of the model system, we apply the Lax-Wendroff method in the exchanged coordinate system, which turns the large pulse wave speed from a liability to a benefit, to solve the wave equation in each artery of the model arterial system. Our numerical studies show that our new algorithm is stable and can perform ∼15 times faster than the traditional implementation of the Lax-Wendroff method under the requirement that the relative numerical

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