Abstract: The development of flow instabilities due to high Reynolds number flow in artificial heart valve geometries inducing high strain rates and stresses often leads to hemolysis and related highly undesired effects. Geometric and functional optimization of artificial heart valves is therefore mandatory. In addition to experimental work in this field it is meanwhile possible to obtain increasing insight into flow dynamics by computer simulation of refined model problems. After giving an introductory overview we report the results of the simulation of three-dimensional transient physiological flows in fixed geometries similar to a CarboMedics bileaflet heart valve at different opening angles. The visualization of emerging complicated flow patterns gives detailed information about the transient history of the system's dynamical stability. Stress analysis indicates temporal shear stress peaks even far away from walls. The mathematical approach used is the Lattice Boltzmann method. We obtained reasonable results for velocity and shear stress fields. The code is implemented on parallel hardware in order to decrease computation time. Finally, we discuss problems, shortcomings and possible extensions of our approach.