The leaflets of the mitral valve determine the flow pattern in the ventricle

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Direct numerical simulations were conducted on an electrophysiology-driven parametric idealized left heart model to compare the effects of different mitral valve orientations on flow patterns. Ventricular movement was achieved by Electromechanical model[1]. High-fidelity direct numerical simulations within the left heart were achieved using a sharp-interface immersed boundary method. Simulation results demonstrate that mitral valve leaflet length determines end-diastolic intraventricular flow direction. The physiological structure, where the anterior leaflet is longer than the posterior leaflet, enhances pumping efficiency during systole. This finding provides valuable guidance for the design of optimized bioprosthetic and mechanical valves.

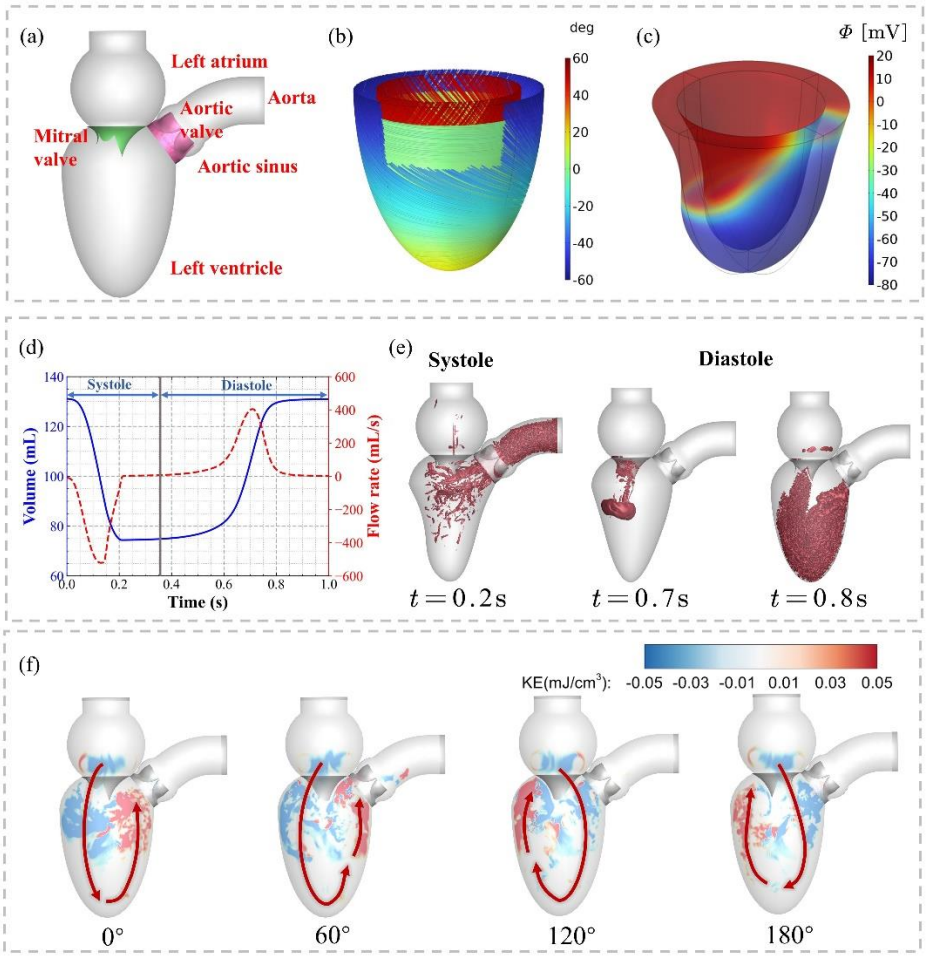

Figure 1: (a) Schematic diagram of the idealized left heart model. (b) Fiber orientation distribution in the ventricle. (c) Ventricular contraction under electrical stimulation. (d) Changes in ventricular volume and the resulting intracardiac flow rate variations. (e) Iso-surface of the Q-criterion during systole and diastole. (f) Kinetic energy distributions at the beginning of systole. Positive and negative values of kinetic energy ($KE = (1/2)\rho(u^2 + v^2 + w^2) \cdot sign(w)$) indicate upward and downward flow directions, respectively.

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[1]Nash et al., *Progress in Biophysics and Molecular Biology*, **85**, 501-522 (2004)