Supplementary information for
Inertia-dependent dynamics of three-dimensional vesicles and red blood cells in shear flow

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**Fig. S1. Numerical performance.** To eliminate the effect of the grid resolution, including the Eulerian grid for the velocity field of fluid flows inside and outside vesicles and the Lagrangian grid or the number of triangular elements for the membrane strain and stress field, we performed simulations on behaviors of vesicles with $\nu = 1, \lambda = 1, Ca = 0.2$ and $EB^* = 0$ at $Re = 0.1$ under various grid resolutions. (A) and (B) is the temporal evolution of deformation index $D$ and orientation angle $\theta$ under various Eulerian grids and time steps. (C) and (D) is the temporal evolution of deformation index $D$ and orientation angle $\theta$ under various Lagrangian grids. The Eulerian grid of 10 grids for $1R$, the time step of $2 \times 10^{-4}$ and the Lagrangian grid of 5120 elements was used for all later simulations in this study.
**Fig. S2. The effect of vesicle confinement (Cn, the ratio of vesicle size to the distance between the upper and bottom plates).** To eliminate the effect of the vesicle confinement, we performed simulations on behaviors of vesicles with $\nu = 1, \lambda = 1, Ca = 0.2$ and $EB^* = 0$ at $Re = 0.1$ under various vesicle confinement ($Cn = 1/12 - 1/4$). (A) and (C) is the temporal evolution of deformation index $D$ and orientation angle $\theta$ under various vesicle confinements. (B) and (D) is the equilibrium deformation index $D_e$ and equilibrium inclination angle $\theta_e$ as a function of the vesicle confinement $Cn$. The vesicle confinement has no significant effect on the deformation and orientation of vesicles when $Cn < 1/8$. 
Fig. S3. The inclination angle versus time shows at least three rotations of vesicles or RBCs. (A) RBCs with \( \lambda = 10 \), Ca = 0.4 and \( E_B^* = 0.0025 \). (B) Vesicles with \( \nu = 0.87 \), \( \lambda = 10 \), Ca = 0.05 and \( E_B^* = 0.05 \).
Fig. S4. Dynamics of vesicles or RBCs starting from different initial angles. (A) The tumbling motion of vesicles with $\nu = 0.87$, $\lambda = 10$, $Ca = 0.05$ and $E_B^* = 0.05$ at $Re = 1$. (B) The swinging motion of vesicles with $\nu = 0.87$, $\lambda = 10$, $Ca = 0.05$ and $E_B^* = 0.05$ at $Re = 5$. (C) The tumbling motion of RBCs with $\lambda = 10$, $Ca = 0.4$ and $E_B^* = 0.0025$ at $Re = 0.5$. (D) The tank-treading motion of RBCs with $\lambda = 4.1$, $Ca = 4$ and $E_B^* = 0.0025$ at $Re = 5$. 

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Fig. S5. The differences between the tank-treading and swinging of RBCs at high Reynolds number. The shape evolution of RBCs with $\lambda = 10$ and $E_B^* = 0.0025$ at $Re = 5$ is presented at $Ca = (A) 4$ and (B) 0.8. The tank-treading and swinging motion is exhibited in (A) and (B), respectively. The inclination angle versus time is presented for RBCs with $\lambda = 10$ and $E_B^* = 0.0025$ at (C) swinging (D) tank-treading, respectively.
**Video S1:** The tumbling motion of oblate-shaped vesicles with $\nu = 0.87$, $\lambda = 10$, $\text{Ca} = 0.05$ and $E_B^* = 0.05$ at $\text{Re} = 1$.

**Video S2:** The swinging motion of oblate-shaped vesicles with $\nu = 0.87$, $\lambda = 10$, $\text{Ca} = 0.05$ and $E_B^* = 0.05$ at $\text{Re} = 5$. 