Simulation of Solid Particles in Constrained Microfluidic Channel

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Abstract

Characterization of cells has numerous applications in science and diagnostics. Recently, cell passage through constrained square micro channels has been proposed to characterize cells based on their passage velocity. Nevertheless, there is no clear understanding of how the physics in this system interact. Recently we proposed a model that takes into consideration the gap between the walls and the cells and that regulates the pressure drop that pushes the cell through the micro channel. Here we quantify the effects of the gap flow by simulating the passage of a solid deformed particle moving at different velocities in an infinite microfluidic channel. The fundamental understanding gained through this work could explain differences on the experimental results already available on cell passage through micro channels and filters. This study uses the cell's moving reference frame for the cell passage simulations implemented in COMSOL Multiphysics. Further, the cell is assumed to have a pill shape (Figure 1a). In the simulations, the cell velocity (particle velocity) and the fluid flow (inlet velocity) are imposed through boundary conditions (Figure 1b). We found that for this model, for Reynolds numbers up to 0.1, the pressure difference between the particle's back and front scale linearly with the inlet velocity (Figure 1c). The pressure difference between the cell's back and front decreases linearly with the particle's velocity, as shown in Figure 1d. Finally, we studied the effects of the corner gap size between the particle (cell) and the channel walls. For this model we use an isosceles triangular corner geometry whose dimensions were varied from 0.5 to 2.5 microns (Figure 2a and Figure 2b). The pressure difference between the particle's back and front decreased as to the gap size increased. The pressure dropped as 1/R^3.5, where R is the length of one of the sides of the triangle. Further, we varied the particles length from 7 to 20 microns. The pressure increases linearly as the length of the particle increases (Figure 2c). Finally, we varied corner dimensions and particle's length to verify the accuracy of the results (Figure 2d).

Figures used in the abstract

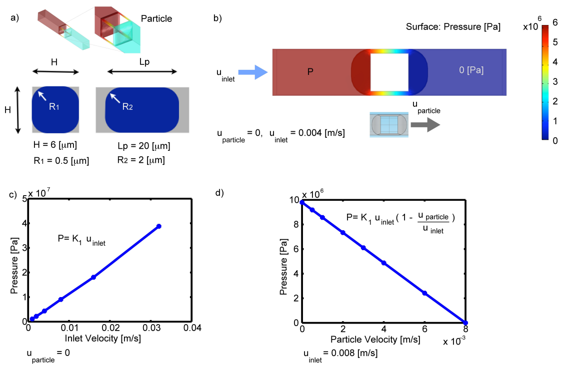

Figure 1

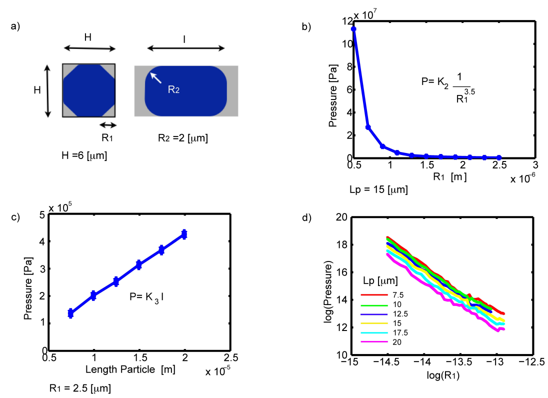

Figure 2