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Et al.

OPTIMIZING MICROFLUIDIC DESIGN FOR CELL SEPARATION

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To evaluate the performance of various designs of crossflow filtration microfluidic devices, blood flow was modeled using computational fluid dynamics software (COMSOL Multiphysics). Velocity profiles were generated and used to analyze four critical design parameters: pillar size, pillar shape, gap size, and wall length. These parameters were optimized to yield greatest flow from an unfiltered main channel into two filtered side channels of the device, thereby maximizing filtration capacity.

Devices containing pillars of 10 µm diameter yielded a significantly greater filtration capacity than devices with pillars of 20 µm diameter. Flow patterns from the main channel to the side channels were not significantly affected when circular, octagonal, and hexagonal pillars were compared; however, use of triangular and square pillars caused a reduction in side channel flow rates. Side channel velocities consistently improved as gap sizes were increased from 3.0 µm to 8.0 µm; however, 3.5 µm gaps were included in the final design for the purpose of separating red and white blood cells. Backflow prevention walls were placed at bends in the device and were systematically lengthened until all backflow was eliminated.

Following optimization of the microfluidic device, two prototypes were prepared: a polydimethylsiloxane (PDMS) device with glass backing and a silicon device with PDMS backing. The filtration capacity of these devices were tested using polystyrene microspheres with sizes corresponding to those of red and white blood cells. In both prototypes, between 73 and 75% of small microspheres were consistently filtered into the side channels. Silicon-PDMS devices demonstrated better retention of large microspheres in the main channel and less microsphere agglomeration than did PDMS-glass devices. The benefits of silicon-PDMS devices, however, came at the cost of a difficult fabrication process.

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