Confined Microfluidic Environments for Studying Cell Mechanics and Cancer Invasion

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Abstract:
We develop microfluidic devices with design features that can elicit mechanical invasion dynamics. We analyze the behavior and responsivity of single cells as they interact with mechanical barriers that define the microarchitecture of their environment, and we elucidate the mechanics of intracellular elements.

Summary of Research:
Cell mechanics is important in many aspects of biology, from development to disease states. In particular, metastasis, the leading cause of cancer related deaths, is intrinsically a mechanical transport phenomena in which cancer cells must break free from the primary tumor, invade across physiological barriers including dense and fibrous matrices, intravasate across endothelial junctions into vascular networks, circulate under shear stress, traffic in microvessels, and then extravasate into distant tissue [1]. While many molecular signals and factors have been identified that drive this process, including autocrine and paracrine chemokine gradients and growth factor signaling, the effects of the mechanical environment as well as the mechanical behavior of cells during the invasion process are not well known. In our work, we develop microfluidic environments with dimensions that mimic highly confined physiological spaces, and we study the mechanical dynamics of cell invasion [2].

As shown in Figure 1, microbeam obstacles integrated into a confined microchannel environment induce dynamic responses in subcellular components. The cell nucleolus navigates across these barriers and the spatiotemporal dynamics of its deformations can be analyzed in the context of cell invasion. Viscoelastic properties can have implications on the cell state and phenotype [3], so here we provide a platform for assessing these properties during the invasion process.

References:

Figure 1: Timelapse image stack displaying cancer cell invasion. As the cell invades across microbarriers in a confined environment, intracellular deformations and dynamics are elicted.