Acidic Dance

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The research story

One of the hallmarks of cancer is the upregulation of glycolysis, both in aerobic and hypoxic conditions, triggering the acidification of the extracellular region, while normal cells have a reduced capability of surviving at low pH values. This seems to confer tumor cells several advantages, among others enhancing migration and reducing sensitivity towards chemo- and radiotherapy. Motivated by the classification of histological tumor infiltrative patterns associated to oncological outcome, in [1] we developed and studied a mathematical model for acid-mediated tumor invasion. The equations couple a chemotaxis system for the motion and spread of tumor cells biased by the gradient of extracellular pH with a stochastic differential equation describing the dynamics of intracellular acidity. Being inherent to most biological processes, randomness is a relevant feature, also on the level of individual cells. In particular, the exchange of protons across the cell membrane has the role of balancing the intra- and extracellular acidity, and is highly erratic, as experiments show. Our model characterising the acid-mediated space-time evolution of cancer cell population density is able to qualitatively reproduce all known types of infiltrative patterns.

The image

The picture shows a sequence of simulated tumor and acidity patterns (contour lines and color patches, respectively) at three successive times. Warmer/lighter colors: high densities of cells and concentrations of acid, colder/darker colors: low densities and concentrations. The most acidic regions correspond to large cancer cell aggregates.

Reference

[1] Hiremath S, Sonner S, Surulescu C, Zhigun A: On a coupled SDE-PDE system modeling acid-mediated tumor invasion, DCDS B 22: 1–31, 2017.

F. Matthäus et al. (eds.), *The Art of Theoretical Biology*, https://doi.org/10.1007/978-3-030-33471-0_42