Quasi-Steady Diffusion Between Two Spherical Cells in Connective Tissues

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Background and Objective: Connective tissues consist of large amount of extracellular matrix (ECM) with embedded cells. Solute transport is critical for nutrition, inter-cellular signaling, and homeostasis in these tissues. To quantify solute transport, fluorescence loss induced by photobleaching (FLIP) is used in combination with theoretical models for data analysis. However, these models assume homogenous tissues, neglecting the embedded cells. Our goal was to develop a mathematical transport model in an inhomogeneous tissue.
Methods: Two spherical cells of higher permeability were embedded in an infinite ECM and subjected to a FLIP experiment, where one cell (sink) was repeatedly photobleached while the other cell acted as a source. Using Laplace equation and bispherical coordinate system, the steady-state solute distribution and outflux from the source were first obtained, from which the time-course of solute concentration in the source were predicted analytically in the case of quasi-steady diffusion.
Results: The concentration in the source decreases exponentially in time, with its time constant decreasing with increasing ratio of cell spacing over cell radius.
Discussion and Conclusions: This model provides a valuable tool to analyze transport in inhomogeneous tissues. Our results provide quantitative measures how the cellular surface curvature and spacing influence the transport between the cells. This influence can only be neglected when the cells are dispersed sparsely.
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