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The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Diffusion in Tumors and Normal Tissues

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The process of delivering blood-borne, diffusible materials such as drugs, nutrients, and imaging tracers from a supply artery to a cell in a tissue depends strongly on the geometry of the vascular network. While normal tissues have vessels that undergo an orderly branching hierarchy that feeds a relatively uniform capillary bed, tumors have vessels that are dilated, tortuous, leaky and haphazardly arranged. In our recent studies we have examined how the differences in vascular architecture between normal and tumor tissues influence diffusion from blood vessel to cell [1].

Specifically, we have developed two simple geometric measures of the blood vessels that can be used in any tissue type to estimate the rates of delivery. The maximum distance that a cell resides from the nearest blood vessel determines the overall duration of the diffusion process, while a newly identified convexity index relates the shape of the spaces between the vessels to the rate of transport at earlier times. Our results are based on a combination of clearance experiments in animal models, numerical simulations built on three-dimensional images of vasculature *in vivo*, and a quasi-one-dimensional analysis of diffusion in irregular geometries. We found a simple analytical relationship between the spatial arrangement of the vessels and the temporal features of diffusive transport in tissues. We offer additional support for the hypothesis that tumor vasculature is geometrically similar to structures found in other percolation processes [2,3].

Our results promise to be useful for evaluating new therapeutic agents that modify vascular growth in tumors thus changing their transport efficiency [4]. Moreover, the methods developed here for medical applications may be broadly applicable to other diffusion processes in irregularly-shaped domains.

References

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