A mathematical model for growth, regression, and regrowth in tumor-induced angiogenesis

Guillermo Vilanova*, Ignasi Colominas*, and Hector Gomez†

* Departamento de Métodos Matemáticos y de Representación
Universidade da Coruña
Campus de Elviña, 15071 A Coruña, Spain
e-mail: gvilanovac@udc.es

† School of Mechanical Engineering
Purdue University
585 Purdue Mall, West Lafayette, IN 47907, USA

ABSTRACT

Angiogenesis is the growth of new capillaries from pre-existing ones. This complex biological phenomenon plays a critical role in the development of cancer: when tumors gain the ability to induce angiogenesis, new capillaries provide the tumor the necessary nourishment for its fast growth as well as potential access to other organs through the circulatory system. For this reason, impeding angiogenesis has become a promising cancer therapy [1]. However, this therapy has not achieved the expected results yet and research continues in this field.

One of the most salient features of tumor-induced vascular networks is their instability: they are stimulus-dependent and may undergo alternating stages of growth, regression, and regrowth [2]. Thus, tumor angiogenesis is a highly dynamic phenomenon in which the new vasculature is a sequence of patterns that are continuously shaping the tumor. Previous efforts to model tumor angiogenesis, have chiefly focused on the initial growth of blood vessels, often using models which are fundamentally unable to predict the natural regression and regrowth observed in experiments. In this work, following a phase-field methodology, we present a new model of tumor angiogenesis [3] that reproduces the aforementioned features and highlights the importance of vascular regression and regrowth. The model also includes a conceptualization of tip endothelial cell filopodia (the cellular protrusions that aid TECs in their migration) that plays a key role in regrowth and loop formation. The predictions of our model are in quantitative agreement with in vivo experiments and may prove useful for the design of antiangiogenic therapies.

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