

Research Highlight:
Tumor angiogenesis: A study using a chemotaxis-haptotaxis model

Work of Associate Professor Peter PANG

In the past few years, A/P Peter Pang and his coauthors have studied various models of cancer invasion based on the mechanisms of chemotaxis and haptotaxis [1,2].

In a 2019 paper [3] published in *Mathematical Models and Methods in Applied Sciences*, Pang and his coauthor Yifu Wang continued their investigation into the use of chemotaxis-haptotaxis systems in cancer modeling. In this paper, instead of the degradation of extra-cellular matrix, they turned their attention to another aspect of cancer invasion, namely, angiogenesis, which leads to vascularization of a tumour, providing it with its own dedicated blood supply and consequently allowing for rapid growth and metastasis [4,5,6]. In the model they studied, the existing blood vessels' endothelial cells migrate chemotactically in response to the concentration gradient of a chemical signal known as the Tumor Angiogenic Factor or TAF secreted by tumor cells, and also migrate haptotactically according to the concentration gradient of non-diffusible glycoprotein fibronectin produced by the endothelial cells.

Generalising several known results [7,8], Pang and Wang obtained new findings on the behaviour of the solutions to the model. Specifically, they showed that: (i) the endothelial cells are globally uniformly bounded, and (ii) the model converges to a spatially homogeneous equilibrium solution in large time. The main mathematical challenge is the strong coupling between the migratory endothelial cells and the glycoprotein fibronectin, which has an important effect on the spatial regularity of both quantities. Delicate analysis is required to overcome this challenge.

References:

- [1] P. Pang & Y. Wang: Global existence of a two-dimensional chemotaxis-haptotaxis model with remodelling of non-diffusible attractant, *J. Differential Equations* 263(2017), 1269-1292.
- [2] P. Pang & Y. Wang: Global boundedness of solutions to a chemotaxis-haptotaxis model with tissue remodelling, in "Special Issue on Challenges in Modeling and Analysis of Cross-Diffusion Systems" (N. Bellomo, Y. Tao & M. Winkler, eds.), *Math. Models Methods Appl. Sci.* 28(2018), 2211-2235.
- [3] P. Pang & Y. Wang: Asymptotic behavior of solutions to a tumor angiogenesis model with chemotaxis-haptotaxis, *Math. Models Methods Appl. Sci.* 29(2019), 1387-1412.
- [4] M.A.J. Chaplain & A.M. Stuart: A model mechanism for the chemotactic response of endothelial cells to tumor angiogenesis, *IMA J. Math. Appl. Med. Biol.* 10(1993), 149-168.
- [5] B.D. Sleeman: Mathematical modelling of tumor growth and angiogenesis, *Adv. Exp. Med. Bio.* 428(1997), 671-677.
- [6] A.R.A. Anderson & M.A.J. Chaplain: Continuous and discrete mathematical models of tumor-induced angiogenesis, *Bull. Math. Biol.* 60(1998), 857-899.
- [7] C. Morales-Rodrigo & J.I. Tello: Global existence and asymptotic behavior of a tumor angiogenesis model with chemotaxis and haptotaxis, *Math. Models Methods Appl. Sci.* 24(2014), 427-464.
- [8] Y. Tao & M. Winkler: Large time behavior in a multidimensional chemotaxis-haptotaxis model with slow signal diffusion, *SIAM J. Math. Anal.* 47(2015), 4229-4250.