Application of a 3D hybrid multi-scale model for simulations of vascular tumour growth

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Vascular tumour growth can be studied with different modelling methodologies according to the scientific questions that should be answered. The mathematical models range from systems of ordinary differential equations, to partial differential equations and agent based approaches. While ordinary and partial differential equation models deal with spatially averaged quantities like tumour size and volume fractions, agent based models can discretely resolve cell populations. The multi-scale modelling methodology presented in this lecture is based on a hybrid approach - a combination of continuous and discrete variables (1). Stochastic and deterministic processes on various temporal and spatial scales are included and coupled. Intracellular models describe the progression through the cell cycle, metabolic and signalling pathways. These processes are usually influenced by extracellular factors like nutrients, growth factors, drugs, mechanical stress etc. Cells are also able to move in the simulation domain by a biased random walk up to growth-factor gradients. Vascular sprouts can anastomosi to other sprouts or the already existing vascular network and build new perfused vessels. Within the vascular network, pressures a flows are calculated, and the radii of the vessel segments evolve due to growth rules.

References

[1] Perfahl, H., Byrne, H.M., Chen, T., Estrella, V., Alarcon, T., Lapin, A., Gatenby, R.A., Gillies, R.J., Lloyd, M.C., Maini, P.K., Reuss, M., Owen, M.R. (2011): *Multiscale modelling of vascular tumor growth in 3D: the roles of domain size and boundary conditions.* PloS One6(4), e14790, doi: 10.1371/journal.pone0014790.