

Towards computer modelling of the therapy of leukaemia

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Many haematological diseases, including various types of leukaemia, are caused by abnormal production of particular blood cells. Their treatment consists mainly of two steps. The first step is chemotherapy and a whole body irradiation to eradicate the patients haematopoietic system. The second step is the transplantation of haematopoietic stem cells (HSCs) obtained from the mobilized peripheral blood of a donor. After transplantation, HSCs find their way to the stem cell niche in the bone marrow. Upon homing they have to multiply rapidly to regenerate the blood system. This is possible due to the two important properties of HSCs: a) rapid migratory activity and ability to "home" to their niche in the bone marrow; b) high self-renewal and differentiation capacity, responsible for the production and regulation of the three blood cell types.

The computer modelling of the processes after transplantation include submodels for a) and b). In the current investigations we use: A) the mathematical model of HSCs migration, proposed by A. Kettemann, M. Neuss-Radu in 2008. The process is described by a chemotaxis system of partial differential equations with nonlinear boundary conditions. B) the mathematical model of production and regulation of blood cells under the action of growth factors, proposed by M. Adimy, F. Crauste, S. Ruan in 2006. A system of stiff nonlinear ordinary differential equations with delays corresponding to the cell cycle duration have to be solved. The parameters and the coefficient functions involved in the model depend on the particular type of blood cells.

Starting from the models A) and B), the steps towards computer simulation of each of the two properties of HSCs include: choice and/or development of numerical methods and software tools; tuning the parameters of the model and software; numerical experiments and analysis of the results.

At the current stage, the numerical tests for the model A) are attempt to answer some questions arisen in a discussion with M. Neuss-Radu. The numerical tests for the model B) are aimed at tuning the parameters on the base of real data for white blood cells (T, B and NK) from clinical practice. The latter will help medical doctors to shorten the period in which the patient is missing his/her effective immune system.