Invited talk (Mathematics and Medicine)

Mathematical modeling of cancer treatment using optimal control

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Abstract

Cancer is a serious health challenge and is one of the leading causes of death in industrialized countries. That is why there is so much interest not only in the search for new, innovative drugs, but also in the pursuit of optimizing treatment protocols for drugs that are known. The mathematical tools of optimal control theory can be helpful here.

I will present two examples of optimal control problems leading to two different treatment strategies.

The first example can be found in the text-book by A. Świerniak *et al.* [1]. It considers the drug targeting a specific phase in cell cycle and the goal of optimization is simple: just to minimize the tumour size at the end of treatment. In this case the structure of optimal control is also simple, it is of bang-bang type, that is a full dose – no dose in medical language. This type of optimal control is typical for problems focusing on minimization of tumour size in homogeneous tumours.

However, malignant cancers are not homogeneous. Therefore, in the second example I will show a novel approach proposed in our papers [2, 3] for heterogeneous populations of cells. We considered two population of cancer cells, one sensitive and the other resistant to some drug, that compete of the resources (like glucose and oxygen). The goal of optimal control is therefore not only to minimize the total size of the tumour, but also to prevent further development of drug resistance. In this case the structure of optimal control is different and consists of both, a full dose and a singular dose (around 10% of a full dose).

References

[1] A. Świerniak, M. Kimmel, J. Smieja, K. Puszynski, K. Psiuk-Maksymowicz: *System Engineering Approach to Planning Anticancer Therapies*, Springer (2016)

[2] P. Bajger, M. Bodzioch, U. Foryś: *Singularity of controls in a simple model of acquired chemotherapy resistance*. DCDS-Series B **24(5)**, p2039 (2019)

[3] P. Bajger, M. Bodzioch, U. Foryś: *Numerical optimisation of chemotherapy dosage under antiangiogenic treatment in the presence of drug resistance*. Math Meth Appl Sci **43(18)**, 10671–10689 (2020).