Analysis and Numerical Simulations of Optimal Controls in Mathematical Models for Cancer Treatments

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Abstract: In clinical trials, because of the great complexity of the underlying medical problem, the scheduling of drugs is pursued in expensive, exhaustive, medically guided trial-and-error approaches. But these difficult scheduling questions related to both dosage sizes and sequencing are far from being answered, especially when more than one treatment is involved. Hence there exists a strong opportunity for mathematical modeling, analysis and numerical simulations to be useful. In the talk we will review our recent research on application of optimal control methods, both analytic and numerical, to design optimal protocols for several classes of mathematical models for cancer treatments. Various challenges arise including singular controls, chattering controls, proofs of optimality and construction of local and global synthesis. Since in many cases the models are too complex for a theoretical analysis to be completed, we combine it with numerical methods for solving optimal control problems like GPOPS (Global Pseudospectral Optimal Control Problems Software). We will show that whereas some of the solutions, like dosage of the anti-angiogenic inhibitors in the models by Hahnfeldt et al., are very robust not only to the values of the parameters, but even to the modeling assumptions, in other models we observe a strong sensitivity of the solutions to the parameters in the sense that varying some of the parameters generates qualitatively different solutions (Stepanova model for tumor-immune interactions). The systems become even more complex if pharmacokinetics of the drugs is taken into account. However, overall a combination of analytic solutions and numerical computations leads to interesting outcomes both mathematically and from the point of view of the underlying application to cancer treatments.

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