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Conflicting objectives in chemotherapy with drug resistance. (English) Zbl 0878.92012

Bull. Math. Biol. 59, No. 4, 707-724 (1997).

Summary: A system of differential equations for the control of tumor cells growth in a cycle nonspecific chemotherapy is presented. Spontaneously acquired drug resistance is accounted for, as well as the evolution in time of normal cells. In addition, optimization of conflicting objectives forms the aim of the chemotherapeutic treatment. For general cell growth, some results are given, whereas for the special case of Malthusian (exponential) growth of tumor cells and rather general growth rate for normal cells, the optimal strategy is worked out. The latter, from the clinical standpoint, corresponds to maximum drug concentration throughout the treatment.

MSC:

92C50 Medical applications (general)
93C95 Application models in control theory
93C15 Control/observation systems governed by ordinary differential equations

Keywords:

control of tumor cells growth; chemotherapy; drug resistance

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References:

[1] Coldman, A. J. and J. H. Goldie. 1983. A model for the resistance of tumor cells to cancer chemotherapeutic agents.Math. Biosci. 65, 291–307. · Zbl 0519.92008 · doi:10.1016/0025-5564(83)90066-4

[2] Coldman, A. J. and J. H. Goldie. 1986. A stochastic model for the origin and treatment of tumors containing drug-resistant cells.Bull. Math. Biol. 48, 279–292. · Zbl 0613.92006

[3] Costa, M. I. S., J. L. Boldrini and R. C. Bassanezi. 1992. Optimal chemical control of populations developing drug resistance.IMA J. Math. Appl. Med. Biol. 9, 215–226. · Zbl 0779.92011 · doi:10.1093/imammb/9.3.215

[4] Costa, M. I. S., J. L. Boldrini and R. C. Bassanezi. 1994. Optimal chemotherapy: a case study with drug resistance, saturation effect and toxicity.IMA J. Math. Appl. Med. Biol. 11, 45–59. · Zbl 0816.92008 · doi:10.1093/imammb/11.1.45

[5] Costa, M. I. S., J. L. Boldrini and R. C. Bassanezi. 1995a. Drug kinetics and drug resistance in optimal chemotherapy.Math. Biosc. 125, 191–209. · Zbl 0821.92015 · doi:10.1016/0025-5564(94)00027-W

[6] Costa, M. I. S., J. L. Boldrini and R. C. Bassanezi. 1995b. Chemotherapeutic treatments involving drug resistance and level of normal cells as a criterion of toxicity.Math. Biosci. 125, 211–228. · Zbl 0821.92016 · doi:10.1016/0025-5564(94)00028-X

[7] Costa, M. I. S. and J. L. Boldrini. 1997. Chemotherapeutic treatments: a study of the interplay among drug resistance, toxicity and recuperation from side effects. Unpublished manuscript. · Zbl 0899.92024

[8] Eisen, M. 1978.Mathematical in Cell Biology and Cancer Chemotherapy. Lecture Notes in Biomathematics, Vol. 30. Heidelberg: Springer-Verlag.

[9] Goldie, J. H. and A. J. Coldman. 1979. A mathematical model for relating the drug sensitivity of tumors to their spontaneous mutation rate.Cancer Treat. Rep. 63, 1727–1733.

[10] Harnevo, L. and Z. Agur. 1992. Drug resistance as a dynamic process in a model for multistep gene amplification under various levels of selection stringency.Cancer Chemother. Pharmacol. 30, 469–476.· doi:10.1007/BF00685599

[11] Kirk, D. 1970.Optimal Control Theory. Englewood Cliffs, NJ: Prentice-Hall.

[12] Leitmann, G. 1974.Cooperative and Non-Cooperative Many Player Differential Games, International Centre for Mechanical Sciences Course Lectures, No. 190. Udine, Italy: Springer-Verlag.

[13] Murray, J. M. 1990a. Optimal control for a cancer chemotherapy problem with general growth and loss functions.Math. Biosci. 98, 273–287. · Zbl 0693.92009 · doi:10.1016/0025-5564(90)90129-M

[14] Murray, J. M. 1990b. Some optimal control problems in cancer chemotherapy with a toxicity limit.Math. Biosci. 100, 49–67. · Zbl 0778.92012 · doi:10.1016/0025-5564(90)90047-3

[15] Murray, J. M. 1995. An example of the effects of drug resistance on the optimal schedule for a single drug in cancer chemotherapy.IMA J. Math. Appl. Med. Biol. 12, 55–71. · Zbl 0832.92009 · doi:10.1093/imammb/12.1.55

[16] Skipper, H. E. 1983. The forty year old mutation theory of Luria and Delbruck and its pertinence to cancer chemotherapy.Adv Cancer Research 40, 331–363.· doi:10.1016/S0065-230X(08)60683-1

[17] Swan, G. W. and T. L. Vincent. 1977. Optimal control analysis in the chemotherapy ofI g G multiple myeloma.Bull. Math. Biol. 39, 317–337. · Zbl 0354.92041

[18] Swan, G. W. 1987. Tumor growth models and cancer chemotherapy. InCancer Modeling, J. R. Thompson and B. W. Brown (Eds), pp. 91–179 New York: Marcel Dekker.

[19] Swan, G. W. 1990. Role of optimal control theory in cancer chemotherapy.Math. Biosc. 101, 237–284. · Zbl 0702.92007 · doi:10.1016/0025-5564(90)90021-P

[20] Vaidya, V. G. and F. J. Alexandro, Jr. 1982. Evaluation of some mathematical models for tumor growth.Int. J. Bio-Med. Comp. 13, 19–35.· doi:10.1016/0020-7101(82)90048-4

[21] Vendite, L. L. 1988.Modelagem matemática para o crescimento tumoral e o problema de resistência celular aos fármacos anti-blásticos. Ph.D. thesis, Faculdade de Engenharia Elétrica, Universidade Estadual de Campinas, SP, Brazil.

[22] Zietz, S. and C. Nicolini. 1979. Mathematical approaches to optimization of cancer chemotherapy.Bull. Math. Biol. 41, 305–324. · Zbl 0404.92004