Simplified model of immunotherapy for glioblastoma multiforme: cancer stem cells hypothesis perspective

Wiktor Jochymczyk

Glioblastoma multiforme (GBM) accounts for 15.6% of all primary brain tumors and as much as 45.2% of malignant primary brain tumors [6]. Due to its sensitive location, high heterogeneity and strong suppression of the immune response, a fully effective treatment for GBM is still unknown [1][2]. Since different kinds of immunotherapy are considered to be potential cure candidates, efforts have been made to assess their effectiveness using mathematical modeling.

In [5], Kronik et al. presented a mathematical model for the treatment of GBM by adoptive transfer of cytotoxic T cells. That work was then continued by Kogan et al. in [7]. In [4], Abernathy and Burke built on the previous results and modified the model to include cancer stem cells (CSCs), i.e. the type of cancer cells that are hypothesized to be largely responsible for cancer recurrence, [3]. In our work we simplify the ODE system from [4] by introducing additional assumptions and then analyze the existence and stability of steady states of the obtained model depending on the treatment levels.

References

[1] A. Becker, B. Sells, S. Hague, and A. Chakravarti, *Tumor Heterogeneity in Glioblastomas: From Light Microscopy to Molecular Pathology*, Cancers 13 (2021), 761

[2] B. T. Himes, P. A. Geiger, K. Ayasoufi, A. G. Bhargav, A. Brown, and I. F. Parney, *Immunosuppression in Glioblastoma: Current Understanding and Therapeutic Implications*, Frontiers in Oncology 11 (2021)

[3] B. T. Tan, C. Y. Park, L. E. Ailles, and I. L. Weissman, *The cancer stem cell hypothesis: a work in progress*, Laboratory Investigation 86 (2006), 1203–1207

[4] K. Abernathy and J. Burke, *Modeling the Treatment of Glioblastoma Multiforme and Cancer Stem Cells with Ordinary Differential Equations*, Computational and Mathematical Methods in Medicine 2016 (2016), 1–11

[5] N. Kronik, Y. Kogan, V. Vainstein, and Z. Agur, *Improving alloreactive CTL immunotherapy for malignant gliomas using a simulation model of their interactive dynamics*, Cancer Immunology, Immunotherapy 57 (2007), 425–439

[6] Q. T. Ostrom, H. Gittleman, P. Farah, A. Ondracek, Y. Chen, Y. Wolinsky, N. E. Stroup, C. Kruchko, and J. S. Barnholtz-Sloan, *CBTRUS Statistical Report: Primary Brain and Central Nervous System Tumors Diagnosed in the United States in 2006-2010*, Neuro-Oncology 15 (2013), ii1–ii56

[7] Y. Kogan, U. Foryś, and N. Kronik, *Analysis of the immunotherapy model for glioblastoma multiforme brain tumour* (2008)

First Author: Wiktor, Jochymczyk
Affiliation: *Faculty of Mathematics, Informatics and Mechanics, University of Warsaw 01-797, Poland*
e-mail: w.jochymczyk@student.uw.edu.pl