A Mathematical Cancer Model with BCG Immunotherapy Combined with Immune Checkpoints Inhibitors: an Optimal Control Approach

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Abstract: We present a mathematical model of cancer growth in the bladder that includes the immune cells, BCG, immune checkpoints and drug therapy (checkpoint inhibitor) in the form of a control function. The control function blocks the action of immune checkpoints on the immune system. Our aim here is to apply optimal control theory to find a control strategy that will minimize the number of cancer cells in the bladder and cost of control. Existence of the optimal control is stated and Pontryagin's maximum principle is used to characterize the nature of the control function. The optimality system obtained gives a two-point boundary value problem; hence, we use the forward-backward sweep method to present the numerical solutions of the system. The optimality conditions and characterization of the control are discussed.

Keywords: Optimal control, mathematical model, Hamiltonian, cancer, immune checkpoint, Pontryagin's principle, forward-backward sweep method.

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