SDE modeling in CAR-T cell therapy

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Abstract: Chimeric Antigen Receptor (CAR) T-cell therapy has recently become highly instrumental in the fight against life-threatening diseases like cancer. T-cells are taken from patient's blood; then the gene for a special receptor, called a Chimeric Antigen Receptor (CAR), that binds to a certain protein on the patient's cancer cells is added to the T-cells in the laboratory. The CAR allows T-cells recognize and attack cancer cells. Large numbers of the CAR T-cells are grown in the laboratory and then given to the patient by infusion. In this study, I introduce a three-dimensional SDE model, which is based on an ODE model built by Kimmel et al. (derived in article "The roles of T cell competition and stochastic extinction events in CAR receptor T cell therapy" - published in 2019), describing features of normal T-cells, CAR T cells, and tumor cells during treatment. The model considers three cell populations in the form of continuous-time birth and death stochastic processes and their deterministic mean-field equations; three white noises are added in growth rates and killing rate of CAR T cells and tumor cells to demonstrate more realistically interactions between these two types of cells. By analyzing the SDE model, we can describes outcomes of the treatment in long term and capture dynamics of small tumor populations near extinction. The insights can be leveraged to better understand why therapy works for some but not all, and how it can be improved.