

AbstractID: 13033 Title: Mathematical Framework to Optimize the Intensity Adaptive to Biological Response to Radiotherapy

Introduction: We propose a mathematical framework to optimize the beamlet intensity spatially and temporally that is adaptive to a patient's radiobiological response to radiotherapy as observed by advanced functional imaging or biomarkers that are soon to be available or as predicted by mathematical model.

Methods and materials: Stochastic control approach was used to model and solve for optimal dose per voxel for any specific time period, i.e. fraction. Tumor cell density and BED for OAR were used to represent the system state, and beamlet intensity was the control variable. The final tumor cell density at the end of the treatment course was minimized by choosing the optimal sequence of beamlet intensities based on the observed or predicted patient's radiobiological response to radiotherapy. BED for OAR was constrained not to exceed its tolerance level and alpha/beta parameters for the tumor were varied stochastically.

Results: For the special case of our stochastic control formulation where the stochasticity is ignored and additional information of the patient's response to radiotherapy is unknown, the constant dose per voxel for any given period is found to be optimal, which agrees with the current practice. Simulations revealed that there was almost 70% decrease in tumor cell density at the end of the treatment when the beamlet intensity was optimally adaptive to patient's response to radiotherapy compared to a constant dose per voxel as in current clinical practice.

Conclusion: Our approach demonstrated the ability to simultaneously balance spatial and temporal aspects of the optimization problem in treatment planning from a biological perspective and adapt to the uncertainty in biological response to radiation over the treatment course. This is a first step in designing the individualized treatment plan that is adaptive biologically conformal radiotherapy and that exploits recent advances in functional imaging and/or mathematical modeling of tumor radiation response.