

Radiobiology in the Modern Treatment Planning System: the Fourth Dimension

The development of treatment planning systems has always emphasized increasing the accuracy and speed of dose calculation and, more recently, optimizing the delivery of highly conformal dose distributions. As these advances begin to approach their asymptotic limits, the role of biological modeling becomes increasingly important as the “fourth dimension” of radiation treatment planning. The general predictive models of Tumor Control Probability (TCP) and Normal Tissue Complication Probability (NTCP) have long been utilized to assess treatment plans. In addition, clinical research on the effects of fractionation and dose-rate has introduced “Biological Effective Dose” (BED) as a real consideration in treatment optimization. In this work, we introduce a collection of planning tools to incorporate biological considerations into everyday clinical planning. The TCP tool estimates the tumor control probability based upon the heterogeneous 3-D dose distributions calculated for target structures, and optionally models the effects of inter-patient variability. The NTCP model incorporates the volume dependence and dose tolerance of critical structures in estimating normal tissue complication. Both the TCP and NTCP tools allow the interactive assessment of dose escalation. Fractionation schedules (external beam) and dose-rate dependence (Brachytherapy) are analyzed using the predicted response of early- and late-responding tissues described by BED. Incorporating these and other radiobiology tools into the clinical treatment planning system will hopefully raise awareness of biological effects, and perhaps facilitate more clinical research in this area. The work was funded by Computerized Medical Systems.