

Local recurrences occur in tumors with adverse intrinsic characteristics leading to radioresistance or if clonogens are left behind following radiotherapy (i.e. the target is missed). The latter may occur due to inadequate dose, the presence of subclinical disease outside radiation target volumes, inaccurate target delineation, treatment error or treatment uncertainties. The potential impact of treatment uncertainties on radiation (RT) planning, tumor control probability (TCP) and clinical outcomes is the focus of this presentation.

Geometric uncertainties, due to setup uncertainty and internal organ motion, degrade RT plans that are based on a static CT scan, potentially introducing cool spots within targets. If the magnitude of uncertainty is known, it can be considered using PTV margins or directly within the radiation plan. This should decrease the chance of underdosage of the target. With IMRT, dose gradients are generally steeper than with conformal RT and geometric uncertainties may result in greater degradation of plans, despite the use of PTV margins. Dosimetric uncertainties may also be larger in IMRT plans.

The impact of an underdosage of the target introduced by treatment uncertainties will be estimated using TCP models. The relationship between the volume and magnitude of “cool spot” and TCP will be demonstrated for selected clinical scenarios. Tumor control appears to be primarily a function of minimum tumor dose, with only a small dependence on hot spots. This suggests that minimal dose or equivalent uniform dose (EUD) must be kept equivalent to or larger than accepted prescription doses if the TCP is to be maintained. Based on these results, the potential exists for some IMRT plans to be degraded into plans with a decreased TCP if realistic uncertainties are not considered during planning. Potential solutions to this problem include minimizing uncertainties, altering the prescription point (introducing hotspots in the tumor and higher doses to normal tissues) and/or developing radiation plans less sensitive to treatment and dose calculation uncertainties (e.g. by incorporating uncertainties into the optimization process).

The predictions from TCP models can only be validated by clinical outcomes. Rates and patterns of local recurrences following IMRT, potentially more sensitive to treatment uncertainties, should be measured. The presence of marginal misses should alert physicians that their irradiation technique may be related to the recurrence. Historically, marginal misses in Hodgkin’s disease and medulloblastoma led to a change in recommended block margins. More recently, the lack of marginal misses following parotid sparing head and neck cancer IMRT is reassuring, and the very high local control rate (100% at 2 years) observed following IMRT for nasopharyngeal cancer is encouraging. However, clinical data are sparse and preliminary.

Educational objectives

1. To describe the potential for underdosage of the target due to treatment uncertainties in IMRT
2. To describe the relationship of the volume and magnitude of underdosage in the target due to treatment uncertainties and TCP
3. To describe clinical outcome data