

Dose-Time Recovery Factors for Spinal Cord Reirradiation

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Abstract

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Abstract

Objectives:

Reirradiation of spinal metastases with radiosurgery in 1-5 fractions is being increasingly used after prior radiation. However, the dose-time recovery factors remain uncertain. To address these uncertainties, a preliminary cumulative normal tissue complication probability (NTCP) model was developed based on existing published data, incorporating the essential recovery factors.

Methods:

Initial simple models incorporating data from existing published literature would provide sufficient information for more advanced models in the near future. Therefore, our first recovery model is simply a raised exponential with two parameters: the saturation level, representing the residual dose effect that may not fully recover, and the recovery half-time, which describes the time required for the portion of the dose effect that does recover.

A PubMed search using the terms (myelopathy OR neuropathy) AND (reirradiation OR re-irradiation) identified 221 cases of spine stereotactic body radiation therapy (SBRT) reirradiation from seven studies, including seven cases of myelopathy. All initial and reirradiation spinal cord maximum point doses were converted to the biological effective dose (BED) using the linear quadratic (LQ) model with an alpha/beta ratio of 2 Gy. The prior doses were then multiplied by the recovery time discount factor. Maximum likelihood parameter fitting was used to estimate the best saturation level, recovery half-time, and the logistic model's TD50 tolerance dose and slope parameter.

Results:

The maximally likely recovery half-time for this dataset was estimated to be less than 24 months, with a saturation level of less than 20%. However, due to the limited availability of data, these parameters were conservatively set to 24 months and 20%, respectively, for subsequent analyses. Therefore, the recovery half-time shorter than 24 months or an asymptotic recovery level exceeding 80% was not used until further high-quality data becomes available for validation. As a clinical example, including the dose-time recovery factor for a spine SBRT reirradiation two years after the initial course, the model estimates risk of myelopathy of 1-2% for cumulative spinal cord maximum point dose BED up to about 100 Gy. Many caveats and limitations will be discussed, along with a roadmap of future work to overcome them.

Conclusion(s):

Preliminary evaluation of published data provides a conservative estimate of recovery half-time and recovery saturation level of dose-time parameters of radiation tolerance for spinal cord reirradiation. Validation with more complete datasets is needed before this model could be widely adopted.