AbstractID: 2971 Title: Evaluation of the limits of accuracy of the high heterogeneity TCP model

Purpose: To determine the limits of accuracy of a TCP model that assumes high heterogeneity, such as the Roberts and Hendry (IJROBP 41 689-699 1998) model.

Method and Materials: A TCP model that incorporates heterogeneity in radiosensitivity, clonogen number and growth rate is reduced to a two parameter model by grouping variables using a method previously introduced by Carlone et al (Carlone et al Med Phys 30 2832-2848 2003). The model is then approximated in the high heterogeneity limit by approximating the TCP function as a Heaviside step function with a step at 0.577. The high heterogeneity approximation, when plotted in the reduced parameter space has iso-TCP lines that are linear, and cross at a common point. This suggests a further variable reduction such that TCP depends on a single variable, \( \delta \): TCP = \( \frac{1}{2} \text{erfc}(\delta/\sqrt{2}) \). A similar variable substitution can be inserted into the exact TCP model; the result is a function of two variables, however the TCP function depends much more strongly on the variable \( \delta \) than on the second variable. The limits of accuracy of the approximation are determined by calculating the difference between the two solutions.

Results: When only heterogeneity in \( \alpha \) is considered, the high heterogeneity TCP approximation is accurate (< 5%) when \( \sigma_\alpha D \) is larger than 1.6. When \( \sigma_\alpha D \) is large as compared to 0.577, the TCP function can be accurately evaluated using only parameter ratios (Roberts and Hendry closed formula), however it does depend on the value of \( \sigma_\alpha \) when \( \sigma_\alpha D \approx 0.577 \). When \( \sigma_\alpha \) is small, maximum errors on the order of 30% to 50% can occur.

Conclusion: When the quantity \( \sigma_\alpha D \) is significantly larger than 1, the heterogeneous TCP function can be accurately modeled using only parameter ratios, and the high heterogeneity approximation.