

AbstractID: 10086 Title: Radiobiologic Evaluations of Stereotactic Body Radiation Therapy (SBRT) Treatment Plans in Patients with Non Small Cell Lung Cancer (NSCLC)

Introduction: Stereotactic Body Radiation Therapy (SBRT) uses large ablative doses (12 to 30 Gy per fraction) that fall far beyond the shoulder of the cell survival curve. The linear quadratic model (LQM), the Biologically Effective Dose (BED) and Standard Effective Dose (SED) have been instruments in the prediction of radiobiological effects for conventionally fractionated schemes, but overestimate the effects on tumor cell population at high doses. A Universal Survival Curve (USC), shown in Fig. 1, has been proposed by Park et al (1) in which the LQM for the low dose region and the Multi-target Model asymptote for the high dose region have been combined at a transitional dose (D_T) for smoothness and continuity. Based on this, the concept of a Single Fraction Equivalent Dose (SFED) was introduced. SFED is the dose delivered in one fraction that would cause the same biological effect as any dose fractionation scheme in question. This study incorporates the concept of the Equivalent Uniform Dose (EUD) into the calculation of radiobiological effective doses. EUD is defined as the dose which causes the same biological effect if distributed homogeneously throughout the entire volume of the structure of interest as the inhomogeneous dose distribution (2). EUD falls between minimum and mean dose, but closer to the minimum dose to which many studies have correlated with tumor control.

Materials and Methods: Data from 20 patients with low stage non-small cell lung cancer (NSCLC) was used. Patients were scanned with a GE Light Speed CT scanner using the Varian's RPM respiratory gating system. The 4D CT images acquired during the full breathing cycle (0% to 90% phases) were averaged and used for treatment planning by Eclipse Treatment Planning system with tissue heterogeneity corrections. The prescription dose was 60 Gy in three fractions using 6 MV non-opposing beams. The Planning Target Volumes (PTVs) were created by adding a 0.7 cm circumferential margin to the Internal Target Volumes (ITVs). Using the concept of USC, the BED, SED, and SFED values were derived:

$$BED = \frac{1}{\alpha \cdot D_0} (D - n \cdot D_q) \quad [\text{Eq. 1}]$$

$$SFED = D - (n - 1) \cdot D_q \quad [\text{Eq. 2}]$$

$$SED = \frac{BED}{1 + \frac{2}{(\alpha/\beta)}} \quad [\text{Eq. 3}]$$

The dose volume histogram (DVH) was used to generate EUDs calculated with clonogen cell density = 220 million, $SF_2=0.4$, and $\alpha/\beta = 10$, or 8.605 derived from Park et al (1), and the values substituted D in the equations above.

Results: The average minimum, mean and maximum PTV doses were 53.07, 62.23 and 66.32 Gy respectively. The dose heterogeneity index ($D_{1\%}/D_{99\%}$) was 1.14%. The calculated radiobiological effective doses are shown in Table 1. The results of Park et al are based solely on the prescribed dose. In our study, the SFED was calculated using EUD values derived from tissue heterogeneity corrected dose distributions optimized to confine 100% of the dose to 95% of the PTV and 90% of the dose to 99% of the PTV. When comparing Park's SFED to ours, a 4% reduction was observed due to tissue and dose distribution heterogeneities.

Conclusions: For radiobiological description of SBRT regimens, the SFED, with the incorporation of tissue heterogeneity corrections and EUD, may be a more practical and

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accurate tool since it brings models for low and high dose together. Clinical trials are needed to correlate the results of these radiobiological models with patient outcomes.

References:

1. Clint Park, Lech Papiez, Shichuan Zhang, Michael Story, and Robert D. Timmerman. 2008. Universal Survival Curve and Single Fraction Equivalent Dose: Useful Tools in Understanding Potency of Ablative Radiotherapy. *Int. J. Radiation Oncology Biol. Phys.*, 70: 847-852.
2. Andrzej Niemerko. 1997. Reporting and Analyzing Dose Distributions: A Concept of Equivalent Uniform Dose. *Med. Phys.*, 24: 103-110.

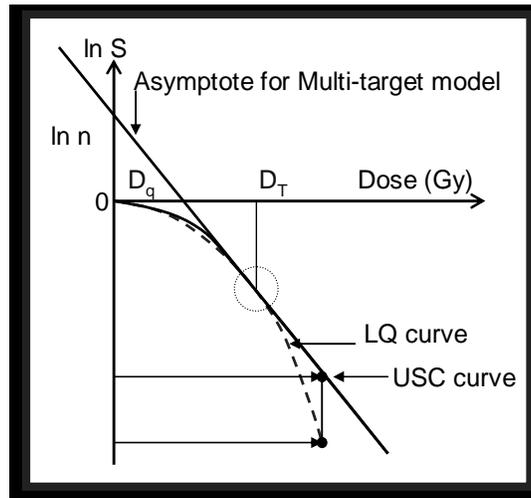


Fig. 1 Universal Survival Curve

Investigator	Plan Description	Dose, Prescription	BED	SED ($\alpha/\beta = 10$ & 8.6048)	SFED
Timmerman and Park et al	no tissue heterogeneity correction, assumed homogeneous PTV dose distribution	20 Gy x 3 (80% isodose)	132.00	107.00 & 110.00	56.40
Present Work	tissue heterogeneity correction, EUD calculated with $\alpha/\beta = 10$	20 Gy x 3 (95% to PTV)	127.14	103.16 & 105.95	54.25
Present Work	tissue heterogeneity correction, EUD calculated with $\alpha/\beta = 8.6048$	20 Gy x 3 (95% to PTV)	126.77	102.86 & 105.64	54.09

Table 1 Radiobiological Effective Doses (Gy)