
Secondary cancer risk from radiotherapy treatment can be quantified using the excessive absolute risk (EAR) concept (Reference 1). Estimation of radiation-induced secondary cancer risks is difficult due to scarcity and heterogeneity of clinical data. Based on different underlying assumptions of cell response to radiation damage, several mathematical models exist to predict EAR values for a specific organ based on dose delivered and the fractionation scheme used. To compare existing EAR models, and to compare predicted EAR risks with different radiotherapy treatment modalities, we evaluated EAR values for secondary lung cancer from SBRT treatment of early-stage non-small cell lung cancer for three EAR models with three delivery techniques.

Among the EAR models in this study, the linear model assumes a simple linear relationship between secondary cancer risk and dose delivered to a unit volume of the organ. The linear-exponential model, on the other hand, takes into account cell sterilization effect of radiation. The linear-plateau model assumes a flat risk profile when radiation dose reaches a certain level. The parameters for the EAR models were obtained from clinical data on secondary cancer occurrence rates of Hodgkin’s disease patients.

Ten patients with non-small cell lung cancer who previously received SBRT treatments to the lung were selected. The average planning target volume (PTV) was 91.1±67.7 cm$^3$. To evaluate relative secondary risks with different SBRT treatment modalities, a helical tomotherapy (HT) plan, a three-dimensional conformal radiotherapy (3D-CRT) plan, and a volumetric modulated arc therapy (VMAT) plan were generated for each of the ten SBRT cases in this study. All the plans were normalized so 95% of the planning target volume received at least the prescription dose. Both HT and VMAT plans were optimized with emphasis on minimizing lung dose, rather than dose homogeneity in the target volume.

The average EAR’s with each model for the ten cases were calculated. As expected, the linear model gave the highest EAR values, while the linear-exponential model gave the lowest EAR values. Paired t-tests were performed to evaluate the significance of the difference in EAR values in the three treatment modalities. There were no statistically significant differences among the three modalities ($p > 0.05$). The magnitude of variation of the EAR to the prescription dose was evaluated by varying the prescription dose in the range of 40 to 60 Gy. Figure 1 shows the mean EAR values as a function of dose for each treatment modality with each model.

![Figure 1: Mean EAR values for each treatment modality and each EAR model as a function of prescription dose. Unit of EAR: expected occurrence per 10,000 patients per year.](image)

References: