AbstractID: 6788 Title: Augmenting Lyman NTCP by adding the influence of non-dose variables via decision trees: application to lung radiation-pneumonitis prediction

Purpose:
Develop a model that augments the dose-based parametric Lyman NTCP formulation using non-parametric decision trees that can additionally account for the influence of non-dose variables. Apply and test the model to predict Grade 2+ lung radiotherapy (RT) induced pneumonitis.

Methods and Materials:
The model was created by sequentially combining weighted sub-models (prediction units) using a recent statistical “boosting” technique. Boosting progressively improves model accuracy with the addition of each prediction unit. Each prediction unit was composed of the sum of the Lyman NTCP (LNTCP) metric and a decision tree. Thus, shortcomings in the more rigidly parametric dose-based LNTCP metric were compensated by decision trees, which selected specific dose and non-dose features to further separate the injured-uninjured populations. The database used to create the model consisted of 234 lung cancer patients treated with RT, of whom 43 were diagnosed with pneumonitis at followup. A realistic estimate of model predictive capability was obtained via 10-fold cross-validation. To facilitate dissemination, a simplified version of the complex model structure was extracted from the cross-validation results.

Results:
The cross-validated model Receiver Operating Characteristics area of 0.72 was significantly better than the corresponding LNTCP area of 0.63 ($p=0.005$). Important variables extracted by the simplified model were: LNTCP, sex, histology, chemotherapy schedule, and treatment schedule. For a given patient radiotherapy treatment plan, injury prediction was highest and lowest for the combinations [pre-RT chemotherapy, once-daily treatment, female sex] and [no pre-RT chemotherapy, non-squamous-cell histology], respectively. Application of the simplified model to two example patients reveals that non-dose variables can heavily influence radiation-pneumonitis prediction (e.g., 3%-64% for various settings of non-dose variables).

Conclusions:
Radiation-pneumonitis prediction was significantly improved by adding the influence of non-dose variables to Lyman NTCP. The simplified model has an easily interpretable architecture that combines Lyman NTCP with a single decision tree.