Abstract

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Improving the efficacy of functional lung avoidance radiation therapy

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Functional lung avoidance radiation therapy (RT) is a technique being investigated to avoid specific regions of the lung that are more susceptible to radiation-induced damage. Reducing dose delivered to high functioning regions may reduce the occurrence of radiation-induced lung toxicities. There is a need to improve current approaches to functional avoidance RT by accounting for irradiating the airways, and developing more accurate models of post-RT ventilation change. The purpose of this work was to develop dose-response models for ventilation changes, investigate indirect ventilation decline due to airway irradiation, and incorporate functional information into the treatment planning process.

Analysis was performed in swine to investigate the effect of irradiating airways and regional ventilation change. A dose-response relationship was observed with reduction in luminal area of the airways. Regions supplied by irradiated airways experienced larger loss in ventilation post-RT compared to regions supplied by unirradiated airways. Additional analysis was performed on human subjects and quantified the relationship between airway resistance and 4DCT-based ventilation changes. Increased cumulative airway resistance was significantly associated with decreases in ventilation function for the region

those airways supplied. A normal tissue complication probability model was built to predict bronchial stenosis.

A polynomial regression model was built to predict change in ventilation based on pre-RT ventilation and dose. This model accounted for out-of-phase ventilation by using a new methodology to derive ventilation maps using multiple phases of the 4DCT, and improved a previously developed model in accuracy and gamma pass rates. Additionally, a conditional generative adversarial network model was developed, and improved upon the polynomial regression model in predicting regions of ventilation decline.

Lastly, a new methodology was developed to incorporate functional information into the treatment planning process. This approach utilized dose-painting-by-numbers to create voxelized dose objectives within the lung based on predictions from the cGAN model. The model developed for airway toxicities was used to include dose objectives to limit the occurrence of bronchial stenosis. The new workflow resulted in more spared lung function compared to standard of care as well as the currently used method for functional avoidance plans.