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Evaluation of Variables Predicting Pulmonary Function Test (PFT) Changes for Lung Cancer Patients Treated On a Prospective 4DCT-Ventilation Functional Avoidance Clinical Trial

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MEDICAL PHYSICS

Ballroom C: Multi-Disciplinary SNAP Oral; Functional, Biologic and Anatomic IGRT

SU-F-BRC-01, Evaluation of Variables Predicting Pulmonary Function Test (PFT) Changes for Lung Cancer Patients Treated On a Prospective 4DCT-Ventilation Functional Avoidance Clinical Trial: N Ghassemi[1*], R Castillo[2], E Castillo[3], B Jones[4], M Miften[5], B Kavanagh[6], B Lu[7], M Werner-Wasik[8], R Miller[9], J Barta[10], I Grills[11], T Guerrero[12], C Rusthoven[13], Y Vinogradskiy14</sup>,(1) Thomas Jefferson University Hospital, Philadelphia, PA, (2) Emory University, Atlanta, GA, (3) University of Texas at Austin, Austin, TX, (4) University of Colorado School of Medicine, Aurora, CO, (5) University of Colorado School of Medicine, Aurora, CO, (6) University of Colorado School of Medicine, Aurora, CO, (7) University of Florida, Gainesville, FL, (8) Sidney Kimmel Cancer Center at Thomas Jefferson University Hospital, Philadelphia, , (9) Thomas Jefferson University, , , (10) Thomas Jefferson University, , , (11) Beaumont Health System, Royal Oak, MI, (12) , Royal Oak, MI, (13) University Of Colorado Anschutz Medical Campus, , , (14) Thomas Jefferson University, Philadelphia, PA

Purpose: Functional avoidance radiotherapy uses functional imaging to reduce pulmonary toxicity by designing radiotherapy plans that reduce doses to the functional lung. A novel form of lung functional imaging uses 4DCT imaging to calculate 4DCT-based lung ventilation (4DCT-ventilation) maps. A phase-II, multi-center, prospective study of 4DCT-ventilation functional avoidance was completed. Pre and post-treatment pulmonary function tests (PFTs) were acquired in order to quantitatively assess pulmonary function change. The purpose of this study is to evaluate which factors predict for PFT changes for patients treated with 4DCT-ventilation functional avoidance radiotherapy. **Methods:** 56 patients with locally advanced lung cancer receiving radiotherapy were accrued. Each patient had a 4DCT-ventilation image generated using 4DCT scans and image procession techniques. Favorable arc geometry and optimization techniques were used to generate functional avoidance plans based on the 4DCT-ventilation images. PFTs were obtained at baseline and 3 months following radiotherapy and included forced expiratory volume (FEV1) and forced vital capacity (FVC). The ability of patient, clinical, dose (lung and heart doses), and dose-function metrics to predict for PFT changes was evaluated using linear regression. Dose-function metrics were calculated as doses (mean dose, V20) to 4DCT-ventilation-based functional regions of the lung**. Results:** The mean pre- to post-treatment changes in FEV1 and FVC were -6.5%+18.1% (mean ± standard deviation) and -9.0%+20.1%, respectively. No patient, clinical, or standard dose metrics were predictive of PFT changes. Dose-function metrics were predictive of FEV1 decline ($p=0.048$) and approached significance for predicting FVC decline ($p=0.061$)**. Conclusion:** The current work is the first to assess factors predicting for PFT changes for lung cancer patients treated on a prospective functional avoidance radiotherapy study. The data revealed that lung dose-function metrics were predictive of PFT changes, therefore validating the significance in reducing doses to functional portions of the lung in order to mitigate decline in pulmonary function.

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SU-F-BRC-02, Using a Residual Neural Network to Predict Radiation-Induced Pulmonary Function Damage: E Wallat[1*], M Flakus[1], A Wuschner[1], J Reinhardt[2], G Christensen[2], J Bayouth[1],(1) University of Wisconsin, Madison, WI, (2) University of Iowa, Iowa City, IA

Purpose: To develop a machine learning-based dose response model that predicts pulmonary function following radiation therapy (RT) in low dose regions**. Methods:** A residual neural network (RNN) was developed and trained with 212 patient datasets (80/20 train/test split) from a prospective randomized clinical trial approved by our institution's IRB to predict post-RT pulmonary function. The RNN inputs were the pre-RT function map, dose distribution, and maximum inhale and exhale CT image volumes. Data was normalized using min-max normalization and online augmentation (rotation) was performed during each training batch. Stochastic gradient descent with momentum optimizer was used with an initial learning rate of 0.01; the loss was an asymmetrical structural similarity index measure (SSIM) function designed to increase penalization of under-prediction of functional damage. Dice similarity coefficient (DSC), SSIM, accuracy (ACC), true positive rate (TPR), and true negative rate (TNR) were used as evaluation metrics. RNN performance was evaluated against a previously developed polynomial regression model in low dose regions (<5 Gy) and the entire lung using paired t-tests for comparison. The validation dataset consisted of an additional 25 patient datasets**. Results:** In the low dose region, the RNN improved over the polynomial model in TPR, 0.12 to 0.56, and DSC, 0.21 to 0.50, but worsened in TNR, 0.99 to 0.83, ACC, 0.82 to 0.78, and SSIM, 0.90 to 0.89. For the entire lung, the RNN improved over the polynomial model in TPR, 0.12 to 0.63, and DSC, 0.20 to 0.49, but worsened in TNR, 0.98 to 0.78, ACC, 0.82 to 0.75, and SSIM, 0.91 to 0.90. All metrics were significantly ($p<0.05$) different between models**. Conclusion:** The proposed RNN model demonstrated significant improvement in TPR and DSC for both dose regions, which can improve the utility of functional avoidance RT by avoiding the specific regions predicted to decline in function.

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