Dosimetric Tradeoffs of Mean Heart Dose Reduction Predicted by Machine Learning-Guided Decision Support Software in Lung Cancer

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Purpose/Objective(s): Cardiac toxicity is a well-recognized risk in patients with non-small cell lung cancer (NSCLC) treated with radiation therapy (RT), however the extent to which modern treatment planning optimization can spare heart irradiation without untoward increases in lung dose or deficits in tumor coverage is unknown. We utilized a machine learning treatment planning prediction model to determine dosimetric tradeoffs between mean heart dose (MHD), lung dose, and tumor coverage in patients with NSCLC.

Materials/Methods: Retrospective analysis of RT plans from 185 consecutive patients with locally advanced NSCLC treated with intensity-modulated RT (IMRT)/volumetric modulated arc therapy (VMAT) or 3-dimensional conformal RT (3D-CRT). Plans were binned by treatment years 2013-2015 (n=78) and 2016-2018 (n=107). A predictive model using machine learning was built using a previously validated boosting framework and employed feature selection (e.g. CT images, beam energy, prescription dose) to avoid overfitting. The model used RT plans from 2016-2018 to predict treatment plans for each patient in 2013-2015 and compared these predictions to the actual delivered dose.

Results: From the 2013-2015 bin, 53% (41/78) were treated with 3D-CRT and 47% (37/78) were treated with IMRT/VMAT. From the 2016-2018 bin, 21% (22/107) were treated with 3D-CRT, while 79% (85/107) were treated with IMRT/VMAT. When using the 2016-2018 model to predict MHD for the 2013-2015 plans, 17.9% of plans (14/78) were predicted to have a MHD lower than that which was delivered, while 26.9% of plans (21/78) were predicted to have a MHD higher than what was actually delivered. When investigating dosimetric tradeoffs, a mean 5.3 Gy reduction in MHD could be achieved in 10.3% of plans (8/78) with a corresponding mean 2.8% increase in lung V20 Gy. Similarly, a mean 4.8 Gy reduction in MHD could be achieved in 14.1% of plans (11/78) with a corresponding mean 7.0% increase in lung V5 Gy and in 2.6% of plans (2/78) with a corresponding mean 1.9 Gy increase in mean lung dose. Planning target volume (PTV) coverage was reduced by a mean of 0.7% in 7.7% of plans (6/78) with a predicted mean 2.5 Gy reduction in MHD.

Conclusion: Nearly one out of five NSCLC patients were predicted to have a MHD lower than what was actually delivered, suggesting treatment planning optimization might be feasible with modern techniques and/or improved dosimetry insight. Furthermore, a MHD reduction of 5 Gy is predicted to be feasible in a subset of patients with potentially acceptable tradeoffs in lung dose, which based on our prior work, may result in a significant reduction in major adverse cardiac events. Together, these findings demonstrate the potential to utilize a decision support tool for optimizing dosimetric tradeoffs and help predict patients who might benefit most from experimental technologies such as proton RT.

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