Cancer Intergroup. **J.C. Roeske**: Research Grant; Varian Medical Systems. **M.M. Harkenrider**: Research Grant; NIH.

1146

Quantitative and Dosimetric Evaluation of Offline Adaptive Radiation Therapy Toward Establishing a Decision Support Framework for Evaluating the Necessity for Real-Time Adaptation

M. Reilly, J. Kavanaugh, O.L. Green, and S. Mutic; *Washington University School of Medicine, St. Louis, MO*

Purpose/Objective(s): To establish decision support metrics via quantitative assessment of dose volume histograms utilizing a retrospective analysis of patients who had secondary treatment plans in our clinic. Specifically, to establish the fraction number, trigger event, and length of time in days at which patients were re-scanned / re-planned to determine the dosimetric impact on a patient's overall composite treatment. Ultimately, this work will permit evolution of adaptive radiotherapy from qualitative / subjective review of a patient's chart and daily imaging toward evidence based / quantitative decision metric system.

Materials/Methods: Retrospective cohort of 52 lung, 35 breast, and 105 head and neck patients were included in an IRB approved study. The initial cohort was down-selected to 5 patients for each of the 3 treatment sites and utilized rescan CT for performing dosimetric outcomes of the composite plans versus if no action or intervention had been taken. Patient composite treatment plans were used for DVH comparison and the patients electronic records used to track progress through the offline adaptive radiotherapy workflow.

Results: Trigger events for determining a patient's candidacy for an on-treatment CT and re-plan included: tumor volume loss via daily CBCT, patient weight loss and/or gain >10%, localized edema, and daily setup and immobilization difficulties. The average length of time between a decision to re-scan a patient and implementation of their new treatment plan was 3.4 ± 1.2 days. The decision to perform adaptive radiotherapy ranged the central 80% of the radiotherapy course, e.g., no patients were adapted earlier or later than 10% of their total number of fractions.

Conclusion: The analyses indicate that adapting a patient's treatment plan with >50% of the total number of fractions remaining has a marginal quantitative influence on the patients composite treatment should an adaptive plan not have been performed, e.g., <1 Gy mean dose sparing for OAR (dependent on proximity to the target). However, for those patients who were adapted earlier in their radiotherapy course an approximate 2-8% improvement in the new target volume covered by prescription dose was observed. This indicates that a new paradigm in monitoring a patient's radiotherapy fractionation course should be considered − moving from a strictly interval or weekly review of a patient's treatment to one that considers a non-linear observation with considerable more emphasis on a front-loaded review.

Author Disclosure: **M. Reilly**: None. **J. Kavanaugh**: None. **O.L. Green**: None. **S. Mutic**: Honoraria & Travel; ViewRay, Inc., Varian Medical Systems, Siemens Healthcare. Stock; Radialogica, LLC. Partnership; TreatSafely, LLC. Responsible for the technical direction of the company; Radialogica, LLC. Responsible for general management of the organization and all aspects of the business; TreatSafely, LLC.

1147

Development of a Novel Deep Learning Algorithm for Autosegmentation of Clinical Tumor Volume and Organs at Risk in Head and Neck Radiation Therapy Planning

B. Ibragimov,[1] F. Pernuš,[2] P. Strojan,[3] and L. Xing[4]; *[1]Stanford University, Stanford, CA, [2]University of Ljubljana, Ljubljana, Slovenia, [3]Institute of Oncology, Ljubljana, Slovenia, [4]Department of Radiation Oncology, Stanford University, Stanford, CA*

Purpose/Objective(s): Accurate and efficient delineation of tumor target and organs-at-risks is essential for the success of radiotherapy. Despite the decades of intense research efforts, auto-segmentation has not yet become clinical practice. In this study, we present a random forest- and deep learning-based algorithm for object classification with the aim to automatically segment organs-at-risk (OAR) for head and neck (H&N) treatment planning.

Materials/Methods: Fifteen H&N cases with CT, MR, and PET images were collected and saved in a library of plans. Experienced physicians manually annotated OARs including spinal cord, brainstem, optic nerves, chiasm, eyes, mandible, tongue, parotid glands. We also have ten super-resolution MR images of the tongue area, where the genioglossus and inferior longitudinalis tongue muscles are defined as organs of interest. We applied the concepts of random forest- and deep learning-based object classification for automated image annotation in order to investigate feasibility of using machine learning for head and neck radiotherapy planning process. In this new paradigm of segmentation, random forests were used to automate the landmark detection from the target super-resolution MR images. The detected landmarks then guided landmark-based atlasing of manual segmentations from training images to the target image. The landmarks are also used to automatically measure the morphological properties of the depicted organs. Alternatively to auto-segmentation with random forest-based landmark detection, we applied deep convolutional neural networks for voxel-wise segmentation of OARs in single and multi-modal images.

Results: We presented a comprehensive study on using machine learning concepts for auto-segmentation of OARs and tongue muscles for the H&N radiotherapy planning. An accuracy of 1.87 mm was achieved in the random forest-based landmarks detection, which, taking into account imperfection of MR images, can be considered to be close-to-human landmark detection performance. Even for the most challenging structures such as the genioglossus and inferior longitudinalis tongue muscles, segmentation accuracy measured in terms of Dice coefficient was of 81.8%, which is close to inter-rater variability. Overall, the use of deep-learning afforded an unprecedented opportunity to improve the accuracy and robustness of OAR segmentation.

Conclusion: A novel machine learning framework has been developed for image annotation and structure segmentation. Our results indicate the great potential of deep learning in radiotherapy treatment planning.

Author Disclosure: **B. Ibragimov**: None. **F. Pernuš**: None. **P. Strojan**: None. **L. Xing**: ; Stanford University.

1148

Computed Tomography Ventilation Image Guided Adaptive Functional Avoidance in Radiation Therapy for Locally Advanced Lung Cancer

T. Yamamoto,[1] S. Kabus,[2] M. Bal,[3] P. Keall,[4] S.H. Benedict,[1] C. Wright,[1] and M.E. Daly[1]; *[1]University of California Davis Comprehensive Cancer Center, Sacramento, CA, [2]Philips Research, Hamburg, Germany, [3]Philips Healthcare, Best, Netherlands, [4]University of Sydney, Sydney, Australia*

Purpose/Objective(s): An emerging technology, CT ventilation imaging, which enables lung functional avoidance radiotherapy (RT), has recently been translated into the clinic to reduce pulmonary toxicity. Tumor regression during a course of treatment is common in lung cancer RT, and often leads to recovery of lung function. Adaptive RT (ART) strategies that account for such changes have not been explored to date. We hypothesized that CT ventilation image-guided adaptive functional avoidance significantly reduces the dose to the functional lung compared to conventional planning schemes.

Materials/Methods: Repeat CT scans were acquired before RT and during a course of RT after ~20 Gy and ~34 Gy for five patients with locally advanced lung cancer enrolled on an ongoing prospective clinical trial. Ventilation images were calculated by deformable image registration of 4D CT image data sets and quantitative image analysis. Spatial heterogeneity of ventilation was assessed based on the difference between the ipsilateral to contralateral ventilation ratio and unity. Four IMRT plans were created for each patient: (1) functional ART, (2) anatomic ART, (3) functional non-ART, and (4) anatomic non-ART. Functional plans were designed to selectively avoid functional lung regions and meet dose-function constraints as well as standard constraints to other normal tissues, while anatomic plans were designed to meet standard constraints. Plan adaptation was performed after both 20 Gy and 34 Gy for ART plans. The following metrics were quantified for each plan: (1) the accumulated function-weighted mean lung dose (fMLD), and (2) mean accumulated dose to (0-25), (25-50), (50-75), and (75-100)% percentile ventilation regions. A paired *t*-test was used to compare those metrics of four plans to test the hypothesis.