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Abstract

Development of a Dose-driven Radiomic Feature Extraction Technique for Early-stage Non-Small-Cell Lung Cancer SBRT

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Objectives: Radiomics can extract and analyze quantitative features from medical images, which can potentially uncover subclinical disease characteristics in a non-invasive manner. The study aims to identify new quantitative parameters from the radiomic data of the peritumoral isodose distribution in the CT images for early-stage Nonsmall-cell Lung Cancer (NSCLC) SBRT evaluation.

Methods: 46 patients who received SBRT for early-stage NSCLC were retrospectively identified by an IRB approved clinical trial with treatment outcome provided. GTVs were segmented on the pre-treatment free-breathing CT images by radiation oncologists. Dose-driven peritumoral volumes were generated by converting ten isodose volumes (100%, 98%, 95%, 90%, 85%, 80%, 70%, 50%, 30%, and 10%) into structures. Peritumoral volumes were then modified by cropping out GTVs and non-lung tissue. 54 radiomic features (4 intensity, 21 GLCOM, 11 GLRLM, 13 GLSZM, and 5 NGLDM) were extracted for each peritumoral volume using an in-house radiomics calculation platform. Per radiomic feature per patient, the numeric values from ten dose-driven peritumoral volumes were plotted into curves. Per radiomic feature, an averaged curve of each patient's result was generated. Levenberg-Marquardt damped least-squares method was then used to find each feature curve's best fitting function. New quantitative parameters were extracted from the fitted averaged curve per radiomic feature. Relations between patients and radiomic features were qualitatively investigated by using k-means clustering algorithm. Patients and radiomic features were separated into different clusters for each newly developed parameter. Clustered heat maps were generated to facilitate the visualization of the classification groups. Davies-Bouldin (DB) index was calculated to evaluate the effectiveness of the clustering algorithm.

Results: 47 out of 54 averaged feature curves for ten dose-driven peritumoral volumes presented monotonic trends. 43 out of 47 monotonic feature curves fitted into quadratics of isodose levels with R2 > 0.95. From the clustered heat maps, selected newly developed parameters from the fitted isodose level curves with near-zero DB index showed better performance in separating patients and radiomic features into different clusters. Using parameters like the derivative and the min/max values of the fitted isodose level curves, DB index values were 0.04, 0.01, and 0.03 respectively. These values indicated the effective

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clustering results with high intra-cluster similarity and low intercluster similarity. Certain parameters, including max/min value locations of the fitted isodose level curves, did not reflect useful clustering information among the patients.

Conclusions: According to the clustered heat maps and DB index results, new quantitative parameters were successfully developed from peritumoral isodose distribution for early-stage NSCLC SBRT evaluation. New quantitative parameters from the curve can potentially help to train the machine learning models (in addition to the GTV radiomic features) to predict general recurrence of early-stage NSCLC SBRT. These parameters may also help with the determination of microscopic margin from GTV to CTV. Investigation in the performance of using dose-driven features and new parameters will be conducted.