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Development of a Radiomics-Based Prediction Model for Radiation-Induced Esophagitis in Lung Cancer Radiotherapy

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Background / Aims:

- Radiation-induced esophagitis (RIE) is a frequent dose-limiting toxicity in lung cancer radiotherapy. We aimed to develop a radiomics-based model to predict Grade ≥2 RIE using planning CT and dose distribution data.

Subjects and Methods:

1.Patient Cohort and Data Extraction

- 30 Lung Cancer Patients analyzed following thoracic radiotherapy
  - 14 patients Grade ≥ 2 esophagitis, 16 patients Grade < 2 toxicity
- Radiomics features were extracted using LIFEx 7.6.0
- Four Data Sources for feature extraction: Planning CT scans, RT dose distributions, Dose-Volume Histograms (DVH), and clinical factors

2.Three-Step Feature Selection Pipeline

1.Initial Screening: Combined filtering using:
- Univariate logistic regression ($p<0.05$)
- LASSO regularization and Random Forest recursive feature elimination (RFECV)
- VIF filtering (VIF < 5) to ensure low multicollinearity

2.Redundancy Reduction: Spearman correlation analysis to remove redundant features

3.Final Model: Multivariate logistic regression with backward stepwise selection

Result:

1. Selected Radiomics Features

- Geometric Uncertainty (CentreOfMassShift)
  - Quantifies the shift between the planned esophageal position and the actual RT dose distribution
- Heart Dose Sparing Quality (LowGreyLevelRunEmphasis)
  - Measures the quality of heart dose sparing by assessing the prevalence of consecutive low-dose regions within the heart contour
- Hotspot-Esophagus Proximity (SmallestDist)
  - Measures the smallest 2D axial distance from the maximum radiation intensity point (hotspot) to the esophageal wall

Performance	
Accuracy	0.87
Precision	0.86
Recall	0.86
F1 Score	0.86
AUC	0.93

Table 1. Performance metrics of the RIE prediction model developed by the finalized features.

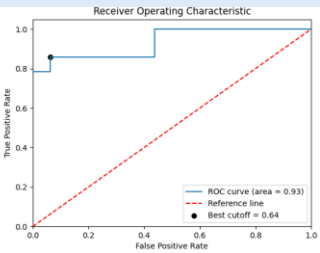

Figure 1. ROC for RIE prediction model dev eloped by the finalized features.

2. Final Prediction Equation

The final logistic regression equation for prediction RIE probability *(p)* was:

$$logit(p)=(-0.3764)+(1.8504)\times CentreOfMassShift+(-2.6912)\times LowGreyLevelRunEmphasis+(-1.4497)\times SmallestDist$$

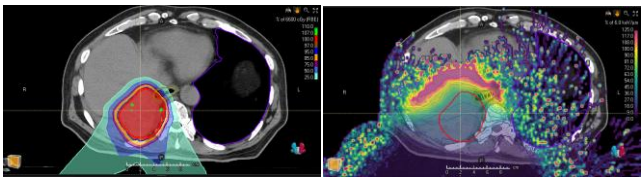

Figure 2. Representative Dose distribution (left) and LET distribution (right) of a patient case.

- The final model achieved high predictive performance (AUC = 0.93, Accuracy = 0.87), indicating excellent discrimination between high- and low-risk patients.

Conclusion:

- Our radiomics-based model effectively identifies patients at high risk of Grade ≥ 2 RIE, enabling early intervention and personalized plan optimization to minimize esophageal toxicity

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