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Background/Aim

Stereotactic body radiotherapy (SBRT) is an established treatment for early-stage non-small cell lung cancer and pulmonary metastases. Magnetic resonance-guided adaptive radiotherapy (MRgART) enables fraction-specific plan adaptation but introduces dynamic dose variations that may not be fully captured by conventional normal tissue complication probability models. We aimed to develop and validate a predictive model for clinically relevant radiation pneumonitis (RP ≥ grade 2) incorporating fraction-level dosimetric data.

Method

We retrospectively analyzed 93 patients with 135 lung lesions treated with MR-guided SBRT between 2020 and 2022, including 612 treatment fractions. Patient-, tumor-, and treatment-related variables were evaluated. Univariable logistic regression identified candidate predictors of RP ≥ grade 2, which were entered into multivariable logistic regression. Performance was assessed using independent test data, repeated cross-validation, bootstrapping, and metrics appropriate for rare event prediction.

Results

Clinically relevant RP occurred in 14 patients (15.1%). Higher mean lung dose (EQD2, α/β = 3) (Figure 1), lower baseline diffusion capacity (DLCO), and lower lobe tumor location were significantly associated with RP ≥ grade 2 (Figure 2). In multivariable analysis, these variables formed the optimal logistic regression model, achieving a ROC-AUC 0.79 (chance level 0.5), Precision-Recall AUC 0.45 (chance level 0.12) and Matthews correlation coefficient (MCC) 0.39 (chance level 0), confirming performance beyond chance (Table 1).

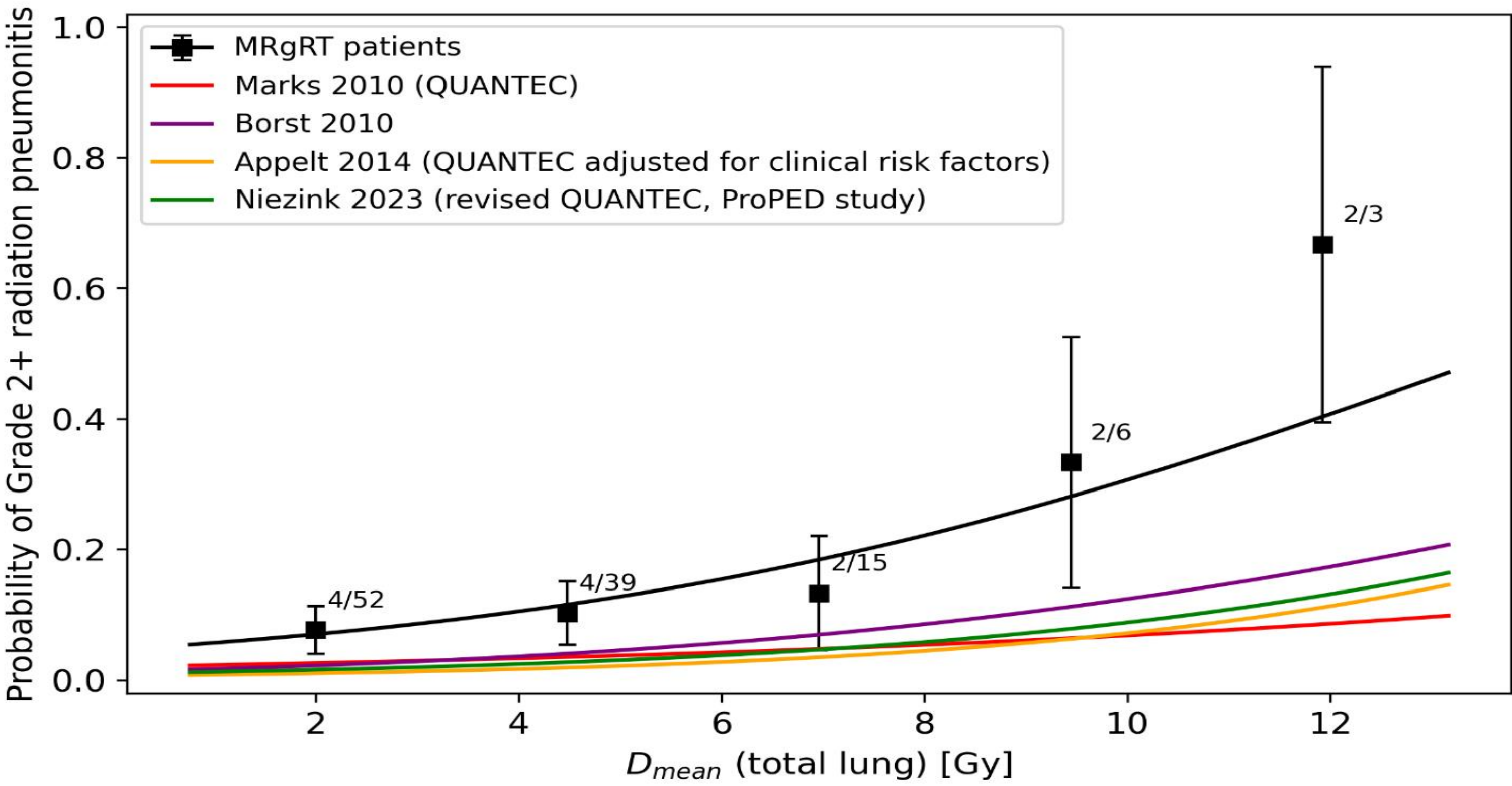


Figure 1 Probability of radiation pneumonitis ≥ grade 2 as a function of total lung D_{mean} (EQD2, α/β = 3).

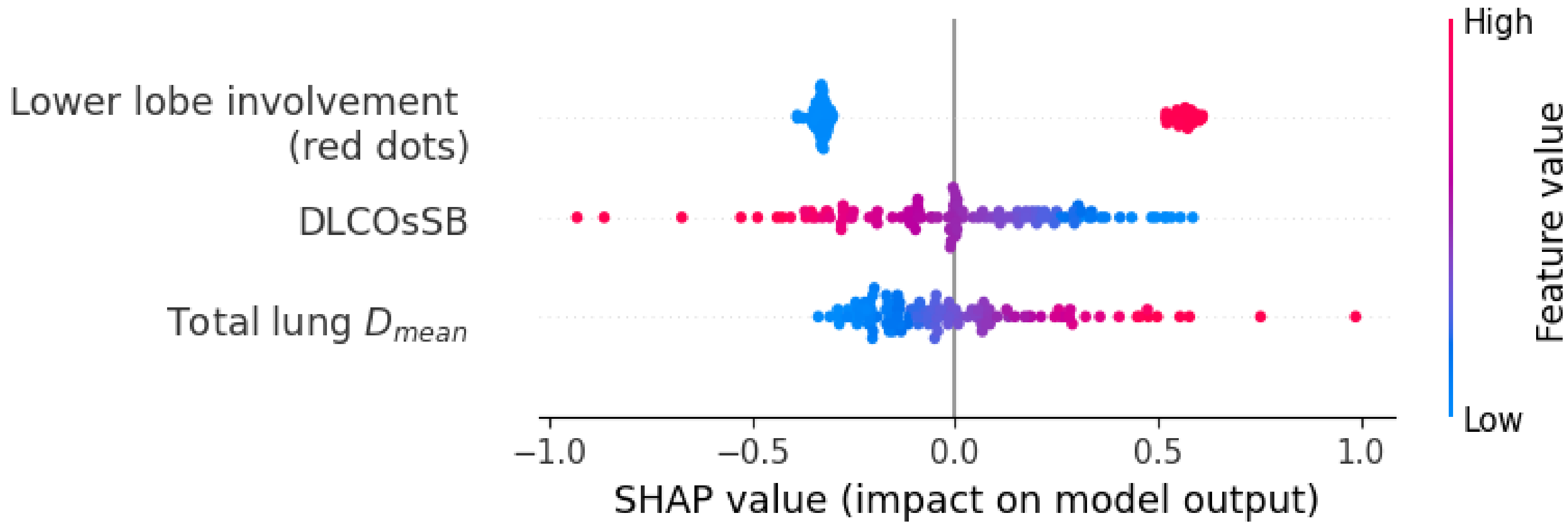


Figure 2 SHAP summary plot showing the impact of individual features and their values on the model output for prediction of RP ≥ grade 2.

Table 1 Performance metrics of the multivariate logistic regression model for prediction of RP ≥ G2			
Performance Metrics	ROC AUC [95% CI]	PR-AUC [95% CI]	MCC [95% CI]
	(baseline = 0.5)	(baseline = 0.12)	(baseline = 0)
5-fold CV (100 iterations)	0.79 [0.76–0.81]	0.45 [0.41–0.49]	0.39 [0.34–0.44]
Abbreviations: AUC = area under the curve; CV = cross-validation; MCC = Matthews correlation coefficient; PR = Precision-Recall; ROC = receiver operating characteristic.			

Conclusion

In MR-guided adaptive SBRT, mean lung dose, baseline pulmonary function, and tumor lobe location are key predictors of clinically relevant pneumonitis. A transparent multivariable logistic regression model provided robust performance, however further prospective validation is warranted.

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The corresponding author declares that there are no conflicts of interest related to this study.