

Predictive Modeling of Radionecrosis in Stereotactic Radiosurgery

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Purpose

Develop and validate a model to predict radiation necrosis (RN) following stereotactic radiosurgery (SRS) for brain metastases (BM).

Materials and Methods

- n = 168, single BM, single-fraction SRS (2 centers)
- Median [range] dose: 20 [15-24] Gy at 80% IDL; median follow-up: 15.5 months
- RN: CTCAE ≥ grade 2 + contrast-enhanced MRI findings
- 62 dosimetric and clinical variables for RN risk modeling
- Predictive parameter selection via nested cross-validation (CV) (Figure 1)
- RN incidence: Aalen-Johansen estimator (death as competing risk); group comparison: Gray's test

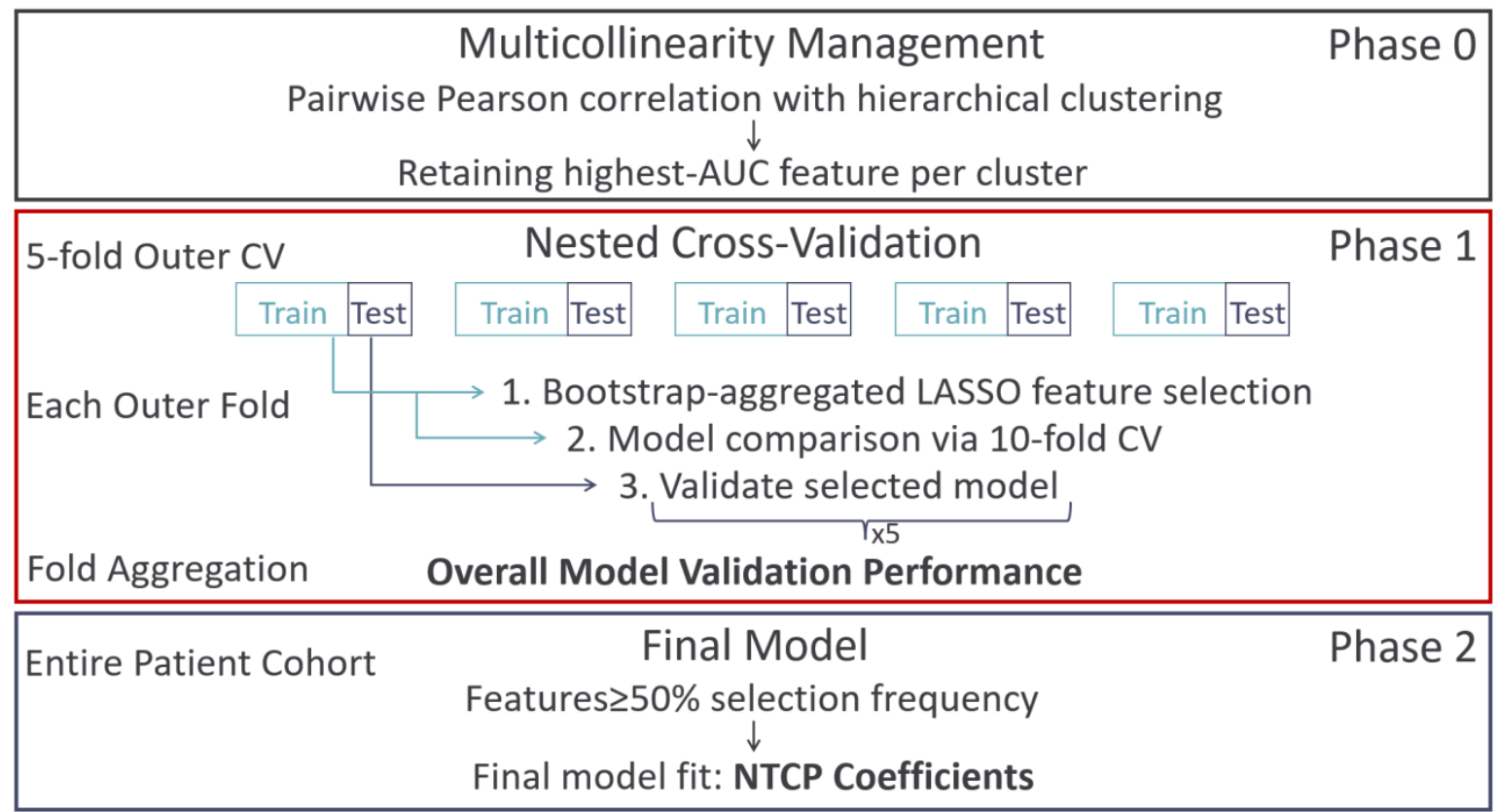


Figure 1. Three-phase methodological framework for RN prediction.

Results

- RN in 32 patients (19%); median [range] onset: 9 [4-63] months post-SRS
- Nested CV: Brain D35% as sole robust RN predictor (100% selected)
- Bootstrap-identified secondary candidates did not improve performance
- Brain D35% model performance: AUC = 0.69 (95% CI: 0.60-0.77) (Figure 2)
- Clear separation at Brain D35% Youden cutoff (p = 0.002; Figure 3)

Final NTCP Model: $1 / (1 + \exp(2.76 - 1.98 * \text{Brain D35\%}))$

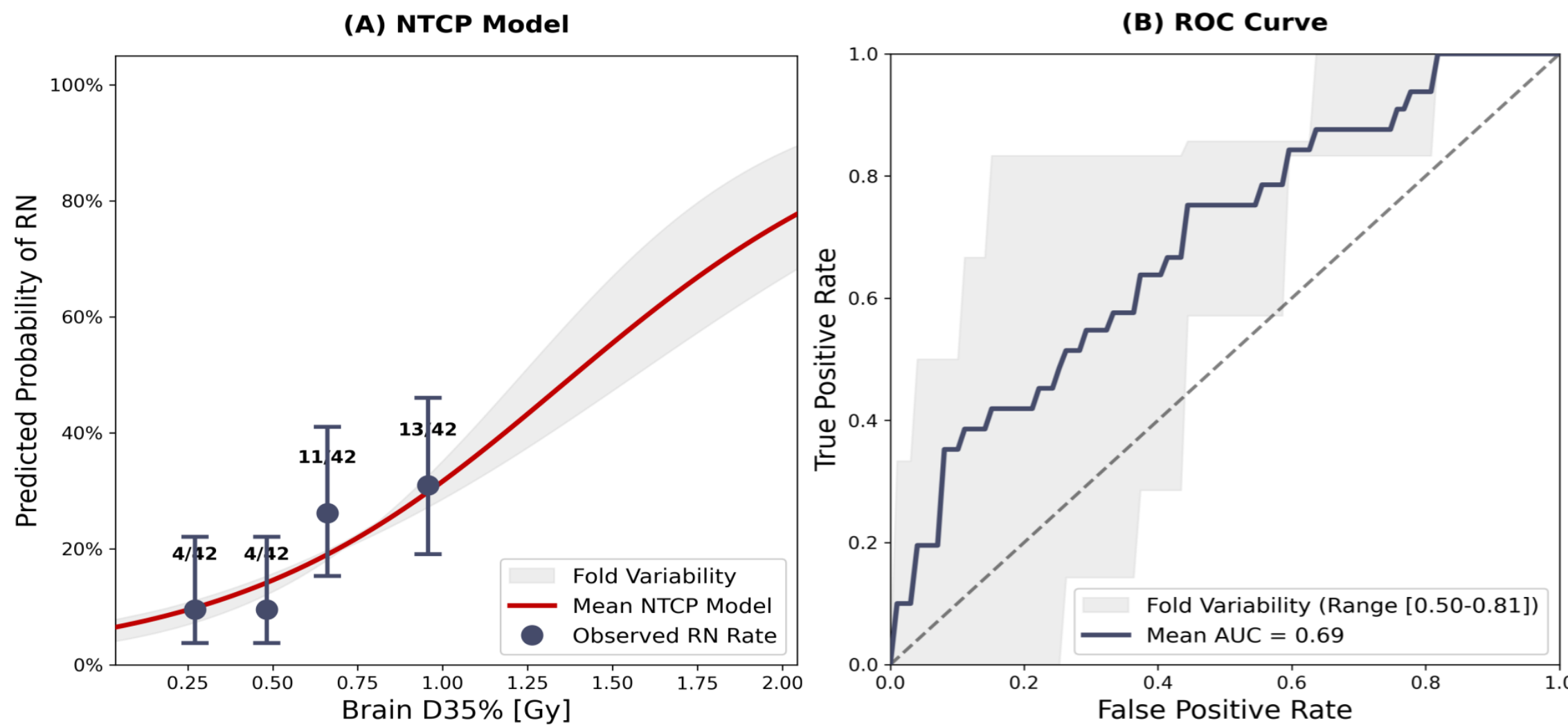


Figure 2. Validated model performance from nested CV. (A) NTCP dose-response curve (B) Mean ROC curve with fold variability.

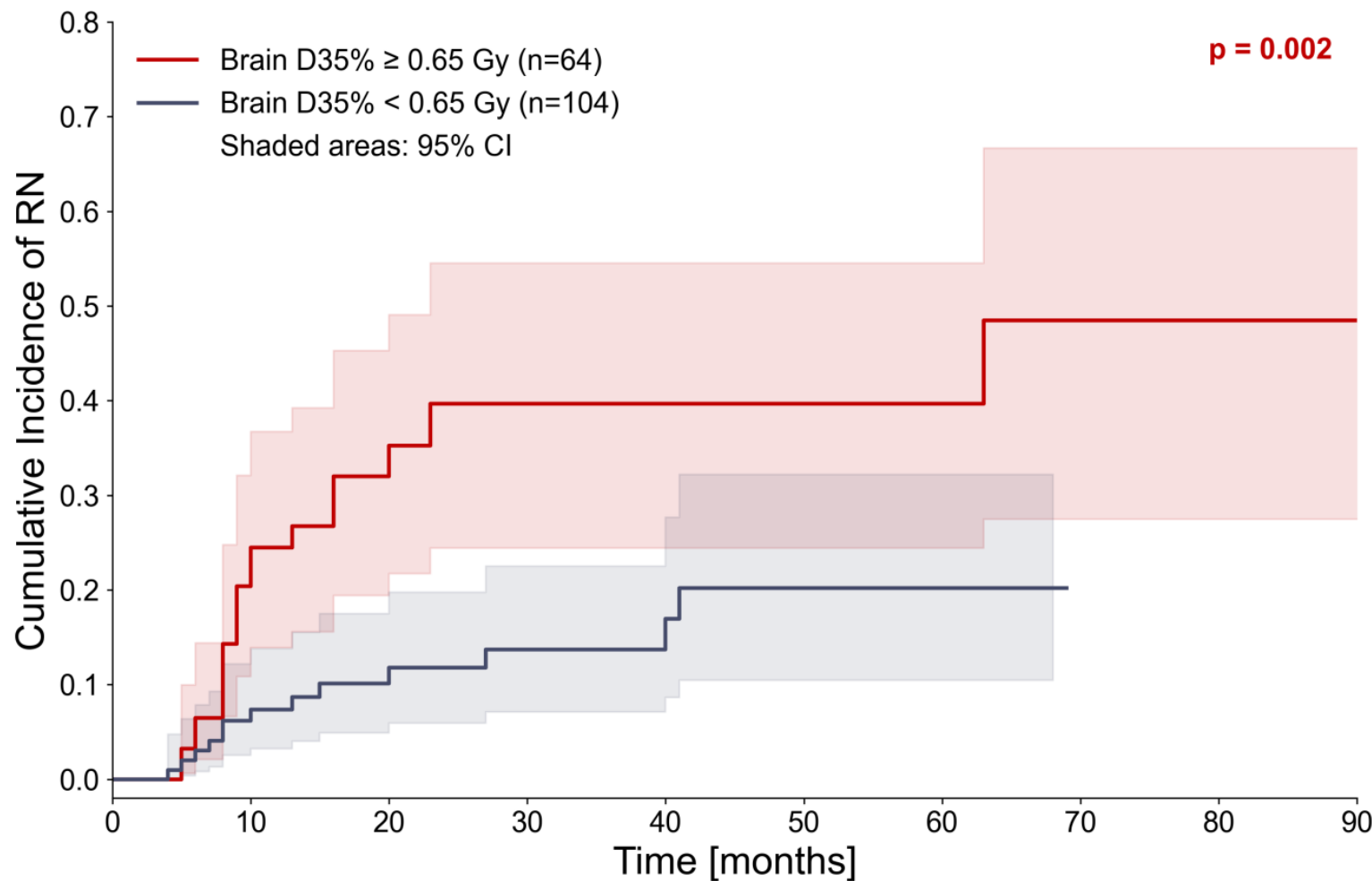


Figure 3. Cumulative incidence of RN stratified by Brain D35% Youden cutoff.

Conclusion

- Robust, bias-controlled NTCP modeling
- Brain D35% consistently identified as RN risk predictor
- Prospective external validation is warranted

Conflict of Interest

The Department of Radiation Oncology Tübingen receives financial support from Brainlab for this project.

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