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Preoperative Enhancing-Tumor Volumetrics Predict Survival in Adult-Type Diffuse Glioma

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Purpose

Adult-type diffuse gliomas are heterogeneous group of primary CNS tumors encompassing oligodendroglioma, astrocytoma, and glioblastoma. Patient prognosis changes across these subtypes, and definitive subtype diagnosis requires an integrated diagnosis that combines histology with molecular testing. In this study, we aimed to correlate preoperative tumor volumetric and size metrics with survival and evaluated whether such imaging-derived features can predict IDH mutation status.

Materials and Methods

This retrospective, single-center adult cohort from MD Anderson included patients with histologically confirmed WHO grade II–IV gliomas who underwent first surgical resection and had at least one complete preoperative MRI study (T1, post-contrast T1, T2, and FLAIR). Overall survival was measured from surgery to last follow-up or death. Shape features were extracted with PyRadiomics over predefined regions (enhancing, non-enhancing, edema, and whole tumor). For each metric, we estimated its association with survival using Cox models adjusted for age, sex, and pre-operative Karnofsky score; false-discovery rate control was applied for multiple testing, and proportional-hazards assumptions were checked for the top signals. To gauge multivariable stability, we performed a sparse penalized Cox analysis that allowed key clinical covariates to remain in the model and then refit selected imaging features to obtain adjusted hazard ratios. As an exploratory analysis, we evaluated whether adding individual volumetric features to a clinical model improved prediction of IDH status using cross-validated logistic models, reporting changes in AUC.

Results

We evaluated 80 pre-operative volumetric metrics in 939 patients with adult-type diffuse glioma. 62.5% of metrics were associated with overall survival after FDR control ($q<0.05$). The strongest signals reflected enhancing-tumor size. Surface area of the enhancing component was most predictive (HR per 1 SD = 1.58; 95% CI, 1.41–1.78; $q = 2.7\times10^{-12}$), followed by enhancing-lesion maximum 2D diameter (HR = 1.55; 95% CI, 1.38–1.75; $q = 2.0\times10^{-11}$) and maximum 3D diameter (HR = 1.53; 95% CI, 1.36–1.72; $q = 3.2\times10^{-11}$). Proportional-hazards checks showed acceptable behavior overall, with global PH tests flagging 4 of the top 10 models; no feature-specific violations were detected among those.
Using a clinical baseline of age and baseline KPS (CV AUC≈0.85), 21/80 volumetric features improved cross-validated AUC when added individually, and the best single feature yielded a modest ΔAUC of ~0.022 (AUC≈0.876). A 50×10-fold repeated screen confirmed small but consistent ΔAUC gains for top features. In nested cross-validated LASSO, the final model incorporated multiple imaging features, alongside age and baseline KPS. This model achieved strong discrimination (AUC ≈0.90) with good calibration. Full-sample

likelihood-ratio tests identified 18 imaging features with significant added value (q<0.05). Refit odds ratios indicated larger enhancing-surface area strongly associated with wild-type IDH, consistent with the survival findings.

Conclusion

Preoperative volumetrics in glioma were independently associated with overall survival. Adding single volumetric features to a clinical model provided only modest incremental discrimination for IDH status, though multivariable selection consistently prioritized enhancing surface area and surface-to-volume ratios. These findings suggest quantitative MRI can augment risk stratification and presurgical counseling.

References

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Figures