Surgical Complexity in Glioblastoma as Preoperative Measure to Predict Resectability, Functional Outcome and Survival

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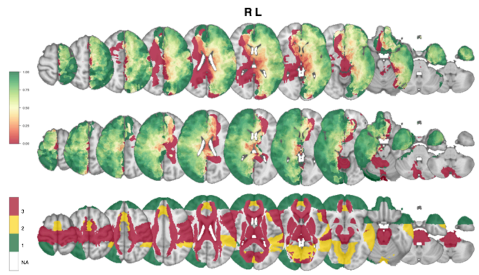
Introduction

Surgical decision-making in glioblastoma depends on a neurosurgeon's preoperative interpretation of brain eloquence, commonly based on anatomy. Here, we present tumor complexity based on prior surgical results as an update to brain eloquence. We compare brain eloquence and surgical complexity as predictor for resectability, survival, and functional outcome.

Methods

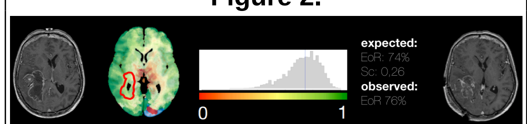
Adults with first-time glioblastoma surgery in 2012-2013 from 7 international referral centers for neuro -oncological care were included in this study. A resection probability map was constructed from segmentations of tumor before and after surgery (Fig 1). A surgical complexity score (0.0-1.0; normal-high complexity) was calculated for every preoperative tumor based on the resection probability map of all other patients (Fig 2). Brain eloquence was scored as the Sawaya eloquence grade (1). We analyzed the preoperative surgical complexity and the eloquence grading to predict resectability in terms of extent of resection and residual tumor volume using ROC analysis, patient survival using multiple Cox regression and postoperative functional changes using multivariable logistic regression.

Figure 1.



Surgical complexity as resection probability map for the left (upper row) and right hemisphere (middle row) and eloquence grading (lower row) in standard brain space. The RPM is calculated by voxel-wise summation of the number of patients without tumor removal (residual disease from incomplete resection or biopsy) divided by the summation of the number of patients with tumor removal in voxels where any patient had a tumor before surgery. A value of 0 (red) represents a location where tumor was never removed; a value of 1 represents a location where tumor was always removed (green). The eloquence grading is a labeling of the regions specified by Sawaya et al (1) where grade I is green, II orange and III red.

Figure 2.

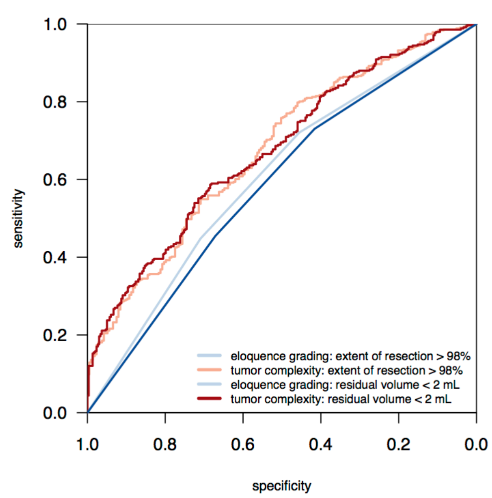


An overlay of a tumor on top of the RPM produces a histogram of the resection probabilities of all overlaid voxels combined and generates an expected extent of resection (median - blue bar). A Surgical complexity (Sc) is calculated by subtracting the median from 1.

Results

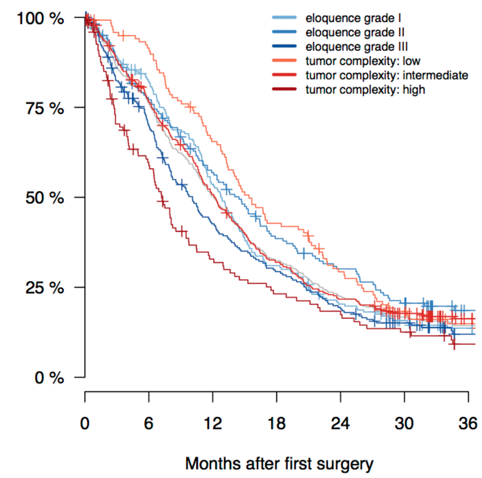
The study cohort consisted of 639 patients of whom 462 (72%) underwent a resection and 177 (28%) a biopsy. Resectability was predicted more accurately by the surgical complexity than the eloquence grading (P=0.002 and P=0.00003) (Fig 3).Higher surgical complexity (hazard ratio: 5.4, 95%CI 2.9-10) was associated with shorter survival, independent from higher age, lower preoperative Karnofsky, larger tumor volume and hospital; higher eloquence grading to a lesser extent (HR: 1.3, 95% CI 1.0-1.6) (Fig 4). Neither surgical complexity nor eloquence grade was associated with functional change improvement (change in KPS > 20) or deterioration (change in KPS < -20).

Figure 3.



Diagnostic accuracy of tumor (=surgical) complexity in red and eloquence grading in blue as receiver operating characteric curves for extent of resection and residual tumor volume for several thresholds.

Figure 4.



Kaplan-meier survival curves in months after diagnosis for categories of low, intermediate and high tumor (=surgical) complexity and eloquence grading I to III. Censoring is shown for last date of follow-up.

Conclusions

Surgical complexity correlates better with resectability and patient survival than brain eloquence, and may be useful for surgical decision-making.

Reference

1. Sawaya R, Hammoud M, Schoppa D, et al. Neurosurgical outcomes in a modern series of 400 craniotomies for treatment of parenchymal tumors. Neurosurgery. 1998;42(5):1044-1055.

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