Localizing seizure-susceptible brain regions in low-grade gliomas using voxel-based lesion–symptom mapping

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Introduction

Patients afflicted with Low-grade gliomas (LGG) frequently suffer fromepileptic seizures. The mechanisms of epileptogenesis in these patients remain poorly understood.

Methods

We present the first study to use a voxel-wise quantitative lesion analysis to investigate the spatial correlation between tumor location and seizure susceptibility. We prospectively collected the medical records and MR images of 410 LGG patients. The data set is divided into a discovery set (n=231) and a validation set (n=179) based on the hositals where the patients were treated. Voxel-based lesion–symptom correlative analysis was performed to determine whether tumor location associate with seizure risk based on the specific type of seizure (simple partial seizure, complex partial, and seizures with secondary generalization).

Table 1 Clinical characteristics

Characteristics	Seizures	No Seizures
Number of patients	152	79
Age, yrs Median (range)	37(15-64)	41(17-67)
Sex M/F	93/59	42/37
Tumor location		
Hemisphere L/R	82/70	42/37
MRI characteristics		
Tumor Size (Mean ± SD), cm³	73.6± 53.3	72.3± 61.8
Tumor pathology		
Oligodendroglioma	15	10
Astrocytoma	48	22
Oligoastrocytoma	89	47

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Table 2. Seizure characteristics

Characteristics	Secondary Generalized	Simple partial	Complex partial
Number of patients	107	17	28
Age,Median (range)	37(15-64)	39(15-61)	38.5(21-64)
Sex M/F	65/42	12/5	16/12
Hemisphere L/R	61/46	7/10	14/14
Tumor Size (Mean±SD), cm3	69.1	84.9	82.2
Tumor pathology			
Oligodendroglioma	11	2	2
Astrocytoma	29	4	15
Oligoastrocytoma	67	11	11

Table 2 Seizure characteristics

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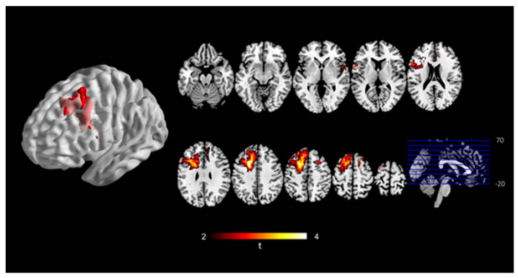
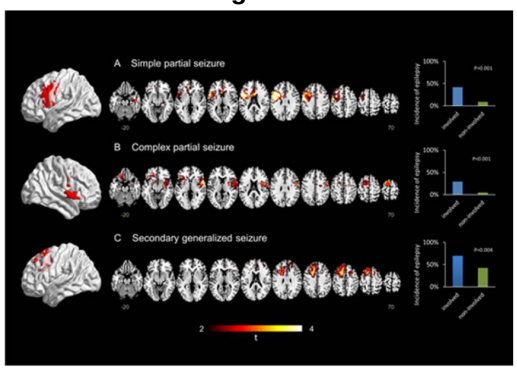
Figure 1



Voxel-based lesion–symptom mapping analysis showing epilepsy-susceptible brain regions associated with low-grade glioma. A voxel-wise comparison was performed between patients with and without seizures. The left frontal lobe is significantly susceptible to tumor-related seizures. The color range indicates the level of t-values from dark to light (least to most significance). Only significant voxels are rendered based on a critical threshold determined by permutation testing (n = 1,000, p<0.05).

Figure 2



Voxel-based lesion–symptom mapping analyses showing the symptom-specific seizure-susceptible brain regions associated with low-grade glioma. A voxel-wise comparison was performed among patients with a specific type of seizure (A, B, C) and those without. Significant clusters (p<0.05) were located in the left inferior frontal lobe for simple partial seizures, right anterior temporal lobe and insula for complex partial seizures, and left superior and middle frontal lobes for secondary generalized seizures. The color range indicates the level of t-values from dark to light (least to most significance). Only significant voxels are shown based on a critical threshold determined by permutation testing (n = 1,000, p<0.05). The graphs on the right show the incidence of epilepsy of each group with different seizure types (A, B, C) between lesions involved and non-involved the peak values.

Results

For all seizure types, increased seizure risks were identified for low-grade gliomas involving the left frontal pre-motor area. By seizure type, the LGGs involving the left inferior frontal gyrus were associated with increased risk of simple partial seizures. LGG involving the right temporal-insular region are associated with increased risk of complex partial seizure. LGG involving the left superior frontal lobe were more likely associated with seizures that secondarily generalize. These correlations were consistently observed in both the discovery and the validation data sets.

Conclusions

Our quantitative neuroimaging analyses support the notion that anatomical location of LGG is contributing factor in tumor-related epilepsy.

References

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Learning Objectives

Understand the anatomic basis for seizure risk in patients