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Radiomics analysis allows for precise prediction of epilepsy in patients with low-grade gliomas

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ABSTRACT

Purpose: To investigate the association between imaging features and low-grade gliomas (LGG) related epilepsy, and to propose a radiomics-based model for the prediction of LGG-associated epilepsy.

Methods: This retrospective study consecutively enrolled 286 patients with LGGs (194 in the primary cohort and 92 in the validation cohort). T2-weighted MR images (T2WI) were used to characterize risk factors for LGG-related epilepsy: Tumor location features and 3-D imaging features were determined, following which the interactions between these two kinds of features were analyzed. Elastic net was applied to generate a radiomics signature combining key imaging features associated with the LGG-related epilepsy with the primary cohort, and then a nomogram incorporating radiomics signature and clinical characteristics was developed. The radiomics signature and nomogram were validated in the validation cohort.

Results: A total of 475 features associated with LGG-related epilepsy were obtained for each patient. A radiomics signature with eleven selected features allowed for discriminating patients with epilepsy or not was detected, which performed better than location and 3-D imaging features. The nomogram incorporating radiomics signature and clinical characteristics achieved a high degree of discrimination with area under receiver operating characteristic (ROC) curve (AUC) at 0.8769 in the primary cohort and 0.8152 in the validation cohort. The nomogram also allowed for good calibration in the primary cohort.

Conclusion: We developed and validated an effective prediction model for LGG-related epilepsy. Our results suggested that radiomics analysis may enable more precise and individualized prediction of LGG-related epilepsy.

1. Introduction

Low grade gliomas (LGG; World Health Organization grade II) (Scheithauer et al., 2008) is the most common type of primary brain tumor in young adults (Sanai et al., 2011). A majority of patients with LGG experience tumor-related epilepsy during the course of the disease (Chang et al., 2008; van Breemen et al., 2007). The impact of tumor-related epilepsy on quality of life for patients with LGG is profound due to life-threatening complications associated with epilepsy onset as well as long-term cognitive damage induced by the use of antiepileptic drugs (Chang et al., 2008; Maschio and Dinapoli, 2012; Weller et al., 2012). Previous studies have suggested a number of risk factors for LGG-related epilepsy, including tumor location, peritumoral environment, and altered expression of the genes mediating neurotransmission(Huang et al., 2011; Pallud et al., 2014; van Breemen et al., 2007; Wang et al., 2015; Weller et al., 2012; You et al., 2012a), though the underlying etiology of such epilepsy remains to be elucidated.

Medical imaging, especially MRI, is indispensable in the investigation of the correlation between LGG and its secondary epilepsy for the ability to detect the brain activity noninvasively. Previous MRI-based demographic studies have mainly investigated the association between tumor location and related epilepsy, observing that involvement of

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Table 1
Clinical characteristic of patients in the primary and validation cohorts.

Characteristics	Primary cohort		*P*	Validation cohort		*P*
	Epilepsy	No epilepsy		Epilepsy	No epilepsy	
Age, y, median (range)	37(15–64)	40(17–67)	0.197	42(17–66)	45(8–72)	0.249
Sex, M/F	81/55	29/29	0.219	41/19	16/16	0.085
MRI characteristics						
Tumor size, mean ± SD	73.5 ± 51.2	72.6 ± 58.3	0.867[a]	71.4 ± 54.5	73.2 ± 60.1	0.796[a]
Tumor pathology (%)						
Oligodendroglioma	14	10	0.178	7	1	0.166
IDH-mutant and 1p/19q-codeleted	10	5		4	1	
NOS	4	5		3	0	
Diffuse Astrocytoma	43	19	0.876	18	14	0.187
IDH-mutant	26	10		9	8	
IDH-wildtype	7	3		3	3	
NOS	10	6		6	3	
Oligoastrocytoma	79	29	0.299	35	17	0.631
NOS	79	29		35	17	
Radiomics score	0.8236 ± 0.29173	0.3540 ± 0.29742	< 0.001[a]	0.6715 ± 0.37991	0.3734 ± 0.28888	< 0.001[a]

NOS, not otherwise specified.
[a] Result of *t*-test.

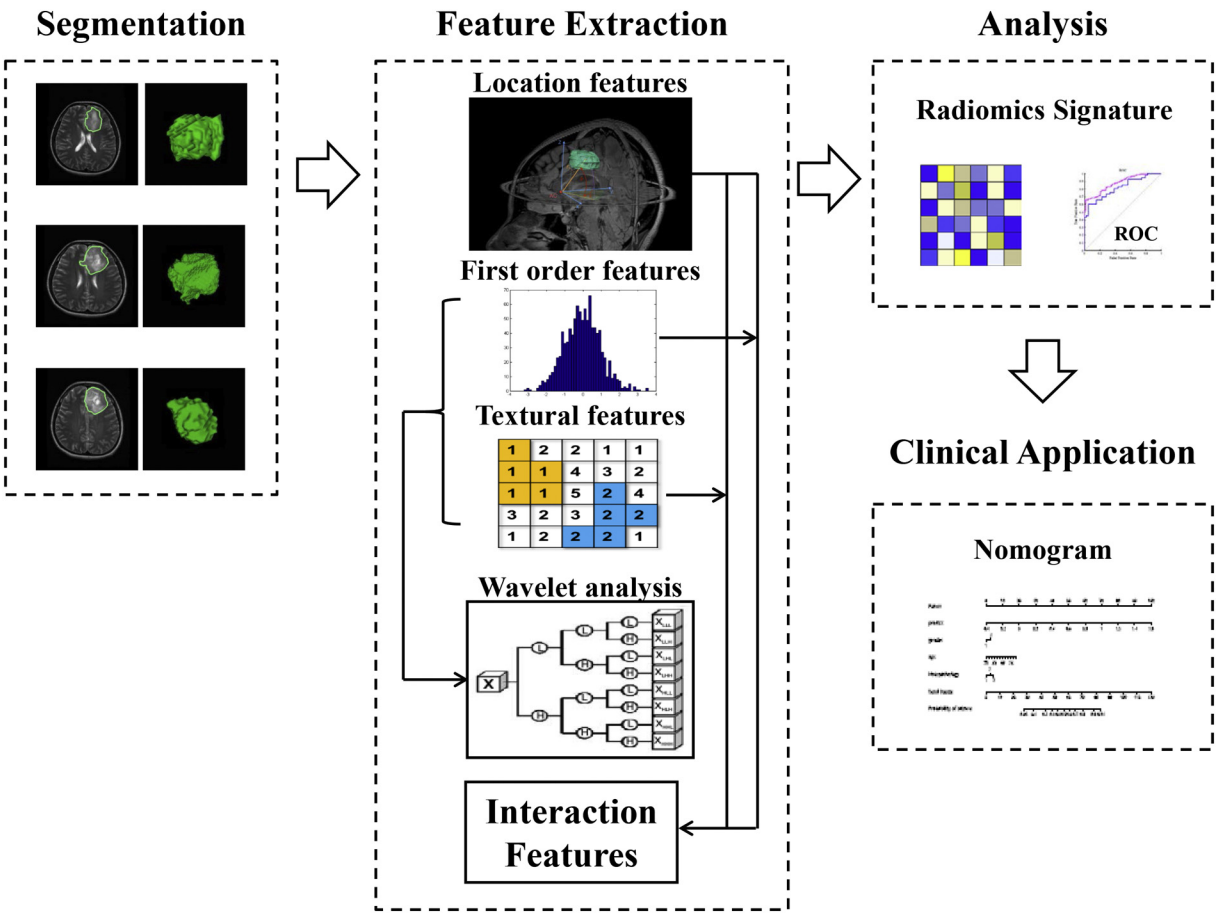

Fig. 1. Flowchart of the study. With manually segmented tumor, we first extracted 474 quantitative imaging features, including location features, 3-D imaging features, and their interactions from masked presurgical T2-weighted MRIs. The general view of the feature extraction algorithm was shown in the figure. Then, feature selection was applied on the extracted features with E-net and a radiomics signature was constructed with the selected features. Finally, radiomics signature and clinical characteristics were incorporated into a nomogram for individually prediction.

eloquent (Pallud et al., 2014), cortical (You et al., 2012b), and insular regions (Lee et al., 2010) is linked with the epilepsy occurrence in LGG patients. Further, a voxel-based imaging analysis provided a probabilistic risk atlas of glioma-related epilepsy (Wang et al., 2015). However, tumor location may be one among a number of comprehensive risk factors for LGG-related epilepsy, and few researchers have focused on the association between quantitative imaging features of intrinsic tumor lesions and epilepsy occurrence.

Advances in pattern recognition tools have facilitated the development of radiomics, which involves the extraction of a large number of quantitative features from medical images in order to determine relationships among these features and a given underlying