

Imprints Following MRI T2-FLAIR-Guided Extended Resection of Glioblastoma

Authors: Zhou Hui (1); Lu Ming (1); He Xiaojun (1); Lai Mingyao (2); Deng Xinghai (1); Lu Jiankan (1)

Date: 2017-12-07T00:00:00+00:00

Abstract

Objective To investigate the impact of extended resection of glioblastoma within the magnetic resonance T2Flair sequence range combined with adjuvant radiochemotherapy on patient prognosis.

Methods A retrospective analysis was conducted on 41 patients with intracranial glioblastoma who underwent surgery under awake anesthesia in our department from September 2010 to January 2016. Among them, 17 patients underwent extended resection of glioblastoma within the MRI T2Flair sequence range, while the remaining 24 patients served as a control group and underwent resection under T1-enhanced imaging. All cases utilized multiple adjunctive techniques during surgery including intraoperative neuronavigation combined with DTI, cortical electrical stimulation, intraoperative ultrasound, and intraoperative fluorescence imaging. Postoperative pathology confirmed glioblastoma (GBM) in all cases. The German Brainlab radiotherapy planning system was used to delineate preoperative and postoperative MRI T1-enhanced lesions and T2Flair ranges, perform image fusion, compare preoperative and postoperative volumes, and clarify the extent of tumor resection in T1-enhanced and T2Flair regions. All patients were followed up until January 2017, and postoperative patients received concurrent radiotherapy and adjuvant chemotherapy.

Results In the control group of 24 cases, all T1-enhanced lesions were completely resected, and no patients developed postoperative neurological dysfunction. Among the 17 patients who underwent extended resection in T2Flair imaging, 7 had 0-10% T2Flair resection, 4 had 10-25% T2Flair resection, and 6 had more than 25% T2Flair resection; All patients were followed up until January 2017. The median survival time was 30.45 months for the 17 GBM patients with T2Flair resection and 15.37 months for the 24 GBM patients in the control group, with a statistically significant difference between the two groups ($2=6.16$, $P=0.013$). For the groups with T2Flair resection ranges of 0-10%,

10-25%, and more than 25%, the median survival times were 20.16 months, 45 months, and 33 months respectively, with no statistically significant differences among the groups.

Conclusion The application of multiple adjunctive techniques including intraoperative neuronavigation combined with DTI, cortical electrical stimulation, intraoperative ultrasound, and intraoperative fluorescence imaging under awake anesthesia effectively ensured surgical safety for patients with intracranial GBM, improved the complete resection rate of lesions in T1-enhanced imaging, and enabled extended T2Flair resection within the maximum safe range; Extended gross total resection of T2Flair can significantly prolong the survival of GBM patients, but more T2Flair resection does not necessarily mean better outcomes, as there were no significant survival differences among different resection extents.

Full Text

Preamble

Journal of Molecular Imaging, 2017, Vol. 40, No. 3

doi: 10.3969/j.issn.1674-4500.2017.03.02

Expand Resection of Glioblastoma Under Magnetic Resonance T2Flair Imaging

ZHOU Hui¹, LU Ming¹, HE Xiaojun¹, LAI Mingyao², DENG Xinghai¹, LU Jiankan¹

¹Unit Five, Department of Neurosurgery; ²Department of Medical Oncology, Guangdong 999 Brain Hospital, Guangzhou 510510, China

Abstract

Objective: To investigate the impact of extended resection guided by MRI T2Flair sequences combined with adjuvant chemoradiotherapy on the prognosis of glioblastoma patients.

Methods: We retrospectively analyzed 41 patients with intracranial glioblastoma who underwent surgery under awake anesthesia between September 2010 and January 2016. Seventeen patients received extended resection based on MRI T2Flair sequence boundaries, while the remaining 24 patients served as controls and underwent resection based on T1-enhanced imaging. All procedures utilized intraoperative neuronavigation combined with DTI, cortical electrical stimulation, intraoperative ultrasound, and intraoperative fluorescence angiography. Postoperative pathology confirmed glioblastoma (GBM) in all cases. The German Brainlab radiotherapy planning system was used to delineate preoperative and postoperative T1-enhanced lesions and T2Flair regions for image fusion. Preoperative and postoperative volumes were compared to determine the extent of T1-enhanced and T2Flair resection. All patients were

followed until January 2017 and received postoperative concurrent radiotherapy and adjuvant chemotherapy.

Results: In the control group, all 24 patients achieved gross total resection of T1-enhanced lesions without postoperative neurological deficits. Among the 17 T2Flair extended resection patients, 7 had 0-10% T2Flair resection, 4 had 10-25% resection, and 6 had >25% resection. Follow-up through January 2017 revealed a median survival of 30.45 months for the T2Flair resection group versus 15.37 months for the control group, a statistically significant difference ($\chi^2=6.16$, $P=0.013$). Median survival times for the 0-10%, 10-25%, and >25% T2Flair resection subgroups were 20.16 months, 45 months, and 33 months, respectively, with no significant intergroup differences.

Conclusion: The application of awake anesthesia combined with intraoperative neuronavigation, DTI, cortical electrical stimulation, intraoperative ultrasound, and intraoperative fluorescence angiography effectively ensures surgical safety for intracranial GBM patients, improves the gross total resection rate of T1-enhanced lesions, and enables maximum safe-range extended T2Flair resection. Extended T2Flair resection significantly prolongs survival in GBM patients, though more extensive resection does not necessarily yield better outcomes, as no significant survival differences exist between resection degrees.

Keywords: glioblastoma; T2Flair; extended resection; awake anesthesia

1.1 General Information

We retrospectively reviewed 80 GBM cases treated surgically in the Department of Neurosurgery (Unit Five) of Guangdong 999 Brain Hospital between September 2010 and January 2016. Sixty-five cases employed awake anesthesia, with 41 meeting inclusion criteria: (1) age >15 years with adequate preoperative functional status, language, handedness, cognitive, and motor capabilities to cooperate; (2) no surgical contraindications; (3) postoperative pathology confirming GBM; (4) awake anesthesia with intraoperative neuronavigation combined with DTI, cortical electrical stimulation, intraoperative ultrasound, and intraoperative fluorescence angiography; (5) preoperative and postoperative KPS scoring; (6) postoperative MRI within 24-48 hours confirming T1-enhanced resection; (7) postoperative treatment per standard Stupp protocol; and (8) successful follow-up completion. The cohort comprised 28 males and 13 females, aged 15-67 years (mean 46.56). Tumor locations included frontal lobe (6), temporal lobe (10), occipital lobe (3), frontoparietal (3), frontotemporal (3), temporoinsular (5), temporo-occipital (3), thalamic/basal ganglia (3), and multiple lobes (5).

1.2 Grouping

The 41 patients were divided into two groups: 17 underwent extended T2Flair-based resection, while the remaining 24 control patients underwent T1-enhanced

imaging-based resection.

1.3 Surgical Methods

The surgical protocol consisted of: (1) preoperative counseling regarding awake anesthesia to ensure psychological preparation; (2) initial laryngeal mask intubation and general anesthesia for craniotomy; (3) post-awakening utilization of neuronavigation combined with DTI, cortical stimulation, ultrasound, and fluorescence to achieve gross total T1-enhanced lesion resection, with selected cases undergoing further T2Flair-extended resection while preserving neurological function; (4) closure with anesthesia resumption and re-intubation; (5) pathological confirmation of GBM; (6) early implementation of standard Stupp protocol upon stabilization; and (7) follow-up and clinical data collection.

1.3 Results Assessment

Consciousness was monitored using the Aspect-Vista EEG monitor to record bispectral index (BIS) values. Intraoperative localization of language, motor, and sensory areas was performed. All patients underwent KPS scoring preoperatively and postoperatively. Postoperative MRI within 48 hours assessed the extent of T1-enhanced resection.

1.4 T2Flair Resection Range Calculation Method

The German Brainlab radiotherapy planning system fused preoperative and postoperative MRI images to calculate T2Flair resection volume percentages. We delineated preoperative T1-enhanced volume (T1), T2Flair range (T2), postoperative T2Flair range (T3), and postoperative resection cavity (T4). Software-based 3D reconstruction calculated T1, T2, T3, and T4 volumes. The T2Flair resection ratio was calculated as: $1 - (T3 - T4) \div (T2 - T1)$, as illustrated in Figure 1 [Figure 1: see original paper]. The figure depicts: red = preoperative T1-enhanced volume (T1), dark yellow = preoperative T2Flair volume (T2), blue = postoperative T2Flair volume (T3), and light yellow = postoperative resection cavity (T4).

1.5 Statistical Methods

SPSS 20.0 software performed statistical analyses using independent samples t-tests and Kaplan-Meier univariate survival analysis. $P < 0.05$ indicated statistical significance.

2.1 Overall Data and Intraoperative/Postoperative Conditions

No significant differences existed in gender or age between groups ($P > 0.05$). All patients could follow intraoperative commands with BIS values > 80 (Figure 2A

[Figure 2: see original paper]). Multiple intraoperative techniques preserved neurological function, including language and motor areas. Motor functional areas were identified (Figure 2B), while neuronavigation combined with DTI and fluorescence clearly defined tumor boundaries (Figure 2C,D). Mean preoperative KPS scores were 92.93, decreasing postoperatively to 88.29, with no significant difference between the T2Flair extended resection group and controls ($P>0.05$), indicating that extended resection did not compromise neurological function or postoperative quality of life. Although 10 patients experienced decreased postoperative KPS scores, all recovered to preoperative levels after treatment. Postoperative MRI confirmed gross total T1-enhanced resection in all 41 patients (Figure 3A,B [Figure 3: see original paper]), with 17 achieving extended T2Flair resection (Figure 3C,D).

2.2 Patient Survival Time

Follow-up data revealed a median survival of 15.37 months for the 24 T1-enhanced resection patients versus 30.45 months for the 17 T2Flair extended resection patients (Figure 4 [Figure 4: see original paper]), representing a statistically significant difference ($\chi^2=6.16$, $P=0.013$). Among T2Flair subgroups, median survival times were 20.16 months (0-10% resection, $n=7$), 45 months (10-25% resection, $n=4$), and 33 months ($>25\%$ resection, $n=6$), with no significant intergroup differences ($P>0.05$, Figure 5 [Figure 5: see original paper]).

3 Discussion

Gliomas represent the most common malignant intracranial tumors, with an incidence of approximately 6.61 per 100,000 but exceptionally high morbidity and mortality. Glioblastoma, as a high-grade glioma, poses significant treatment challenges due to its highly invasive and infiltrative growth patterns, making complete resection difficult and recurrence common, resulting in poor prognosis. Current treatment principles emphasize maximal safe tumor resection combined with adjuvant chemoradiotherapy while preserving neurological function. Extent of resection directly impacts prognosis, with residual tumor volume serving as a critical prognostic factor. Gross total resection extends median survival in newly diagnosed GBM, and some evidence suggests T2Flair residual volume correlates with outcomes.

Historically, controversy surrounded extended resection due to concerns about increased neurological injury risk and questionable survival benefits. However, technological advances have revolutionized surgical safety and efficacy. Awake anesthesia, combined with intraoperative DTI-based neuronavigation, cortical stimulation, ultrasound, and fluorescence angiography, has dramatically expanded the operative landscape for functional brain areas, enabling safer extended resection. Consequently, eliminating potential recurrence sources during initial surgery has become paramount for improving GBM outcomes. Recent studies demonstrate that neuronavigation-guided T2Flair extended resection

beyond T1-enhanced lesions can further prolong survival when performed with multimodal technological support.

In our study, all 41 patients underwent awake anesthesia with neuronavigation, electrophysiological monitoring, direct cortical stimulation, ultrasound, and fluorescence, achieving gross total T1-enhanced resection. Seventeen patients underwent varying degrees of extended T2Flair resection. Although 10 patients experienced temporary postoperative KPS decline, all recovered to baseline, demonstrating the efficacy of multimodal techniques for intraoperative neurological protection. The overall median survival of 18.57 months exceeded reported values in contemporary literature, confirming that gross total and extended resection improve survival.

Our findings demonstrate that T2Flair extended resection significantly prolongs survival compared to T1-enhanced resection alone (30.45 vs. 15.37 months). However, survival did not correlate linearly with resection extent among subgroups (20.16, 45, and 33 months for 0-10%, 10-25%, and >25% resection, respectively). This lack of statistical significance may reflect insufficient sample size or suboptimal stratification, requiring further investigation to determine the optimal T2Flair resection percentage.

All patients received standard Stupp protocol chemoradiotherapy, which undoubtedly contributed to survival prolongation and remains essential adjuvant therapy. In conclusion, awake anesthesia combined with neuronavigation, DTI, cortical stimulation, ultrasound, and fluorescence angiography enables maximal safe resection of intracranial GBM while preserving function. Extended T2Flair resection significantly prolongs survival, offering a novel surgical strategy for GBM management, though the optimal resection range requires further study.

References

1. Chen W, Zheng R, Baade PD, et al. Cancer statistics in China, 2015[J]. *CA Cancer J Clin*, 2016, 66(2): 115-32.
2. Ostrom QT, Gittleman H, Liao P, et al. CBTRUS statistical report: primary brain and central nervous system tumors diagnosed in the United States in 2007-2011[J]. *Neuro Oncol*, 2014, 16(Suppl 4): iv1-63.
3. Schwartzbaum JA, Fisher JL, Aldape KD. Epidemiology and molecular pathology of glioma[J]. *Nat Clin Pract Neurol*, 2006, 2(9): 494-503.
4. Sanai N, Berger MS. Glioma extent of resection and its impact on patient outcome[J]. *Neurosurgery*, 2008, 62(4): 753-66.
5. Gorlia T, van den Bent MJ, Hegi ME, et al. Nomograms for predicting survival of patients with newly diagnosed glioblastoma: prognostic factor analysis of EORTC and NCIC trial 26981-22981/CE.3[J]. *Lancet Oncol*, 2008, 9(1): 29-38.

6. 王永志, 杨帆, 季玉陈, 等. 手术切除程度对胶质母细胞瘤预后预测因素的影响 [J]. 中国微侵袭神经外科杂志, 2015, (07).
7. Pan IW FS, treatment factors associated with survival among adult glioblastoma patients: A USA population-based study from 2000-2010[J]. J Clin Neurosci, 2015, 22(10): 1575-81.
8. Ostrom QT, Gittleman H, Fulop J, et al. CBTRUS statistical report: primary brain and central nervous system tumors diagnosed in the United States in 2008-2012[J]. Neuro Oncol, 2015, 17(4): 1-62.
9. 张忠, 江涛, 王忠诚. 功能区胶质瘤的手术治疗进展 [J]. 中国微侵袭神经外科杂志, 2006, (02): 88-90.
10. De Witte O, Levivier M, Violon P, et al. Quantitative imaging study of extent of surgical resection and prognosis of malignant astrocytomas[J]. Neurosurgery, 1998, 43(2): 398-9.
11. McGirt MJ, Chaichana KL, Gathinji MA, et al. Independent association of extent of resection with survival in patients with malignant brain astrocytoma[J]. J Neurosurg, 2009, 110(1): 156-62.
12. Hardesty DA, Sanai N. The value of glioma extent of resection in the modern neurosurgical era[J]. Front Neurol, 2012, 3(6): 140-2.
13. Feng C, Yang Y, DM Xiao, et al. Optimizing the extent of resection and minimizing the morbidity in insular high-grade glioma surgery by high-field intraoperative MRI guidance[J]. Turk Neurosurg, 2016, 25(7): 45-7.
14. 马翔宇, 李新钢, 刘佳, 等. 影响胶质母细胞瘤切除术后的预后因素分析 [J]. 中华神经外科杂志, 2008, 24(6): 464-7.
15. 张忠, 江涛, 谢坚, 等. 唤醒麻醉和术中功能定位切除语言区胶质瘤 [J]. 中华神经外科杂志, 2007, 23(9): 643-5.
16. Laws ER, Parney IF, Huang W, et al. Survival following surgery and prognostic factors for recently diagnosed malignant glioma: data from the glioma outcomes project[J]. J Neurosurg, 2003, 99(3): 467-73.
17. Almeida JP, Chaichana KL, Rincon-Torroella J, et al. The value of extent of resection of glioblastomas: clinical evidence and current approach[J]. Curr Neurol Neurosci Rep, 2014, 15(2): 517.
18. 周辉, 鲁明, 邓心情, 等. 术中唤醒麻醉结合定位技术切除脑深部病灶的临床研究 [J]. 中华神经医学杂志, 2015, 14(8): 835-8.
19. Grabowski MM, Recinos PF, Nowacki AS, et al. Residual tumor volume versus extent of resection: predictors of survival after surgery for glioblastoma[J]. J Neurosurg, 2014, 121(5): 1115-23.
20. 杨伯捷, 吴劲松, 姚成军, 等. 术中 MRI 监测下行胶质母细胞瘤扩大全切除术的临床研究 [J]. 中国临床神经科学, 2010, (04).

21. 梁进华, 刘湘衡, 白红民, 等. 多形性胶质母细胞瘤的预后影响因素分析 [J]. 中华神经外科杂志, 2016, 32(8): 831-5.

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.