# Insular glioma case series

Data from 100 cases of insular glioma treated by either a transsylvian or a transcortical approach were analyzed to see whether one or the other approach was more likely to be associated with surgically induced brain injury depending on the lesion location within the insula. This information can aid surgeons in determining whether insular glioma anatomy can inform a neurosurgeon's decision as to which approach is best suited for individual patients [1].

## 2018

A total of 50 patients with newly diagnosed insular glioma in the age group of 18-60 year, were evaluated with heart rate variability (HRV). All the HRV parameters in patients with insular glioma were compared with normal healthy age and gender matched controls.

There was a significant difference (p-value < 0.05) in most of the HRV parameters between patients and controls. Patients with left insular glioma showed significantly increased heart rate (p =0.027), LF nu (p=0.048), and also increased LF/HF (p=0.015), which indicates sympathetic dominance. Patients with seizures had significantly lower values of total power (p=0.042). No significant difference was found in terms of the extent and size of the tumor or histopathological grades of gliomas.

Patients with insular gliomas have significant impairment of autonomic functions with left insular glioma showing sympathetic dominance. Suppression of autonomic function is more in those presenting with seizures [2].

### 2017

The study population included adults who had undergone resection of insular gliomas between 1997 and 2015 at the Department of Neurological Surgery, University of California, San Francisco. Preoperative seizure characteristics, tumor characteristics, surgical factors, and postoperative seizure outcomes were reviewed.

One-hundred nine patients with sufficient clinical data were included in the study. At 1 yr after surgery, 74 patients (68%) were seizure free. At final follow-up, 42 patients (39%) were seizure free. Median time to seizure recurrence was 46 mo (95% confidence interval 31-65 mo). Multivariate Cox regression analysis revealed that greater extent of resection (hazard ratio = 0.2899 [0.1129, 0.7973], P = .0127) was a significant predictor of seizure freedom. Of patients who had seizure recurrence and tumor progression, seizure usually recurred within 3 mo prior to tumor progression. Repeat resection offered additional seizure control, as 8 of the 22 patients with recurrent seizures became seizure free after reoperation.

Maximizing the extent of resection in insular gliomas portends greater seizure freedom after surgery. Seizure recurrence is associated with tumor progression, and repeat operation can provide additional seizure control [3].

Data from patients treated at the Department of Neurosurgery, Erasmus MC , Rotterdam , The Netherlands. between 2005 and 2015 were analyzed retrospectively. The preoperative, intraoperative, postoperative, and longer term follow-up characteristics and outcomes of patients who underwent surgery for primary insular glioma using either an AC or GA were compared.

Of the 52 identified patients, 24 had surgery using an AC and 28 had surgery under GA. The extent of resection was similar for the two anesthesia techniques: the median extent of resection was 61.4% (IQR: 37.8-74.3%) in the WHO grade <4 AC group vs. 50.5% (IQR: 35.0-71.2%) in the grade <4 GA group and 73.4% (IQR: 54.8-87.2%) in the grade 4 AC group vs. 88.6% (IQR: 61.2-93.0%) in the grade 4 GA group. Consistent with literature, there were more early neurological deficits after an AC, while the GA group showed more new late neurological deficits; however, these trends were not significant. Survival was similar between the two groups, with 100% 1- and 2-year survival in the grade <4 groups.

Our results showed that the extent of resection, neurological outcomes, and survival were similar using the two anesthesia techniques. Since AC is more challenging for the patient and for his or her caregiver after surgery, this finding has implications for clinical decision-making [4)].

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From the Department of Neurosurgery, University of Oklahoma Health Sciences Center.Hyperaggressive resection refers to a philosophy that maximal resection should be pursued in gliomas, wherever possible. In this study, we provide a detailed report of the outcomes with hyperaggressive surgery for multilobar insular-involving gliomas (MIGs). Methods We report outcomes in patients with MIGs undergoing surgery aiming at gross total resection in all cases. Risk factors for neurologic deficits and survival were modeled using logistic and Cox regression. Results There were 72 consecutive patients, of whom 53 (74%) had undergone previous surgery. A greater than 90% resection was obtained in 67 patients (93%). Nineteen of 23 patients (83%) with Grade 2 tumors survived to the end of the follow-up period. Patients with Grade 3 tumors experienced 75% two-year survival rates and 48% four-year survival rates. Patients with Grade 4 tumors experienced 55% one-year survival rates and 33% two-year survival rates; eight of 33 patients (24%) lived longer than three years and three of 33 patients were alive at five years. Fifty-eight of 68 patients (85%) surviving to the three-month follow-up had a Karnofsky performance status (KPS) of 70 or greater, and 31 of 72 patients (43%) experienced improvement in KPS postoperatively. Permanent weakness occurred in 12 patients (17%), and permanent speech problems in three patients (13% of left-sided tumors). Conclusion Hyperaggressive surgical resection of MIGs yields rates of neurologic deficits within acceptable ranges and are lower than expected. In many cases, patients exceed the long-term survival expectations of conventional treatment [5)].

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Seventy-four patients who had undergone initial resection for insular glioma by the same surgeon between 2006 and 2016 were analyzed. Low-grade gliomas (LGGs) (grade II) and high-grade gliomas (HGGs) (grade III/IV) were analyzed for the prognostic role of volumetric EOR and molecular markers in patient survival outcomes.

The cohort included 25 patients with LGGs (33.8%) and 49 patients with HGGs (66.2%). Median EOR was 91.7% (range, 10%-100%). New permanent postoperative deficits were found in 2.7% of patients. Patients with LGGs with ≥90% EOR had 5-year survival of 100%, and patients with <90% EOR had 5-year survival of 80%. Patients with HGGs with ≥90% EOR had 2-year survival of 83.7%, and patients with <90% EOR had 2-year survival of 43.8%. For LGGs, EOR was predictive of overall survival (P =

0.017), progression-free survival (PFS) (P = 0.039), and malignant PFS (P = 0.014), whereas 1p/19q codeletion was predictive of PFS (P = 0.014). For HGGs, EOR was predictive of overall survival (P = 0.020) and PFS (P = 0.024). Preoperative tumor volume most significantly affected EOR for insular gliomas (R2 = 0.053, P = 0.048).

Extensive resections of insular gliomas can be achieved with low morbidity and can improve overall survival and PFS. In this series of LGGs, EOR was associated with longer malignant PFS, and 1p/19q codeletion was predictive of PFS [6].

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Panigrahi et al. retrospectively compared the clinical and outcome variables of 61 patients who underwent surgical resection of insular gliomas. The study population was divided into 2 groups according to the use of fMRI and DTI tractography in planning the resection. RESULTS: The average age of the study population was 44.1 ± 12.6 years with 21 (34.4%) of the patients women. Nearly two thirds of them (40, or 65.6%) had World Health Organization grade II tumors, and 16 patients (26.2%) had grade IV tumors. The most common tumor was glioblastoma, observed in 16 patients (26.2%). In 10 (16.4%) patients, fMRI and DTI tractography were used. The overall mortality in the study population was 15 (24.6%). None of the patients where fMRI and DTI were used for planning the surgery died (29.4% vs. 0.0%; P = 0.05), and all of them had normal functioning (70.5% vs. 100.0%; P = 0.05) at 3 months' follow-up. CONCLUSION: Surgical resection of insular gliomas remains a challenge to the neurosurgeon and demands good knowledge of anatomic landmarks. Use of fMRI and DTI tractography may help achieve a good outcome [7].

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Between July 2010 and July 2014, 51 insular HGG patients underwent operations guided by combined high-field iMRI and functional neuronavigation. Twenty-two insular HGG patients underwent conventional neuronavigation operations were assessed as the control group. Preoperative and postoperative tumor volumetric scan analysis, Karnofsky performance score (KPS) and follow-up results were reviewed retrospectively. RESULTS: Residual tumor was detected by the iMRI in 42 patients, and residual tumor of 37 patients was further resected in the iMRI-assisted group. The median extent of resection (EOR) increased significantly from 79% (58%?100%) to [96% (86%?100%), p < 0.001]. The median EOR of iMRI-assisted group [96% (86%?100%)] was significantly higher than that of conventional neuronavigation group [84% (69%?100%); p=0.031]. Mean residual tumor volume of iMRI-assisted group [0.6 (0.0-5.2) cm3] was significantly smaller than that of conventional neuronavigation group [3.8 (0.0-12.1) cm3; p=0.003]. KPS within 3 days after surgery reduced and KPS at 3 months after surgery improved for both groups. KPS of iMRI-assisted group [90(70-100)] was significantly higher than that of control group [80(60-100); p=0.021] at 3 months after surgery. The median progression-free survival (PFS) of iMRI-assisted group [18(9-42) months] was better than that of control group [15(3-32) months; p=0.010]. The median overall survival (OS) of iMRI-assisted group [28(14-49) months] was better than that of control group [18 (7-38) months; p=0.035]. CONCLUSION: Combined high-field iMRI and functional neuronavigation optimize the extent of resection and minimize the morbidity in insular HGG surgery. Aggressive resection of insular HGG is predictive of improved OS and PFS [8].

**2016**

A total of 211 consecutively collected patients diagnosed with low-grade insular gliomas was analyzed. All patients were classified according to whether tumor involved the putamen on MR

images. The prognostic role of this novel putaminal classification, as well as that of Yaşargil's classification, was examined using multivariate analyses.

Ninety-nine cases (46.9%) of insular gliomas involved the putamen. Those tumors involving the putamen, as compared with nonputaminal tumors, were larger ($p < 0.001$), less likely to be associated with a history of seizures ($p = 0.04$), more likely to have wild-type IDH1 ($p = 0.003$), and less likely to be totally removed ($p = 0.02$). Significant favorable predictors of overall survival on univariate analysis included a high preoperative Karnofsky Performance Scale score ($p = 0.02$), a history of seizures ($p = 0.04$), gross-total resection ($p = 0.006$), nonputaminal tumors ($p < 0.001$), and an IDH1 mutation ($p < 0.001$). On multivariate analysis, extent of resection ($p = 0.035$), putamen classification ($p = 0.014$), and IDH1 mutation ($p = 0.026$) were independent predictors of overall survival. No prognostic role was found for Yaşargil's classification.

The study findings of Wang et al., suggest that the putamen classification is an independent predictor of survival outcome in patients with insular low-grade gliomas. This newly proposed classification allows preoperative survival prediction for patients with insular gliomas [9].

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One hundred twenty-nine procedures involving 114 consecutive patients were identified. The study population from the authors' previously published experience included 115 procedures involving 104 patients. Thus, the total experience included 244 procedures involving 218 patients with insular gliomas treated at the authors' institution. The most common presenting symptoms were seizure (68.2%) and asymptomatic recurrence (17.8%). WHO Grade II glioma histology was the most common (54.3%), followed by Grades III (34.1%) and IV (11.6%). The median tumor volume was 48.5 cm(3). The majority of insular gliomas were located in the anterior portion of the insula with 31.0% in Zone I, 10.9% in Zone IV, and 16.3% in Zones I+IV. The Berger-Sanai zone classification system was highly reliable, with a kappa coefficient of 0.857. The median EOR for all zones was 85%. Comparison of EOR between the current and prior series showed no change and Zone I gliomas continue to have the highest median EOR. Short- and long-term neurological complications remain low, and zone classification correlated with short-term complications, which were highest in Zone I and in Giant insular gliomas. CONCLUSIONS: The previously proposed Berger-Sanai classification system is highly reliable and predictive of insular glioma EOR and morbidity [10].

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A series of 28 insular gliomas operated on consecutively were analyzed. The definition of exophytic glioma included these 2 criteria: 1) preoperative magnetic resonance imaging with evidence of exophytic local tumor extension outside the anatomical superficial boundaries of the brain; and 2) surgical identification of piamater and arachnoid invasion, with tumor growth to the adjacent cisterns. RESULTS: A series of 6 exophytic gliomas (21.4%) are reported, among a series of 28 consecutive insular gliomas operated. The exophytic component originated from the posterior portion of the basal frontal lobe, with extension to the sphenoidal compartment of the sylvian cistern, reaching the temporal pole. All exophytic tumors were type 5A in Yasargil classification. The histologic diagnosis was World Health Organization grade II glioma in 3 cases and anaplastic glioma in 3 cases. All patients underwent surgery, and the exophytic component was removed completely. CONCLUSIONS: Radiologic features that define the exophytic growth pattern in insular gliomas are the posterior displacement of the middle cerebral artery and a sharp subarachnoid margin that separates the exophytic tumor from the temporal pole. Contrary to the tumor that infiltrates the anterior perforating substance, the exophytic tumor is amenable for safe and complete resection [11].

From March 2011 to June 2013, 30 gliomas involving the dominant insular lobe were resected in the IMRIS 3.0-T iMRI integrated neurosurgical suite. For 20 patients, awake craniotomy with cortical electrical stimulation mapping was performed to locate the language areas. For 10 patients who were not suitable for awake surgery, general anesthesia and functional navigation were performed. Diffusion tensor imaging tractography-based navigation, continuous motor evoked potential monitoring, and subcortical electrical stimulation mapping were applied to localize and monitor the motor pathway in all cases. iMRI was used to assess the extent of resection. The results of intraoperative imaging, IONM, and the surgical consequences were analyzed. RESULTS: Intraoperative imaging revealed residual tumor in 26 cases and led to further resection in 9 cases. As a result, the median extent of resection was increased from 90% to 93% (P = 0.008) in all cases, and from 88% to 92% (P = 0.018) in low-grade gliomas. The use of iMRI also resulted in an increase in the percentage of gross and near total resection from 53% to 77% (P = 0.016). The rates of permanent language and motor deficits resulting from tumor removal were 11% and 7.1%, respectively. CONCLUSIONS: The combination of iMRI, awake craniotomy, multimodal brain mapping, and IONM tailored for each patient permits the maximal safe resection of dominant-sided insular glioma [12)].

Patients with newly diagnosed gliomas of dominant insula were enrolled. The exclusion criteria were severe cognitive disturbances, communication difficulty, age greater than 75 years, severe obesity, difficult airways for intubation and severe cardiopulmonary diseases. All were evaluated preoperatively with contrast-enhanced brain magnetic resonance imaging (MRI), functional brain MRI, and diffusion tensor tractography of language and motor systems. All underwent awake craniotomy with the same anesthesiology protocol. Intraoperative monitoring included continuous motor-evoked potential, electromyography, electrocorticography, direct electrical stimulation of cortex, and subcortical tracts. The patients were followed with serial neurologic examination and imaging. RESULTS: Ten patients were enrolled (4 men, 6 women) with a mean age of 43.6 years. Seven patients suffered from low-grade glioma, and 3 patients had high-grade glioma. The most common clinical presentation was seizure followed by speech disturbance, hemiparesis, and memory loss. Extent of tumor resection ranged from 73% to 100%. No mortality or new major postoperative neurologic deficit was encountered. Seizure control improved in three fourths of patients with medical refractory epilepsy. In one patient with speech disorder at presentation, the speech problem became worse after surgery. CONCLUSION: Brain mapping during awake craniotomy helps to maximize extent of tumor resection while preserving neurologic function in patients with dominant insular lobe glioma [13)].

Five patients with insular gliomas were surgically treated by the authors from June 2013 to June 2014. The patients presented with complaints of either a headache or recurring episodes of convulsions. All the patients were operated with the aid of neuronavigation and tractography. The long perforating branches of the middle cerebral artery course through the insula and pass onward to supply the corona radiata. It is essential to preserve these vessels to prevent postoperative neurological deficits. ICG (Aurogreen) was used to identify and preserve the long perforating arteries of the middle cerebral artery.

ICG dye correctly identified the long perforating branches of the middle cerebral artery and easily distinguished these vessels from the short perforating branches. All the branches of the middle cerebral artery that coursed through the tumor and had an onward course were preserved in all the

patients. Only one patient developed a transient right sided hemiparesis that had improved at follow-up.

Surgery for insular gliomas is challenging due to its location adjacent to eloquent areas, important white fiber tracts and the course of the middle cerebral artery within it. ICG is useful to identify and preserve the long perforating branches of the middle cerebral artery that course through the tumor and traverse onward to supply the corona radiata [14].

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There were 12 right-sided and 8 left-sided tumors. The median skin-to-skin operative time was 215 minutes. 15/20 patients were discharged from the hospital on or before post-operative day 3, with 5 of those going home the day after surgery. Greater than 90% of the tumor was removed in 18 of 20 cases, with an additional case achieving 89.5% resection. In no case was the residual tumor volume greater than 3 cc. Permanent weakness occurred in 2 patients (10%). Despite a significant number of left-sided tumors, temporary dysphasia occurred in only 1 patient (12.5%), which resolved by first follow up.

Localized insular gliomas can be effectively removed through a minimally invasive approach without increasing the risk of neurological morbidity. This minimizes manipulation of uninvolved, potentially eloquent cortices, and minimizes damage to the overlying soft tissue [15].

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reviewed all cases of insular tumors operated on at the Department of Neurosurgery, University Hospital of Tübingen - Germany, between May 2008 and November 2013. EOR was determined by volumetric analysis. Mann Whitney, Chi-square and Kaplan Meier functions were used for assessment of each technology's effect on primary and secondary outcomes. RESULTS: 28 cases (18 men (64%) and 10 women (36%); median age at diagnosis: 52.5 years, range 12 - 59) were considered eligible for analysis. High grade and low-grade glioma s accounted for 20 (71%) and 8 (29%) cases, respectively. The most used technologies were IOM (64%) and Neuronavigation (68%). 5-ALA was the only technique associated with EOR ≥90% (p=0.05). Tractography determined improvement in the Karnofsky Performance Scale (50% vs. 5% cases improved, p=0.02). There was a positive association between the use of neuronavigation and overall survival (23 vs. 27.4 months, p=0.03), but the use of 5-ALA was associated with shorter OS (34.8 vs. 21.1 months, p=0.01) and PFS (24.4 vs. 11.8, p=0.01). CONCLUSIONS: We demonstrate for the first time that for insular gliomas 5-ALA plays a role in achieving higher EOR, although this technology was associated with poor OS and PFS; also tractography and neuronavigation can be of great importance in the treatment of insular gliomas as they determined better functionality and OS in this study, respectively. Prospective studies with a more prominent sample and proper multivariate analysis will help determine the real benefit of these adjuncts in the setting of insular gliomas [16].

**2015**

In a retrospective study 20 purely insular grade II gliomas patients and 22 paralimbic grade II gliomas that involved frontal and/or temporal lobes were compared with regard to epidemiological and clinical characteristics. The molecular profiles including Isocitrate dehydrogenase 1 (IDH1), telomerase reverse transcriptase (TERT) promoter, and P53 mutations, 1p19q co-deletion were analyzed, and microRNA profiles were assessed by microarray and bioinformatics analysis. Purely insular grade II gliomas displayed a high frequency of IDH1 mutations with favorable outcome. IDH1 mutated

paralimbic glioma shared many parameters with the purely insular glioma in respect to growth patterns, survival, and microRNA profile, but differed significantly from the IDH1 wild type paralimbic gliomas. The findings suggest that IDH1 mutations can define subpopulations of insular gliomas with distinct disease entities regardless of tumor extension patterns. These findings could be useful to develop a customized treatment strategy for insular glioma patients [17].

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A consecutive series of 53 patients with insular LGGs was retrospectively reviewed; 23 patients had two operations.

At the time of second surgery, almost half of the patients had experienced progression into high-grade gliomas (HGGs). Univariate analysis showed that tumor recurrence (TR) is influenced by the following: extent of resection (EOR) ($P < 0.002$), ΔVT2T1 value ($P < 0.001$), histological diagnosis of oligodendroglioma ($P = 0.017$), and mutation of IDH1 ($P = 0.022$). The multivariate analysis showed that EOR at first surgery was the independent predictor for TR ($P < 0.001$).

In patients with insular LGG the EOR at first surgery represents the major predictive factor for TR. At time of TR, more than 50% of cases had progressed in HGG, raising the question of the oncological management after the first surgery [18].

**2014**

The authors evaluated predictors of seizure outcome with special emphasis on both the extent of tumor resection (EOR) and the tumor's infiltrative pattern quantified by computing the difference between the preoperative T2- and T1-weighted MR images (ΔVT2T1) in 52 patients with preoperative drug-resistant epilepsy. RESULTS: The 12-month postoperative seizure outcome (Engel class) was as follows: seizure free (Class I), 67.31%; rare seizures (Class II), 7.69%; meaningful seizure improvement (Class III), 15.38%; and no improvement or worsening (Class IV), 9.62%. Poor seizure control was more common in patients with a longer preoperative seizure history ($p < 0.002$) and higher frequency of seizures ($p = 0.008$). Better seizure control was achieved in cases with EOR ≥ 90% ($p < 0.001$) and ΔVT2T1 < 30 cm(3) ($p < 0.001$). In the final model, ΔVT2T1 proved to be the strongest independent predictor of seizure outcome in insular LGG patients ($p < 0.0001$). CONCLUSIONS: No or little postoperative seizure improvement occurs mainly in cases with a prevalent infiltrative tumor growth pattern, expressed by high ΔVT2T1 values, which consequently reflects a smaller EOR [19].

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This retrospective study included 83 consecutively treated patients with newly diagnosed gliomas located at the insulo-opercular region and extending to the sylvian fissure around the primary motor and somatosensory cortices. The authors selected 4 characteristics as surgical indicators: clear tumor boundaries, negative enhancement, intact lenticulostriate arteries, and intact superior extremity of the central insular sulcus. RESULTS: Univariate analysis showed that tumors with clear boundaries were associated with higher rates of gross-total resection than were tumors with ambiguous boundaries (75.7% vs 19.6%). Tumors with negative enhancement compared with enhanced tumors were associated with lower frequency of tumor progression (32.0% vs 81.8%, respectively) and lower rates of surgical complications (14.0% vs 45.5%, respectively). Tumors with intact lenticulostriate arteries were associated with higher rates of gross-total resection than were tumors with involved lenticulostriate arteries (67.3% vs 11.8%, respectively). Tumors with intact superior extremity of the

central insular sulcus were associated with higher rates of gross-total resection (57.4% vs 20.7%, respectively) and lower rates of surgical complications (18.5% vs 41.4%, respectively) than were tumors with involved anatomical structures. Multivariate analysis showed that clear tumor boundaries were independently associated with gross-total resection ($p < 0.001$). Negative enhancement was found to be independently associated with surgical complications ($p = 0.005$), overall survival times ($p < 0.001$), and progression-free survival times ($p = 0.004$). Independent associations were also found between intact lenticulostriate arteries and gross-total resection ($p < 0.001$), between intact lenticulostriate arteries and progression-free survival times ($p = 0.026$), and between intact superior extremity of the central insular sulcus and gross-total resection ($p = 0.043$). Among patients in whom all 4 indicators were present, prognosis was good (5-year survival rate 93.3%), resection rate was maximal (gross-total resection 100%), and surgical complication rate was minimal (6.7%). Also among these patients, overall rates of survival ($p = 0.003$) and progression-free survival ($p = 0.005$) were significantly higher than among patients in whom fewer indicators were present. CONCLUSIONS: The authors propose 4 simple indicators that can be used to identify ideal candidates for radical resection of insulo-opercular gliomas, improve the outcomes, and promote maximum resection without introducing neurological complications. The indicators are clear tumor boundaries, negative enhancement, intact lenticulostriate arteries, and intact superior extremity of the central insular sulcus [20].

### 2012

Skrap et al. in 2012 demonstrated EOR to be an independent prognostic factor for OS and PFS. This series included 66 patients with nonenhancing insular gliomas (53 WHO Grade II and 13 WHO Grade III). The 5-year OS rate was 92% for patients with > 90% EOR and 82% for patients with EOR between 70% and 90%. Patients with an EOR < 70% had a 5-year OS rate of 57% [21].

### 2011

Thirty-three patients with WHO Grade II or III insular gliomas participated in neuropsychological evaluations before and after resection. To establish whether the pattern of neurocognitive performance was different from that of other patients with tumors in neighboring areas, patients with insular tumors were matched with control patients for age, educational level, preoperative Karnofsky Performance Scale score, tumor side, grade, and volume. The control group comprised patients in whom gliomas had been resected from frontal, temporal, and parietal areas near the insula. Baseline pre- and postoperative neurocognitive test results were compared between and within groups. RESULTS: Preoperative neurocognitive impairment was common in both insular and control groups. Patients with insular tumors had significantly worse preoperative performance on naming tests. In both groups, postoperative decline occurred in most neurocognitive domains. There were no statistically significant differences between patients in the insular and control groups with regard to rates of postoperative decline on any test. However, there were trends suggesting differential cognitive performance postoperatively, because patients with insular tumors were more likely to experience greater decline in learning and memory. Neurological morbidity was similar to prior rates reported in the literature. CONCLUSIONS: Few statistically significant differences in cognitive function were observed between patients in the insular and control groups at either the pre- or postoperative evaluation, although there was a trend for patients with insular tumors to exhibit greater postoperative decline in learning and memory. Although technically more challenging, surgery for insular region glioma appears feasible without profound neurological or cognitive morbidity for many patients [22].

**2010**

Among 36 patients who suffered glioma at insulo-opercular regions and underwent radical resection at our institute between February 2002 and August 2008, cases that showed four different development patterns were retrospectively reviewed. In our series of patients, 7 patients were followed up for more than 100 days after detection of the diseases until surgery. Among these patients, there existed cases that represent four different progression patterns of insulo-opercular gliomas. Surgical complications associated with insulo-opercular gliomas often result from damage to surrounding structures, especially the perforating arteries. Resection of tumors invading medially to the putamen can result in damage to the lenticulostriate arteries, and resection higher than the superior limiting sulcus can result in injury to the long insular arteries. Consequently, the surgical indications for insulo-opercular gliomas should be limited to small tumors within the insular cortex or progressing via the anterior or inferior limiting sulcus. Tumors that progress via the superior limiting sulcus carry a high risk of injuring the long insular arteries [23].

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One hundred fifteen procedures involving 104 patients with insular gliomas were identified. Patients presented with low-grade gliomas (LGGs) in 70 cases (60%) and high-grade gliomas (HGGs) in 45 (40%). Zone I (anterior-superior) was the most common site within the insula (40 patients [39%]), followed by Zone I+IV (anterior-superior + anterior-inferior; 26 patients [25%]). The median EOR was 82% (range 31-100%) for low-grade lesions and 81% (range 47-100%) for high-grade lesions. Zone I was associated with the highest median EOR (86%), and among all lesion grades, the insular quadrant anatomy was predictive of the EOR ($p = 0.0313$). Overall, there were 16 deaths (15%) during a median follow-up of 4.2 years. There were no surgery-related deaths, and new, permanent postoperative deficits were noted in 6 patients (6%). Among LGGs, tumor progression and malignant transformation were identified in 20 (29%) and 14 cases (20%), respectively. Among HGGs, progression was identified in 16 cases (36%). Patients with LGGs resected >or= 90% had a 5-year overall survival (OS) rate of 100%, whereas those with lesions resected < 90% had a 5-year OS rate of 84%. Patients with HGGs resected >or= 90% had a 2-year OS rate of 91%; when the EOR was < 90%, the 2-year OS rate was 75%. The EOR was predictive of OS both in cases of LGGs (hazard ratio [HR] 0.955, 95% CI 0.921-0.992, $p = 0.017$) and HGGs (HR 0.955, 95% CI 0.918-0.994, $p = 0.024$). Progression-free survival (PFS) was also predicted by the EOR in both LGGs (HR 0.973, 95% CI 0.948-0.998, $p = 0.0414$) and HGGs (HR 0.958, 95% CI 0.919-0.999, $p = 0.0475$). Interestingly, among patients with LGGs, malignant progression was also significantly associated with a lower EOR (HR 0.968, 95% CI 0.393-0.998, $p = 0.0369$).

This series included 70 low-grade (WHO Grade II only; Grade I was excluded) and 45 high-grade (WHO III and IV) tumors. For low-grade gliomas, the 5-year OS increased by 16% for patients with an EOR ≥ 90%. For high-grade gliomas, a 16% difference in the 2-year OS was also noted for patients with an EOR ≥ 90%. Most importantly, EOR provided a significant impact in delaying malignant progression. The 5-year malignant PFS increased by 17% for patients with an EOR ≥ 90%.

Aggressive resection of insular gliomas of all grades can be accomplished with an acceptable morbidity profile and is predictive of improved OS and PFS. Among insular LGGs, a greater EOR is also associated with longer malignant PFS. Data in this study also suggest that insular gliomas generally follow a more indolent course than similar lesions in other brain regions [24].

**2009**

Available data on 46 patients harboring insular GIIGs were extracted from a local database of 288 GIIGs. The various therapeutic sequences were analyzed in parallel with the course of seizure frequency. RESULTS: Despite the usual difficulties with seizure quantification in retrospective studies, the authors showed that 1) the negative course of seizure frequency was mostly connected to tumor progression, 2) surgery almost always had a favorable effect on epilepsy, and 3) chemotherapy had a mostly favorable effect with acceptable tolerance. The authors were unable to draw conclusions about the role of radiotherapy given the too few cases. CONCLUSIONS: This extensive experience with insular GIIGs tends to confirm interest in their surgical removal and supports interest in chemotherapy from an epileptological point of view [25].

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Twenty-four patients underwent surgery for an insular Grade II glioma involving the dominant hemisphere (22 left, 2 right), revealed by seizures in all but 1 case. The preoperative neurological examination result was normal in 17 patients (71%), whereas 7 patients presented with language disorders detected using an accurate language assessment performed by a speech therapist. All surgeries were performed on awake patients utilizing intra-operative language mapping involving cortical and subcortical stimulation. RESULTS: There were no intrasurgical complications or postsurgical sensorimotor deficits. Despite an immediate postoperative language worsening in 12 cases (50%), all patients recovered to a normal status within 3 months, and 6 cases even improved in comparison with their preoperative examination results. The 24 patients returned to normal social and professional lives. Moreover, the surgery had a favorable impact on epilepsy in all but 4 cases (83%). On control MR imaging, 62.5% of resections were total or subtotal. Three patients underwent a second or third awake surgery, with no additional deficit. All but 2 patients (92%) are alive after a mean follow-up of 3 years (range 3-133 months). CONCLUSIONS: Although insular surgery was long believed to be too risky, the present results show that the rate of permanent deficit, especially dysphasia, following resection of Grade II gliomas involving the dominant insula has been dramatically reduced (none in this patient series), thanks to the systematic use of intraoperative awake mapping, even in cases of repeated operations. Furthermore, patient quality of life may be improved due to a decrease of epilepsy after surgery. Thus, the authors suggest systematically considering resection when an insular Grade II glioma is diagnosed after seizures in a patient with no or mild deficit, even a glioma invading the dominant hemisphere [26].

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We retrospectively analyzed 54 patients with insular gliomas who underwent microsurgical operation by trans-syvian fissure approach between May, 2003 and August, 2008 in Xiangya Hospital. We discussed the techniques in the operation and summarized how to protect the key blood vessels, distinguish and protect the surrounding normal structures. RESULTS: There were 36 complete removals,14 secondary complete removals, and 4 partial removals.Six patients had complications after the craniotomy who had temporal speech disorder (aphasia mostly began to recover about 10 days after the craniotomy),4 patients had opposite side paralysis worsening (3 recovered normally and 1 improved after 6 months),4 had light paralysis, and another 3 had paralysis and speech disorder. CONCLUSION: The microsurgery by means of trans-syvian fissure approach can well expose the anatomical relation between tumor and its surrounding structures,so that we can remove the tumor and protect the surrounding normal tissues as much as we can [27].

Fifty-one patients harboring an insular Grade II glioma (revealed by seizures in 50 cases) underwent surgery. Findings on preoperative neurological examination were normal in 45 patients (88%). All surgeries were conducted under cortico-subcortical stimulation, and in the case of 16 patients while awake. RESULTS: Despite an immediate postoperative worsening in 30 cases (59%), the condition of all but 2 patients (96%) returned to baseline or better. Postoperative MR imaging demonstrated that 77% of resections were total or subtotal. Ten patients underwent a second or third surgery, with no additional deficit. Forty-two patients (82%) are alive with a median follow-up of 4 years. CONCLUSIONS: This is the largest reported experience with insular Grade II glioma surgery. The better knowledge of the insular pathophysiology and the use of intraoperative functional mapping allow the risk of permanent deficit to be minimized (and even enable improvement in quality of life) while increasing the extent of resection and thus the impact on the course of the disease. Therefore, surgical removal must always be considered for insular Grade II glioma. However, this surgery remains challenging, especially within the anterior perforating substance and the posterior part of the (dominant) insula. Additional surgery can be suggested in cases in which the first resection is not complete [28)].

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The authors analyzed complications, functional outcomes, and survival in a series of 101 operations performed in 94 patients between 1995 and 2005. RESULTS: A > 90% resection was achieved in 42%, and 70-90% tumor removal was accomplished in 51% of cases. Functional outcomes varied considerably between patient subgroups. For example, in neurologically intact patients < or = 40 years of age with WHO Grade I-III tumors, good outcomes (Karnofsky Performance Scale Score 80-100) were seen in 91% of cases. Predictors of an unfavorable functional outcome included histological features of glioblastoma, advanced age, and a low preoperative Karnofsky Performance Scale score. One year after surgery, 76% of patients who had presented with epilepsy were seizure free or experienced only isolated, nondebilitating seizures. Surprisingly good survival rates were seen after surgery for anaplastic gliomas. The median survival for patients with anaplastic astrocytomas (WHO Grade III) was 5 years, and the 5-year survival rate for those with anaplastic oligodendroglial tumors was 80%. Independent predictors of survival included younger age, favorable histological features (WHO Grade I and oligodendroglial tumors), Yaşargil Type 5A/B tumors with frontal extensions, and more extensive resections. CONCLUSIONS: Insular tumor surgery carries substantial complication rates. However, surprisingly similar figures have been reported in large unselected craniotomy series and also after alternative treatment regimens. In view of the oncological benefits of resective surgery, our data would therefore argue for microsurgery as the primary treatment for most patients with a presumed WHO Grade I-III tumor. Patients with glioblastomas and/or age > 60 years require a more cautious approach [29)].

**2008**

One hundred fifteen patients harboring a World Health Organization Grade II glioma within language areas underwent operation after induction of local anesthesia, using direct electrical stimulation to perform online cortical and subcortical language mapping throughout the resection.

RESULTS: After detection of cortical language sites, the authors identified 1 or several of the following subcortical language pathways in all patients: 1) arcuate fasciculus, eliciting phonemic paraphasia when stimulated; 2) inferior frontooccipital fasciculus, generating semantic paraphasia when stimulated; 3) subcallosal fasciculus, inducing transcortical motor aphasia during stimulation; 4)

frontoparietal phonological loop, eliciting speech apraxia during stimulation; and 5) fibers coming from the ventral premotor cortex, inducing anarthria when stimulated. These structures were preserved, representing the limits of the resection. Despite a transient immediate postoperative worsening, all but 2 patients (98%) returned to baseline or better. On control MR imaging, 83% of resections were total or subtotal.

CONCLUSIONS: These results represent the largest experience with human subcortical language mapping ever reported. The use of intraoperative cortical and subcortical stimulation gives a unique opportunity to perform an accurate and reliable real-time anatomofunctional study of language connectivity. Such knowledge of the individual organization of language networks enables practitioners to optimize the benefit-to-risk ratio of surgery for Grade II glioma within the left dominant hemisphere [30)].

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Thirty-eight patients with insular gliomas underwent transsylvian resection between 1995 and 2007. Patient demographics, presenting symptoms, pathological findings, and neurological outcomes were retrospectively reviewed. Preoperative MR imaging-defined tumor volumes were superimposed onto the preoperative stereotactic cerebral angiograms to determine whether the insular tumor was confined lateral to (Group I) or extended medially around (Group II) the lenticulostriate arteries (LSAs). RESULTS: Twenty-five patients (66%) had tumors situated lateral to the LSAs and 13 (34%) had tumors encasing the LSAs. Insular gliomas situated lateral to the LSAs led to significant medial displacement of these vessels (161 +/- 39%). In 20 (80%) of these 25 cases the boundaries between tumor and brain parenchyma were well demarcated on preoperative T2-weighted MR images. In contrast, there was less displacement of the LSAs (130 +/- 14%) in patients with insular gliomas extending around the LSAs on angiography. In 11 (85%) of these 13 cases, the tumor boundaries were diffuse on T2-weighted MR images. Postoperative hemiparesis or worsening of a preexisting hemiparesis, secondary to LSA compromise, occurred in 5 patients, all of whom had tumor volumes that extended medial to the LSAs. Gross-total or near-total resection was achieved more frequently in cases in which the insular glioma remained lateral to the LSAs (84 vs 54%). CONCLUSIONS: Insular gliomas with an MR imaging-defined tumor volume located lateral to the LSAs on stereotactic angiography displace the LSAs medially by expanding the insula, have well-demarcated tumor boundaries on MR images, and can be completely resected with minimal neurological morbidity. In contrast, insular tumors that appear to surround the LSAs do not displace these vessels medially, are poorly demarcated from normal brain parenchyma on MR images, and are associated with higher rates of neurological morbidity if aggressive resection is pursued. Preoperative identification of these anatomical growth patterns can be of value in planning resection [31)].

**2007**

Motor evoked potentials (MEPs) were successfully monitored during 73 operations to remove insular gliomas. Seventy-two cases were assessable, and one patient died during the early postoperative course. In this prospective observational approach, MEP monitoring results were correlated with intraoperative events and perioperative clinical data. Intraoperative recordings of MEPs remained stable in 40 cases (56%), indicating unimpaired motor outcome and allowing safe completion of the hazardous steps of the procedure. Deterioration of MEPs occurred in 32 cases (44%). This deterioration was reversible after intervention in 21 cases (29%), and there was no new motor deficit except for transient paresis in nine of these cases (13%). Surgical measures could not prevent irreversible MEP deterioration in 11 cases (15%). Transient mild or moderate paresis occurred if complete MEP loss was avoided. Irreversible MEP loss in seven cases (10%) occurred after completion

of resection in four of these seven cases, and was consistently an indicator of both a stroke within the deep motor pathways and permanent paresis, which remained severely disabling in three patients (4%). In contrast, permanently severe paresis occurred in two (18%) of 11 cases without useful MEP monitoring. CONCLUSIONS: Continuous MEP monitoring is a valid indicator of motor pathway function during insular glioma surgery. This method indicates that remote ischemia, in this study the leading cause of impending motor deterioration, helps to avert definitive stroke of the motor pathways and permanent new paresis in the majority of cases. The rate of permanently severe new deficit appears to be greater in unmonitored cases [32].

**2006**

We surgically resected an insular low-grade glioma, using intraoperative electrical stimulation, in 42 patients who experienced seizures, but who presented no or only a slight neurological deficit. Surgery was performed under local anesthesia in patients with a lesion in the dominant hemisphere. The resection was systematically stopped according to cortico-subcortical functional boundaries. RESULTS: Intraoperative electrical mapping induced language disturbances, pain and vertigo, but no other side effects were observed. Post-operatively, the patients experienced a transient hemiparesis in 21 cases, language disorders in 10 cases, an athymhormic syndrome in 7 cases, a Foix-Chavany-Marie syndrome in 3 cases, and micturition disturbances in one case. Despite this immediate post-surgical worsening, all the patients recovered their preoperative neurological status within 3 months, except in three cases due to a deep stroke. CONCLUSION: These results show that the insula, a complex associative multimodal structure poorly studied until now, can be functionally compensated. Such a plastic potential may have important fundamental and clinical implications, in particular in the field of oncological neurosurgery [33].

**2002**

Eleven patients (8 men, 3 women, mean age: 35 years) harboring an insular LGG generating intractable seizures, underwent tumor removal and perilesional opercular cortex resection (lesionectomy “plus”) using intraoperative functional electrical mapping, combined with ultrasonography and/or neuronavigation. RESULTS: Despite the occurrence of five postoperative deficits, the patients recovered in all cases. The epileptological results showed improvement in all cases: 9 Engel's Class I (82%), 1 Class II and 1 Class III. Ten lesionectomies were total [3] or subtotal [7], while one resection was partial (the patient in Engel's III). CONCLUSION: The high rate of pharmacologically intractable seizures associated with insular LGG, and the favorable epilepsy outcome following surgical resection of these tumors seemingly indicate that the insular cortex itself may induce chronic seizures when injured. These results suggest, taking account of the technical surgical progress allowing now to minimize the morbidity after surgery in this region, that there is another indication than the sole oncological reason for surgery in patients with diffuse insular glioma – even if total tumor removal is not systematically possible [34].

**2000**

A low-grade insular glioma, revealed by seizures, was diagnosed in 12 right-handed patients with a normal neurological status. Preoperative magnetic resonance imaging showed that, according to Yasargil's classification system, three patients harbored Type 3 lesions and nine patients had Type 5 lesions (10 tumors on the right side and 2 on the left dominant side). All patients underwent surgery

using direct cerebral stimulation, under general anesthesia in nine patients (motor mapping) and under local anesthesia in three patients (sensorimotor and language mapping). Ultrasonography and/or neuronavigation was used in all cases. Preoperative angio-computed tomographic scanning showed the lenticulostriate arteries in two patients. RESULTS: The internal capsule was systematically detected, and the language areas were identified within the left insula in the awake patients. The lenticulostriate arteries were seen in two patients. Seven patients presented an immediate postoperative deficit; six of them recovered completely within 3 months. Four resections were total, six were subtotal, and two were partial (left insula). CONCLUSION: The use of intraoperative direct cerebral stimulation and neuronavigation allows surgery of the insula with minimization of the risk of sequelae, but its use is still limited with regard to the dominant hemisphere, owing to the essential role of this structure in language [35].

### 1997

Between 1st October 1989 and 1st September 1996 we treated twenty-three patients harbouring insular gliomas. To increase the radicality of the resection the surgical procedure was performed under local anaesthesia whenever possible, as general anaesthesia usually leads to more conservative resections. In 20/23 (86.9%) patients complete resection was accomplished, and subtotal in three (13.1%). The removed tumours were: two oligodendrogliomas, five grade I astrocytomas, nine grade II, four grade III and three grade IV. Postoperative neurological deficits occurred in five patients. Four suffered a hemiparesis (that recovered in an average of 6 months) and one a motor dysphasia which took a week to recover. Two of the seventeen patients operated on for low grade insular gliomas underwent malignant change. We conclude that complete surgical removal of insular gliomas should be considered and at least attempted in all cases [36].

1)
Przybylowski CJ, Baranoski JF, So VM, Wilson J, Sanai N. Surgical morbidity of transsylvian versus transcortical approaches to insular gliomas. J Neurosurg. 2019 Apr 5:1-8. doi: 10.3171/2018.12.JNS183075. [Epub ahead of print] PubMed PMID: 30952129.
2)
Mishra A, John AP, Shukla D, Sathyaprabha T, Devi BI. Autonomic Function In Insular Glioma - An Exploratory Study. World Neurosurg. 2018 Jul 20. pii: S1878-8750(18)31585-7. doi: 10.1016/j.wneu.2018.07.107. [Epub ahead of print] PubMed PMID: 30036712.
3)
Wang DD, Deng H, Hervey-Jumper SL, Molinaro AA, Chang EF, Berger MS. Seizure Outcome After Surgical Resection of Insular Glioma. Neurosurgery. 2017 Nov 8. doi: 10.1093/neuros/nyx486. [Epub ahead of print] PubMed PMID: 29126238.
4)
Gravesteijn BY, Keizer ME, Vincent AJPE, Schouten JW, Stolker RJ, Klimek M. Awake craniotomy versus craniotomy under general anesthesia for the surgical treatment of insular glioma: choices and outcomes. Neurol Res. 2017 Nov 23:1-10. doi: 10.1080/01616412.2017.1402147. [Epub ahead of print] PubMed PMID: 29168669.
5)
Sughrue M, Bonney PA, Burks JD, Othman J, Baker C, Glenn CA, Teo C. Multilobar Insular-Involving Gliomas: Results with Hyperaggressive Resection. Cureus. 2017 Aug 28;9(8):e1623. doi: 10.7759/cureus.1623. PubMed PMID: 29098133; PubMed Central PMCID: PMC5659303.
6)
Eseonu CI, ReFaey K, Garcia O, Raghuraman G, Quinones-Hinojosa A. Volumetric Analysis of Extent of Resection, Survival, and Surgical Outcomes for Insular Gliomas. World Neurosurg. 2017 Jul;103:265-274. doi: 10.1016/j.wneu.2017.04.002. Epub 2017 Apr 10. PubMed PMID: 28408263.
7)

Panigrahi M, Chandrasekhar YB, Vooturi S, Ram GA, Rammohan VS. Surgical Resection of Insular Gliomas and Roles of Functional Magnetic Resonance Imaging and Diffusion Tensor Imaging Tractography-Single Surgeon Experience. World Neurosurg. 2017 Feb;98:587-593. doi: 10.1016/j.wneu.2016.11.001. Epub 2016 Nov 10. PubMed PMID: 27838429.
8)

Chen LF, Yang Y, Ma XD, Yu XG, Gui QP, Xu BN, Zhou DB. Optimizing the Extent of Resection and Minimizing the Morbidity in Insular High-Grade Glioma Surgery by High-Field Intraoperative MRI Guidance. Turk Neurosurg. 2017;27(5):696-706. doi: 10.5137/1019-5149.JTN.18346-16.1. PubMed PMID: 27651342.
9)

Wang Y, Wang Y, Fan X, Li S, Liu X, Wang J, Jiang T. Putamen involvement and survival outcomes in patients with insular low-grade gliomas. J Neurosurg. 2016 Aug 26:1-7. [Epub ahead of print] PubMed PMID: 27564467.
10)

Hervey-Jumper SL, Li J, Osorio JA, Lau D, Molinaro AM, Benet A, Berger MS. Surgical assessment of the insula. Part 2: validation of the Berger-Sanai zone classification system for predicting extent of glioma resection. J Neurosurg. 2016 Feb;124(2):482-8. doi: 10.3171/2015.4.JNS1521. Epub 2015 Sep 4. PubMed PMID: 26339856.
11)

Velasquez C, Caballero H, Vazquez-Barquero A, Vega M, Rial JC, Carcedo-Barrio MC, Martino J. Insular Gliomas with Exophytic Extension to the Sylvian Cistern: A Glioma Growth Pattern That Has Gone Previously Unnoticed. World Neurosurg. 2016 Mar;87:200-6. doi: 10.1016/j.wneu.2015.12.035. Epub 2015 Dec 25. PubMed PMID: 26724624.
12)

Zhuang DX, Wu JS, Yao CJ, Qiu TM, Lu JF, Zhu FP, Xu G, Zhu W, Zhou LF. Intraoperative Multi-Information-Guided Resection of Dominant-Sided Insular Gliomas in a 3-T Intraoperative Magnetic Resonance Imaging Integrated Neurosurgical Suite. World Neurosurg. 2016 May;89:84-92. doi: 10.1016/j.wneu.2016.01.067. Epub 2016 Feb 4. PubMed PMID: 26851745.
13)

Alimohamadi M, Shirani M, Shariat Moharari R, Pour-Rashidi A, Ketabchi M, Khajavi M, Arami M, Amirjamshidi A. Application of Awake Craniotomy and Intraoperative Brain Mapping for Surgical Resection of Insular Gliomas of the Dominant Hemisphere. World Neurosurg. 2016 Aug;92:151-8. doi: 10.1016/j.wneu.2016.04.079. Epub 2016 May 2. PubMed PMID: 27150651.
14)

Shah A, Rangarajan V, Kaswa A, Jain S, Goel A. Indocyanine green as an adjunct for resection of insular gliomas. Asian J Neurosurg. 2016 Jul-Sep;11(3):276-81. doi: 10.4103/1793-5482.175626. PubMed PMID: 27366256; PubMed Central PMCID: PMC4849298.
15)

Sughrue ME, Othman J, Mills SA, Bonney PA, Maurer AJ, Teo C. Keyhole Transsylvian Resection of Infiltrative Insular Gliomas: Technique and Anatomic Results. Turk Neurosurg. 2016;26(4):475-83. doi: 10.5137/1019-5149.JTN.14534-15.0. PubMed PMID: 27400092.
16)

Barbosa BJ, Dimostheni A, Teixeira MJ, Tatagiba M, Lepski G. Insular gliomas and the role of intraoperative assistive technologies: Results from a volumetry-based retrospective cohort. Clin Neurol Neurosurg. 2016 Oct;149:104-10. doi: 10.1016/j.clineuro.2016.08.001. Epub 2016 Aug 2. PubMed PMID: 27509592.
17)

Tang C, Zhang ZY, Chen LC, Sun Z, Zhang Y, Qin Z, Yao Y, Zhou LF. Subgroup characteristics of insular low-grade glioma based on clinical and molecular analysis of 42 cases. J Neurooncol. 2015 Nov 19. [Epub ahead of print] PubMed PMID: 26586262.
18)

Ius T, Pauletto G, Cesselli D, Isola M, Turella L, Budai R, DeMaglio G, Eleopra R, Fadiga L, Lettieri C, Pizzolitto S, Beltrami CA, Skrap M. Second Surgery in Insular Low-Grade Gliomas. Biomed Res Int.

2015;2015:497610. doi: 10.1155/2015/497610. Epub 2015 Oct 11. PubMed PMID: 26539503; PubMed Central PMCID: PMC4619843.

19)

Ius T, Pauletto G, Isola M, Gregoraci G, Budai R, Lettieri C, Eleopra R, Fadiga L, Skrap M. Surgery for insular low-grade glioma: predictors of postoperative seizure outcome. J Neurosurg. 2014 Jan;120(1):12-23. doi: 10.3171/2013.9.JNS13728. Epub 2013 Nov 15. PubMed PMID: 24236654.

20)

Kawaguchi T, Kumabe T, Saito R, Kanamori M, Iwasaki M, Yamashita Y, Sonoda Y, Tominaga T. Practical surgical indicators to identify candidates for radical resection of insulo-opercular gliomas. J Neurosurg. 2014 Nov;121(5):1124-32. doi: 10.3171/2014.7.JNS13899. Epub 2014 Aug 15. PubMed PMID: 25127416.

21)

Skrap M, Mondani M, Tomasino B, Weis L, Budai R, Pauletto G, Eleopra R, Fadiga L, Ius T. Surgery of insular nonenhancing gliomas: volumetric analysis of tumoral resection, clinical outcome, and survival in a consecutive series of 66 cases. Neurosurgery. 2012 May;70(5):1081-93; discussion 1093-4. doi: 10.1227/NEU.0b013e31823f5be5. PubMed PMID: 22067417.

22)

Wu AS, Witgert ME, Lang FF, Xiao L, Bekele BN, Meyers CA, Ferson D, Wefel JS. Neurocognitive function before and after surgery for insular gliomas. J Neurosurg. 2011 Dec;115(6):1115-25. doi: 10.3171/2011.8.JNS11488. Epub 2011 Sep 9. PubMed PMID: 21905800.

23)

Saito R, Kumabe T, Kanamori M, Sonoda Y, Tominaga T. Insulo-opercular gliomas: four different natural progression patterns and implications for surgical indications. Neurol Med Chir (Tokyo). 2010;50(4):286-90. PubMed PMID: 20448419.

24)

Sanai N, Polley MY, Berger MS. Insular glioma resection: assessment of patient morbidity, survival, and tumor progression. J Neurosurg. 2010 Jan;112(1):1-9. doi: 10.3171/2009.6.JNS0952. PubMed PMID: 19612970.

25)

Taillandier L, Duffau H. Epilepsy and insular Grade II gliomas: an interdisciplinary point of view from a retrospective monocentric series of 46 cases. Neurosurg Focus. 2009 Aug;27(2):E8. doi: 10.3171/2009.6.FOCUS09102. Review. PubMed PMID: 19757989.

26)

Duffau H, Moritz-Gasser S, Gatignol P. Functional outcome after language mapping for insular World Health Organization Grade II gliomas in the dominant hemisphere: experience with 24 patients. Neurosurg Focus. 2009 Aug;27(2):E7. doi: 10.3171/2009.5.FOCUS0938. PubMed PMID: 19645563.

27)

Zhang M, Huo L, Wang J, Ma Z, Fang J, Rao Y, Tan Z, Zhang Z. [Microsurgery techniques for insular glioma]. Zhong Nan Da Xue Xue Bao Yi Xue Ban. 2009 Apr;34(4):345-8. Chinese. PubMed PMID: 19411754.

28)

Duffau H. A personal consecutive series of surgically treated 51 cases of insular WHO Grade II glioma: advances and limitations. J Neurosurg. 2009 Apr;110(4):696-708. doi: 10.3171/2008.8.JNS08741. Erratum in: J Neurosurg. 2011 May;114(5):1486. PubMed PMID: 19133753.

29)

Simon M, Neuloh G, von Lehe M, Meyer B, Schramm J. Insular gliomas: the case for surgical management. J Neurosurg. 2009 Apr;110(4):685-95. doi: 10.3171/2008.7.JNS17639. PubMed PMID: 19099379.

30)

Duffau H, Peggy Gatignol ST, Mandonnet E, Capelle L, Taillandier L. Intraoperative subcortical stimulation mapping of language pathways in a consecutive series of 115 patients with Grade II glioma in the left dominant hemisphere. J Neurosurg. 2008 Sep;109(3):461-71. doi: 10.3171/JNS/2008/109/9/0461. PubMed PMID: 18759577.

31)
Moshel YA, Marcus JD, Parker EC, Kelly PJ. Resection of insular gliomas: the importance of lenticulostriate artery position. J Neurosurg. 2008 Nov;109(5):825-34. doi: 10.3171/JNS/2008/109/11/0825. PubMed PMID: 18976071.
32)
Neuloh G, Pechstein U, Schramm J. Motor tract monitoring during insular glioma surgery. J Neurosurg. 2007 Apr;106(4):582-92. PubMed PMID: 17432707.
33)
Duffau H, Taillandier L, Gatignol P, Capelle L. The insular lobe and brain plasticity: Lessons from tumor surgery. Clin Neurol Neurosurg. 2006 Sep;108(6):543-8. Epub 2005 Oct 6. PubMed PMID: 16213653.
34)
Duffau H, Capelle L, Lopes M, Bitar A, Sichez JP, van Effenterre R. Medically intractable epilepsy from insular low-grade gliomas: improvement after an extended lesionectomy. Acta Neurochir (Wien). 2002 Jun;144(6):563-72; discussion 572-3. PubMed PMID: 12111489.
35)
Duffau H, Capelle L, Lopes M, Faillot T, Sichez JP, Fohanno D. The insular lobe: physiopathological and surgical considerations. Neurosurgery. 2000 Oct;47(4):801-10; discussion 810-1. PubMed PMID: 11014418.
36)
Vanaclocha V, Sáiz-Sapena N, García-Casasola C. Surgical treatment of insular gliomas. Acta Neurochir (Wien). 1997;139(12):1126-34; discussion 1134-5. PubMed PMID: 9479418.