Innovative Journal of Medical and Healthcare Research (IJMHR)
Volume-1 Issue-1 January-2024

Clinical Trial on the Results of Insular Tumor Excision

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ABSTRACT

The insular cortex, located in the lateral sulcus of the brain, is a challenging area for neuro-oncology surgery. Successful removal of these tumors improves survival but can lead to impaired neurological function. Patients often experience minor focal impairments, such as seizures or headaches. The insular area is considered a nonsurgical entity due to the risks associated with surgical resection. A study of 62 patients with insular tumors found that awake resection delivered a comparable or superior degree of resection than asleep resection. However, the study also found that post-operative deficits were similar in both awake and asleep subgroups at 6 months. Neurocognitive function showed a tendency for a larger percentage of patients to decline in their fluency, verbal, and visual working memory. However, postoperative mental speed, attention, inhibition, planning, and learning memory improved in 3.8% of patients. These findings highlight the importance of understanding surgical anatomy, microsurgical procedures, imaging guidance, and cortical and subcortical mapping in achieving full resection in the insular area.

Keywords: Insular tumours, Cortical mapping, Subcortical monitoring.

I. INTRODUCTION

Language, somatosensory processing, gustation, cognition, balance, etc. are just a few of the critical neurological processes that are controlled by the insular cortex, also known as the island of Reil or the fifth lobe of the brain. These pathways may become dysfunctional as a result of neoplasms, notably gliomas, and metastases.

Insular gliomas can be distinguished into LGG (Low Grade Gliomas) and HGG (High-Grade Gliomas) based on the clinical, radiological and more definitely by histopathological characteristics.
It accounts for 25% of all LGG (Low Grade Gliomas) and 10% of all HGG (High-Grade Gliomas) among neoplasms of the central nervous system[1,2].

Eloquent cortex-like insula may have a greater incidence of gliomas, might be attributed to cytoarchitectonic, chemoarchitectonic, neuron, and glial interaction and multiple functional interfaces of insula between different areas of the brain[3].
Insular lesions commonly presents with

- Seizure
- Headache
- Weakness of limbs
- Speech difficulty
- Incidentally detected.

It is diagnosed based on clinical and radiological (MRI) findings
Insular lesions are radiologically sub-grouped into “types” based on Yasargil[3] classification of the limbic system and “Zones” based Berger-Sanai classification[4].

Treatment options are primarily surgical followed by radiotherapy with concurrent / adjuvant chemotherapy (based on histopathological findings).
The surgical method is determined by the presenting disease, the side of the lesion, morbidity, comorbidities, anaesthesia risks, and the patient's willingness to undergo surgery.

1. Awake craniotomy surgery with cortical & subcortical mapping/stimulation
2. Surgery under general anaesthesia

In this study we aim to analyse specific pre-operative factors such as types and duration of symptoms, demographic profile, location and radiological aspects of these tumors. We also seek to analyse intraoperative factors like insular anatomy, tumor character, surgical techniques (awake surgery with mapping / Surgery under general anaesthesia) and intend to analyse how these findings correlate and influence postoperative outcomes and survival of these patients.
We believe this study will help to prognosticate patients pre-operatively and can influence decision making in insular tumor surgery.

II. REVIEW OF LITERATURE:

2.1. Anatomical organization of the insular cortex

In humans and other primates, the frontal, temporal, and parietal regions that make up the opercula (also known as the "lids") cover the insula, a fold of brain tissue that is found in the lateral sulcus of the each cerebral hemisphere. (Figure 1). This unusual location has been given several names, including "the Island of Reil," "hidden fifth lobe," and Insula (Latin for "island"). In humans, the anterior and posterior insula are divided by the central sulcus of insula (Figure 1), which runs along the central sulcus of the cerebrum. The anterior insula is divided into three short gyri, while the posterior insula is divided into two long gyri. The anterior-inferior part of the insular cortical surface is formed by the limen insulae, which joins the inferior insular point, the anterior perforated substance, and the temporal-mesial surface. The basal ganglia components putamen, external capsule, claustrum, and extreme capsule may all be located medially to the insula. [5,6] The insula has a pyramidal shape in three dimensions, with its most lateral and superficial point lying between 9 and 16 millimeters below the cortex.

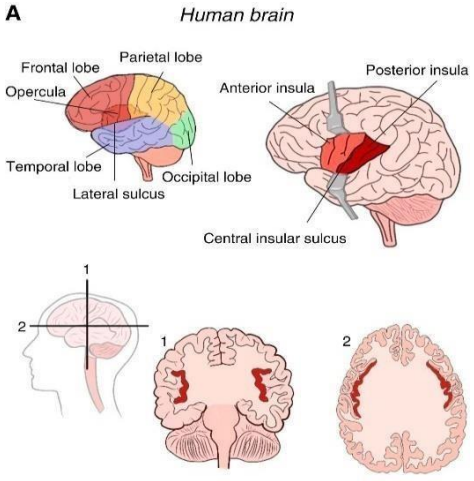


Figure 1: Insula is buried deep below6 the opercula (shaded region) of the frontal, parietal, and temporal lobes and is folded underneath the lateral sulcus.
Top right: the underlying insula may be seen when the temporal and parietal lobes are moved aside; it is divided into anterior & posterior lobes by the central sulcus of insula. Bottom image: coronal section (1) and horizontal section (2) of human brain shows the location of the insular lobe (red).

The insula is subdivided into three parts that vary in cellular architecture between species: the granular, dys-granular, and agranular region. This nomenclature alludes to the granular layer 4's increasing loss. The granular insular cortex is a typically six-layered; in the dysgranular part of insula, layer 4 gets thin; and the agranular insula is three layered, altogether layer 4 is absent. Along the dorso-ventral and rostro-caudal axis, there is a robust interconnection between the three subdivisions.

A specific cell type is present in layer 5 of the insular lobes of humans and other animals including big apes. Ramon y Cajal had already made notice of the massive, bipolar "von Economo neurons" before Constantin von Economo publicly identified them in the 1920s. These neurons are specifically damaged in frontotemporal dementia and are only seen in animals with huge brains and well developed social abilities. The precise role of this unique cell type is unclear. Due to these findings, researchers have hypothesised that they play a unique part in the development of social and emotional competence[7].

The insular cortex is a real structural integration station since it has strong connections to several cortical & subcortical brain areas involved in sensory, affective, motivational, and behavioural functions (Figure 2). It is inundated with data from every sensory modality. The insula receives input from both the internal environment and the external environment (hearing, touch, smell, taste, and vision) via direct afferents from the thalamus and the horizontal cortex (interoceptive information). The "visceral insular cortex," "gustatory cortex," (primary taste centre), and "insular auditory and somatosensory fields" are the topographically structured projections of these inputs to insular sensory areas. " Instead of being thought of as regions that just process their primary modality, every area in the insula receives substantial cross innervations, making them better characterised as multifunctional integration sites.

Along with receiving sensory data, the limbic system also sends and receives messages to and from the insula. For instance, the basolateral, lateral, and central nuclei of the amygdala receive a large number of efferents from the granular and dysgranular areas of the insula. In addition to the parahippocampal areas, perirhinal, and lateral entorhinal cortices, the insula interfaces with the lateral section of the bed nucleus of the stria terminalis, the mediodorsal nucleus of the thalamus, and the lateral hypothalamus.

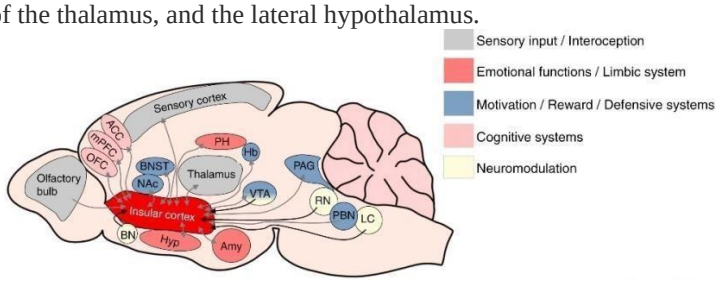


Figure 2: Connectivity of the insular cortex.

The anterior cingulate, orbitofrontal, and medial prefrontal cortices, which are involved in executive, affective, and learning functions, are connected to the insula reciprocally. The insula also projects to areas of the brain associated with impulse, pursuit and pleasure, including the nucleus accumbens and the caudate putamen. Overall, the cholinergic, dopaminergic, serotonergic, and noradrenergic afferents provide the insular lobe with robust neuromodulatory input.

Vasculature of insula cortex

Most of the blood for the insula comes from short perforating arteries from the M2 and M3 branches of the MCA, which are distributed as a series of fine branches with a range of 5 to 24 vessels. The M2 segments form long perforating branches that extend posteriorly and superiorly on the insula and supply the corona radiata[8] with blood.

The majority of the anterior & posterior insular gyri are supplied by the middle cerebral artery's superior branch, respectively, and its inferior branch. There are many short & medium perforating arteries arising from these vessels that supply the external capsule, claustrum, and extreme capsule[9,10].

The lateral lenticulostriate artery, a crucial perforating arterial emerging from the M1 segment, vascularizes the internal capsule & lenticular nucleus. The limen is a key landmark for locating the lenticulostriate arteries (LSAs), which lie medial to the limen and cross the anterior perforated material. At the limen, the M1 segment of the MCA bends and divides to create the M2 divisions. They most frequently vascularize the corona radiata and enter the posterior insular region [9,10]. This division of vascular supply is the primary logic insular tumours may be removed without inducing internal capsule strokes [11].

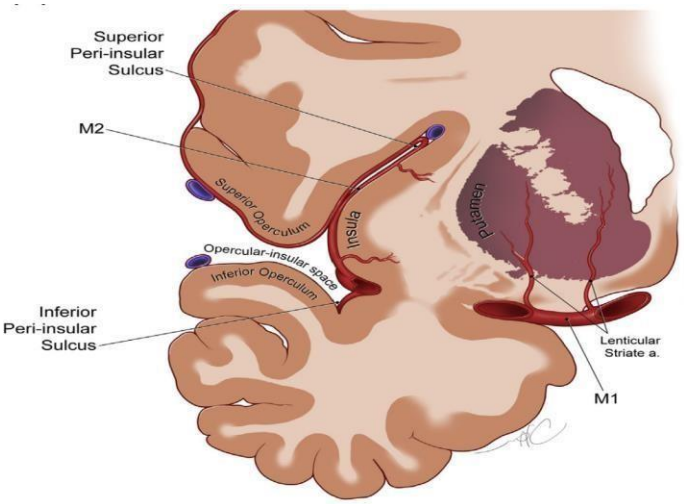


Figure 3: Coronal view of the insula with surrounding operculum and deep structures.

The vascular supply to the insula & basal ganglia is shown separately. The insula is supplied by the short & medium M2 perforating segments, while the basal ganglia is supplied by the lenticulostriate vessels, which arise from the M1 segment of the middle cerebral artery MCA proximal to the limen insula;

The venous drainage of the insula is more complex and unpredictable than that of the arterial supply. Despite many connections to the superficial Sylvian vein, the DMCV is responsible for the largest proportion of deep venous outflow. The anterior, precentral, central, and posterior veins comprise the deep middle cerebral vein (DMCV), often known as the insular veins. In cadaveric studies, the central and posterior insular veins[8] were the most consistent. The deep MCV eventually joins the basal vein. Because the insular veins doesn't drain any other cortical areas or deep tissues, they can be harmlessly removed following insular tumour excision. However, it is critical to protect the SSV and MCV during dissection. The removal of these conspicuous veins raises the risk of postoperative seizures, cerebral oedema, and neurologic impairments like aphasia. If necessary, the superficial Sylvian veins can be severed to widen the fissure, but there should be enough venous drainage from the remnant veins to avoid parenchymal edema[8,12,13].

An expert understanding of the insula's complicated vascularization patterns and a command of insular anatomy are necessary for effective preoperative planning and the safe, effective excision of pathological lesions.

Sylvian fissure and Perisylvian Cortex

The Sylvian fissure is a prime surgical corridor for neurosurgeons since it can develop any type of pathological lesion. Neurosurgeons can reach pathological lesions buried on the brain's surface by employing a transsylvian procedure to open the Sylvian fissure (also known as "splitting the fissure"). Oncologists who specialise in neurosurgery can access malignancies on the anterior basal brain surface (such as suprasellar region) and the anterior and middle skull base by opening the proximal fissure (the stem). By opening the lateral Sylvian fissure, also known as the posterior ramus, tissues bordering the bottom of the frontoparietal and temporal opercula can be accessed. Most The transsylvian corridor, which may also be utilised to access the thalamus, basal ganglia, limbic, and perilimbic regions, is very effective in exposing malignancies of the insula [8,11].

III. OBJECTIVES

PRIMARY OBJECTIVE:

1. To analyse post-operative neurological outcome in patients who had insular lesions and underwent surgery.

SECONDARY OBJECTIVE:

2. To analyse the difference in the neurological outcomes in terms of post-operative morbidity in these patients undergoing awake craniotomy surgery against patients undergoing surgery under general anaesthesia for insular lesions
3. To analyse the time course of improvement in neurological outcomes in these patients
4. To discover pathological diversity of insular lesions based on their anatomical extent within insular / peri-insular region.
5. To analyse our surgical approach to maximal safe resection in patients with insular lesions undergoing awake craniotomy or traditional surgery using general anaesthesia.
6. To quantify volumetrically the extent of surgical resection (EOR) between these surgical approaches

7. To determine the impact of these surgical approaches on neuropsychological outcomes and overall survival.

IV. METHODOLOGY

Patients who met the inclusion/exclusion criteria and gave informed consent for surgery were admitted. They underwent either of the surgical procedures as mentioned above. Eloquent cortical regions and subcortical tracts may be identified using mapping techniques, that also includes spatial distance data. Monitoring Techniques give real-time feedback on the functional integrity and trigger an alert in the event of a distant vascular damage.

Decision of surgery is completely case-specific, based on tumour location, hemisphere dominance, type, feasibility, surgical expertise, anaesthetic/comorbid features, as well based on their willingness and co-operation before and during surgery. Their preoperative, intraoperative and postoperative data were collected and labelled as per study proforma. They were followed up closely and their histopathological reports were collected and analysed.

Patients who undergoing re-surgery, chemotherapy / radiotherapy were be documented subsequently. Tumour board discussions and inputs were noted and followed. Patients were followed up in terms of clinical / neurological / neuropsychological / radiological outcomes and survival analysis till the end of study period.

Few patients who underwent surgery before the commencement of study were followed up the same way as mentioned above. Data relevant to the study were collected from MRD - Medical Records Department.

V. RESULTS

Patient characteristics

Sixty-two patients were included; 22 received awake resection with intraoperative cortical / subcortical mapping, and 40 underwent resection while sleeping [17 has undergone asleep surgery with intraoperative subcortical mapping and monitoring; 23 has undergone asleep surgery without monitoring].

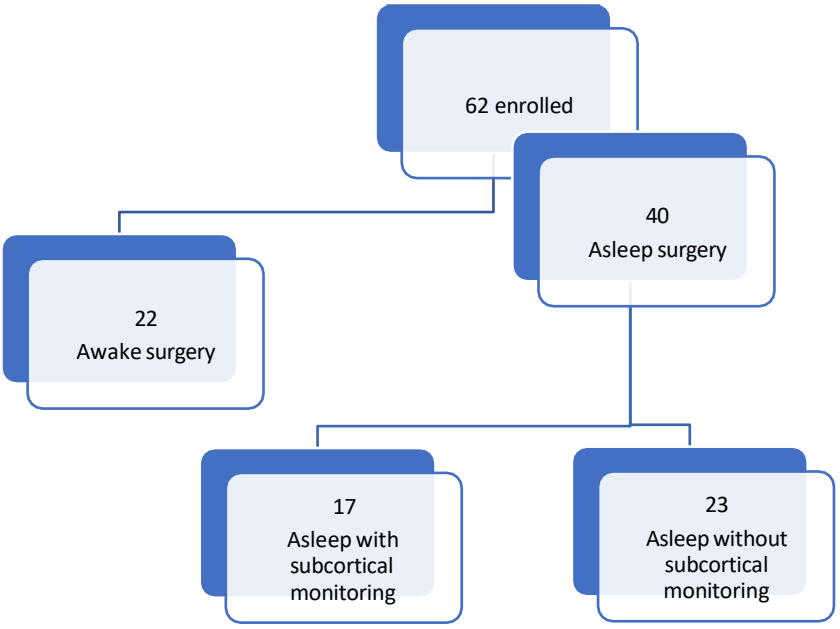


Figure 4: Flowchart showing case distribution among various sub-groups.

The study's participants, who were of Indian and Bangladeshi descent and ranged in age from 18 to 67, had a mean age of 40.6 years.

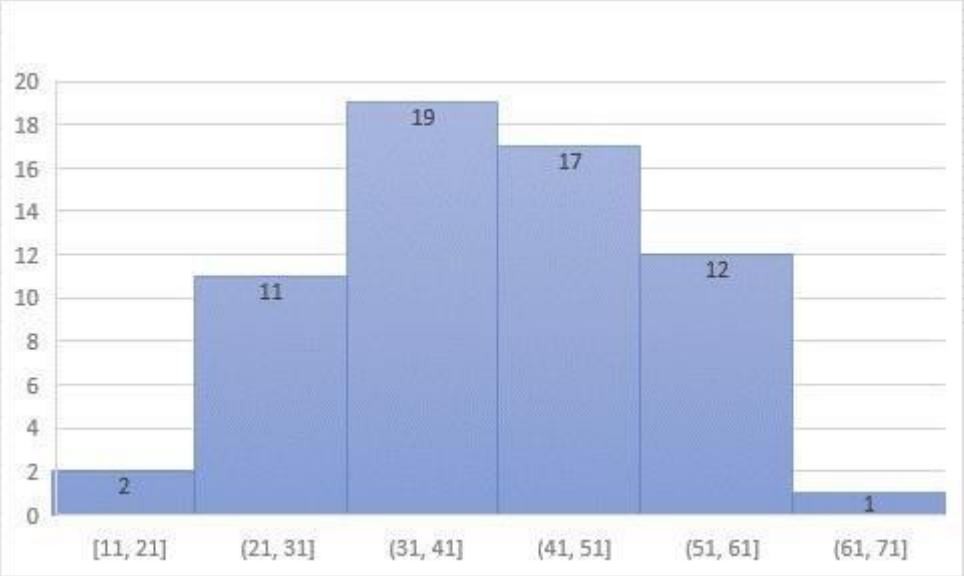


Figure 5: Age distribution of subjects in the study sample

All subjects were above 18 years of age, with the majority 36 of the 60 patients (60%) between 31 -51 years of age.

Table 1: Mean age with standard deviation among sub-groups

		Awake (N=22)	Asleep (N=40)	P value
Age	Mean ± SD	37.18 ± 11.15	42.6 ± 11	0.073

Table 1 provides specifics on the population's age distribution between the two subgroups. The age distribution in subgroups did not significantly differ from one another.

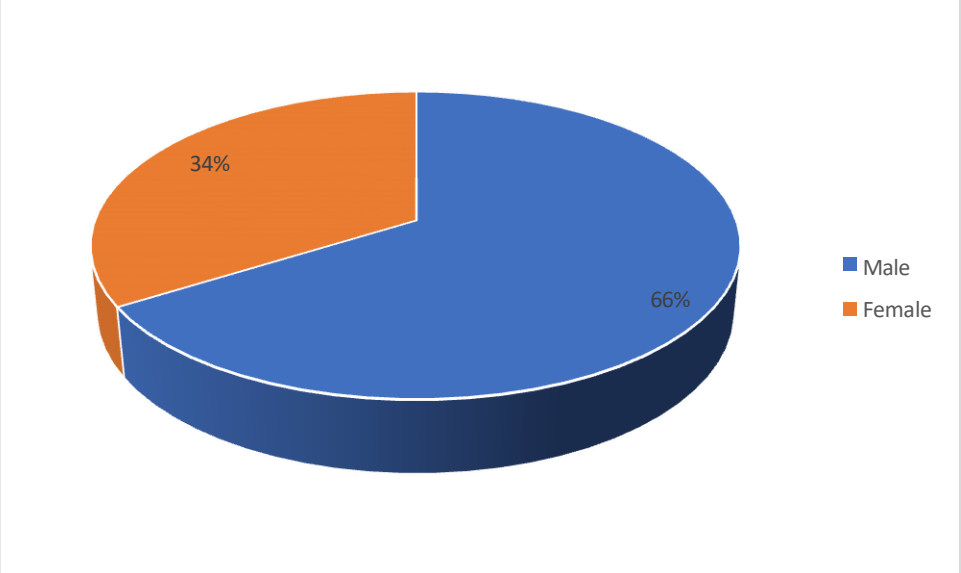


Figure 6: Gender distribution in the study sample

Most literature suggest no gender preponderance between men or women; however, our study in the Indian population showed a male preponderance, with 41 of the 62 patients (66%) male and 12 patients (34%) female.

Table 2: Gender distribution among the study sub-groups

			Awake (N=22)	Asleep (N=40)	P value
Gender	Males	Number (Percentage)	15 (68.2)	26 (65)	0.8
	Females		7 (31.8)	14 (35)	

Table 2 provides details on the population's gender distribution in relation to two subgroups. Between patient subgroups, there was no statistically significant variation in the distribution of patients by gender.

Symptoms on presentation:

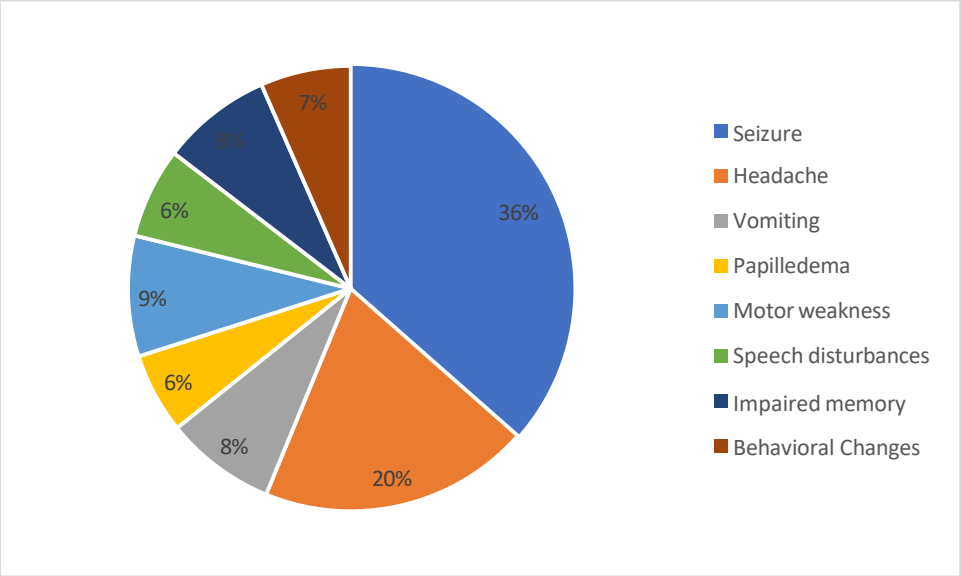


Figure 7: Clinical symptoms and signs of the study sample

All patients presented with clinical symptoms. Our patients most often report experiencing convulsions (n = 50, or 36%) as their primary presenting symptom. Following this, patients most often presented with complaints including holocranial headache (n = 27, 20%) and projectile vomiting (n = 11, 8%), both of which are clinical signs of elevated intracranial pressure (ICP). Eight patients (6%) reported visual blurring and worsening as a result of their elevated ICP. The next most common clinical manifestation was motor impairments (n =12, 9%) followed by speech problems (n = 9, 6%). Impairment of memory (n = 11, 8%) and changes in behavior (n = 9, 7%) were also reported as other uncommon symptoms. The following table 3 shows distribution of clinical symptoms of the population between two subgroups.

Table 3: Distribution of clinical symptoms and signs among the study sub-group

		Awake (N=22)	Asleep (N=40)	P value
Seizure	Mean ± SD Number (Percentage)	18 (81.8)	32 (80)	1
Headache		8 (36.4)	19 (47.5)	0.397
Vomiting		3 (13.6)	8 (20)	0.53
Papilledema		1 (4.5)	7 (17.5)	0.24
Motor Weakness		5 (22.7)	7 (17.5)	0.618
Speech Disturbances		3 (13.6)	6 (15)	1
Impaired Memory		2 (9.1)	9 (22.5)	0.3
Behavioural Changes		4 (18.2)	5 (12.5)	0.709

Duration of symptoms:
Symptoms persisted for an average of 15 days but might last as long as 2 years. Mean tenure of symptoms was 4 months.

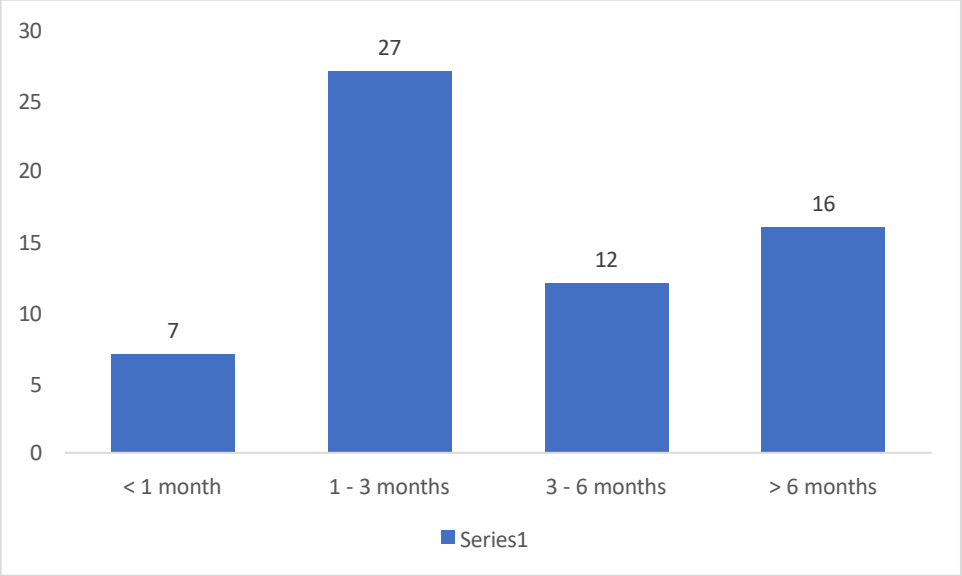


Figure 8: Duration of presenting symptoms (in months) in the study sample

Thirty-four (34) patients (54.8%) presented within 3 months of the onset of symptoms

Table 4: Duration of presenting symptoms (in months) among the study subgroups

Duration of Symptoms			Awake (N=22)	Asleep (N=40)	P value
Duration (months)		Median (IQR)	1.5 (1 - 7.25)	2 (1 - 4)	0.976
Range	< 1	Number (Percentage)	2 (9.1)	5 (12.5)	0.783
	1 - 3		11 (50)	16 (40)	
	3 - 6		3 (13.6)	9 (22.5)	
	> 6		6 (27.3)	10 (25)	

Co-morbidities:

In our study, 20 patients (32%) had co-morbidities on admission to our hospital for surgery. Diabetes mellitus and hypertension were commonly noted in about 65% of these patients with co-morbidities.

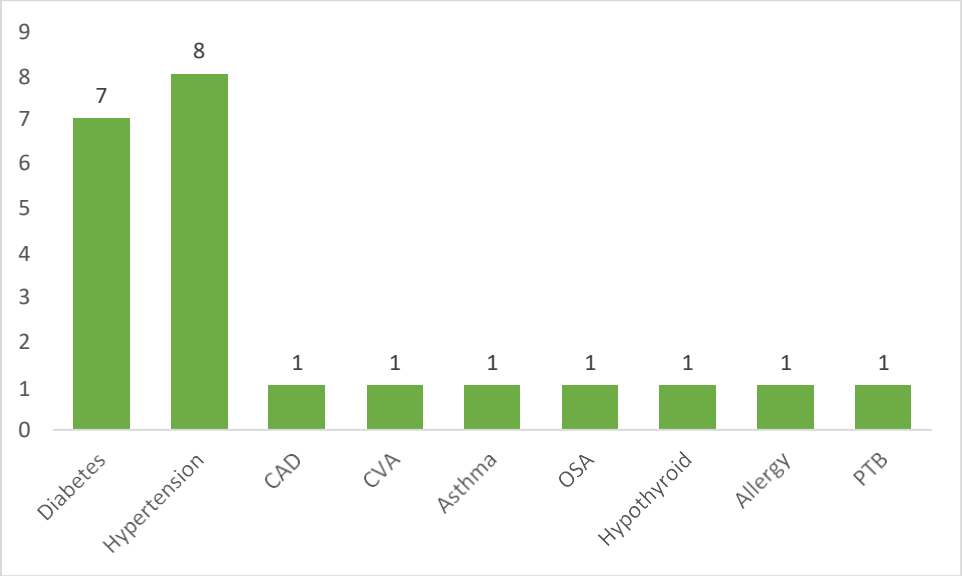


Figure 9: Co-morbidities in the study sample population

Though these co-morbidities affect the patient condition independently, they do not affect the survival of these patients with insular tumours undergoing surgery (based on univariate analysis).

Table 5 : Co-morbidities in the study population sub-group

Comorbidities		Awake (N=22)	Asleep (N=40)
Diabetes	Number (Percentage)	2 (9.1)	5 (12.5)
Hypertension		0 (0)	8 (20)
Coronary Artery Disease		1 (4.54)	0 (0)
Cerebrovascular Events		0 (0)	1 (2.5)
Asthma		0 (0)	1 (2.5)
Obstructive Sleep Apnoea		0 (0)	1 (2.5)
Hypothyroid		0 (0)	1 (2.5)
Allergy		0 (0)	0 (0)
Old Pulmonary TB		0 (0)	1 (2.5)

The above illustrated table 5 shows distribution of co-morbidities among the patient population between two subgroups. Interestingly most patients with co- morbidities underwent asleep surgery.

Table 6: Radiological parameters in the study sample ; Berger Sanai zonal classification and distribution of tumour among sample subgroups.

Radiological data

Tumour Details			Awake (N=22)	Asleep (N=40)	P value
Side	Right	Number (Percentage)	4 (18.2)	26 (65)	**0.001**
	Left		18 (81.8)	14 (35)	
Tumour Volume		Median (IQR)	86.8 (44.25 - 155)	85 (49.85 - 121.5)	0.965
Lesion	Ill Define	Number (Percentage)	12 (57.1)	27 (67.5)	0.423
	Well Defined		9 (42.9)	13 (32.5)	
Contrast Enhanced			7 (31.8)	19 (47.5)	0.231
Radiological Impression	Low / intermediate glioma		15 (68.2)	23 (57.3)	0.305
	High grade Glioma		6 (27.3)	15 (37.5)	
	CNS Lymphoma		1 (4.5)	0 (0)	
	Metastasis		0 (0)	2 (5)	
Midline Shift			8 (36.4)	11 (28.2)	0.509
Berger Sanai Zones	Zone I		4 (18.2)	6 (15)	0.841
	Zone II		0 (0)	0 (0)	
	Zone III		0 (0)	0 (0)	
	Zone IV		1 (4.5)	1 (2.5)	
	Zones I + II		5 (22.7)	12 (30)	
	Zones I + IV		3 (13.6)	5 (12.5)	
	Zones III + IV		0 (0)	2 (5)	
	Giant (all zones)		8 (36.4)	14 (35)	

In our series, thirty-two (52%) tumours were lateralized on the left side and remaining thirty (48%) tumours were on the right side. Most patients (26/30) with right sided insular tumours underwent asleep surgery with / without subcortical monitoring. Among patients with left sided insular tumours, 18 patients out of 32 (56%) underwent awake surgery with cortical mapping and subcortical monitoring and remaining 14 patients out of 32 (44%) underwent asleep surgery with / without subcortical monitoring.
Tumour volume measured using volumetric analysis with MRI suggests both subgroups had similar pre-operative tumour volume [Awake - 86.8 (44.25 - 155) cc] [Asleep - 85 (49.85 - 121.5) cc]. Tumor volume was not statistically different between the two groups.

Twenty-two (36%) patients had big insular tumours (size >4 cm) according to the Berger-Sanai zones. The remaining tumours were distributed as follows: 27% of them were in zone I+II (antero- and posterior-superior), and 13% were in zone I+IV (antero-superior and antero-inferior). Nearly 30% of the patients had mass effect and an opposite-side midline shift.

Table 7: Yasargil classification and tumour distribution in sample subgroups

Yasargil Classification		Awake (N=22)	Asleep (N=40)
3A	Number	6	15
3B		16	30
5A		15	18
5B		6	14

In our series, as per Yasargil's classification nearly 38% of the tumour were involving insula and the operculum (3B) . 27.5% and 16.7% of the insular tumours had paralimbic orbitofrontal (5A) and temporopolar (5B) areas involvement, respectively. Only 20% of it was pure insular (3A) tumours without any extension.
Based on the tumour location, solid or cystic nature, ill / well defined borders, enhancement pattern, diffusion restriction, calcification and MR Spectroscopy features, these tumours can be classified as low / intermediate glioma or high-grade glioma (even can predict WHO grades II / III). This concept is termed as radio genomics. In our study, 38 (61%) insular tumours were predicted to be low / intermediate glioma and 21 (33%) insular tumours were predicted to be high-grade glioma using radio genomics.

Surgical data

As mentioned earlier, one neurosurgeon (n◦1) performed transcortical/trans-sylvian awake resections with intraoperative mapping / monitoring (awake resection subgroup) and most cases of asleep resection with intraoperative mapping / monitoring (asleep resection with monitoring subgroup). The other neurosurgeons (n◦2-5) predominantly performed neuronavigation-assisted tumor decompression under asleep conditions without intraoperative mapping / monitoring. (asleep resection subgroup without monitoring).

Forty patients (64.5%) were given general anesthesia, whereas twenty-two patients (35.5%) had craniotomy while awake. In 47 (75.8%) patients, tumors were removed using a "trans-cortical" method, whereas in 15 (24%) patients, tumors were removed using a "trans-sylvian" strategy. In our research, we had 7 patients (11.2%) with GTR – gross total resection of tumor, 15 patients (24.2%) with NTR - near total resection of tumor, and 20 patients (32.2%) with STR - subtotal resection of tumor, with evidence of residual lesion on postoperative MRI scan.

Table 8: Surgeon and other surgical factors between sample sub-groups

Surgical Details			Awake (N=22)	Asleep (N=40)	P value
Neurosurgeon	1	Number (Percentage)	20 (90.9)	17 (43.6)	**0.008***
	2		1 (4.5)	3 (7.7)	
	3		0 (0)	7 (17.9)	
	4		1 (4.5)	11 (28.2)	
	5		0 (0)	1 (2.6)	
Tumour volume (Postop)		Median (IQR)	12.8 (1.78 - 27.2)	22 (4.5 - 42.5)	0.112
Extent of resection		Mean ± SD	84.2 ± 18.68	74.45 ± 21.15	0.072
EOR Category	Total 100%	Number (Percentage)	4 (19)	3 (7.7)	0.265
	Near Total >90%		5 (23.8)	10 (25.6)	
	Subtotal <89% to >70%		9 (42.9)	11 (28.2)	
	Partial < 70%		2 (9.5)	12 (30.8)	
	Biopsy		1 (4.8)	3 (7.7)	
Transcortical			18 (81%)	29 (72.5)	0.241
Trans-Sylvian			4 (18%)	11 (27.5)	
Duration of entire surgery		Mean ± SD	8.04 ± 0.89	6.97 ± 1.07	**<0.001**

The degree of resection was higher in the awake resection cohort, despite there being no statistically significant difference between the two groups (median 84.2 percent vs. median 74.45 percent; P< 0.07).Overall, the awake resection group had a higher rate of total resection (19% vs. 7.7%) and a lower rate of partial resection (9.5% vs. 30.8%).

Table 9: Surgery related factors and post-operative outcomes in trans-sylvian / transcortical approaches

Variables			Transcortical (N = 47)	Trans sylvian (N = 15)	P value
Post-op Tumour Volume		Median (IQR)	14 (3.3 - 42)	11 (1.6 - 34.6)	0.9
EOR		Mean ± SD	77.37 ± 21.39	79.58 ± 18.65	0.718
EOR Category	Total	Number (Percentage)	6 (12.8)	1 (7.7	0.982
	Near Total		12 (25.5)	3 (23.1)	
	Subtotal		15 (31.9)	5 (38.5)	
	Partial		11 (23.4)	3 (23.1)	
	Biopsy		3 (6.4)	1 (7.7)	
No New Deficits (47/15)			14 (29.8)	4 (26.7)	1
6 Months Overall Deficits (45/14)			13 (28.9)	5 (35.7)	0.742

In our study, extent of resection is same between trans-cortical or trans-sylvian approaches.
Both groups had similar immediate and 6 months post-operative morbidity.

Overall duration of surgery was noted be more in awake surgery (8+1 hours) owing to technical and anaesthetic reasons and patient compliance. Average duration of awake surgery is 2.91 hours and average duration of second phase of asleep in awake surgery is 1.71 hours.

Histopathological and molecular data:
Histopathologically, WHO Grade II gliomas were detected in 28 patients (45%), WHO Grade III gliomas were found in 15 patients (24.19%), and WHO Grade IV tumours were found in 16 patients (25.8%) of the patients. Oligodendrogliomas 1p19q co-deleted status were often discovered (82%) in Grade II tumours. Anaplastic astrocytomas (6 instances) and anaplastic oligodendrogliomas (9 cases) were discovered among the Grade III tumours. In our series, high-grade tumours included glioblastoma (n = 13), gliosarcoma (n = 2), and one case of Histone H3 G34R/V mutant Glioma. Histopathology results with IDH status, including subgroup distribution are shown in next two subsequent tables below.

Table 10: Tumour histopathological and molecular profile in the study sample

Tumours	IDH Status	Overall (N=62)
Oligodendroglioma		
Grade II	IDH Mutated	21
	IDH Wild Type	0
Grade III	IDH Mutated	9
	IDH Wild Type	0
Astrocytoma		
Grade II	IDH Mutated	6
	IDH Wild Type	1
Grade III	IDH Mutated	5
	IDH Wild Type	1
Glioblastoma		
Grade IV	IDH Mutated	2
	IDH Wild Type	11
Gliosarcoma		2
Histone H3 G34R/V mutant Glioma		1
Pilocytic astrocytoma		1

Table 11: Tumour histopathological trend in the sample subgroups

Tumour Details			Awake (N=22)	Asleep (N=40)	P value
HPE	Oligodendroglioma	Number (Percentage)	11 (50)	19 (47.5)	0.536
	Astrocytoma		4 (18.2)	9 (22.5)	
	Glioblastoma		5 (22.7)	8 (20)	
	Gliosarcoma		0 (0)	2 (5)	
	Lymphoma		1 (4.5)	0 (0)	
	Histone H3 G34R/V		1 (4.5)	0 (0)	

	mutant Glioma				
	Lung primary with brain metastasis		0 (0)	1 (2.5)	
	Pilocytic astrocytoma		0 (0)	1 (2.5)	

Intraoperative Findings During Awake Surgery

Twenty-two of the patients cooperated well during awake surgery. (19 were right-handed, 3 were left-handed, and all had left-hemisphere dominance for language). Pain during surgery was experienced by 60% of patients, postural discomfort by 22%, tachycardia by 60%, and intraoperative seizures by 18%, however these complications did not prevent the procedure from being completed in all but two patients. The surgical cavity and the indicated eloquent regions are separated by a safety margin known as positive functional mapping, which establishes the deep functional boundaries of resection with no neural tissue remaining, was successfully carried out in each cases (mean current intensity, >5mA [90%]). Surgery-related characteristics are detailed in below table

Table 12: Intraoperative findings during awake surgery

Awake Surgery			N=22
Speech Arrest – Language area		Number (Percentage)	22 (100)
Motor cortex SSEP			20 (90.9)
CST identification			21 (95.5)
Current Intensity	>5 mA		2 (10)
	≤5 mA		18 (90)
MEP's Loss	Reversible		1 (4.5)
	Irreversible		21 (95.5)
Pain During Surgery			13 (59.1)
Discomfort			5 (22.7)
Numbness			1 (4.5)
High BP			6 (27.3)
Tachycardia			13 (59.1)
Seizures			4 (18.2)
Abandonment of surgery			0 (0)
Intra op Motor Weakness			1 (4.5)
Intra-op Speech Deficit			4 (18.2)

Immediate surgical outcome

Perioperative mortality was not noted in our series. The awake resection subgroup had deterioration of the clinical status more frequently in the first postoperative week compared to the preoperative evaluation. (n=10; 45.5%) than in the asleep resection subgroup (n=8; 20%, $P < .035$) {statistically significant}. Major postoperative complications includes surgical cavity hematoma which required evacuation ($n = 1$, 1.6%), diffuse oedema which required anti-oedema escalation or decompressive craniectomy ($n = 3$, 4.8%), Vasospasm ($n = 3$, 4.8 %), persistent new motor deficits ($n = 18$, 29%) (hemiparesis scored according to the MRC score: 3-4/5 in 8 cases and 0-2/5 in 10 cases), and motor aphasia ($n = 13$, 20%). No patient had wound infection / meningitis in our series.

Surgical Details		Awake (N=22)	Asleep (N=40)	P value
New Deficit	Number (Percentage)	10 (45.5)	8 (20)	**0.035**

Table 13: Immediate surgical outcome in sample sub-groups

Immediate Postop Details		Awake (N=22)	Asleep (N=40)	P value
Motor Weakness	Number (Percentage)	5 (22.7)	13 (32.5)	0.417
Speech Deficit		6 (27.3)	7 (17.5)	0.366
Seizure		1 (4.5)	3 (7.5)	1

Infection		0 (0)	0 (0)	NA
Medical Complications		0 (0)	1 (2.5)	1
Vasospasm/Infarct		3 (13.6)	0 (0)	**0.041**
Surgical/hematoma oedema		4 (18.2)	2 (5)	0.174
KPS Score	Mean ± SD	69.1 ± 21.6	68 ± 20.5	0.847
Decrease in KPS Score	Median (IQR)	10 (0 - 30)	10 (0 - 15)	0.362
Duration of Hospital Stay		6 (6 - 7.25)	7 (5 - 9.5)	0.389
Radiotherapy	Number (Percentage)	18 (85.7)	31 (79.5)	0.731
Chemotherapy		19 (90.5)	29 (74.4)	0.185
Observation		3 (13.6)	8 (20.5)	0.731

Average duration of hospital stay was noted to be 6-7 days [min. 5 days / max. 9 days] in our series. Both the awake resection and the asleep resection subgroups had similar mean hospital stays.

Fifty-one patients (or 82% of the total) were recommended to have adjuvant chemoradiation treatment after surgery. Only 47 out of 51 patients (92.1% completion rate) actually took all of their scheduled doses of adjuvant chemoradiation treatment. Tumor recurrence has occurred in six (6) individuals receiving adjuvant therapy. This outcome is likely attributable to the very low OS seen in this patient population.

Table 14: Survival and long-term outcomes in sample sub-groups

Long term outcome

Follow Up Details			
Mean Duration of Follow Up		Mean ± SD	34 ± 20.55
Follow Up Complete		Percentage	95.2%
Survival	Alive	Number	46
	Death		13

In our study, follow-up lasted an average of 34 months, ranging from 13 to 55 months. 95 percent of the trial participants had been thoroughly followed-up. Three (3) patients could not be reached for follow-up.

Table 15: Presence of post-operative morbidity at 6 months follow up

6 Months Postop Overall Deficits		Awake (N = 22)	Asleep (N = 40)	P value
Yes		8 (36.4)	10 (25)	0.451
No		14 (63.6)	30 (75)	

Post operative deficits at six months follow up were noted among 8 patients (36.4%) in awake subgroup and 10 patients (25 %) in asleep subgroup {statistically not significant}. This shows awake surgery provides similar or better extent of resection compared to asleep group. Though awake insular surgery caused more new deficits during immediate post operative period, at 6 months follow up residual weakness or deficits are similar in both awake and asleep subgroups.

Diffusion-weighted hyperintensity was seen in 3/22 postoperative MRI scans (13.6%) after awake surgery; this occurred in the lenticulostriate artery area in 2/22 instances and the M2/M3 perforator region in 1/22 cases. These three infarcts were consistently accompanied by a motor deficit (MRC scores of 3–4–5 in one case and 0–2–5 in two cases).

Table 16: Post operative outcome trend between sample sub-groups at 3 months follow up

3 months Post-op Details		Awake (N=22)	Asleep (N=39)	P value
Motor Weakness	Number (Percentage)	6 (27.3)	12 (30.8)	0.774
Speech Deficit		6 (27.3)	8 (20.5)	0.547
Seizure		1 (4.5)	1 (2.6)	1

KPS Score	Mean ± SD	76.82 ± 16.15	73.85 ± 19.41	0.525
Decrease in KPS Score	Median (IQR)	0 (0 - 20)	0 (0 - 10)	0.933

At 3 months postoperative follow up, the seizure control was better in the asleep resection subgroup (97.4%), than in the awake surgery group (95.5%) in patients with pre-operative seizures. The seizure control has increased in the subgroup of asleep resection patients (97.4% vs 92.5% immediately post-op). At a 3-month follow-up, none of the 62 patients who were seizure-free before surgery developed seizures afterward. The 18/61 individuals who experienced an early postoperative motor impairment recovered well. Early postoperative hemiplegia in 4/61 individuals improved as well. Two patients made a full recovery, one was able to walk (MRC lower limb score of 4/5, MRC upper limb score of 2/5), while the other was unable to walk (MRC both lower and upper limb scores of 2/5).

Table 17: : Post operative outcome trend between sample sub-groups at 6 months follow *up*

6 months Post-op Details		Awake (N=22)	Asleep (N=40)	P value
Motor Weakness	Number (Percentage)	6 (27.3)	9 (24.3)	0.801
Speech Deficit		2 (9.1)	6 (16.2)	0.697
Seizure		1 (4.5)	0 (0)	0.373
KPS Score	Mean ± SD	81.36 ± 12.83	76.76 ± 17	0.277
Decrease in KPS Score	Median (IQR)	0 (0 - 10)	0 (0 - 10)	0.867

When compared to the awake resection subgroup (95.5% at 6 months postoperative follow up), patients with preoperative seizures had a higher seizure control rate in the asleep resection cohort (100% at 6 months postoperative follow up). Only 1 patient experienced sporadic seizures as a result of noncompliance. The group that underwent surgery under anaesthesia had better seizure control (100% vs. 92.5% immediately post-op). None of the 62 patients who had no seizures before to surgery had any at the 6-month follow-up. The hemiplegic patients (2/61) also made progress; one of them could walk (MRC score 4+/5 lower limb, MRC score 2/5 upper limb), while the other was unable to do so (MRC score 2/5 both lower and upper limbs). Of the 18/61 patients who had motor hemiparesis right after surgery, all of them recovered fully.

Table 18: Mean KPS score trend in sample sub-groups at pre-op, immediate post-op, 3 months & 6 months follow up

		Group 1	Within the group P Value vs Pre-op	Group 2	Within the group P Value vs Pre-op	P value Between the 2 groups
Pre-op	Mean ± SD	84.09 ± 10.07	NA	79.5 ± 16.63	NA	0.243
Immediate Post-op		69.1 ± 21.6	**0.001**	68 ± 20.5	**<0.001**	0.847
3 months		76.82 ± 16.15	**0.042**	73.85 ± 19.41	**<0.001**	0.525
6 months		81.36 ± 12.83	0.355	76.76 ± 17	**0.01**	0.277

In the awake resection grouping, the pre-operative Karnofsky Performance Status (KPS) score was higher (mean 84.09±10.07) than in the sleeping resection subgroup (mean 79.5±16.63) (P =<.243). The 3-months post-operative KPS score did differ from the pre-operative KPS score in the awake resection subgroup (76.82±16.15; P = 0.042) and the asleep resection subgroup (73.85±19.41; P = 0.001) despite the fact that there was no statistical significance between these groupings on the within analysis. In the subset of patients who underwent asleep resection, the 6-month postoperative KPS score was still different from the preoperative KPS score (76.76 17; P =< 0.01), but the postoperative KPS score at 6-month follow-up was the same as the preoperative KPS score (81.36±12.83; P = 0.355). No statistical significance was found between these subgroups on the within-group analysis.

Neurocognitive outcomes following awake surgery

During the preoperative and postoperative (6 month) workup of awake resections, a senior speech therapist carefully examined language and neurocognitive functioning using a regionally approved NIMHANS battery of neuropsychological tests (but not for asleep resection subgroups). Standardized scores were calculated by

transforming raw values and controls for factors like age, education, gender, and race. A standardised score ≥1.5 SD below the normative mean was used to define impairment in neurocognitive test performance prior to surgery.

Table 19: Neuro-cognitive outcomes (mean) and its trend in study population undergoing awake resection at pre-op & 6 months follow up

Neurocognition		Pre-op	6 Months	P value
Mental Speed	Median (IQR)	0 (0 - 10)	0 (0 - 10)	0.762
Sustained Attention		0 (0 - 0)	0 (0 - 10)	0.288
Categorical Fluency		0 (0 - 20)	0 (0 - 40)	**0.031**
Phonemic/Verbal fluency		0 (0 - 35)	10 (0 - 30)	0.647
Verbal working Memory		0 (0 - 20)	0 (0 - 20)	**0.018**
Visual working Memory		0 (0 - 20)	0 (0 - 20)	**0.023**
Inhibition		0 (0 - 20)	0 (0 - 30)	0.739
Planning		0 (0 - 20)	0 (0 - 25)	0.81
Verbal Learning and memory immediate		0 (0 - 15)	0 (0 - 15)	0.129
Verbal learning and memory delayed		0 (0 - 15)	0 (0 - 10)	0.48
Visual memory immediate		0 (0 - 0)	0 (0 - 10)	0.931
Visual memory delayed		0 (0 - 0)	0 (0 - 10)	0.783
Visuospatial construction		0 (0 - 0)	0 (0 - 0)	0.317

We discovered that a significant proportion of patients had declined in all domains of neurocognitive function at 6 months after surgery, including fluency, verbal working memory, and visual working memory. Postoperative assessments found increases in mental speed in 3.8% of patients, attention in 9.5%, inhibition in 5.7%, planning in 6.4%, and learning memory in 4.0%.

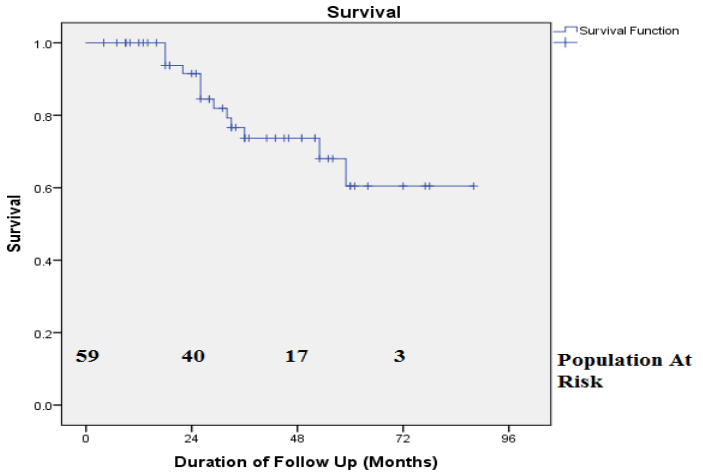
Table 20: Univariate and Multivariate Predictors of Overall Survival in study sample sub-groups

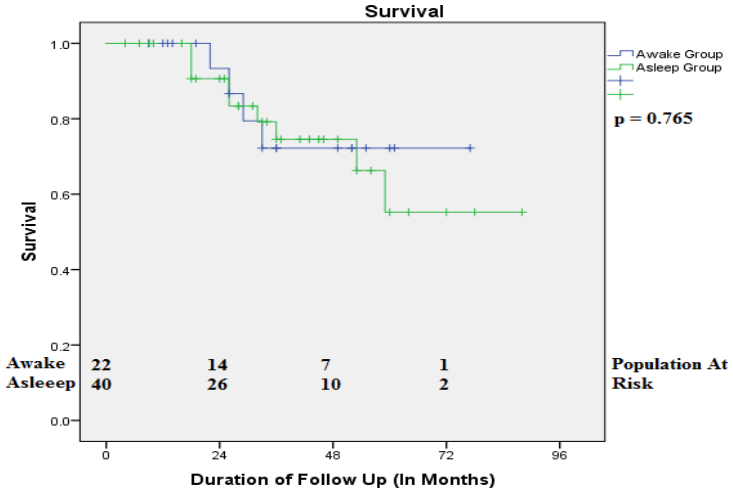
Survival Outcomes

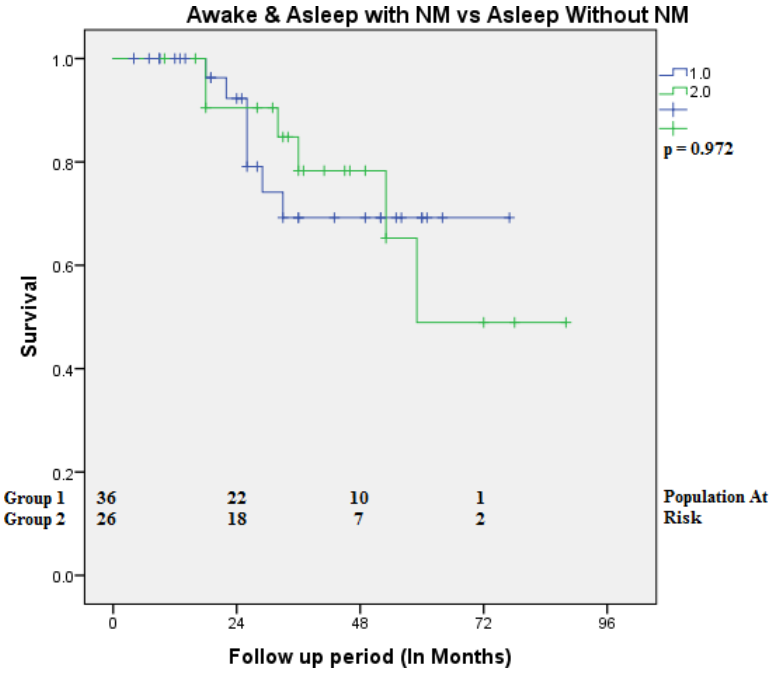
Univariate Analysis for Survival			Dead (N=13)	Alive (N=46)	P value
Gender	Males	Number (Percentage)	12 (92.3)	27 (58.7)	0.043
	Females		1 (7.7)	19 (41.3)	
Contrast enhancement			12 (92.3)	14 (30.4)	<0.001
Radiological Impression	Low Grade Glioma (Oligodendroglioma)		1 (7.7)	34 (73.9)	<0.001
	High grade Glioma		10 (76.9)	11 (23.9)	
	CNS Lymphoma		0 (0)	1 (2.2)	
	Metastasis		2 (15.4)	0 (0)	
IDH Status	Mutated		5 (45.5)	31 (79.5)	0.026
	Wild		6 (54.5)	8 (20.5)	
EOR	Total		2 (15.4)	5 (11.1)	0.392
	Near Total		1 (7.7)	13 (29.9)	
	Subtotal		4 (30.8)	15 (33.3)	
	Partial		4 (30.8)	10 (22.2)	
	Biopsy		2 (15.4)	2 (4.4)	
Type of Surgery	Awake		4 (30.8)	17 (37)	0.754
	Asleep		9 (69.2)	29 (63)	

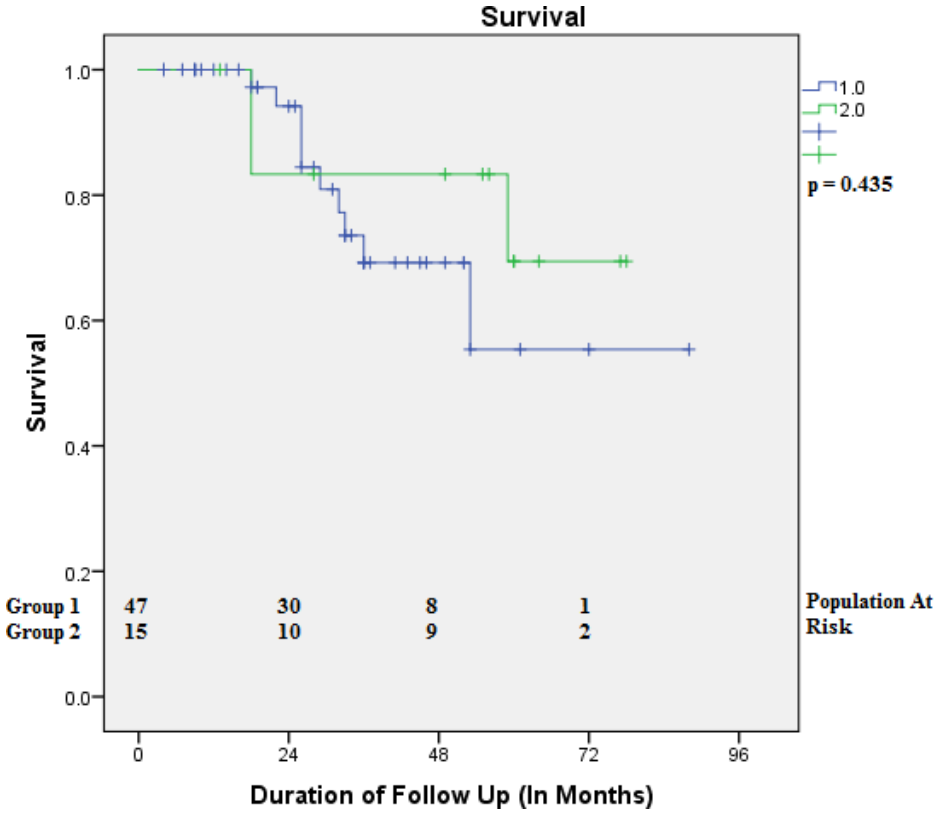
EOR	Mean + SD		68.51 ± 23.84	79.92 ± 19.44	0.133

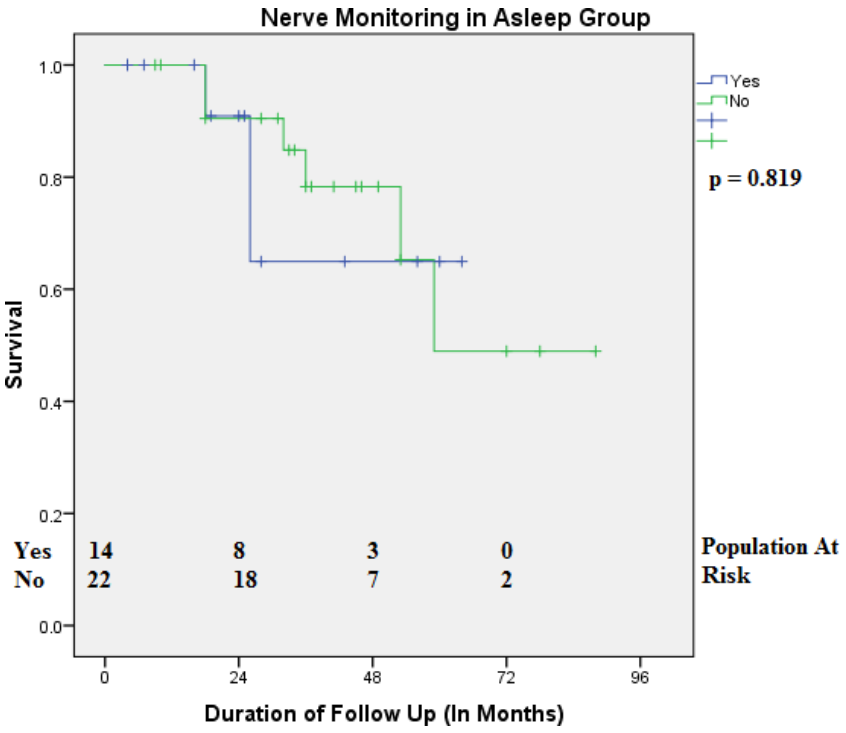
During follow-up, 13/62 patients (20.9%) died from oncological cause. Overall survival predictors are included in Table. Overall survival was predicted to be lower for females (P =.043) and males with contrast enhancement (P <0.001). Adjusted standardized residuals show that patients with Low Grade Glioma (Oligodendroglioma) had substantially greater survival (<0.001) than patients with High Grade Glioma (<0.001), irrespective of their radiological imaging or histopathology. Patients with these tumors who also have the IDH mutation have a far better chance of survival. No statistically significant difference in survival rates was found depending on the level of the resection or whether the patient was awake or asleep throughout the procedure.
The link between the degree of resection and the kind of surgery did not significantly affect overall survival. In a multivariate study of components that had been noteworthy in a univariate analysis, no factors were discovered to have a statistically significant impact on survival.

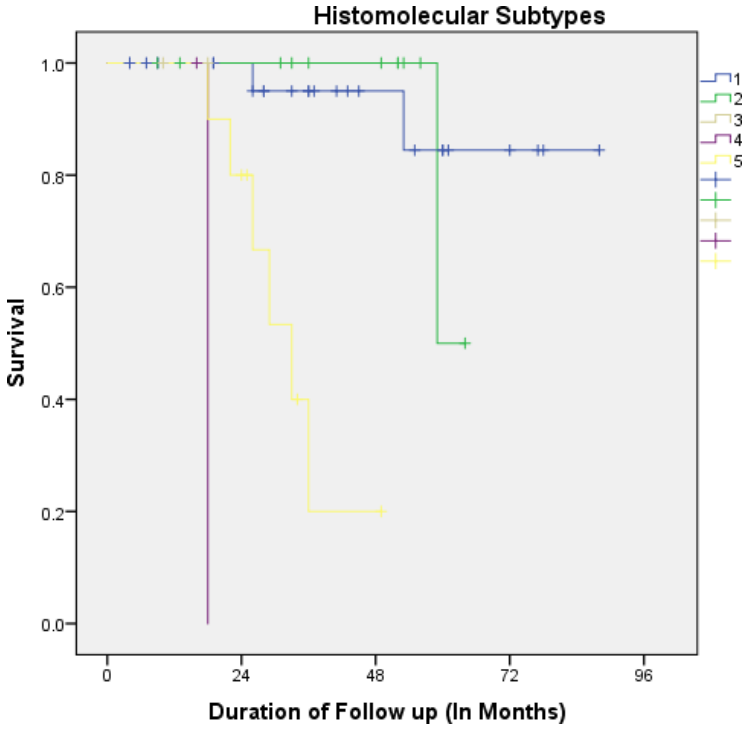





Awake & Asleep with NM vs Asleep Without NM
Survival
1.0
0.8
0.6
0.4
0.2
0.0
1.0
2.0
p = 0.972
Group 1 36 22 10 1
Group 2 26 18 7 2
Population At Risk
0
24
48
72
96
Follow up period (In Months)


Survival
Survival
1.0
0.8
0.6
0.4
0.2
0.0
1.0
2.0
p = 0.435
Group 1 47 30 8 1
Group 2 15 10 9 2
Population At Risk
0
24
48
72
96
Duration of Follow Up (In Months)


Nerve Monitoring in Asleep Group
Survival
1.0
0.8
0.6
0.4
0.2
0.0
Yes
No
p = 0.819
Yes 14 8 3 0
No 22 18 7 2
Population At Risk
0
24
48
72
96
Duration of Follow Up (In Months)


Histomolecular Subtypes
Survival
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
0
24
48
72
96
Duration of Follow up (In Months)

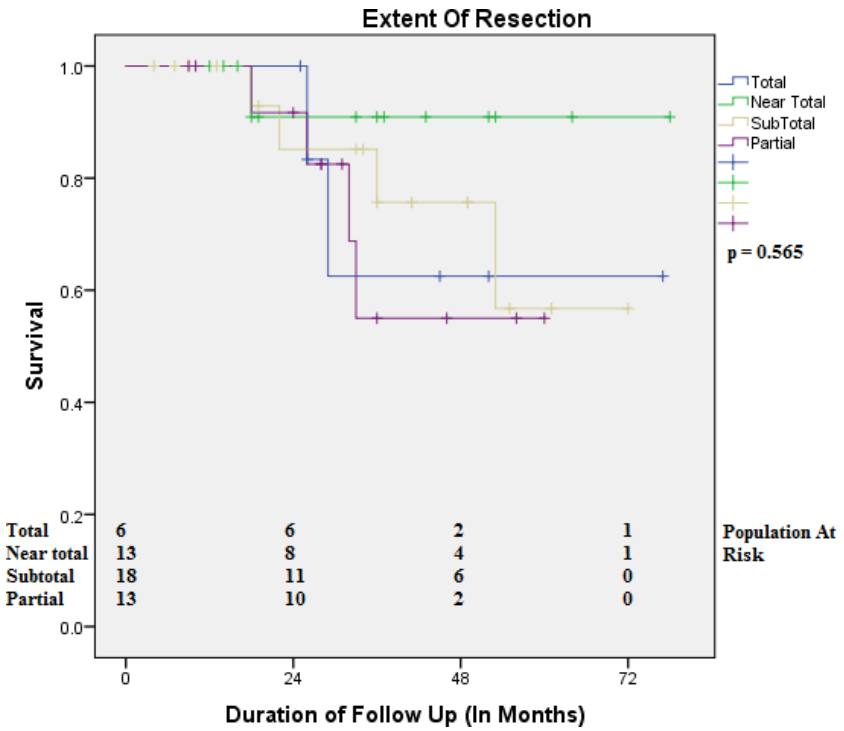


Figure 10: Kaplan-Meier estimates of overall survival (OS). **A**, OS in the whole series. **B**, OS according to awake / asleep surgery. **C**, OS according to awake + asleep surgery with neuro monitoring / asleep surgery without neuro monitoring. **D**, OS according to transcortical (group 1) / trans-sylvian (group 2). **E** OS according to asleep surgery with / without neuro-monitoring. **F**, OS according to histomolecular subtypes. **G**, OS according to extent of resection.

Kaplan-Meier curves estimating overall survival, in relation to multiple factors were presented in Figure 3. Awake resection patients had a longer median overall survival (not reached) than those who had asleep surgery (not reached; P=.765, not significant). The median overall survival followed a similar pattern, being higher for patients who had awake resections or asleep surgeries with monitoring relative to those who had asleep surgeries without monitoring (P=.972; not significant). Among patients with WHO Stage III disease, there was no discernible difference in OS between those with oligohistology and those without, or between those with IDH mutant and those with wild genotype. Patients with glioblastoma, a grade IV tumor, have been shown to live for 22 months, far longer than other research (14.5months).
Patients who had a whole or nearly entire resection had a longer median overall survival (72.0 months) than those who had a subtotal or partial resection (72 months and not achieved, respectively) (P=.565; not significant).

VI. DISCUSSION

One of the brain's most complicated and complex regions is the insula. The insula's anatomical and functional network, as well as the peri-insular area, have been strong reasons for requiring significant anatomical understanding, surgical expertise, and the use of contemporary technologies in managing tumor of this region.

Epidemiology:

About 10% of high-grade gliomas and 25% of low-grade gliomas in the central nervous system are found in the insular region[1,2]. The vast majority of our patients were between 30 and 60 years old when they were first seen for treatment. Males were more predisposed than females (male:female = 2:1) in our sample, where the median age at diagnosis was 40.6 years. This pattern was noticed in other studies pertaining to insular tumours in Indian population[45] as well as in European population[43] except that no gender predilection was noted in European population[43] and Western population[4].

Clinical Characteristics and Symptomatology:

The most common clinical manifestation in our analysis was seizures (35%), which is in line with findings by other authors[4,35,36,43,46]. In our investigation, holocranial headache (20%) was shown to be the second most typical pattern of presentation. The most prevalent tumour (48%) in our collection according to histology was an

oligodendroglioma, which is well known for causing seizures. The small subset of patients with high-grade lesions (24%) in our study may explain why ICP was increased. Similar to other studies, we found that the infiltrative character of the high-grade lesions, substantial peritumoral oedema, and large tumor sizes contributed to higher ICP[4,46–48].

The present study's results corroborate those of the vast majority of previous studies[4,17,35,43,45] in showing that the left side of the brain (51.6%) is more often involved than the right (48.3%).

Mean duration of symptoms was 4 months. Thirty-four (34) patients (54.8%) in our research sought care within 3 months after experiencing symptoms. Khatri D et al[45] observed similar pattern in his series where most patients were presenting with increased intracranial pressure.

Imaging and classification:

Classification schemes for insular tumors have been developed based on several anatomical characteristics, such as volume of tumor[4], lobar spread, putaminal extension [48], destruction / displacement of corticospinal pathways, and lenticulostriate arteries[49]. According to the most widely used Berger-Sanai zonal classification[4], we have found that zone I is the most prevalent site of tumor localization in the insular area. We also noticed that most (27%) tumours are found superior to the sylvian fissure (Zone I+II) and 13% of the tumours anterior to the line passing through foramen of Monroe (Zone I+II). This finding is exact opposite to location of tumours observed by Berger-Sanai et al[4] and Pallud J et al[43]. While 35% of patients in the study by Khatri D et al.[45] presented with tumors that had spread to all four of the body's zones, we found that a far larger proportion of our patients presented with giant tumors of various sizes.

Our research has also made use of Yasargil's classification. Type 3B was the most often occurring subtype (38%), whereas type 3A was the least frequently encountered at 20%. Most studies show more temporal polar extension than opercular involvement, as observed by Pallud J et al[43] and Khatri et al[45].

Surgical and post-operative outcomes (morbidity)

In addition to peritumoral edoema, brain bulge was observed in 22 of our patients who had large-sized enormous tumours that contained all Berger-Sanai zones. This discovery has enormous implications for our surgical strategy. Only 8 of these instances were found to be suitable for awake craniotomy, while the remaining 14 required sleep excision of tumours. In addition, the transcortical window was employed more frequently (n = 18, 81.81%) since it was difficult to open the Sylvian fissure in these patients (n = 4, 18.18%). Due to the high degree of tumour involvement and edoema, a lobectomy was required in a small subset of patients (n = 5; 22.72%). Similar findings were reported in a research that examined large insular tumours (30/41 patients). In their study[45] only 2 awake craniotomy was done and 31.7% cases employed transsylvian route

Numerous studies have demonstrated that the level of resection (EOR) is a strong determinant of survival for patients with insular tumors4,43. We found no evidence that the amount of excision (EOR), whether it was carried out when the patient was awake or asleep, or via a transcortical or trans-sylvian route, played a significant impact, contrary to the findings of the great majority of other studies4,43. Similar results were seen in an Indian investigation by Khatri et al45 that included 41 insula tumours. We agree with their opinion that full tumour removal continues to be a difficult task because of the insula's delicate anatomical structure and the high level of surgical skill required. Therefore, a STR or NTR for insular tumors is an oncosurgical aim that is more frequent and "safely achievable." On the other hand, we agree with the large body of literature that finds improved survival outcomes in tandem with increasing excisional size[4,36]. We also found that the frequency of patients receiving amount of resection >90% did not vary significantly across the surgical techniques (Near total resection). However, the outcome at 6 months did not significantly differ between these surgical approaches irrespective of extent of resection (GTR or NTR). Panigrahi et al[36] had similar finding in his study with no statistically significant difference between surgical approaches (TS / TC) over 6 months post operative outcomes.

A functional reshaping of the multimodal insular lobe was suggested by the neurological condition of the patients immediately deteriorating in 18 cases (29%), [(worsening of the clinical situation as opposed to the preoperative evaluation happened more frequently in the awake resection cohort (n=10; 45.5%) than in the asleep resection subgroup (n=8; 20%), P.035,] and then improving over the course of the following 6 months. Numerous additional studies24,35,36,43 have noted this deterioration of weakness that occurs in the initial postoperative period.[24,35,36,43]. Our study has shown, in accordance with the literature[1], there were more early neurological abnormalities following an awake surgery, whereas the asleep surgery under general anaesthesia group revealed more late neurological impairments; however, these patterns were not statistically significant. Similar rates of survival were seen in the two groups.

Permanent neurological impairments are most often caused by vascular injury to the lateral lenticulostriate arteries. In our study, in awake resection group we observed 2/22 cases had developed infarct in internal capsular region. Those 2 patients had developed weakness which has improved but these patients had residual hemiparesis at 6 months follow up. Moshel et al49, who have extensively researched the relationship between these vascular architecture patterns and their tumour associations, have proposed that preoperative identification

of these anatomical growth patterns might be advantageous in planning tumour excision and reducing surgical morbidity.Due to the harmful effects of damaging these veins, Yasargil et al.[3], Duffau et al.20, and Simon et al.[37] have all suggested leaving a covering of tumoral tissue surrounding them. The rate of persistent deficit reduced from 9% in the series supplied by Lang et al.17 and Simon et al.37 to 8% in the series reported by Moshel et al.49 throughout the course of the previous ten years. Duffau et al.32 and Sanai et al.4 found postoperative persistent deficits in 4% and 6% of patients, respectively. In the present series, the rate of irreversible decline was 6.4%.

For this reason, Duffau et al. have proposed doing the procedure with constant intraoperative neuromonitoring to ensure the safety of the neighboring eloquent functional regions. Functional guided resection reduces the risk of complications after surgery and increases the likelihood of a successful outcome, particularly in cases with low-grade glioma. Although we found comparable results, reducing post-operative morbidity and overall survival using intra-operative cortical mapping and sub-cortical monitoring was not statistically significant. According to Berger et al.[28], Harvey-Junmper et al[25], Pallud et al[43], and Duffau et al[20,32], using technology like intraoperative MRI / ultrasonography, and fluorescence-guided surgery can help surgeons perform the safest possible resection while also maximising the amount of tissue removed.

VII. CONCLUSIONS

Our findings revealed that the amount of resection, neurological impairment, and survival were fairly similar when the two techniques were used. The complex anatomy, vascular systems, and functions of the dominant hemisphere make surgery for insular gliomas extremely difficult. The utilisation of awake surgery, intraoperative techniques with cortical and subcortical mapping, and neuropsychological rehabilitation allow for the maximal "safe excision" of insular gliomas with a manageable risk of neurological impairments. Grade IV histology and the occurrence of recurrence negatively impact survival, but IDH mutation and successful adjuvant treatment are associated with a better prognosis.

Based on our early research, we believe that awake surgery, cortical mapping and subcortical monitoring, and continuous intraoperative neuropsychological tests will become standard operating procedure for neurosurgeons. We conclude that awake resection is a viable alternative to asleep surgery, since it is just as safe, permits greater resections for insular tumors, and in our series, had comparable post-operative morbidity.

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