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TOPIC REVIEW

The transsylvian approach for resection of insular gliomas: technical nuances of splitting the Sylvian fissure

Michael M. Safaee[1] · **Dario J. Englot**[1] · **Seunggu J. Han**[1] · **Michael T. Lawton**[1] · **Mitchel S. Berger**[1]

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Abstract Insular gliomas represent a unique surgical challenge due to the complex anatomy and nearby vascular elements associated within the Sylvian fissure. For certain tumors, the transsylvian approach provides an effective technique for achieving maximal safe resection. The goal of this manuscript and video are to present and discuss the surgical nuances and appropriate application of splitting the Sylvian fissure. Our hope is that this video highlights the safety and efficacy of the transsylvian approach for appropriately selected insular gliomas.

Keywords Insula · Glioma · Sylvian fissure · Transsylvian approach

Introduction

Gliomas are the most common primary intraparenchymal brain tumors in adults and cause significant morbidity and mortality [1]. Incidence rates for all gliomas range from 4.7 to 5.7 per 100,000 persons and vary by age; oligodendrogliomas are more common in the 35–44 year-old age group, while anaplastic astrocytoma and glioblastoma reach a peak incidence in the 75–84 year-old age group [2, 3]. In general, gliomas are more common in men than women, although pilocytic astrocytomas represent an exception [4–7]. Our understanding of tumor genetics has grown tremendously over the past decade and recent studies have shown that gliomas can be classified into molecular subgroups based on key markers including 1p/19q codeletion, *IDH* mutation, and *TERT* promoter mutations. These markers provide important prognostic value and may help identify therapeutic targets [8, 9].

The surgical management of insular gliomas remains a notable challenge. Tumors in this region accounts for up to 25 % of low grade gliomas (LGGs) and 10 % of high grade gliomas (HGGs) [10]. The insula features complex anatomy including eloquent cortex and vasculature that supplies critical motor and language systems [11, 12]. The insula itself also plays a role in memory, drive, affect, gustation, olfaction, visceral sensorimotor processing, sympathetic control of cardiovascular tone, somatosensory input and pain processing, motor planning, and language [13, 14]. Anatomically, the insula is covered by the opercula of the frontal, parietal and temporal lobes and forms a pyramid. The anterior, superior, and inferior periinsular sulci mark the borders of insula and allow it to be distinguished from surrounding cortical areas [14]. The anterior periinsular sulcus separates anterior insula from frontoorbital operculum, the superior periinsular sulcus separates the superior insula from the frontoparietal operculum, and the inferior periinsular sulcus separates the inferior insula from the temporal operculum. The central insular sulcus is the deepest within the insula and courses obliquely, dividing the insula into two zones: anterior (larger) and posterior (smaller) insula [14]. The anterior insula includes the transverse gyrus and accessory gyrus, which form the insular pole, and three principal short insular gyri (anterior, middle, and posterior). The posterior insular contains the anterior and posterior long gyri. Two important landmarks of the insula are the insular

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✉ Michael M. Safaee
Michael.safaee@ucsf.edu

[1] Department of Neurological Surgery, University of California, San Francisco, CA, USA

stem (anterobasal portion of insula located in the depth of the proximal Sylvian fissure) and the limen insulae (located within the insular stem) [15].

In additional to the insular cortex itself there are critical landmarks in this region including deep grey matter structures, descending fibers, and the middle cerebral artery (MCA). The extreme capsule, claustrum, external capsule, and striatum are deep to the central portion of the insula with motor fibers that form the posterior limb of the internal capsule running immediately deep to the posterior segment of the superior periinsular sulcus. Additionally, the uncinate fasciculus lies below the superior periinsular sulcus [11, 14, 16]. The insula receives most of its blood supply from short perforators off the M2 and M3 segments, which can often be distorted or encased by tumor [11, 12, 16]. Short perforators can generally be safely coagulated, however long perforators that travel posteriorly and supply the corona radiata must be preserved to avoid potential complications such as hemiparesis [12, 17]. More proximally, the MCA gives off lateral lenticulostriates in the M1 segment, which generally supply the basal ganglia and internal capsule, but can also supply insular tumors in addition to short perforators off the M2 and M3 segments. The lateral lenticulostriates are generally considered to represent the most medial limit of tumor resection [17, 18].

Advancements in awake surgery and cortical/subcortical mapping have improved the safety of insular gliomas surgery. Given the importance of extent of resection for progression-free and overall survival, maximal and safe resection remains critical [19–26]. Sanai et al. introduced an anatomic classification of insular gliomas that correlates with extent of resection [25]. Using this scheme, insular gliomas are divided into four zones based on the location of the majority of tumor: zone 1 (anterior to the Foramen of Monro and above the Sylvian fissure), zone 2 (posterior to the Foramen of Monro and above the Sylvian fissure), zone 3 (posterior to the Foramen of Monro and below the Sylvian fissure), and zone 4 (anterior to the Foramen of Monro and below the Sylvian fissure). Subsequent analysis confirmed that the Berger–Sanai classification system is a reliable and predictive method for assessing extent of resection and morbidity for insular gliomas [27].

In general, resection of these tumors involves a transcortical or transsylvian approach. Advances in cortical and subcortical mapping have allowed for mapping of the operculum to identify and preserve functional areas while entering functionally silent cortex to safely access the insula while preserving important anatomic and vascular structures [28, 29]. The transcortical technique typically involves creating “windows” through the operculum between surface vessels to safely access the insula and maximize surgical resection. The transsylvian approach, initially described by Yaşargil, provides an alternative strategy and continues to be expanded upon [17, 18, 30, 31]. This technique requires opening of the superficial and deep Sylvian cisterns with careful preservation of key vascular structures including the insular and opercular branches of the MCA and their perforators, as well as the superficial Sylvian veins. Using this approach to access the insular often requires retracting the operculum, which can be limited by the need to preserve superficial veins, which makes this approach more challenging for large lesions requiring significant exposure.

Our group recently compared the transcortical and transsylvian approaches to the insula. In this report, Benet et al. found that the transcortical approach provided better insular exposure and surgical freedom, with the caveat that expertise in cortical and subcortical mapping are required to perform this safely. It is important to note that the surgical approach must be tailored to the individual lesion. The transsylvian approach remains appealing given preservation of opercular cortex and may be best suited for certain lesions where the eloquent cortex precludes the use of a transcortical approach. In this manuscript, we present a detailed description of the transsylvian approach to insular gliomas with a focus on operative nuances that help ensure maximal and safe resection of these lesions.

Methods

Details on the technical nuances of splitting the Sylvian fissure for resection of insular gliomas can be seen in the accompanying video. A frontotemporal craniotomy is performed with the bone flap turned overlying the Sylvian fissure. The pterion is drilled until flat. The dura is opened in a semicircular fashion and preserved with two pieces of moist non-adherent telfa. The Sylvian fissure is split widely, mobilizing superficial Sylvian veins to the temporal side of the fissure since they course inferiorly and bridge to the sphenoparietal sinus. Cortical arachnoid is incised with a number 11 scalpel blade to allow for insertion of short microscissors, which are used to lift and cut arachnoid as underlying veins are cleared. Venous tributaries from the frontal lobe are coagulated as the incision is carried forward. The superficial Sylvian vein is gradually detached from the frontal lobe and mobilized temporally. In general, veins of the Sylvian fissure should be preserved, but opening the fissure can require some sacrifice. Since this can increase venous pressure in the remaining Sylvian veins, sacrifice should be delayed until the split is further advanced. Once dissection reaches the temporal pole, one must identify and open the sphenoidal arachnoid of the proximal fissure since it resists deep spreading dissection.

After mobilizing superficial veins temporally and opening Sylvian cistern, an artery is identified as it emerges from the fissure. Arteries naturally separate frontal and temporal lobes and define the dissection plane. This artery is followed into the depths of the Sylvian fissure to develop the plane further. Cutting arachnoid bands between frontal and temporal lobes initiates this dissection. The working area around an artery is widened circumferentially like a funnel rather than a cylinder to avoid constricted holes. Similar working areas around adjacent arteries can be developed and connected to neighboring areas of dissection.

Small opercular branches will lead to arterial bifurcations and larger insular segments. The dissection becomes easier as it deepens because larger arteries widely separate the frontal and temporal lobes. Spreading dissection along MCA trunks will part the lobes from "inside out," following a wide plane of separation deep in the Sylvian fissure to narrow and more adherent areas superficially. The Sylvian fissure is often most adherent superficially near the pterion where frontal and temporal lobes come in contact with few arteries in between to separate the lobes. Lobules can interdigitate, adding a rolling contour to this plane of contact. Spreading dissection from inside-out is the best method for opening these difficult tissue planes.

Once inside the Sylvian cistern, the challenge shifts from separating lobes to unscrambling arteries. Inferior, middle, and superior divisions of MCA, anterior temporal artery, lenticulostriates, and other branch arteries are untangled to complete the fissure split. Arteries faithfully serve one lobe, coursing temporally or frontally. Consequently, arteries in the Sylvian cistern are moved to one side or the other. Unlike arteries that faithfully serve one lobe, veins can branch to both lobes and frequently bridge the Sylvian fissure.

Following the M2 segments overlying the insula along their course posteriorly opens the distal Sylvian fissure, which is typically easier to do after already splitting the proximal Sylvian fissure. The dissection follows these deep arteries beneath the operculum, but must also use the superficial cortical arteries that emerge from the operculum, alternating between deep and superficial dissection to work the operculum open from both sides. The cortical arteries lead down into the operculum and dissection along their course opens the outer operculum superficially. The insular arteries lead back in the distal Sylvian recesses and dissection along their course opens the deep inner operculum. As these two areas of dissection meet, the operculum gradually widens to reveal the insula. The stem arteries that comprise the M2 segments course prominently across the insular gyri. Lastly, the peri-insular sulci must be opened aggressively, especially the anterior and superior sulci, to free up the frontal operculum and gain full access to insula, with the help of some retraction to open the operculum widely.

Once the Sylvian fissure dissection and split is complete attention is turned to resection of tumor. Intraoperative motor or speech/language mapping are used to identify safe areas for resection. Then, with the additional benefits of intraoperative image guidance, a combination of bipolar cautery and ultrasonic aspiration are used to meticulously resect tumor around eloquent structures and vascular elements. Windows are used to create corridors that allow for preservation of key neural and vascular structures, while subcortical mapping allows the surgeon to push the limits of resection safely by identifying and preserving deep fiber tracts. Once resection is complete, meticulous hemostasis is achieved and the resection cavity is lined with absorbable hemostatic agent.

Discussion

Insular gliomas pose great technical challenge and the appropriate surgical approach must be selected on an individual basis in order to minimize morbidity and allow for maximal safe resection. In a contemporary cohort of patients with insular gliomas resected using a transsylvian approach, we have had no complications or permanent neurologic deficits. Our group has shown that tumor location within the insula correlates with extent of resection [25] and recent cadaveric studies showed that for tumors in the anterior insula (zones 1 and 4), the transsylvian approach can provide sufficient exposure [32]. The sacrifice of Sylvian bridging veins may be required to achieve the desired exposure, however this can be dangerous in up to 30 % of patients where there is poor collateral outflow through the vein of Labbé or superior sagittal sinus [32, 33]. It is also recognized that the transsylvian approach may in some cases require significant retraction, particularly for exposure of large insular tumors. Retraction is associated with complications including ischemia, cerebral edema, and direct cortical damage with an estimated frequency of 10 % in skull base surgery and 5 % in intracranial aneurysm operations [34, 35]. Although early reports associate the transsylvian approach with higher rates of complication (up to 30 %), likely secondary to ischemic injury from retraction and arterial dissection, our multi-disciplinary approach using two expert surgeons has thus far been safe and efficacious with no major surgical or neurologic complications [17, 30, 36].

A key advantage of the transsylvian approach is sparing of the frontal operculum, particularly in the dominant hemisphere. The frontal operculum is typically characterized as featuring three regions: the pars orbitalis (anterior), pars triangularis (medial), and pars opercularis (posterior). Broca's area is defined as Brodmann's areas 44 and 45 (pars opercularis and triangularis) and believed to contain critical areas required for expression of speech, however in the largest study to date only 61 % of patients had cortical language sites identified within the dominant frontal operculum [19]. Sparing the frontal operculum is desirable to minimize the risk of postoperative language deficits as well as minimizing potential injury to the superior longitudinal fasciculus (SLF), a critical connection between anterior and posterior language areas, however resection of gliomas within the dominant frontal operculum is well-tolerated with acceptabile morbidity [37].

The transcortical approach, when used with adjuncts such image-guidance, cortical and subcortical mapping, is a safe alternative for certain insular lesions [17, 23, 25, 36]. This approach may be particularly useful for posterior insular lesions (zones 2 and 3) where the transsylvian approach is severely limited by the narrow Sylvian cistern [32]. An important consideration for the transcortical approach in cases of posterior-based insular lesions is that the surgical profile is highly dependent on brain mapping, thus difficulty to predict preoperatively. Furthermore, in the posterior insula the transsylvian approach is more challenging since the Sylvian fissure is deeper with a greater surface of opposing parietal operculum compared to the anterior Sylvian fissure. A benefit of this approach, particularly in the posterior insula, is that cortical and subcortical stimulation allow for safe resection, while transsylvian dissection relies on meticulous dissection of vascular structures in a very narrow corridor, which explains the higher complication rate in early reports, although we have shown it to be safe and effective when using a two-surgeon approach.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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