

. 综 述 .

岛叶胶质瘤的外科治疗策略的研究进展

杨 辉 崔 萌 张 猛 马晓东

【摘要】岛叶位于外侧沟底,借其周围的环状沟与额、颞、顶叶分界。岛叶的尖部称岛阈,藏于大脑外侧沟深部的脑叶被顶、额、颞叶覆盖,其深面分别为最外囊、屏状核、壳核、外囊、内囊前后肢等,是胶质瘤的好发部位之一。由于位置深在、毗邻重要功能区 and 血管,而且术中难以准确判断边界,因此,岛叶胶质瘤的手术治疗难度大。Yasargil 于 1992 年首次报道边缘系统和旁边缘系统肿瘤的手术治疗,开启了岛叶肿瘤手术治疗的新篇章。近年来,随着术中辅助技术的进步,岛叶胶质瘤外科治疗的可行性和安全性取得了较大的提升。本文就岛叶胶质瘤的外科治疗手段、术中辅助技术研究进展进行综述,为临床提供参考。

【关键词】岛叶胶质母;显微手术;手术入路;术中辅助技术

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Advances in surgical treatment strategies for insular gliomas

YANG Hui, CUI Meng, ZHANG Meng, MA Xiao-dong. Department of Neurosurgery, The First Medical Center of PLA General Hospital, Beijing 100853, China

【Abstract】Insular lobe is located at the bottom of the lateral sulcus, and is separated from the frontal, temporal, and parietal lobes by the annular sulcus around it. The tip of the insula is called the insular threshold. The lobe hidden in the deep of the lateral sulcus of the brain is covered by the parietal, frontal, and temporal lobes, and its deep surface is respectively the most outer capsule, the parietal nucleus, the putamen, the outer capsule, and the anterior and posterior limbs of the inner capsule, which is one of the most common sites of gliomas. Because of its deep location, adjacent to important functional areas and blood vessels, and the difficulty in accurately judging the boundary during surgery, the surgical treatment of insular gliomas is difficult. Yasargil first reported the surgical treatment of limbic system and paralimbic system tumors in 1992, starting a new chapter in the surgical treatment of insular tumors. In recent years, with the progress of intraoperative assisted techniques, the feasibility and safety of surgical treatment of insular gliomas have been greatly improved. This article reviewed the research progress of surgical treatment and intraoperative assisted techniques of insular gliomas, providing reference for clinical practice.

【Key words】Insular gliomas; Microsurgery; Surgical approach; Intraoperative assisted techniques

岛叶胶质瘤是脑部常见的肿瘤之一,占有脑胶质瘤的 20%~30%。由于位置深在,周围解剖结构复杂,岛叶胶质瘤的手术治疗具有较高的风险和难度。Yasargil 等^[1]于 1992 年首次报道边缘和旁边缘系统肿瘤的手术治疗。近年来,随着神经影像学、神经导航技术、术中 MRI 等技术的不断发展,岛叶胶质瘤的手术治疗取得了一定的进展,手术成为岛叶胶质瘤的主要治疗方法,并提倡最大化安全切除肿瘤^[2,3],改善癫痫发作^[4,5]。

1 岛叶胶质瘤的手术治疗

目前,岛叶胶质瘤可采取经外侧裂入路、经皮质

入路,或两者相结合的方式,并提倡在软膜下分块切除肿瘤;术中注意识别保护功能皮质、内囊后肢、弓状束、额枕下束、钩状束及重要血管等结构;外侧组豆纹动脉(lateral lenticulostriate arteries, LLAs)常作为切除的内侧界^[6,7],一旦损伤,可造成对侧肢体偏瘫;术前 DSA、MRI 等可帮助识别 LLAs^[8,9]。术中还应注意对静脉的保护,避免术后严重脑水肿或因静脉回流不畅而致术区渗血等情况。

1.1 外侧裂入路 显微镜下沿侧裂的自然间隙锐性分离蛛网膜,开放侧裂池、降低颅内压,有利于侧裂的分离,注意保护侧裂静脉,一般将侧裂静脉分向颞侧。当肿瘤较大时,侧裂分离需达环岛沟附近,并根据肿瘤的后极决定向后分离的范围。在此过程中,会不可避免地牺牲一些侧裂静脉^[2,10]。分离侧裂同时牵开岛盖,逐渐暴露岛叶、肿瘤、大脑中动脉及其分支,并在间隙内切除肿瘤。为避免长时间对岛盖的牵拉,可采取动态牵拉技术^[7]。因保留了岛盖,在

优势侧最大化地减少了语言中枢的直接损伤^[2]。术中牵拉岛盖组织有挫伤、水肿等风险,且因血管及岛盖的限制,岛叶后部的暴露较困难,术后脑缺血发生率高^[7,10]。

1.2 经皮质入路 此入路是在距肿瘤最近或易建立“手术通路”的非功能区造瘘,造瘘范围根据肿瘤而定^[11],可通过多个造口切除肿瘤^[2]。结合术中唤醒麻醉技术、皮层及皮层下标记技术可更准确地避开功能区及纤维束。当肿瘤累及侧裂血管时,利用造瘘切除肿瘤可使血管呈“镂空”状态。经皮质入路保留了侧裂血管,自持式牵引避免了对岛盖持续牵拉,且对各个方向的肿瘤均能切除。造口边缘需与功能皮质有一定的距离,避免双极电凝、吸引器来回操作对功能区造成损伤。与侧裂入路相比,经皮质入路具有更好的术野暴露,尤其是在岛叶后部(Berger分类Ⅱ、Ⅲ区)^[2,7]。尽管如此,岛叶后部仍是残留肿瘤常见部位之一^[11]。

1.3 经侧裂与皮质结合入路 如果肿瘤巨大而无法充分、安全的暴露,则可采取两种入路相结合的方式^[2,10]。首先,分离侧裂,切除前部肿瘤;然后,经皮质造瘘切除肿瘤后部;最后,将肿瘤内侧边界剥离至内囊,既保留了岛盖,又获得了最大化的暴露和手术自由度^[2]。

2 术中辅助技术

神经导航、术中MRI、术中唤醒麻醉及皮层和皮层下标记等技术可为岛叶胶质瘤的手术带来更高的肿瘤切除率 and 功能保护率。为实现最大化安全切除肿瘤,在权衡岛叶的复杂情况后,术中采用多模态技术更具优势。

2.1 皮层和皮层下标记 电刺激技术具有简单可靠、精确安全等优势,在提高肿瘤切除率同时最大限度地减少神经损伤^[12]。因岛叶解剖及功能复杂,皮层和皮层下标记技术在岛叶胶质瘤术中行功能区标记,可获得更好的功能保护^[13]。Alimohamadi等^[14]报道10例优势半球的岛叶胶质瘤,在神经电生理监测、皮层和皮层下标记技术辅助下进行显微手术,肿瘤切除率平均为86.2%,术后也获得了良好的语言保护和癫痫控制。最近,Pallud等^[15]报道利用皮层及皮层下标记技术行脑功能区标记,在岛叶弥漫胶质瘤中绘制皮质-皮质下地形图和切除性概率图谱,可为手术提供帮助。

2.2 神经电生理监测技术 神经电生理监测技术可以在术中对躯体感觉、运动、脑干听觉等诱发电位及

大脑皮质功能等进行动态监测,实时了解神经功能状态,明确可切除的安全界限,提高手术的安全性,减少术后神经功能损伤。在功能区胶质瘤的手术中,此技术可提高语言、运动、感觉等神经功能的保留率,实现最大化的安全切除肿瘤。Breitkopf等^[16]将神经电生理监测、皮层和皮层下标记、术中MRI等技术相结合,具有术中切除肿瘤可控和更加彻底的优势。

2.3 术中唤醒麻醉技术 岛叶胶质瘤常毗邻语言区,而对语言的无创精准定位目前仍难以达到;因此,术中唤醒麻醉技术已被用于岛叶胶质瘤的手术中,并已取得较好的结果。术中唤醒麻醉技术结合皮层和皮层下标记及神经电生理监测技术可获得对功能区、神经纤维束准确的定位,减少术后神经缺损。最近的一项荟萃分析显示,术中唤醒麻醉技术辅助显微手术切除岛叶胶质瘤,明显降低术后永久神经损伤率^[12]。Pallud等^[17]报道岛叶胶质瘤术中唤醒组与非唤醒组的肿瘤切除率分别94%、46%,唤醒麻醉技术对岛叶胶质瘤病人的总生存期具有积极的影响。术中唤醒麻醉会存在心率和血压升高、觉醒不足、烦躁、癫痫发作等情况,故术前应仔细评估、选择适合的病人^[18,19]。然而,也有文献报道唤醒或非唤醒方式切除岛叶胶质瘤具有相似的肿瘤切除率、神经缺损率,而唤醒麻醉手术对病人和医护人员更具挑战^[20]。术中唤醒麻醉不适合儿童、术前已有严重语言障碍的病人^[18,19]。因此,术中唤醒与非唤醒谁更具优势还需进一步的前瞻性研究。

2.4 神经导航 可直观地显示肿瘤与纤维束的位置关系,辅助手术的安全性和准确性也更高,尤其是功能肿瘤区^[21,22]。术前MRI扫描可获得多个序列,DTI可用于锥体束、弓状束、额枕下束、钩状束等的重建,fMRI可用于语言区(Broca区和Wernicke区)的示踪重建,MRA、MRV用于重要的血管重建。研究认为高级别胶质瘤和低级别胶质瘤分别利用T₁+C、T₂Flair序列勾画肿瘤边界从而实现三维重建^[23]。将以上数据整合即可实现肿瘤及周围结构的可视化,可提高肿瘤切除率、减少副损伤。Dasenbrock等^[8]报道DSA与MRI整合入导航系统有助于岛区胶质瘤术中对LLAs的保护。随着手术的进行,脑组织会发生漂移,术前配准的导航会失准^[24,25]。有报道脑组织漂移并不是均匀的^[25],因此多采取神经导航联合术中MRI、超声、皮层和皮层下标记等多模态技术切除肿瘤^[23,26]。

2.5 术中MRI 是在手术室安装有磁共振设备,术中

可随时扫描。当无法判断肿瘤边界、可疑导航漂移、怀疑肿瘤残留或认为切除满意时,可进行 MRI 扫描,需继续切除时,则可更新导航数据,指导手术朝向正确的方向进行。术中 MRI 也可在术中及时发现远隔部位血肿、脑组织缺血等情况^[25,27],指导术者及时进行处理,利于神经功能的恢复。目前,MRI 是确定肿瘤切除率的金标准^[25,28],而术中 MRI 在术中即可明确肿瘤切除率,如有残留可继续手术,最终实现最大化安全切除的目的。有文献报道术中 MRI 评估肿瘤切除率优于显微镜下的判断、5-ALA 肿瘤标记和术中超声等技术^[25]。术中 MRI 还可用于指导立体定向活检和激光间质热疗(laser interstitial thermotherapy, LITT),提高检出率,实时监测治疗情况等^[25]。

Leroy 等^[29]报道在术中 MRI 指导下切除额颞岛叶胶质瘤 20 例,最终残余肿瘤中位体积为 4.3 cm³,中位肿瘤切除率达 92%,术后 45% 的病人重返工作岗位。Chen 等^[30]报道术中 MRI 结合神经导航辅助显微手术切除岛叶高级别胶质瘤可明显提高肿瘤切除率和降低并发症发生率,延长总生存期和无进展生存期。研究显示,术中 MRI 指导显微手术切除岛叶肿瘤,术中 MRI 指导使岛叶肿瘤切除率提高了 15.1%,而其他部位肿瘤切除率仅提高了 8%^[27]。一项前瞻性研究指出,无论肿瘤的亚型和位置,术中 MRI 都能提供最大的肿瘤切除率,对无强化或轻度强化的肿瘤更有优势^[31];功能区(包括岛叶)肿瘤手术首次扫描显示残留的肿瘤体积是大于其他部位的,而最终各部位的肿瘤残留体积无明显差异,则说明如岛叶等功能区在术中 MRI 指导下手术可获得良好的肿瘤切除率。这提示,在岛叶胶质瘤手术中,术中 MRI 具有明显优势^[27,30],但也存在麻醉及手术时间长、设备昂贵、需专业人员操作、感染风险增加等不足^[28,32],以及病人体内有无抗磁金属材料时存在安全隐患^[25]。

3 LITT

LITT 是在术中 MRI 指导下对病灶定位和实时监测,利用激光设备发出的热量选择性消融病变,与传统开颅手术相比具有创伤小、并发症少、住院时间短等优势。LITT 适用于:肿瘤直径 3 cm;手术难以触及的深部病变;开颅手术或放射治疗失败、无法耐受麻醉和失血^[33]。Hafez 等^[34]报道 1 例 LITT 分期治疗的左侧岛叶少突胶质细胞瘤,随访两年,肿瘤消失。Easwaran 等^[35]报道 1 例采用 LITT 治疗的岛叶复发弥漫星形细胞瘤,治疗后肿瘤完全消失,癫痫发作明显

改善。然而,术前无准确病理结果的病人,在 LITT 后无法进行后续治疗,因此在术前明确病理后效果更佳。LITT 也有出血、脑水肿、正常脑组织热损伤、手术失败、癫痫和脑脊液漏等风险^[36]。

总之,岛叶胶质瘤通常采用以手术治疗为主的综合治疗,目前的肿瘤切除率得到显著提高,中位数在 84%~99%^[14,29,30,37]。一项岛叶胶质瘤术后神经损伤的荟萃分析指出永久运动、语言障碍发生率分别为 4%、2%^[38]。另一项岛叶胶质瘤术后并发症的荟萃分析指出后遗症发生率低至 3.5%^[12]。根据肿瘤的特点采取适合的手术入路、制定合理的术前计划及结合多模态技术有助于实现最大化安全切除肿瘤的目的。不能耐受开颅手术的病人,可选择 LITT。根据术后组织和分子病理结果制定个体化的辅助治疗方案,如放化疗、电场治疗等。最后,行长时间的随访实时掌握复发情况并再次制定诊疗计划。随着手术及辅助技术的不断进步和对岛叶胶质瘤的认识的不断加深,对每个病人制定个体化、精准的诊疗方案,未来可期进一步降低岛叶胶质瘤的病死率、致残率,提高肿瘤全切除率,改善病人的生活质量,延长病人生存期。

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【作者贡献声明】:杨辉查阅文献、拟定思路、撰写文章、修改文章;崔萌查阅文献、提供思路、修改文章;张猛修改文章;马晓东拟定思路、整体把握文章思路、指导修改文章以及最后定稿。

【参考文献】

[1] YASARGIL MG, VON AMMON K, CAVAZOS E, *et al.* Tumours of the limbic and paralimbic systems [J]. *Acta Neurochir (Wien)*, 1992, 118(1-2): 40-52.

[2] PRZYBYLOWSKI CJ, HERVEY-JUMPER SL, SANAI N. Surgical strategy for insular glioma [J]. *J Neurooncol*, 2021, 151(3): 491-497.

[3] HERVEY-JUMPER SL, BERGER MS. Insular glioma surgery: an evolution of thought and practice [J]. *J Neurosurg*, 2019, 130(1): 9-16.

[4] GAUHAR F, BAKHSHI SK, SHAMIM MS. Seizure control after surgical resection of insular glioma [J]. *J Pak Med Assoc*, 2021, 71(8): 2103-2104.

[5] PEPPER J, CUTHBERT H, SCOTT T, *et al.* Seizure outcome after surgery for insular high-grade glioma [J]. *World Neurosurg*, 2021, 154: e718-e723.

[6] PITSKHELAURI DI, BYKANOV AE. Complication avoidance: resection of the insular glioma complicated by iatrogenic injury to the lenticulostriate artery [J]. *Acta Neurochir (Wien)*, 2021, 163(11): 3093–3096.

[7] PRZYBYŁOWSKI CJ, BARANOSKI JF, SO VM, *et al.* Surgical morbidity of transsylvian versus transcortical approaches to insular gliomas [J]. *J Neurosurg*, 2019, 132(6): 1731–1738.

[8] DASENBROCK HH, SEE AP, SMALLEY RJ, *et al.* Frameless stereotactic navigation during insular glioma resection using fusion of three-dimensional rotational angiography and magnetic resonance imaging [J]. *World Neurosurg*, 2019, 126: 322–330.

[9] GHALI M. Preservation of the lenticulostriate arteries during insular glioma resection [J]. *Asian J Neurosurg*, 2020, 15(1): 16–21.

[10] SAFAEE MM, ENLOT DJ, HAN SJ, *et al.* The transsylvian approach for resection of insular gliomas: technical nuances of splitting the Sylvian fissure [J]. *J Neurooncol*, 2016, 130(2): 283–287.

[11] LI Z, LI G, LIU Z, *et al.* Transcortical approach for insular gliomas: a series of 253 patients [J]. *J Neurooncol*, 2020, 147(1): 59–66.

[12] DI CARLO DT, CAGNAZZO F, ANANIA Y, *et al.* Post-operative morbidity ensuing surgery for insular gliomas: a systematic review and meta-analysis [J]. *Neurosurg Rev*, 2020, 43(3): 987–997.

[13] LU JJ, ZHANG ZH, CHEN AB, *et al.* Microsurgery assisted by cortical and subcortical stimulation under intraoperative awake anesthesia combined with neuro-navigation for patients with insular glioma [J]. *Chin J Clin Neurosurg*, 2021, 26(4): 229–232.

卢锦江, 张志浩, 陈奥博, 等. 唤醒麻醉下皮层及皮层下电刺激联合神经导航辅助显微手术治疗岛叶胶质瘤[J]. *中国临床神经外科杂志*, 2021, 26(4): 229–232.

[14] ALIMOHAMADI M, SHIRANI M, SHARIAT MOHARARI R, *et al.* Application of awake craniotomy and intraoperative brain mapping for surgical resection of insular gliomas of the dominant hemisphere [J]. *World Neurosurg*, 2016, 92: 151–158.

[15] PALLUD J, ROUX A, TRANCART B, *et al.* Surgery of insular diffuse gliomas—Part 2: Probabilistic cortico-subcortical atlas of critical eloquent brain structures and probabilistic resection map during transcortical awake resection [J]. *Neurosurgery*, 2021, 89(4): 579–590.

[16] BREITKOPF M, BISDAS S, LIEBSCH M, *et al.* Safety, utility, and clinical results of continuous intraoperative electrophysiologic monitoring in 1.5t imri-guided surgery [J]. *World Neurosurg*, 2017, 106: 198–205.

[17] PALLUD J, ZANELLO M, MOIRAGHI A, *et al.* Surgery of insular diffuse gliomas—Part 1: Transcortical awake resection is safe and independently improves overall survival [J]. *Neurosurgery*, 2021, 89(4): 565–578.

[18] KWINTA BM, MYSZKA AM, BIGAJ MM, *et al.* Intra- and post-operative adverse events in awake craniotomy for intrinsic supratentorial brain tumors [J]. *Neurol Sci*, 2021, 42(4): 1437–1441.

[19] KURIBARA T, AKIYAMA Y, MIKAMI T, *et al.* Preoperative prediction of communication difficulties during awake craniotomy in glioma patients: a retrospective evaluation of 136 cases at a single institution [J]. *Neurol Med Chir (Tokyo)*, 2021, 61(1): 21–32.

[20] GRAVESTEIJN BY, KEIZER ME, VINCENT A, *et al.* Awake craniotomy versus craniotomy under general anesthesia for the surgical treatment of insular glioma: choices and outcomes [J]. *Neurol Res*, 2018, 40(2): 87–96.

[21] SHURKHAY VA, GORYAYNOV SA, ALEKSANDROVA EV, *et al.* Navigation systems in neurosurgery [J]. *Zh Vopr Neirokhir Im N N Burdenko*, 2016, 80(6): 107–114.

[22] SANG S, WANGGOU S, WANG Z, *et al.* Clinical long-term follow-up evaluation of functional neuronavigation in adult cerebral gliomas [J]. *World Neurosurg*, 2018, 119:e262–e271.

[23] AKAY A, NASIROV R, RUKSEN M, *et al.* DTI-based neuronavigation guided eloquent area glioma resection with awake craniotomy: supra-functional resection of eloquent area gliomas [J]. *Turk Neurosurg*, 2019, 29(5): 759–767.

[24] GERARD IJ, KERSTEN-OERTEL M, PETRECCA K, *et al.* Brain shift in neuronavigation of brain tumors: a review [J]. *Med Image Anal*, 2017, 35: 403–420.

[25] ROGERS CM, JONES PS, WEINBERG JS. Intraoperative MRI for brain tumors [J]. *J Neurooncol*, 2021, 151(3): 479–490.

[26] LU CY, CHEN XL, CHEN XL, *et al.* Clinical application of 3.0 T intraoperative magnetic resonance combined with multimodal neuronavigation in resection of cerebral eloquent area glioma [J]. *Medicine (Baltimore)*, 2018, 97(34): e11702.

[27] MOTOMURA K, NATSUME A, IJIMA K, *et al.* Surgical benefits of combined awake craniotomy and intraoperative magnetic resonance imaging for gliomas associated with eloquent areas [J]. *J Neurosurg*, 2017, 127(4): 790–797.

[28] RAO G. Intraoperative MRI and maximizing extent of resection [J]. *Neurosurg Clin N Am*, 2017, 28(4): 477–485.

[29] LEROY HA, STRACHOWSKI O, TULEASCA C, *et al.* Microsurgical resection of fronto-temporo-insular gliomas in the non-dominant hemisphere, under general anesthesia using adjunct intraoperative MRI and no cortical and subcortical mapping: a series of 20 consecutive patients [J]. *Sci Rep*, 2021, 11(1): 6994.

[9] XIANG T, LIN YX, MA W, *et al.* Vasculogenic mimicry formation in EBV-associated epithelial malignancies [J]. *Nat Commun*, 2018, 9 (1): 5009.

[10] YUE WY, CHEN ZP. Does vasculogenic mimicry exist in astrocytoma [J]. *J Histochem Cytochem*, 2005, 3(8): 997-1002.

[11] RICCI-VITIANI L, PALLINI R, BIFFONI M, *et al.* Tumour vascularization via endothelial differentiation of glioblastoma stem-like cells [J]. *Nature*, 2010, 468(7325): 824-828.

[12] BISEROVA K, JAKOVLEVS A, ULJANOVS R, *et al.* Cancer stem cells: significance in origin, pathogenesis and treatment of glioblastoma [J]. *Cells*, 2021, 10(3): 621.

[13] LIU TJ, SUN BC, ZHAO XL, *et al.* CD133⁺ cells with cancer stem cell characteristics associates with vasculogenic mimicry in triple-negative breast cancer [J]. *Oncogene*, 2013, 32(5): 544-553.

[14] XIAO Y, YU D. Tumor microenvironment as a therapeutic target in cancer [J]. *Pharmacol Ther*, 2021, 221: 107753.

[15] FANG C, CEN D, WANG Y, *et al.* ZnS@ZIF-8 core-shell nanoparticles incorporated with ICG and TPZ to enable H2S-amplified synergistic therapy [J]. *Theranostics*, 2020, 10(17): 7671-7682.

[16] WEI X, CHEN Y, JIANG X, *et al.* Mechanisms of vasculogenic mimicry in hypoxic tumor microenvironments [J]. *Mol Cancer*, 2021, 20(1): 1-18.

[17] JIA J, CHU L, ZENG X, *et al.* GOLPH3 promotes vascular mimicry via the epithelial mesenchymal transition in glioblastoma cells [J]. *Turk Neurosurg*, 2023, 33(5): 722-730.

[18] LIU Q, QIAO L, LIANG N, *et al.* The relationship between vasculogenic mimicry and epithelial-mesenchymal transitions [J]. *J Cell Mol Med*, 2016, 20(9): 1761-1769.

[19] DING XC, WANG LL, ZHANG XD, *et al.* The relationship between expression of PD-L1 and HIF-1 α in glioma cells under hypoxia [J]. *J Hematol Oncol*, 2021, 14(1): 1-5.

[20] FERNNDEZ-BARRAL A, ORGAZ JL, GOMEZ V, *et al.* Hypoxia negatively regulates antimetastatic PEDF in melanoma cells by a hypoxia inducible factor-independent, autophagy dependent mechanism [J]. *PLoS One*, 2012, 7(3): e32989.

[21] LE JONCOUR V, GUICHET PO, DEMBL KP, *et al.* Targeting the urotensin II/UT G protein-coupled receptor to counteract angiogenesis and mesenchymal hypoxia/necrosis in glioblastoma [J]. *Front Cell Dev Biol*, 2021, 9: 652544.

[22] TUNCKALE T, CALISKAN T, POTOGLU B, *et al.* Investigation of serum E-Cadherin, VEGF121, survivin, tenascin C and tetraspanin 8 levels in patients with glioblastoma [J]. *Bratisl Lek Listy*, 2023, 124(4): 304-308.

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[30] CHEN LF, YANG Y, MA XD, *et al.* Optimizing the extent of Resection and minimizing the morbidity in insular high-grade glioma surgery by high-field intraoperative MRI guidance [J]. *Turk Neurosurg*, 2017, 27(5): 696-706.

[31] LEROY HA, DELMAIRE C, LE RHUN E, *et al.* High-field intraoperative MRI and glioma surgery: results after the first 100 consecutive patients [J]. *Acta Neurochir (Wien)*, 2019, 161(7): 1467-1474.

[32] MATSUMAE M, NISHIYAMA J, KURODA K. Intraoperative MR imaging during glioma resection [J]. *Magn Reson Med Sci*, 2022, 21(1): 148-167.

[33] SHAH AH, SEMONCHE A, EICHBERG DG, *et al.* The role of laser interstitial thermal therapy in surgical neuro-oncology: series of 100 consecutive patients [J]. *Neurosurgery*, 2020, 87(2): 266-275.

[34] HAFEZ DM, LIEKWEG C, LEUTHARDT EC. Staged laser interstitial thermal therapy (LITT) treatments to left insular low-grade glioma [J]. *Neurosurgery*, 2020, 86(3): E337-E342.

[35] EASWARAN TP, LION A, VORTMEYER AO, *et al.* Seizure freedom from recurrent insular low-grade glioma following laser interstitial thermal therapy [J]. *Childs Nerv Syst*, 2020, 36(5): 1055-1059.

[36] SALEM U, KUMAR VA, MADEWELL JE, *et al.* Neurosurgical applications of MRI guided laser interstitial thermal therapy (LITT) [J]. *Cancer Imaging*, 2019, 19(1): 65.

[37] ROSSI M, GAY L, CONTI NIBALI M, *et al.* Challenging giant insular gliomas with brain mapping: evaluation of neurosurgical, neurological, neuropsychological, and quality of life results in a large mono-institutional series [J]. *Front Oncol*, 2021, 11: 629166.

[38] LU VM, GOYAL A, QUINONES-HINOJOSA A, *et al.* Updated incidence of neurological deficits following insular glioma resection: a systematic review and meta-analysis [J]. *Clin Neurol Neurosurg*, 2019, 177: 20-26.

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