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Intraventricular Meningioma Resection with Post-Operative Ischemia of the Lateral Geniculate Nucleus

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Intraventricular Meningioma Resection and LGN Ischemia

1 Title: Intraventricular Meningioma Resection with Post-Operative Ischemia of the Lateral

2 Geniculate Nucleus

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- 20
- 21 Key words: Meningioma, Complication, Intraventricular, Lateral Geniculate, Ischemia
- 22 <u>Running title</u>: Intraventicular Meningioma Resection and LGN Ischemia
- 23 <u>Abbreviations</u>: IVM, intraventricular meningiomas; LGN, lateral geniculate nucleus; MRI, magnetic
- 24 resonance imaging; DTI, diffusion tensor imaging; DWI, diffusion weighted image; AChA, anterior
- 25 choroidal artery; LPChA, lateral posterior choroidal artery.

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26	<u>Abstract:</u>
27	
28	Background: Intraventricular meningiomas (IVMs) comprise 0.5-3% of intracranial meningiomas. They
29	often cause obstructive hydrocephalus and are commonly treated with surgical resection or stereotactic
30	radiosurgery.
31	
32	Objective: To describe the surgical approaches and resection techniques needed to approach
33	intraventricular tumors, while highlighting the eloquent anatomy and blood supply surrounding the
34	ventricular system in order to avoid neurological injury.
35	
36	Methods: Two cases of left atrial IVMs that were complicated by postoperative lateral geniculate nucleus
37	(LGN) ischemia and resultant temporary contralateral quadrantanopia are described. The safe surgical
38	approaches to the atrium of lateral ventricles as well as the anatomy and blood supply to the LGN and
39	optic radiation are discussed and illustrated.
40	
41	<u>Results</u> : In both cases, the patients had complete resection of their tumors. They both ultimately made a
42	good recovery after transient visual deficits. These cases provide useful demonstrations of eloquent
43	anatomy of the ventricular walls and visual pathway anatomy.
44	
45	Conclusion: Care must be taken to avoid visual pathways along the lateral ventricle wall and the nearby
46	arterial supply of the lateral geniculate nucleus from the choroidal arteries when resecting intraventricular
47	tumors.

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49 Introduction:

50	Patients with intraventricular meningiomas (IVMs) often present with symptoms secondary to
51	obstructive hydrocephalus or mass effect from a trapped lateral ventricle ^{1,2} . IVMs account for 0.5-3% of
52	meningiomas ^{3,4} . Although the majority of IVMs occur within the atrium of the lateral ventricle (80%)
53	they also may originate from the third (15%) and fourth ventricle (5%) ^{1,3} . Treatment options include
54	radiosurgery or surgical resection ⁵ .
55	Depending on tumor depth, within the ventricular system, IVMs can be located adjacent to
56	arteries that supply eloquent white matter pathways or cortical structures. Therefore, surgical resection is
57	often technically challenging ⁶ . Various surgical approaches can be used to access the ventricular system
58	and the surgeon should tailor his plan to individual patients, taking into account the tumor location,
59	handedness and other clinical factors to optimize safety ^{6,7} .
60	Here we report two patients with lateral ventricle IVMs that resulted in lateral geniculate nucleus
61	(LGN) ischemia after surgical resection via a parieto-occipital transcortical approach through the occipital
62	horn of the lateral ventricle. A brief overview of the neurosurgical approaches to the lateral ventricular
63	atrium is followed by the anatomy and blood supply of the LGN and the trajectory of the optic radiations.
64	
65	Materials and Methods:
66	This is a retrospective review of two cases. The electronic medical record and radiology were reviewed
67	for both cases. The institutional review board of the author's university approved this study (IRB# 13-
68	12587).
69	
70	Results:
71	Case 1: A 34-year-old right-handed woman had a surfing accident, and, in addition to an orbital fracture,
72	the head CT revealed an intra-ventricular mass. Contrast-enhanced magnetic resonance imaging (MRI)
73	demonstrated a mass within the atrium of the left lateral ventricle with surrounding edema in the

temporal, parietal and occipital lobes (Figure 1A, B). The left temporal horn and the occipital horn were

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75 obstructed. The patient had been having daily morning left temporal headaches, which were often accompanied by dizziness, nausea and vomiting. She also had intermittent visual symptoms. These had 76 77 been attributed to migraines, which were diagnosed 8 years prior. An MRI at that time was normal. On physical exam, the patient was neurologically intact, including full visual fields and normal ocular fundi. 78 79 Her language and reading comprehension were also normal. She had no family history of meningioma, radiation, breast or thyroid tumors. She elected to undergo surgical resection of the tumor. A left parieto-80 81 occipital trans-cortical approach via the occipital horn was selected and performed as described below with a Simpson Grade 1 resection. Post-operatively the patient was neurologically intact except for a right 82 83 inferior quadrantanopia. While the post-operative MRI showed a gross total resection of the tumor 84 (Figure 1C), it also revealed a small infarct in the left LGN (Figure 1D). Final pathology was atypical 85 meningioma, WHO grade II. At 6 months post-operative, her visual fields had recovered and her tumor 86 had not recurred.

87

Case 2: A 36-year-old male obtained a CT scan as part of an insurance screening and was incidentally 88 89 found to have a left atrial mass. MRI demonstrated a 3 cm left atrial contrast enhancing mass consistent 90 with meningioma (Figure 2A, B). The left occipital horn displayed slight dilation with some surrounding 91 edema in the parietal lobe. He described generalized headaches for the past 6 months, especially while reading, but these were similar to migraines he had had since childhood. The patient's neurological exam 92 93 was normal, including full visual fields and normal ocular fundi as well as normal language and reading 94 comprehension. He has no family history of meningioma, radiation, breast or thyroid tumors. He elected 95 to under surgical resection of the tumor. A Simpson Grade 1 resection was performed via a left parieto-96 occipital transcortical approach via the occipital horn was described in detail below. Post-operatively he 97 had a right homonymous hemianopsia. Post-operative MRI showed a gross total resection (Figure 2C, D) 98 as well as a left LGN infarct (Figure 2E). Diffusion tensor imaging (DTI) based tractography showed that 99 the infarct interrupted the left optic radiations at the LGN (Figure 2F). Final pathology was meningioma, 100 WHO Grade 1. At three week follow up with Humphrey Visual Field tests, his right superior quadrant

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had recovered fully, but he still had a right inferior quadrantanopia. At four month follow up his visionand visual fields had returned to normal.

103

104 Operative Technique: The IVMs presented here were both located within the atrium of the left lateral 105 ventricle and were resected via a left parieto-occipital transcortical transventricular approach via the 106 occipital horn. Both patients were positioned laterally with the head secured with the Mayfield apparatus. 107 Intraoperative stereotactic neuronavigation was used to map the tumor. A U-shaped skin incision was made and a occipital parietal craniotomy was performed with burr holes and a footplate drill attachment. 108 The dura was incised in a U-shaped manner and reflected medially towards the superior sagittal sinus. 109 110 Using the stereotactic neuro-navigation system, a vertically oriented paramedian occipital gyrus 111 was selected with the shortest safe direct trajectory into the occipital horn of the lateral ventricle. 112 Diffusion tensor imaging was used to project occipital visual fiber pathways on axial (as shown in Figure 113 2F), and coronal MRI images at surgery. The pial surface of the superior occipital gyrus 2 cm lateral to the midline was then coagulated and opened with an 11-blade and straight microscissors. An image-114 115 guided stylet was used to position a catheter into the occipital horn of lateral ventricle. Blunt dissection 116 with a Rhoton #4 dissector was used to follow the catheter down to the occipital horn of the lateral 117 ventricle. Self-retaining retractors were placed along the tract.

Using the operative microscope, the posterior margin of the tumor was identified. The surface of 118 119 the tumor was coagulated in a rectangular fashion on its posterior surface and incised with straight microscissors. A sample was taken for biopsy. Both tumors were very fibrous. They were debulked 120 internally with the ultrasonic aspirator and the carbon dioxide laser. Once adequately debulked, we 121 dissected around the margins of the tumor, respecting the ependymal surface, and detaching it from the 122 ventricular wall. The choroid plexus and choroidal artery were identified and the choroidal artery was 123 124 coagulated where it was supplying the tumor. In both cases, there were multiple small vessels supplying 125 the tumor that were coagulated and divided. An external ventricular drain was left in the cavity and the 126 dura was repaired with interrupted sutures. The bone flap was repositioned and secured with titanium

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- 127 plates and screws prior to scalp closure.
- 128
- 129 **Discussion:**

130 Surgical approaches to meningiomas in the atrium of the lateral ventricle

131 The operative approach to IVMs depends on tumor location within the lateral ventricle and is beyond the

132 scope of this article⁸. Here, we focus on a brief review of approaches to tumors within the atrium of the

133 lateral ventricle and our surgical considerations for approach selection.

134

135 *Transtemporal Transcortical Approach:* For meningiomas located in the posterior or middle temporal 136 horn, or the atrium of the lateral ventricle, a transtemporal transcortical approach via the middle temporal 137 gyrus provides the shortest trajectory and early access to the choroidal blood supply to the tumor. This 138 approach can be used for meningiomas of the atrium in the non-dominant hemisphere. This approach 139 should be avoided on the dominant hemisphere, as language centers within the posterior part of the 140 middle temporal gyrus are at risk.

141 A temporal craniotomy followed by a horizontal corticectomy along the posterior one-third of the 142 middle temporal gyrus begins this approach. The transcortical path should be developed towards the 143 tumor in the most direct manner possible. When taking this approach, one must also consider the eloquent fibers of the inferior loop of the optic radiations. We use the projected visual fiber pathways from axial 144 145 and coronal reconstructed images to select the best trajectory on the image guidance system so as to avoid these fibers within the posterior temporal lobe and along the inferior aspect of the lateral wall of the 146 147 atrium (Figure 3). In order to minimize damage, it is important to advance within a horizontal plane, with gentle retraction parallel to these fibers. Alternatively, one may avoid the optic radiations by beginning 148 149 their approach along the inferior temporal gyrus and traversing around the fibers infero-medially towards 150 the ventricle. This approach permits early coagulation of choroidal artery branches that may supply the tumor⁵. 151

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153 Posterior Interhemispheric Precuneal Approach: For IVMs located in the atrium, one may use the posterior interhemispheric precuneal approach. An occipital craniotomy on the side of the lesion is 154 155 performed taking care to protect the torcula, sagittal, and transverse sinuses. Posterior interhemispheric 156 dissection is followed by a precuneal corticectomy, just in front of the parieto-occipital sulcus. As this 157 transcortical path is developed, the surgeon will reach the medial wall of the posterior atrium, behind the 158 choroidal fissure. This provides an operative corridor to the atrium and aims to avoid as much eloquent 159 occipital cortex as possible. 160 161 Posterior Interhemispheric Transcallosal Approach: A lesion within the posterior aspect of the body of 162 the lateral ventricle can be approached transcallosally. A parieto-occipital craniotomy is performed 163 followed by dissection along the posterior longitudinal fissure through the posterior body or splenium of 164 the corpus callosum. This dissection will open the ventricle at the posterior body or atrium, respectively. 165 Parietal, Parieto-Occipital, and Occipital Transcortical Approach: A parietal, parieto-occipital, or 166 occipital craniotomy and transcortical approach can provide access to IVMs within the body, atrium, or 167 168 occipital horn of the lateral ventricle, respectively. These approaches are grouped together as they are 169 similar in their transcortical trajectories. 170 For the parietal approach, a paramedian corticectomy is made posterior to the postcentral gyrus. 171 The subcortical trajectory should provide the shortest route to the tumor, taking care to avoid the optic radiations. A parieto-occipital or occipital approach also utilizes a paramedian corticectomy, but located 172 more posteriorly. A horizontally oriented paramedian corticectomy in the superior occipital gyrus can 173 174 provide direct access to the occipital horn. 175 Approaches through the superior or inferior parietal lobule of the dominant hemisphere may lead 176 to dyslexia, agraphia, finger agnosia, acalculia, and visual field deficits. In the non-dominant hemisphere,

177 hemi-special neglect and visual field deficits may occur. With a purely occipital approach only visual

178 fiber pathways and visual deficits are at risk. Using image guidance and visual fiber pathway projections,

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- a trajectory into the superior part of the occipital horn can minimize the risk of visual fiber damage.
- 180

181 Approach Selection: There is no single "ideal" approach to tumors in the atrium. Our approach selection is based on multiple factors. Our first consideration is whether the tumor is in the dominant or non-182 dominant hemisphere. For non-dominant tumors, we typically take a transcortical transtemporal approach 183 to get to the atrium (Figure 3B). One problem with the transcortical transtemporal approach is that the 184 visual fibers from Meyer's loop run on the inferior and lateral wall of the atrium (Figure 3A). The advent 185 of diffusion tensor imaging and fiber tracking now allows the surgeon easy visualization of the pathways 186 187 and can assist with planning of the approach and entry site. These visual fibers are best seen in the coronal 188 plane. If a more anterior approach is taken, the surgeon can angle posteriorly and avoid the visual fiber 189 pathways (Figure 3B). The transcortical transtemporal approach gives the surgeon early access to control 190 the choroidal arterial blood supply. However, even with early control of choroidal blood supply, big 191 tumors often develop arterial supply off local perforators, and care must be taken during resection not to injure perforators, which can lead to LGN infarct, as happened in the cases presented. For tumors on the 192 193 dominant hemisphere, this approach would require speech mapping, and thus, we typically select a 194 parieto-occipital approach, as shown in the case examples. The parieto-occipital approach keeps the 195 surgeon away from eloquent cortex, but has the disadvantage of not gaining access to the choroidal blood supply until later in the dissection. The senior author rarely uses the interhemispheric approaches, as they 196 197 are far from the choroidal blood supply and are less conducive to tumor dissection in our hands. Finally, we now routinely use diffusion weighted imaging with tractography on our post-operative scans to 198 199 monitor for small local injuries, which may have been missed before we included those protocols and 200 sequences.

201

202 Anatomy and Blood Supply of the Lateral Geniculate Nucleus

203 The LGN is located within the posterolateral thalamus and receives bilateral visual information from the 204 optic tract. The LGN has a dual blood supply from the anterior choroidal artery and the lateral posterior

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205	choroidal artery (Figure 4) ⁹ . The choroidal arteries supply the choroid plexus and provide branches to
206	nearby neural structures as they pass along the choroidal fissure. Frequent sites of anastomoses occur
207	between the anterior and lateral posterior choroidal artery throughout the choroid plexus.
208	The anterior choroidal artery branches off the internal carotid artery where it navigates posteriorly
209	to the middle incisural space and through the choroidal fissure, after which it courses posteriorly and
210	dorsally beside the plexus. The lateral posterior choroidal artery branches from the posterior cerebral
211	artery as it traverses within the ambient and quadrigeminal cisterns; it then passes around the pulvinar
212	laterally. It travels through the choroidal fissure at the level of the body of the fornix so that it can feed the
213	choroid plexus within the temporal horn, atrium and body ¹⁰ .
214	
215	Anatomy of the Optic Radiation
216	Originating from the LGN, the optic radiations course along the margins of the ventricular system to
217	reach the primary visual cortex along the calcarine sulcus. The fibers are divided into three groups:
218	anterior, central, and posterior. The anterior fibers, which carry information from the upper half of the
219	visual field, traverse superior and anterior to the temporal horn of the lateral ventricle; this anterior
220	portion of the radiation is also known as Meyer's loop. As the fibers traverse laterally and inferiorly to the
221	atrium and occipital horn they terminate within the lower lip of the calcarine fissure. The central fibers
222	serve the macula and course along the roof of the temporal horn towards the lateral wall of the atrium and
223	occipital horn prior to terminating along the calcarine fissure. The posterior fibers carry information from
224	the inferior visual field and travel directly from the LGN to the superior lip of the calcarine fissure along
225	the lateral wall of the atrium and occipital horn of the ventricle ¹⁰ .
226	
227	Conclusions:

We present two cases of atrial IVMs where surgical resection resulted in LGN ischemia with contralateral quadrantanopia. Both patients had excellent recovery of their vision several months postoperatively. The blood supply to the LGN comes from terminal branches of both the anterior choroidal artery and posterior

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231	choroidal artery. Great care should be taken when resecting IVMs due to the eloquent neuroanatomy and			
232	vascu	lature within the operative corridor and adjacent to the ventricles. With large tumors the anterior		
233	margi	n of the tumor may be adjacent to the take off from choroidal arteries to the LGN so the surgeon		
234	should	d always coagulate vessels supplying the tumor as close to the capsule of the tumor as possible.		
235				
236				
237	Acknowledgements:			
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239				
240				
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267 **Figure Legends:** Figure 1: Case 1 Imaging: A) Pre-operative post-contrast T1 weighted MRI shows the left atrial mass. 268 269 B) FLAIR imaging showing surrounding peri-tumoral edema. C) Post-operative post-contrast T1 MRI 270 shows gross total resection of the tumor. D) Post-operative diffusion weighted imaging (DWI) shows an 271 infarct in the superficial left LGN. 272 Figure 2: Case 2 Imaging: A) Axial, and B) Coronal pre-operative post-contrast T1 weighted MRI 273 274 shows the intraventricular tumor. C) Axial, and D) Coronal post-operative post-contrast T1 weighted MRI shows gross total resection of the tumor. E) Axial DWI images showing a left LGN infarction. F) Post-275 276 contrast T1 weighted MRI with diffusion tensor imaging (DTI) tractography overlay showing a disruption 277 in the left optic radiations at the region of the infarct (arrow), 278 Figure 3: Intraoperative navigation images showing transcortical transtemporal approach to the 279 280 right (non-dominant) atrium. A) Axial (left) and coronal (right) FLAIR (upper) and T2 (lower) 281 weighted MR diffusion tensor imaging fiber tractography study showing the relationship between tumors 282 in the atrium and the optic radiations (turquoise), which pass along the inferior and lateral border of the 283 ventricle. B) Axial (upper left), coronal (upper right), inline/trajectory view 1 (lower left), and inline/trajectory view 2 (lower right), post-contrast T1 weighted MRI showing the transtemporal 284 285 transcortical approach trajectory to tumors in the right atrium. Fiber tracts are labeled as follows: turquoise = optic radiations; red = motor/corticospinal; green/yellow = arcuate fasciculus/association 286 fibers; blue = inferior frontal occipital fasiculus; purple/pink = magnetic source imaging for unrelated 287 magnetoencephalography study. 288 289 290 Figure 4: Illustration demonstrating blood supply to the LGN. The anterior choroidal artery (AChA) 291 branches from the internal carotid artery and supplies the choroid plexus. The lateral posterior choroidal

artery (LPChA) branches from the P2 segment of the posterior cerebral arteries and also supplies the

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- 293 choroid plexus, where it anastomoses with branches of the AChA. Terminal branches from both the
- AChA and LPChA supply the LGN.







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1 Highlights

- Intraventricular tumors often lie adjacent to the lateral geniculate nucleus.
- Choroidal arteries that supply tumors also supply nuclei near the ventricular wall.
- Tumor blood vessels must be coagulated as close to the tumor capsule as possible.

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- 11