Anatomic Relationship of the Optic Radiations to the Atrium of the Lateral Ventricle: Description of a Novel Entry Point to the Trigone

Kelly B. Mahaney, B.A.
Saint Louis University Center for Cerebrovascular and Skull Base Surgery, St. Louis, Missouri

Saleem I. Abdulrauf, M.D.
Saint Louis University Center for Cerebrovascular and Skull Base Surgery, St. Louis, Missouri

Reprint requests:
Saleem I. Abdulrauf, M.D.,
Department of Surgery,
Saint Louis University Hospital,
3635 Vista Avenue,
St. Louis, MO 63110.
Email: abdulrsi@slu.edu

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OBJECTIVE: The aim of this study was to delineate the anatomic relationship of the optic radiations to the atrium of the lateral ventricle using the Klingler method of white matter fiber dissection. These findings were applied to define a surgical approach to the trigone that avoids injury to the optic radiations.

METHODS: Sixteen cadaveric hemispheres were prepared by several cycles of freezing and thawing. With the use of wooden spatulas, the specimens were dissected in a stepwise fashion. Each hemisphere was dissected first from a lateromedial direction and then from a mediolateral approach, and careful attention was given to the course and direction of the optic radiation fibers at all points from Meyer's loop to their termination at the cuneus and the lingual gyrus.

RESULTS: In all 16 dissected hemispheres, the following observations were made: 1) the entire lateral wall of the lateral ventricle—from the temporal horn to the trigone to the occipital horn—is covered by the optic radiations; and 2) the medial wall of the lateral ventricle in the area of the trigone is entirely free of the optic radiations.

CONCLUSION: The results of this study confirm that the medial parieto-occipital interhemispheric approach to the ventricular trigone will avoid injury to the optic radiations and the calcarine cortex. The authors describe the most direct trajectory to the ventricular trigone using this approach and propose a point of entry that transects the cingulate gyrus at a point 5 mm superior and 5 mm posterior to the falcotentorial junction.

KEY WORDS: Lateral ventricle, Meningioma, Optic radiation, Trigone, Vascular malformation, Ventricular surgery, Ventricular tumor

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Surgical approaches to the atrium of the lateral ventricle remain among the more challenging procedures faced by neurosurgeons because of the eloquent nature of the surrounding anatomy. Aside from the task of navigating delicate vasculature, the surgeon must give appreciable attention to the cortical and white matter tract anatomy traversed to enter the ventricle. The trigone of the lateral ventricle has an intimate relationship to fibers of the internal capsule, the optic radiations, and the striate cortex. Thus, surgical trajectories to the trigone, such as might be indicated for resection of intraventricular meningiomas, risk injury to the motor tracts, sensory tracts, speech conduction tracts, and visual system. In this study, we aimed to focus on the relationships of surgical trajectories to the optic radiation system. We specifically sought to identify those trajectories that would traverse these fiber tracts and those that would not.

Although considerable advances have been made toward understanding the eloquent topography of the cortex, relatively little attention has been given to the underlying white matter tracts. However, the recent advent of diffusion tensor magnetic resonance imaging, which allows visualization of these white matter fiber tracts, may represent a shift in this paradigm (37). This technology has proven to be particularly useful in identifying and studying the larger fiber bundles, including the corpus callosum, the corticospinal tracts, and the optic radiations (18, 40), and it has been applied to preoperative planning and intraoperative navigation tailored to the preservation of these white matter tracts (5, 19). This advanced technology and future advances will certainly contribute to the surgeon's appreciation of the 3-dimensional anatomy of the brain, which is necessary for planning technically demanding procedures. However, sophisticated imaging cannot replace the intimate familiarity with the anatomic relationships of these white matter tracts that is required of the surgeon. Klingler's technique of white matter tract dissection affords an excellent method of illustrating these relationships (20, 23). Although hands-on study and dissection of 3-dimensional brain anatomy has not been part of standard training for neurosurgeons, the Klingler method has recently been repopularized as a means of appreciating white matter tract anatomy. In 2000, Türe et al. (38) described in depth the fiber dissection technique applied to the lateral aspect of the brain. This fiber dissection technique has been applied to the study of the temporal lobe, with particular attention to the optic radiations and implications for surgical approaches to the temporal horn (4, 6, 8, 27, 34, 35). This method of dissection and study of white matter tracts will certainly have relevance to the surgical approach to the trigone. The aim of this study was to explore the anatomic relationship of the optic radiations to the atrium of the lateral ventricle to define a surgical trajectory to the trigone that avoids transection of the optic radiations at any point in their course.

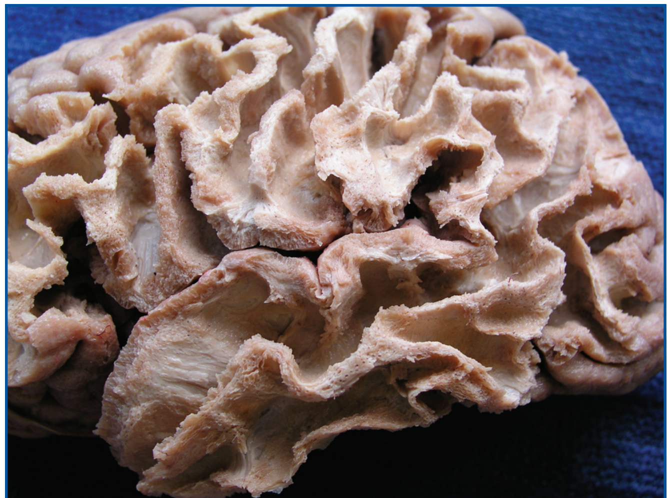

FIGURE 1. *Photograph (lateral view) of the left hemisphere after removal of the cortical gray matter demonstrating the arcuate fibers.*

MATERIALS AND METHODS

Sixteen hemispheres were prepared by a method modeled after that used by Klingler (20). Brains were first fixed in 4% formalin solution for 10 days and subsequently frozen at −10°C for 24 hours. The brains were then immersed in water, thawed, and refrozen for another 24 hours. This freeze-thaw procedure was repeated for a total of 3 to 5 cycles. This process results in the formation of ice crystals between fibers, forcing separation of fiber tracts and permitting their subsequent dissection. Between dissection sessions, brains were stored at room temperature in 4% formalin solution.

Dissection was performed with the use of wooden tongue depressors that had been carefully shaped into dissecting spatulas of various sizes. Each specimen was dissected first from the lateral aspect with a stepwise approach similar to that detailed by Türe et al. (38). The lateral dissection focused especially on revealing the course of the optic radiations. Next, each specimen was dissected from the medial aspect of the hemisphere in a similar stepwise approach, with careful attention given to demonstrating Meyer's loop and following the optic radiations to their termination at the cuneus and lingual gyrus (which constitute the visual cortex). After each progressive step in the dissection, photographs were taken to document the dissection and illustrate the anatomy.

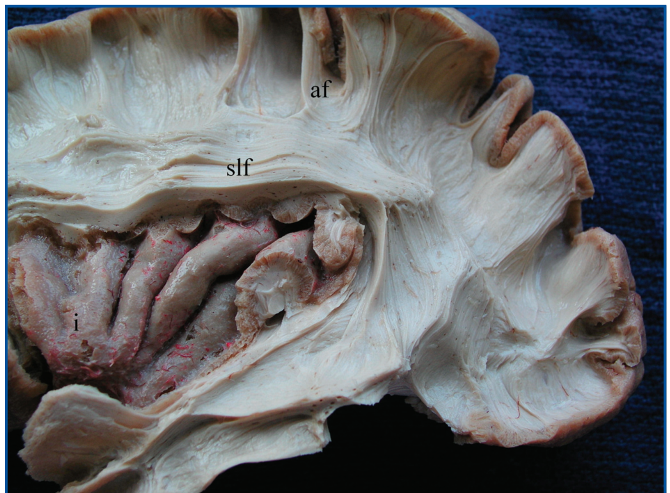

FIGURE 2. *Photograph (lateral view) of the left hemisphere. Stepwise dissection reveals the superior longitudinal fasciculus (slf) and the insula (i). af, arcuate fibers.*

RESULTS

Dissection of each specimen was begun with the lateral approach. Initially, the gray matter of the cerebral cortex was removed to expose the underlying arcuate fibers, which are also referred to as "U fibers" and connect adjacent gyri (Fig. 1). As the dissection continued in a stepwise approach, the arcuate fibers were next removed to reveal the superior longitudinal fasciculus, which connects the frontal lobe to the parietal, occipital, and temporal lobes and is easily visualized by its arching shape (Fig. 2) as it courses along the periphery of the insula. The insular cortex was then removed to demonstrate the extreme capsule, composed of the arcuate fibers connecting the insula with the opercula. These fibers were next peeled away to reveal the claustrum. At this level of the dissection, 2 merging association fiber bundles were clearly visualized: the uncinate fasciculus, which connects the frontal and temporal lobes, and the occipitofrontal fasciculus, which connects the frontal lobe with the occipital lobe (Fig. 3). Removal of the superior longitudinal fasciculus at this point revealed the posterior extension of the occipitofrontal fasciculus. Next, the claustrum and the underlying external capsule were removed, and the uncinate fasciculus and anterior portion of the occipitofrontal fasciculus were dissected to reveal the putamen (Fig. 4). Inferior to the putamen, the optic radiations were visualized projecting posteriorly to the occipital lobe.

FIGURE 3. *Photograph (lateral view) demonstrating the uncinate fasciculus (uf), the occipitofrontal fasciculus (of), and the claustrum (c).*

FIGURE 4. *Photograph (lateral view) of the left hemisphere. Stepwise dissection reveals the putamen (p) and the optic radiations (or) coursing inferiorly. cr, corona radiata.*

Dissection of each specimen was continued at this point with a medial approach, and the same stepwise technique was used. From the medial aspect, the gray matter was first removed in the cingulate cortex. Removal of gray matter revealed the underlying cingulum, the association bundle that is part of the limbic system (Fig. 5). Removal of the adjacent gray matter revealed the arcuate fibers connecting the cingulate gyrus to adjacent gyri. In the superficial portion of the medial dissection, particular attention was paid to the main association bundle, the cingulum. Resection of the cingulum and related arcuate fibers revealed the fibers of the splenium of the corpus callosum. From these splenial fibers was found to arise the posteriorly coursing forceps major as well as the tapetum, which also

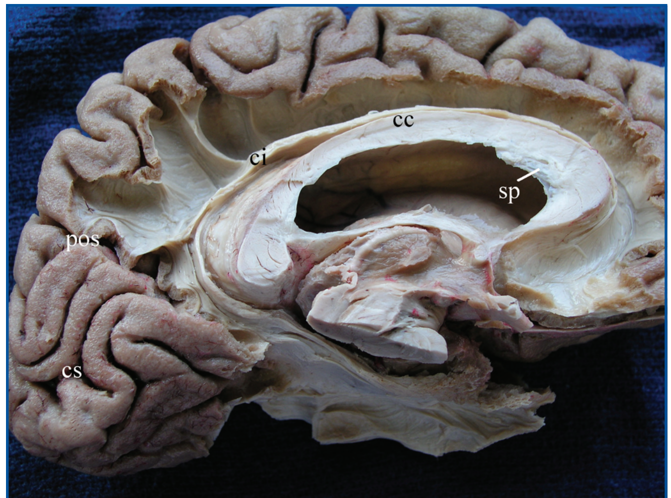

FIGURE 5. *Photograph (medial view) of the left hemisphere demonstrating the cingulum (ci) after removal of the cortex of the cingulate gyrus. cc, corpus callosum; cs, calcarine sulcus; pos, parieto-occipital sulcus; sp, septum pellucidum.*

appeared to have contributions from the body of the corpus callosum and formed a very thin layer of fibers covering the lateral wall of the ventricle, separating it from the laterally placed optic radiation fibers along the length of the atrium and the temporal horn. In contrast, the posteriorly coursing forceps major related superomedially to the atrium, fanning out to form 2 larger bundles terminating posteriorly in the occipital lobe and 1 bundle more superiorly terminating in the parietal lobe. The forceps major was significant in its relationship to the atrium, as its fibers formed the uppermost prominence in the medial wall of the atrium: the callosal bulb. Inferior to the callosal bulb was another prominence in the medial wall of the atrium, the calcar avis, formed by an indentation of the deepest portion of the anterior calcarine sulcus. In contrast to the callosal bulb, a prominence created by a thick bundle of callosal fibers, the calcar avis was noted to be a prominence created by the indentation of a sulcus and was separated from the atrium only by a thin layer of tapetal fibers. Similarly, the most inferior prominence, the collateral trigone (reported as the "accessory intraventricular prominence" by Vandewalle et al. [39]), was noted to be formed by the indentation of the collateral sulcus into the inferior wall of the atrium (and similarly separated from the atrium of the ventricle by only a thin tapetal layer). As it has been mentioned that the medial and inferior walls of the atrium, as well as the innermost layer of the lateral wall of the atrium, were found to be formed by contributing fibers of the splenium, it should be noted that the anterior wall of the atrium was found to be formed by the pulvinar of the thalamus and, in the medial portion of the anterior wall, the crus of the fornix, which connected fibers from the hippocampus.

The medial dissection was continued in an inferomedial approach in the temporal lobe, after removal of the cingulum. The gray matter of the temporal lobe was removed in its

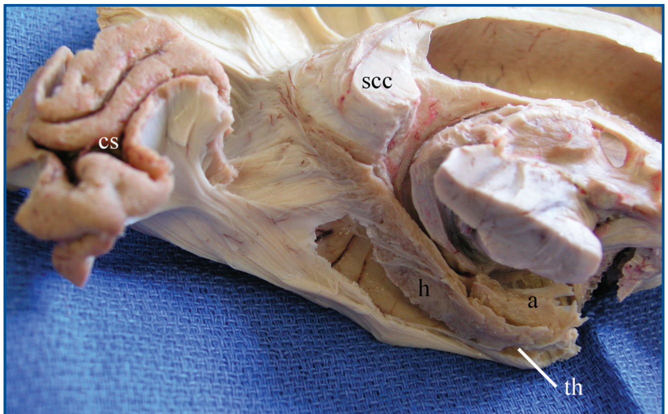

FIGURE 6. *Photograph of the medial aspect of the left hemisphere. Stepwise dissection reveals the hippocampus (h), amygdala (a), and a view of the temporal horn (th). scc, splenium of corpus callosum.*

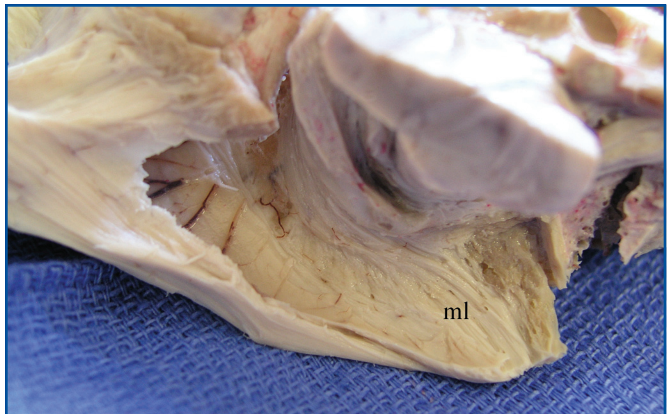

FIGURE 7. *Photograph of the medial aspect of the left hemisphere demonstrating Meyer's loop (ml), shown by removing the hippocampus and amygdala.*

entirety to reveal underlying arcuate fibers. These arcuate fibers were removed, followed by a thin layer of tapetal fibers lining the ventricle. Entry into the temporal horn of the lateral ventricle and further dissection revealed the hippocampus and amygdala (Fig. 6). By exposure of the lateral ventricle in the temporal horn to gain access in an inferomedial direction, the optic radiations could be visualized by carefully dissecting the tapetum from the lateral wall of the ventricle. In all specimens, the optic radiations were found to cover the lateral wall of the lateral ventricle—in the temporal horn and extending posteriorly through the trigone. These fibers were dissected carefully to demonstrate the bundle that curves most anteriorly and is known as Meyer's loop (Fig. 7). Further dissection from the inferior aspect followed these fibers from their origin at the lateral geniculate nucleus of the thalamus.

With the lateral ventricle opened in the region of the temporal horn, the fibers of the optic radiation, including the anterior bundle (Meyer's loop) and the posterior and central bundles, could be followed as they covered the lateral wall of the lateral ventricle to its most posterior aspect, where they curved medially around the occipital horn to terminate at the superior and inferior banks of the primary visual cortex (Fig. 8). Between these two gyri, arcuate or "U" fibers were found. However, the optic radiation fibers consistently terminated at the upper and lower banks of the calcarine cortex, never crossing the medial wall of the ventricle. In all 16 dissected specimens, the medial wall of the lateral ventricle was found to be entirely free from the optic radiations. As described previously, in the area of the trigone of the lateral ventricle, the medial wall was found to be composed of commissural fibers extending posteriorly in 3 main bundles from the splenium of the corpus callosum. Between these 3 main bundles, the fibers overlying the lateral ventricle were found to be very thin.

In the completely dissected specimen, the optic radiations were demonstrated from their origin at the lateral geniculate nucleus of the thalamus to their termination at the superior and inferior banks of the calcarine sulcus. Three main bundles

FIGURE 8. *Photograph of the medial aspect of the left hemisphere demonstrating termination of the optic radiations (or) at the superior and inferior banks of the calcarine sulcus (cs). scc, splenium of corpus callosum.*

of the optic radiation (anterior, central, and posterior) have been described (8, 35). Although we agree that these 3 main bundles can be distinguished on the basis of the general direction of their fibers and the course the fibers travel from the lateral geniculate nucleus to the primary visual cortex, we found that no clear delineation could be made demarcating boundaries between one bundle and the next. These bundles blended fibers and were not distinctly separate in the gross specimen but were clinically significant entities (8). As was initially observed by Klingler (20) and described by Türe et al. (38), the optic radiation fibers were actually found to be part of a larger fiber tract identified as the sagittal stratum; the sagittal stratum could be properly described as containing fibers from the anterior commissure, the occipitofrontal fasciculus, and the thalamic peduncle (of which the optic radiation fibers were found to constitute a part) (23, 35, 38). We found that, not only were the 3 main bundles of geniculocalcarine fibers not distinctly delineated, but the optic radiation fibers as a whole were not definitively demarcated from the greater sagittal stratum. With this observation kept in mind, the course that these bundles of optic radiation fibers traverse will be described. The anterior bundle, commonly referred to as Meyer's loop, coursed anteriorly from the lateral geniculate nucleus, extending over the roof of the inferior horn before curving posteriorly along the lateral aspect of the inferior horn. These fibers continued posteriorly along the inferior aspect of the trigone and occipital horn, turning medially to terminate at the inferior bank of the calcarine sulcus. The central bundle initially extended laterally to cover a portion of the inferior horn before extending posteriorly over the lateral wall of the trigone and occipital horn, terminating at the pole of the occipital lobe. The posterior bundle, in contrast to the anterior and central bundles, extended directly posterior from the lateral geniculate nucleus, passing over the superolateral aspect of the trigone and occipital lobe to terminate at the superior bank of the calcarine sulcus.

These dissections illustrate important relationships of the optic radiations to the lateral ventricles. The first observation is that the entire lateral wall of the lateral ventricle from the temporal horn to the trigone to the occipital horn is covered by the optic radiations. A second key observation is that the medial wall of the lateral ventricle in the area of the trigone is entirely free of optic radiations. More posteriorly, in the occipital horn, structures medial to the lateral ventricle become critical as the primary visual cortex, which borders the calcarine sulcus, is related medially to the occipital horn.

DISCUSSION

Access to the trigone of the lateral ventricle remains challenging because of the intimate relationships of the trigone to eloquent areas. A number of approaches for neoplastic and vascular lesions involving the ventricular trigone have been described. Although each of the various approaches to the atrium will be discussed, it is important to consider that a large number of visual deficits concomitant with atrial lesions are attributable to direct involvement of the optic radiation fibers in the tumor or lesion. In such a case where a visual deficit is present preoperatively because of an atrial tumor invading the laterally oriented optic radiation fibers, the site of cortical entry should be chosen for maximal access to the tumor, as injury to the optic radiation fibers in this case is a direct result of the infiltrating tumor.

The superior parieto-occipital approach has been described as a commonly preferred approach to the trigone, because it allows access to lesions occupying the medial and lateral regions of the trigone (1, 7, 9, 12, 14, 26, 28–30, 36). With this approach, a cortical incision is made along the superior parietal gyrus to enter the lateral ventricle (36). Fornari et al. (9) further specify that this incision should be made at a distance 1 cm posterior to the postcentral fissure and extending 4 to 5 cm posteriorly, as far as the parieto-occipital sulcus. This approach has been preferred for its direct access to lesions in the trigone but has been associated with neurological deficits, including apraxia (13), acalculia (22), and visual field deficits, most commonly a homonymous hemianopsia (28). In a recent anatomic study, Ribas et al. (31) proposed a superior parietal approach to the atrium via the anteriormost portion of the intraparietal sulcus, at the junction with the postcentral sulcus, citing this as the point having the "closest topographical relationship with the atrium," (31, p 204). We agree that a transsulcal approach provides a more direct and less traumatic trajectory to the ventricle than a transgyral approach. However, based on the findings of our study, even a transsulcal approach to the trigone from these superior parietal trajectories would traverse the optic radiation fibers.

A second, less commonly used approach is the transtemporal approach (1–3, 7, 28–30). Such an approach involves a cortical incision through the posterior portion of the middle temporal gyrus or the inferior temporal gyrus. Morbidities associated with this approach include visual quadrantanopsia and aphasia during operations on the dominant hemisphere (11). Lesions in the nondominant hemisphere may have a less severe impact, such as impaired recognition of emotion (33). On the basis of our anatomic study, the transtemporal approach to the trigone would transect the optic radiation fibers—more specifically, Meyer's loop—resulting in the observed visual quadrantanopsia.

A third approach to the ventricular trigone from the lateral aspect of the hemisphere is a lateral temporoparietal incision (25, 29). Approaches to the trigone transecting the temporoparietal junction are not commonly supported because of the risk of visual deficit resulting from direct disruption of the optic radiations. Further morbidities of this approach in the dominant hemisphere include dyslexia (10, 24), agraphia (32), acalculia (22), and ideomotor apraxia (14). However, Nagata and Sasaki (25) propose a lateral insular transsulcal approach through a horizontal incision of 15 mm at the posterior aspect of the insular cortex, along the longitudinal axis of the anterior transverse gyrus of Heschl. In this trajectory, access to the insula is gained by a wide opening of the sylvian fissure and retraction of the parietal and temporal lobes. Although Nagata and Sasaki (25) assert that such an incision will not damage the optic radiations, they report 1 case (of 4) in which an inferior extension of this incision did result in damage to the optic radiations, manifest as a homonymous left lower quadrantanopsia. Ribas et al. (31) recommend a similar approach for atrial lesions in the nondominant hemisphere based on their anatomic findings. In this approach, a transsulcal incision can be made through the posterior segment of the superior temporal sulcus. The authors advocating this approach recommend it only for lesions in the nondominant hemisphere to avoid language deficits and assert that, at its posterior segment, the superior temporal sulcus is posterior to the insula, the posterior limb of the internal capsule, and the thalamus, so injury to these elements can be avoided. On the basis of the findings of our study, which focuses on the visual pathways, both of these trajectories would traverse the optic radiations. It is evident that any approach to the trigone that involves cortical incision in the vicinity of the temporoparietal junction risks direct injury to the optic radiations. Moreover, risk to the internal capsule and thalamus exists when aiming to enter the trigone from the insular cortex area.

FIGURE 9. *Sagittal T1-weighted magnetic resonance imaging (MRI) scan demonstrating the point of entry into the trigone through the cingulate gyrus. Arrows designate a point 5 mm superior and 5 mm posterior to the falcotentorial junction.*

FIGURE 10. *Axial T1-weighted MRI scan demonstrating the same point of entry shown in Figure 9 (sagittal view). The tip of the arrow designates that point in the axial plane which, in the sagittal view, is found to be 5 mm superior and 5 mm posterior to the falcotentorial junction.*

The posterior transcallosal approach to enter the ventricular trigone has also been described (1, 7, 15, 16, 28–30). Kempe and Blaylock (17) gave the original description of this approach. Rhoton (30) describes an incision through the posterior part of the cingulate gyrus that in turn transects the lateral part of the splenium before entering the trigone. This approach has been recommended for lesions that extend superiorly from the trigone or involve the splenium of the corpus callosum (30). However, D'Angelo et al. (7) suggest that this approach may not allow for resection of larger tumors in the trigone. Although this approach does not pose a risk of damage to the optic radiations, like the 3 previous approaches, it is sometimes associated with an auditory or visual disconnection syndrome (as a result of the posterior transection of the corpus callosum) (15). Levin and Rose (21) report a case of alexia without agraphia in a patient after surgical resection of a lateral ventricle tumor in the dominant hemisphere.

The posterior interhemispheric parieto-occipital approach to the ventricular trigone has been described by Yaşargil (41) and Yaşargil et al. (42). This approach is commonly described as the preferred approach for lesions involving the medial wall of the trigone (2, 3). Yaşargil (41) describes an incision through the precuneal gyrus, anterior to the parieto-occipital sulcus, that avoids injury to the optic radiations and the visual cortex. Based on 2 important variables for trigonal surgery, extent of access and risk of injury to optic radiation fibers, the posterior interhemispheric approach provides the optimal trajectory to the ventricular trigone. This is supported by the anatomic evidence demonstrated by our dissected specimens. In this study, we sought to define the most direct approach to the ventricular trigone that would maximize access and minimize risk of injury to the optic radiation fibers. On the basis of these anatomic findings, we propose a point of entry into the trigone via the cingulate gyrus at a point 5 mm superior and 5 mm posterior to the falcotentorial junction (Figs. 9 and 10). Our proposed entry point is posterior to the entry point of the posterior transcallosal approach and is inferior to the precuneus entry point of the posterior interhemispheric parieto-occipital approach. The posterior transcallosal and posterior interhemispheric parieto-occipital approaches, by definition, transect splenial fibers of the corpus callosum to enter into the ventricular trigone. In addition, there is an inherent risk of memory impairment when the cingulate gyrus (specifically, in the dominant hemisphere) is the site of cortical entry, as these fibers are a component of the limbic system.

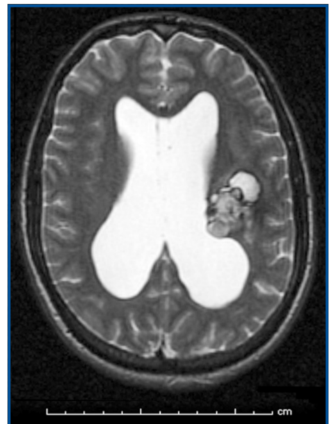

FIGURE 11. *Illustrative case. Axial T2-weighted MRI scan showing a cavernous malformation with hemorrhage in the posterosuperior aspect of the left thalamus with protrusion into the left atrium.*

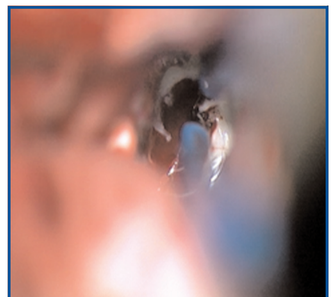

FIGURE 12. *Illustrative case. Intraoperative microsurgical view along the described transcingulate gyrus trajectory (5 mm superior and 5 mm posterior to the falcotentorial junction) demonstrating the direct trajectory to the cavernous malformation on the lateral wall of the atrium.*

Illustrative Case

The clinical applicability of our described trajectory to the ventricular trigone is demonstrated in the following illustrative case. A 39-year-old man presented with a history of multiple hemorrhages from a cavernous malformation located in the posterosuperior aspect of the left thalamus projecting into the ventricular atrium. This patient presented with progressive hemiparesis involving his right side. He did not have any visual field deficit. The patient underwent surgical access using the aforementioned trajectory to the trigone. After surgical resection, the patient displayed his baseline hemiparesis and did not incur any new visual field deficits (Figs. 11–13).

CONCLUSION

On the basis of our anatomic study, we recommend the medial parieto-occipital interhemispheric approach to the ventricular trigone as described by Yaşargil (41) and Yaşargil et al. (42). Our study anatomically validates his descriptions that such an approach would avoid the optic radiation fibers. It must be emphasized that in many trigonal lesions, it is the direct invasion of the optic radiation fibers by the lesion itself that results in a visual field deficit. However, in trigonal lesions in which the patient's vision is preoperatively intact, it is appropriate to choose an approach that will preserve the patient's vision, when possible. This study proposes a mesial entry point that is anterior to the calcarine and parieto-occipital sulci and posterior and inferior to the parietal lobule. This specific trajectory is achieved by entering the trigone via a cortical incision through the cingulate gyrus at a point 5 mm superior and 5 mm posterior to the falcotentorial junction. The latter trajectory is the most direct entry point into the trigonal area that would spare the optic radiations, the calcarine sulcus, the sensory mesial parietal cortex, and the internal capsular fibers, while transecting the fibers of the cingulate gyrus and the splenium.

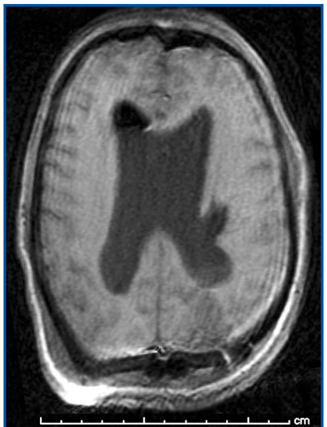

FIGURE 13. *Illustrative case. Immediate postoperative T1-weighted axial MRI scan demonstrating resection of the cavernous malformation.*

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials or devices described in this article.

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COMMENTS

As stated by Mahaney and Abdulrauf in this elegant article, accesses to lesions of the trigone of the lateral ventricle and to lesions harbored in its related structures still remain challenging owing to their intimate relationships with eloquent brain areas adjacent to the trigone in both cerebral hemispheres, which definitely include the optic radiation fibers. Although it is well known that the lateral wall of the temporal horn, atrium, and occipital horn of the lateral ventricle are covered by the optic radiations (8–10), Mahaney and Abdulrauf restudied their anatomy through the elegant method of fiber dissection (3, 4, 10) in light of a parieto-occipital mesial point of entry to the trigone, very similar to the interhemispheric parieto-occipital approach originally described by Yaşargil (12), which preserve the integrity of the optic radiations.

Given the mesial cortex anatomy and its spatial relationships with the trigone that is located posteriorly and laterally to the midline splenium, such a cortical entry point obligatorily has to be roughly at the level of the splenium, anterior to the parieto-occipital sulcus (to avoid damage to the cuneus, which is already more related to the occipital horn) and superior to the proximal segment of the calcarine fissure (which is not related to the primary visual cortex). This narrow cortical area is bounded by the isthmus cinguli and by the inferior extension of the precuneal gyrus. Yaşargil (12) described his parieto-occipital interhemispheric approach to the trigone as being performed through the base of the precuneus, and in this article, Mahaney and Abdulrauf "propose a point of entry that transects the cingulate gyrus at a point 5 mm superior and 5 mm posterior to the falcotentorial junction." Considering that the authors did not study the actual relationships of this mesial parieto-occipital cortical area with the falcotentorial junction itself in their specimens, despite their elegant findings one can still speculate about the possible anatomic variations of this proposed point of entry.

Considering our anatomic studies (7) and our own surgical experience, although limited, with this particular approach, we strongly believe that the midline splenium should be widely exposed and should constitute our main anatomic reference. The identification of the proximal and distal segments of the calcarine fissure and of the parieto-occipital sulcus can, usually, be facilitated through the identification of the posterior cerebral artery bifurcation into parieto-occipital and calcarine arteries (6, 13), and then the cortical incision should be made at the level of the splenium and should be restricted to the isthmus cinguli and to the base of the precuneal gyrus, laterally and anteriorly toward the trigone. For the sake of craniotomy placement, one should keep in mind the fact that along the occipital mesial surface the opisthocranion (the most prominent occipital cranial point), the distal half of the calcarine fissure, the isthmus of the cingulate gyrus, and the splenium are roughly at the same level (7).

Other approaches to the ventricular trigone through the superolateral surface of both cerebral hemispheres definitely risk direct injuries to the optic radiations and can cause specific neurological impairments as was discussed by Mahaney and Abdulrauf in this article, but the lesions related to the trigone before surgical planning should, of course, also be evaluated regarding their side, their major extensions within the ventricular cavity, their vascular relationships, and the presence of already established neurological deficits, and, in my view, the relationships between the costs and the benefits of each possible approach should then be considered. Visual deficits resulting from microneurosurgical approaches through the optic radiations, although pertinent to more anterior temporal cortical incisions, sometimes are not clinically significant for these patients (1, 2, 5, 11).

Although limited to a few cases as already mentioned, our experience with the interhemispheric parieto-occipital approach to trigone-related lesions was satisfactory, particularly for small lesions located at the level of the splenium. I believe that the deep and limited cortical incision and the required parieto-occipital retraction might make this approach difficult for large posterior intraventricular lesions, particularly if they extend superiorly and/or toward the temporal horn.

Guilherme C. Ribas
São Paulo, Brazil

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In this well conducted and comprehensively written article, Mahaney and Abdulrauf presented the delicate anatomic and surgical aspects of atrial lesions. The neoplastic atrial lesions tend to more frequently grow in the direction of the falcotentorial incisura. They rarely extend toward the dorsal and lateral surfaces of the atrium, and in such cases, naturally they should be explored via dorsolateral approaches. For the parieto-occipital interhemispheric approach, the patient should be routinely placed in the sitting position for removal of vascular and neoplastic lesions in the parasplenial and atrial locations. The interhemispheric approach with a parasplenial incision (10–15 mm) in the interoposterior part of the precuneus just anterior to the parieto-occipital sulcus will certainly avoid any injury to the optic radiations and essentially avoid the cortices of the parieto-occipital-temporal areas, as well as some nine layers of the deep complex white matter systems. Mahaney and Abdulrauf have illuminated this fact.

M. Gazi Yaşargil
Little Rock, Arkansas

The fact that a variety of approaches to the ventricular trigone have been described and used underscores the difficulty of approaching pathological lesions arising in this region. Mahaney and Abdulrauf reported an elegant technique using the Klinger method of white matter fiber dissection to fully elucidate the relationship of the optic radiations to the atrium of the lateral ventricle. The aim of this study was to explore the anatomic relationship of the optic radiations to the atrium of the lateral ventricle to define a surgical trajectory to the trigone that would spare transsection of the optic radiations at any point in their course. On the basis of these careful dissections, Mahaney and Abdulrauf have demonstrated that the entire lateral wall of the lateral ventricle—from the temporal horn to the trigone to the occipital horn—is covered with the optic radiations. Theoretically, any lateral or superior approach to the atrium would disturb the optic radiations and place the patient at risk for a visual field deficit. They found, however, that the medial wall of the lateral ventricle in the area of the trigone was entirely free of optic radiations. On the basis of these anatomic dissections, they described a posterior, medial, parietal-occipital, interhemispheric approach to the ventricular trigone via the cingulate gyrus at a point 5 mm superior and 5 mm posterior to the falcotentorial junction that provides access to the atrium without risking injury to the optic radiations.

For a wide variety of pathological lesions that occur in the region of the trigone of the lateral ventricle, this approach would provide a safe corridor for access. In practice, individual pathological conditions and preoperative neurological examination of the patient will dictate the desired approach. For lesions involving the lateral aspect of the ventricular trigone, a lateral approach through the inferior temporal gyrus using a horizontal corticectomy along the same trajectory as the optic radiations may provide better access for particular lesions such as arteriovenous malformations for which access to the feeding arteries may be more direct. This is particularly true if the patient presents with a visual field deficit that is frequently not worsened by the operative approach.

Mahaney and Abdulrauf demonstrated careful dissection techniques and attention to detail in describing this approach that should gain popularity.

Daniel L. Barrow
Atlanta, Georgia

Mahaney and Abdulrauf presented an interesting approach to the trigone and discussed its benefits and liabilities. The anatomic dissections are dramatic and useful. It is most important to note that regardless of the site for entry, postoperative visual field loss more commonly results from manipulation of the lateral wall of the trigone and not from a cortical injury. The proposed surgical technique also poses significant risk for memory loss in the dominant hemisphere. Regardless, this is an interesting alternative and merits consideration.

Joseph M. Piepmeier
New Haven, Connecticut