DOI: 10.5137/1019-5149.JTN.16296-15.1
Received: 07.10.2015 / Accepted: 08.12.2015
Published Online: 04.03.2016

Original Investigation

Parieto-Occipital Interhemispheric Precuneal Approach to the Lesions of the Atrium: Experience with 66 patients

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ABSTRACT

AIM: The atrium (trigone) is the most common site for intraventricular lesions. The parieto-occipital interhemispheric precuneal approach (POIPA) is one of the particular ways to reach these lesions. The aim of this study was to draw specific attention to the surgical difficulties of these lesions and to present our experience with this operative approach.

MATERIAL and METHODS: Sixty-six patients with lesions located in the atrium of the lateral ventricles underwent surgical treatment in our institution using POIPA over a 13-year period. The clinical, radiological and surgical characteristics of these patients were retrieved and reviewed retrospectively. The histological diagnosis of the cases and postoperative complications were specifically focused on in this study.

RESULTS: Thirty-six (54.5%) patients were male and 30 patients were female with a mean age 37.9 years (range between 8 and 74 years). The lesion was in the right atrium in 25 cases and in the left in 41 (62.1%) patients. POIPA was used in all cases to remove the lesions. The most common tumor was glioblastoma (34.8%), followed by glial tumors grade I, II and III and meningiomas. The other lesions were metastases, ganglioglioma, epidermoid cysts and arteriovenous malformations. Gross total resection of the tumors was achieved in 59 patients (89.4%) while subtotal removal was performed in 7 cases. Five (7.5%) patients died within the first month after surgery.

CONCLUSION: POIPA provides a safe and effective way to reach lesions located in the atrium of the lateral ventricle. Knowledge of precise anatomy associated with the meticulous surgical techniques decreases the surgical morbidity and mortality of the patients.

KEYWORDS: Lateral ventricle, Atrium, Parieto-occipital interhemispheric precuneal approach

INTRODUCTION

Lateral ventricle tumors account for 10% of all central nervous system tumors and 85% of these tumors are benign (4). The atrium (trigone) is the most common site for tumors arising in the lateral ventricles (9,26,30). Meningiomas are the most common tumors of the trigone in adults (39). In addition, choroid plexus papilloma, subependymoma, astrocytoma, subependymal giant cell astrocytoma, ependymoma, oligodendroglioma, neurocytoma, teratoma, and metastatic tumors may be seen in the trigone (24,25,29-32).

Trigonal tumors including neoplasms that orginate in the ventricular wall and its lining tissue (primary ventricular origin) and those that arise in the adjacent cerebral parenchyma have a major exophytic component within the ventricle (primary cerebral or paratrigonal origin) (1,24). Lesions, which arise solely within the trigonal area of the lateral ventricle, can be benign and curable by surgical resection (31).

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For tumors located in the trigone, clinical symptoms and signs include increased intracranial pressure syndrome and visual field defects. The most common symptoms are headaches, nausea and vomiting, as well as visual field defects, sensorimotor deficits and seizures (16,19,20).

Magnetic resonance imaging (MRI) and computed tomography (CT) have become the preferred modality for preoperative surgical planning and evaluation of the ventricular lesions because they provide the best images and elucidate their relationships to surrounding vital structures (6,7,32). MR angiography and cerebral angiography are important studies for determining the vascular supply and drainage pattern of these tumors such as meningioma, choroid plexus tumors, arteriovenous malformation (AVM) and central neurocytoma which has a rich vascular structure (6,8). Angiography also allows the neurosurgeons to understand the surrounding vascular anatomy, and such studies guide the surgical approach (16).

Although various surgical approaches to the atrium of the lateral ventricles have been described such as posterior middle temporal gyrotomy, lateral temporoparietal incision, transtemporal horn occipitotemporal incision, occipital gyrotomy or lobectomy, parietooccipital gyrotomy, and posterior transcallosal approach in the literature (8,9,12,26), these are not classified systematically yet (18,23). Kawashima et al. (14) reported that surgical approaches to the trigone of the lateral ventricles may be divided into three main categories: anterior, lateral and posterior approaches (Table I). In addition, these approaches can also be divided into subtypes in terms of the cortical area where the first surgical incision is made (1,4,10,12-14, 15,19,28,34,39).

Surgical resection of these lesions may cause severe morbidities if the surgical approach is not properly selected. The main concept of the surgical approach is to avoid functional areas, minimal retraction of the brain, and to reach the arterial pedicle of the tumors or AVMs as soon as possible. Xie et al. (35) described the contralateral transfalcine transprecuneus approach for most trigonal lesions. They suggested that this approach provides a wider surgical angle for the surgeon and reduces the risk of disturbance of the optic radiation compared with the other approaches.

In this retropective study, we tried to present our series on 66 patients who underwent surgical treatment using the parieto-occipital interhemispheric precuneal approach (POIPA). The clinical, radiological, surgical and histological features of these patients were presented and discussed with the current literature. Special attention was paid to analyze the surgical anatomy of this approach and to compare this approach with the others in terms of risks and complications.

MATERIAL and METHODS

A total of 66 patients underwent surgical treatment for the lesions located in the atrium of the lateral ventricles using POIPA in our department between 2001 and 2014 (Figure 1). Preoperative radiological evaluation was performed using CT and MRI scans. MR angiography and MR spectroscopy were used to evaluate the nature of the lesion and to plan the surgical approach. Once the diagnosis was made, the patient underwent surgical treatment using POIPA. A parieto-occipital craniotomy and classical microsurgical techniques and instruments were used to perform this approach. All the patients remained in the intensive care unit for 1 to 3 days after surgery. Postoperative CT scan was obtained within 24 hours after surgery. Postoperative functional evaluation was performed at the time of discharge from the hospital. All patients were followed-up post-operatively with CT scan in the early and with MRI in the late postoperative period.

RESULTS

A total of 66 patients underwent surgical resection using POIPA. Thirty-six patients were male (54.5%) and 30 patients were female with a mean age 37.9 years (range 8 to 75 years). Fourteen (21.2%) patients were children (younger than 18 years) and 42 patients were adults. The lesion was in the right atrium in 25 cases and in the left in 41 (62.1%) patients. POIPA was used in all cases to remove the lesions. The most common tumor was glioblastoma (n=23, 34.8%), followed by glial tumor grade I, II and III (n=14) and meningioma (n=9). The other lesions were metastases, ganglioglioma, primitive neuroectodermal tumor (PNET), epidermoid cysts, benign epithelial cysts and AVM (Figures 2A-D; 3A-D; 4A-D; 5)(Table II). Gross total resection (GTR) was achieved in 59 patients (89.4%) while subtotal removal was performed in 7 cases. All of the tumors which were gross totally removed were benign and low grade tumors. Subtotal resection was performed mainly in patients with malignant tumors such as glioblastoma. The reasons for subtotal resection were neurovascular adhesions, non-distinct borders, eloquent location and the dominant hemispheric side.

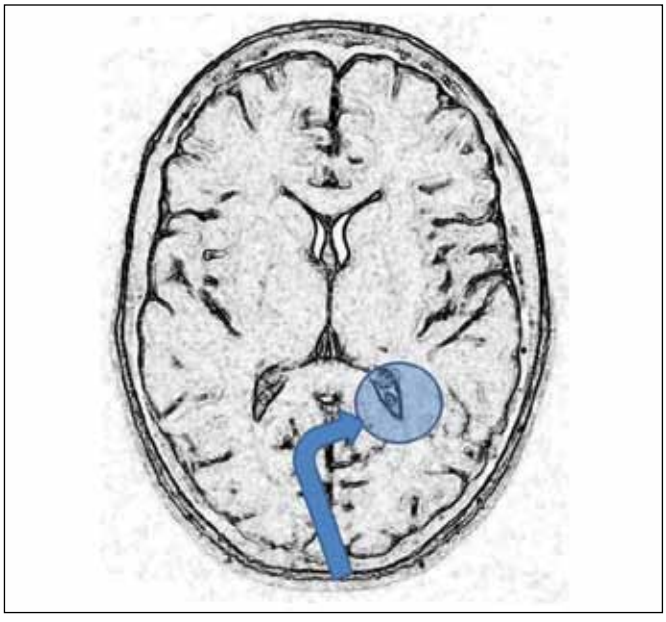

Figure 1: Line drawing depicting the interhemispheric precuneal approach to the atrium. Blue arrow shows the way to reach the atrium by the POIPA.

Table I: Surgical Approach Types to the Tumors Located in the Trigone of the Lateral Ventricle and the Paratrigonal Region (14)

Approach type		Craniotomy	Incision site	Advantages and Disadvantages
Anterior	Distal Sylvian	Fronto-temporal (Pterioal)	• Medial end of the transverse gyrus of Heschl	• to remove small lesions in the atrium of the lateral ventricle
Lateral	Transtemporal	Temporal	• Posterior middle temporal or inferior temporal gyrus especially in dominant side	• may cause visual quadrantanopia and aphasia in dominant side • impaired recognition of emotion in non-dominant side
Posterior	Temporoparietal junction	Temporo-parietal	• Temporoparietal junction	• exposes the lower part of the atrium • may cause a homonymous visual field deficit in either side • disturbance of visuospatial function in the non-dominant side • aphasia and agnostic disorders in the dominant side
	Subtemporal	Temporo-occipital	• In the inferior temporal or • Occipitotemporal gyrus or • The collateral sulcus on the lower surface of the temporal lobe	• minimizes the possibility of damage to the optic radiations and speech centers of the dominant side • the risk of hemorrhage, venous infarction, and edema after retraction of the temporal lobe (especially in occlusion of the vein of Labbé)
Posterior **Posterior**	Transcortical-superior parietal lobule	Parietal	• In the long axis of the superior parietal lobule in the region behind the postcentral sulcus	• exposes the interior of the atrium and the posterior part of the body of the lateral ventricle, the calcar avis and bulb of the corpus callosum in the medial wall, pulvinar, and the collateral trigone • may cause mild apraxia and transient acalculia in the dominant side • an incorrectly placed incision can result in hemiparesis and homonymous hemianopia in either hemisphere. • retraction or dissection medially to the atrium, in the region of the quadrigeminal plate, can cause disorders of eye movements, or even blindness from pressure on the colliculi or geniculate bodies. • an incision in the lateral parietal region of the dominant hemisphere yield an extremely high likelihood of postoperative speech deficits
Posterior	Interhemispheric-Transcallosal	Parieto-occipital	• In the midline of the posterior part of the corpus callosum	• is best suited to lesions that extend upward from the atrium through the posterior part of the splenium or that arise in the splenium and extend into the atrium • exposes the crus of the fornix, bulb of the corpus callosum, pulvinar, and choroid plexus • may cause a disconnection syndrome in right-handed patients with preexisting right homonymous hemianopia • it is not suitable for large tumors extending laterally
	Interhemispheric-Transcingular	Occipital	• Through the posterior part of the cingulate gyrus, which in turn transects the lateral part of the splenium	• shortens the distance between the AVM and accessing point on the cerebral tissue • may cause auditory or visual disconnection syndrome
	Interhemispheric-Precuneal	Occipital	• Precuneus	• allows access to medial surfaces of the parietal and occipital lobes, splenium, cella media, and posterior parts of the occipital horn • It is made easy to reach to splenium and parasplenial area • minimizes the possibility of damage to the optic radiations
	Supracerebellar transtentorial	Occipital-suboccipital	• Sectioning the occipitotemporal gyrus or • Collateral sulcus, on the inferior surface of the temporal lobe	• visualization of the posterior inferior surface of the temporal lobe • provides access to the inferior part of atrium and posterior part of the hippocampus

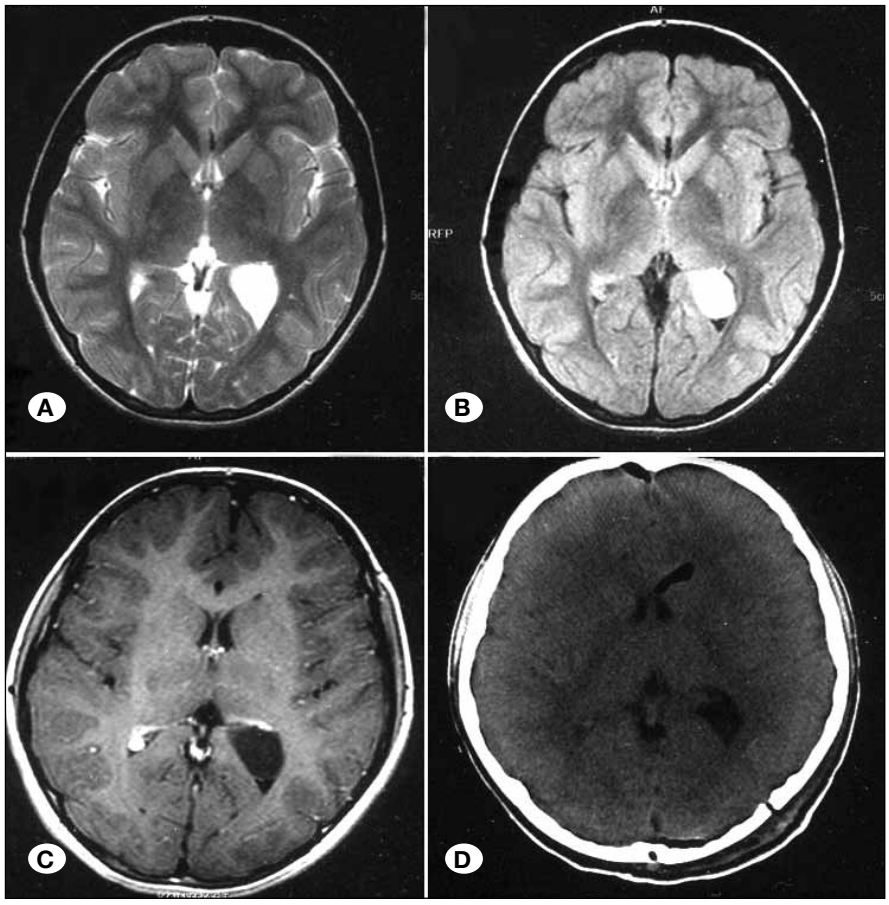

Figure 2: The T1-weighted MR images showed a round hypointense mass with a regular margin which was hyperintense in T2-weighted images in the left trigone of the lateral ventricle **(A,B,C)**. CT scan, taken 1 day after the operation, revealed the total resection of the cyst and some postoperative changes **(D)**. The diagnosis was benign epithelial cyst.

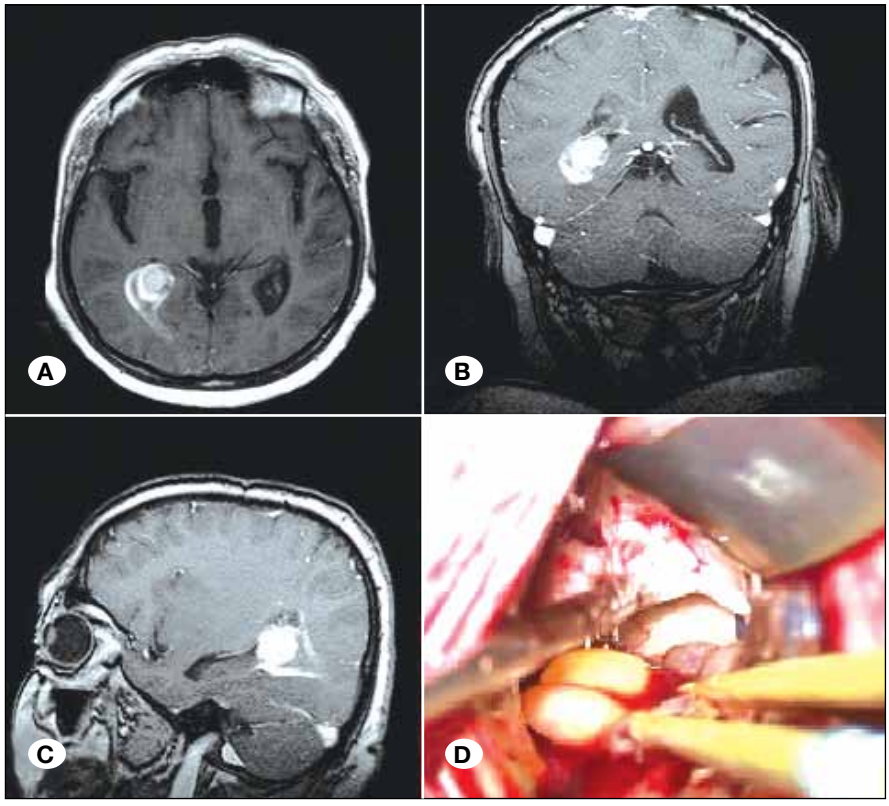

Figure 3: Preoperative axial **(A),** coronal **(B)** and sagittal **(C)** MR images show a hyperintense contrast-enhancing mass lesion in the right atrium. The lesion was removed via POIPA **(D)** and the diagnosis was choroid plexus papilloma.

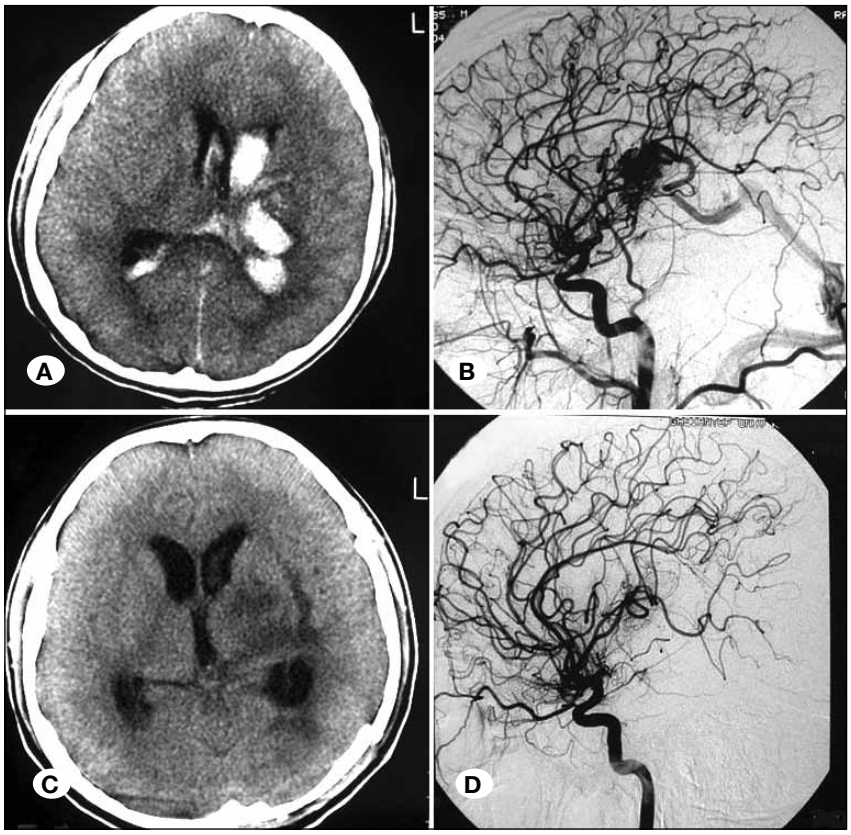

Figure 4: Computerized tomography of the brain revealed an intracerebral haemorrhage in left diencephalic structures opening to the lateral ventricles, which was thought to be an AVM as the patient was 19 years old **(A)**. The plexiform AVM had a single feeder from the left lenticulostriate artery and a single vein draining to the Galenic system **(B)**. A postoperative control CT scan taken 2 months after the operation revealed total resection of the AVM **(C)** and DSA also confirmed total resection of the lesion **(D).**

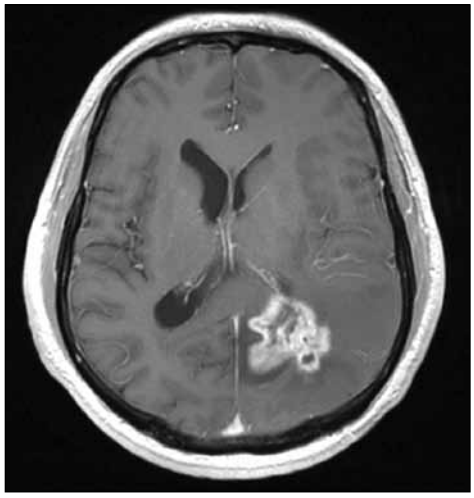

Figure 5: A 43-year-old male patient. Preoperative axial T1-weighted MRI scan shows left trigonal tumor with irregular contrast enhancement and mild edema. The histological diagnosis was glioblastoma.

Complications such as hemiparesis (n=5) and visual field defects were observed in 17 (25.8%) patients. The visual field defects were improved in 13 patients after the discharge and hemiparesis was improved in all patients in the first month after surgery. Five patients (7.5%) died within the first month after surgery due to their poor clinical condition. Three of them had a diagnosis of glioblastoma, and the others had metastasis and choroid plexus carcinoma. The causes of death were summarized in Table III. The mean follow-up period was 17.4 months (ranged between 15 days and 60 months). Thirty patients underwent adjuvant chemo/radiotherapy after surgery.

■ DISCUSSION

POIPA was used in 66 patients in a period of 13 years and a successful outcome was obtained with low permanent morbidity and mortality rates by this technique for the lesions located in the atrium of the lateral ventricle.

A direct approach to the atrium is always a challenge to neurosurgeons due to its deep location and neighbourhood with important neurovascular structures and the deep venous system (12). The parieto-occipital interhemispheric precuneal approach was first defined by Yasargil (38). This approach should be advised for the lesions, such as tumors and AVMs, which are located in atrium, pulvinar thalami, and occipital horn of the lateral ventricles (26). POIPA is especially the preferred route to reach the atrium and allows access to medial surfaces of the parietal and occipital lobes, splenium, cella media, and posterior parts of the occipital horn. This approach made it easy to reach the splenium and parasplenial area. The anatomy of the medial parietal lobe and the safety and complexity of this approach have been previously shown by anatomical reports (11,22). Gurer et al. (11) demonstrated the complexities in the patterns of the subparietal and parietooccipital sulci and they showed that these sulci fall within an expected range of variations. Good anatomical knowledge of the medial surface of the parietal lobe is required for surgical approaches through this region. In addition, the anatomical study performed by Mahaney et al. (22) confirmed that the medial parieto-occipital interhemispheric approach to the ventricular trigone may avoid injury to the optic radiations and the calcarine cortex.

Although the more detailed role of the precuneus is unclear, it has been reported that there is a specific role in episodic memory retrieval independent of imagery content of the words and differing presentation modalities (verbal–visual versus verbal–auditory) (17,33). Wang et al. (36) performed a cadaveric study on the posterior interhemispheric transfalx transprecuneus approach to the atrium of the lateral ventricle. They suggested that this approach can expose the atrium and the posterior part of the temporal horn of the lateral ventricle with a wider surgical angle compared to the conventional homolateral posterior interhemispheric transprecuneus gyrus approach (36).

Table II: Histological Diagnosis of the Cases

Histological diagnosis	Number of Cases
Glioblastoma	23
Anaplastic astrocytoma WHO grade III	9
Meningioma WHO grade I	7
Meningioma WHO grade II	2
Metastasis	4
Ganglioglioma	3
Arteriovenous malformation	2
Oligodendroglioma WHO grade II	2
Epidermoid tumor	2
Gliosarcoma	2
Ependymoma WHO grade II	1
Primitive neuroectodermal tumor (PNET)	1
Diffuse astrocytoma WHO grade II	1
Choroid plexus papilloma	1
Choroid plexus carcinoma	1
Anaplastic ependymoma WHO grade III	1
Astroblastoma	1
Ependymal cyst	2
Benign epithelial cyst	1
Total	**66**

WHO: *World Health Organization.*

At this point, we would like to emphasize some important points of our study. Firstly, the great majority of the histopathologies in this series were malignant tumors such as glioblastoma (GBM) (Figure 5) and metastases in contrast to the previous reports (4). The possible reason of the high number of malignant tumors is that the number of cases was limited to 66 patients. Another reason is that the majority of the tumors in this series did not arise primarily from the ventricular wall. Most of them originated from the surrounding tissue of the ventricle wall and they generally had a malignant histopathological character. Secondly, the precuneal approach may cause verbal-visual memory deficits after surgery (33). The precuneus has been recognized to play a role in retrieving visual, auditory, and episodic memory, regardless of dominancy of the brain hemisphere. Careful evaluation of the patient's cognitive functions is recommended before and after surgery by this approach. In our series, none of the patients experienced memory disturbance or worsening of preexisting symptoms in our series. This complication should be taken into consideration although it has not been reported so far except for the case reports (17,33). Thirdly, the experience of the physician should be not only sufficient to detect the neurological status of the patients, but also the level of the patient's consciousness and educational status are of high importance in terms of visual tests such as perimetry or confrontation. Visual evoked potentials and perimetry should be performed in the pre- and postoperative periods. MR tractography might give more reliable information about the anatomo-morphological structures around the tumor and visual pathways if the visual tests can not be performed (30).

AVMs of this region are those that involve the superior, medial, and inferior walls of the trigone and, occasionally, the adjacent pulvinar of the thalamus. The supply is primarily from the posterior cerebral and posterolateral choroidal artery branches, with medial venous drainage into the basal vein of Rosenthal. The surgical approach to these lesions depends on whether the lesion is located superior and medial or inferior and lateral to the trigone (31). The transcortical dissection proceeds through a relatively non-eloquent area between

Table III: Demographic Features, Histological Diagnosis, Time and Cause of Death of Patients Who Died in the First Month After Surgery

Number	Age/Sex	Histological diagnosis	Death time (Postoperative)	Cause of death
1	68/F	Anaplastic astrocytoma grade III	3rd day	Acute myocardial infarct
2	17/M	Choroid plexus carcinoma	10th day	Cardiopulmonary arrest
3	59/M	Metastasis	20th day	ARDS
4	41/F	Anaplastic astrocytoma grade III	15th day	Cardiopulmonary arrest
5	47/M	Glioblastoma	15th day	Sepsis

M: *Male,* ***F:*** *Female,* ***ARDS:*** *Acute respiratory distress syndrome.*

visual and somatosensory association fibers until the trigonal area is reached. Additionally, if the lesion is located mainly posterior to the atrium, the feeding vessels coming from the antero-inferior direction can be interrupted by working in a plane anterior to the AVM (2,21,27,37).

The main goal of all the approaches is to minimize the risk of postoperative neurological deficits by using a reliable and safe surgical corridor, minimal retraction of the brain tissue, and early control of the tumor's blood supply. The decision on where to place the "opening incision" must depend on the actual neurological deficit, the surgical difficulty of the approach, the relative risk of additional deficits, the hemispheric dominance of the tumor, the experience of the surgeon and some morphological features of the tumor.

Some authors have advised the usage of intraoperative ultrasound to guide the approach and excision, as its real-time imaging is advantageous for resection of the tumor (5,18). In cases of tumors involving the trigone, neuropsychological studies, such as visual verbal learning and memorizing functions, should also be performed pre- and postoperatively (3). Meanwhile, neuroradiological studies, such as digital substraction angiography (DSA) or MR angiography, are the gold standard diagnostic methods for trigonal AVMs (16,17,27).

Based on our 13-year (2001-2014) experience, we suggest that POIPA is a safe and effective method without additional visual defects for the tumors located in the atrium of the lateral ventricles. In the current series, we did not observe any morbidity or mortality directly related to this surgical approach. POIPA is definitely the preferred surgical strategy, offering good access to the lesions and also permitting conservation of normal tissue and structures.

CONCLUSION

POIPA is probably the best chance for the patients with lesions in the atrium with limiting visual field defects and does not necessitate the use of over-retraction if the lateral borders of the craniotomy are made wide enough. The superior features of POIPA over the other approaches are better preservation of optic, providing a safe surgical corridor and having appropriate qualities for many tumors located in the atrium and surrounding tissue. In the point of view of the optic radiation, it is obvious that POIPA is the most reliable technique for trigonal tumors. Consequently, the transcortical approach should not be advised unless the tumor does not reach the subpial region of the brain.

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