Tumors of the Lateral Ventricle: The Factors that Affected the Preference of the Surgical Approach in 46 Patiens

Lateral Ventrikül Tümörlü 46 Hastada Cerrahi Yolun Seçimine Etki Eden Faktörler

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ABSTRACT

AIM: Optimal surgical pathway for lateral ventricle tumors is still controversial. The purpose of this study is to discuss the factors that affected the preference of the surgical techniques for removing lateral ventricle tumors.

MATERIAL and METHODS: 46 consecutive patients underwent operation for lateral ventricle tumors. The mean age was 36 years. Preoperative magnetic resonance imaging (MRI) images were examined to determine the location, expansion and size of each tumor. The transcallosal approach was used in 25 patients, and the transcortical approach was used in 21 patients. We performed MRI to determine the tumor size and recurrence or increased size of the residual tumor.

RESULTS: Total resection was performed in 31 patients. Only one patient, with glioblastoma, died due to hepatic encephalopathy and intraventricular hemorrhage after the operation. Additional neurological deficits were seen 4 patients, and postoperative seizure occurred in one patient. The mean duration of follow-up was 38,37 months.

CONCLUSION: Lateral ventricle tumors can be treated best by careful selection of the surgical approach according to localization of the tumor within the ventricle, the expansion side of the tumor, the size of the tumor, the origin of the vascular feeding branches, the venous drainage, and the relationship of the structures, and the histopathological features.

KEY WORDS: Lateral ventricle neoplasm, Surgical approach, Transcallosal, Transcortical

ÖZ

AMAÇ: Lateral ventrikül tümörlerinin cerrahi tedavisinde seçilmesi gereken en uygun cerrahi teknik halen tartışmalıdır. Bu çalışmada, lateral ventrikül tümörlerinin cerrahi tedavisinde cerrahi tekniğin seçimine etki eden faktörler değerlendirilmiştir.

YÖNTEM ve GEREÇ: 46-hasta lateral ventrikül tümörü nedeniyle opere edildiler. Olguların yaş ortalaması 36 olup, 2 ile 71 arasında değişmekteydi. Klinik belirti ve bulgular tümörün lokalizasyonuna göre farklılık göstermekteydi. Tüm olgularda tümörün lokalizasyonu, yayılımı ve büyüklüğü MRI tetkikleri ile belirlendi. 25 olguda transkallozal yaklaşım uygulanırken 21 olguda transkortikal yaklaşım uygulandı. Ameliyat sonrası üçer aylık periodlarla takip süresince olgular MRI tetkiki ile değerlendirildi.

BULGULAR: 31 olguda tümör total olarak eksize edildi. Total olarak çıkarılan tümörlerin büyük bölümünü benign ve düşük gradeli tümörler oluştururken, subtotal eksize edilen tümörler malign karakterdeydi. Glioblastomalı bir olgu postoperatif 7. günde gelişen hepatik ensefalopati ve intraventriküler kanama nedeniyle ex oldu. 4 olguda postoperatif dönemde ek nörolojik defisit gelişirken, 1 olguda epilepsi oluştu. Ortalama takip süresi 38,37 ay olup 1 ile 110 ay arasında değişmektedir.

SONUÇ: Lateral ventrikül tümörlerinin cerrahi tedavisinde tümörün lokalizasyonu, yayılım yönü, dominant hemisferde olup olmadığı, büyüklüğü, vasküler beslenmesi, venöz boşalımı, koroid pleksus ve internal serebral venle komşuluğu ve histopatolojik tanısı değerlendirilerek cerrahi teknik seçilmelidir.

ANAHTAR SÖZCÜKLER: Lateral ventrikül tümörleri, Cerrahi yaklaşım, Transkallozal, Transkortikal

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INTRODUCTION

Tumors of the lateral ventricle are rare lesions in general neurosurgical practice, with a reported incidence between 0.81% and 1.6% (7,9). Lesions that affect the lateral ventricle include a large variety of benign tumors, malignant tumors, and cyst formations (3,8,9,11,12,19,23). Tumors that originate in the ventricular wall and expand mainly within the ventricular cavity, or arising and expand within the lateral ventricle are considered real lateral ventricle tumors (5,9). Tumors in this location are generally slow growing, and can become large before causing symptoms (4,9). Typically, these lesions cause symptoms and signs of obstruction of the normal cerebrospinal fluid (CSF) pathways, compression of the adjacent neural structures, or hydrocephalus induced by overproduction of CSF (18,20,33). Tumors that are most likely to occur in the lateral ventricles are astrocytoma, ependymoma, oligodendroglyoma, choroid plexus papilloma, and meningioma (9,18). Subependymal giant cell astrocytoma (SGCA), subependymoma, pilocytic astrocytoma, neurocytoma, choroid plexus carcinoma, teratoma, choroid plexus cyst, hemangioblastoma, epidermoid tumor, cavernous angioma, and metastatic carcinoma are rare intraventricular tumors (9,16,18,28). Lateral ventricular tumors are easily detected with computed tomography (CT) and magnetic resonance imaging (MRI) at a time when they are still small and produce insignificant clinical manifestations (11,15,30). Microsurgical resection has been the treatment of choice for the majority of these lesions. Complete resection of many, but not all, of these lesions is possible via the transcortical or transcallosal route. Multimodal strategies, including stereotactic biopsy, radiosurgery, adjuvant radiotherapy, and chemotherapy further improve clinical outcomes (19,27,36). The location of the lateral ventricles makes passing through cortical structures mandatory in all approaches to these lesions (33). The surgeons must choose the way that will cause least morbidity, provide adequate working space, and achieve a complete resection by surgery for these deep lesions. The transcallosal route is performed by some neurosurgeons for a variety of reasons. The transcallosal approach may decrease the risk of postoperative seizures and functional deficits (1,10,34). It is recognized that the transcallosal route to the ventricles can be safely used to excise lesions in the ventricular body, anterior horn, and atrium. The transcortical approach to the lateral ventricles is a simple and attractive alternative to the transcallosal approach for many deep tumors. It has the advantage of simplicity. Especially, tumors located in the temporal horn and atrium are safely and easily operated on with transcortical approach. The transcortical approach provides superior working space, and more flexibility in traversing the lateral ventricle (7). Planning and performing surgery via the transcallosal or transcortical approach is dependent on the tumor localization and origin, tumor size, tumor mature, and tumor expanding side (5,7,12,35). We present our clinical and surgical data for 46 patients with lateral ventricle lesions.

PATIENTS and METHODS

Between 1995 and 2006 in the Neurosurgical Department of Gülhane Military Medical Faculty, 46 patients underwent surgery for tumors of the lateral ventricles. Lateral ventricular tumors included neoplasms that originate in the lateral ventricular wall and its lining either with or without transependymal development. We reviewed the clinical, radiological, surgical, pathological data of these cases retrospectively. The factors of the preference of the best surgical approach in each case were analyzed with preoperative clinical symptoms, tumor size, tumor mature, tumor location and expansion, postoperative complications, additional therapy, postoperative residue tumor size, and recurrence during the follow-up period.

Patient Characteristics

The 46 patients included 26 males and 20 females. Half of the patients were younger than 30 years of age. The mean age at admission was 36 (range 2-71 years). The distribution of tumors according to the age and sex groups is shown in Table I. The number of the males and females are approximately equal in all tumor categories, except glioblastoma multiforme. Male dominancy was seen in this group. The natural age grouping of the ependymoma and choroid plexus papilloma is 0-30 years, and meningioma is over 30 years.

Symptoms and Signs

The main clinical symptoms and signs were associated with the localization of the tumors. The symptoms and signs for tumors located in the frontal horn and foramen of Monro were headache, and

Table I: The distribution of tumors according to the age and sex groups

Tumors	Number of patient	Sex		Age (years)						
		Male	Female	0-10	11-20	21-30	31-40	41-50	51-60	≥61
Subependymal giant cell astrocytoma	1	0	1	0	0	1	0	0	0	0
Anaplastic astrocytoma	1	1	0	0	1	0	0	0	0	0
Pilocytic astrocytoma	2	2	0	0	0	0	0	2	0	0
Glioblastoma	9	7	2	0	1	2	0	3	1	2
Oligodendroglioma	2	1	1	0	0	0	0	0	2	0
Ependymoma	6	4	2	0	3	3	0	0	0	0
Subependymoma	1	0	1	0	0	0	0	1	0	0
Choroid plexus papilloma	7	5	2	0	4	3	0	0	0	0
Choroid plexus carcinoma	2	1	1	0	0	0	1	1	0	0
Meningioma	6	2	4	0	0	0	0	2	1	3
Lymphoma	2	0	2	0	0	0	0	0	2	0
Teratoma	1	1	0	1	0	0	0	0	0	0
Arachnoid cyst	4	1	3	1	2	1	0	0	0	0
Metastasis	2	1	1	0	0	0	0	0	0	2
TOTAL	46	26	20	2	11	10	1	9	6	7

seizure, mental disturbances and high intracranial pressure syndromes. For tumors located in the ventricular body, symptoms and signs were high intracranial pressure syndromes, headache, mental disturbance, motor and sensorial deficits. Clinical symptoms and signs for tumors located in the atrium included headache, high intracranial pressure syndromes and motor deficits. For tumors located in the temporal horn, clinical symptoms and signs were seizure, high intracranial pressure syndromes, motor and sensorial deficits, and aphasia. Tumors located in the septum pellicidum were characterized by mental disturbance, high intracranial pressure syndromes, and motor and sensorial deficits. For tumors located in the occipital horn, clinical symptoms and signs were headache, high intracranial pressure syndromes, motor and sensorial deficits. Visual defects were seen in two cases located in the occipital horn with an occipital extension (Table II).

Radiological Findings

Preoperative magnetic resonance imaging (MRI) images were examined to determine the location and expansion of each tumor. Additionally, the

Table II: Symptoms and signs according to the tumor location

Tumor Location	Symptoms and Signs								
	Number of patient	Headache	Seizures	Mental disturbance	High intracranial pressure syndromes	Motor deficits	Sensorial deficits	Aphasia	Visual deficits
Frontal Horn, foramen of Monro	5	5	2	2	3	0	0	0	0
Ventricular body	19	8	0	2	12	8	10	0	0
Atrium	7	7	0	0	1	1	0	0	0
Temporal horn	6	0	2	0	3	2	2	2	0
Septum pellicidum	4	0	0	1	2	3	3	0	0
Occipital horn	5	3	0	0	3	2	2	0	2
	46	23	4	5	24	16	17	2	2

neoplasm's morphological characteristics were evaluated by CT scans and T1-weighted, T2-weighted, and either proton-density-weighted or intermediate MRI images, both contrast-enhanced, and unenhanced. Contour, appearance, and specific tissue signal characteristics, such as fat or hemorrhage were evaluated. The venous anatomy, temporal vessels, and arterial supplies were studied in 17 patients with MRI angiography, and in 10 patients with digital subtraction angiography. Preoperative radiological diagnoses were the same as the postoperative pathological diagnosis in 25 cases. Preoperative hydrocephalus was present in 9 patients.

Tumor Localization and Expansion

Localizations of the lateral ventricle tumors were the frontal horn and foramen Monro (n=5), ventricular body (n=19), atrium (n=7), temporal horn (n=6), septum pellicidum (n=4), and occipital horn (n=5). Topographically, the most common sites for the tumors were ventricular body for glioblastomas, atrium for arachnoid cysts, and metastasis for frontal horn. In 26 patients, the tumors had transependymal expansion, mainly in the temporal lobe, corpus callosum, and thalamus. There was no expansion in choroid plexus papillomas, and arachnoid cysts, but all meningiomas, metastases, and lymphomas had

transependymal expansion. The tumor that had the lowest average tumor size was choroid plexus papilloma, while meningiomas had the maximum average tumor size (Figure 1).

Surgical Planning

The choice of the surgical approaches depends on the location, expansion and the size of the tumor, whether it is in the dominant or non-dominant hemisphere, the size of the ventricles, vascularity, origin of the arterial feeders, the venous drainage, and the relationship between the choroid plexus and the internal cerebral veins. It is impossible to reach lateral ventricle tumors without opening some neural structures, but some important structures must be preserved during surgery. We used the frontal transcortical approach (n=8), temporal transcortical approach (n=6), parietal transcortical approach (n=7), anterior transcallosal approach (n=20), and posterior transcallosal approach (n=5) (Figure 1).

Frontal Transcortical Approach

In our series, the tumors in the frontal region were astrocytoma, oligodendroglioma, and meningioma. Tumors of the frontal horn can become very large and cause obstruction of the foramen of Monro with ventricular dilatation. The transcortical middle frontal gyrus approach is an excellent route
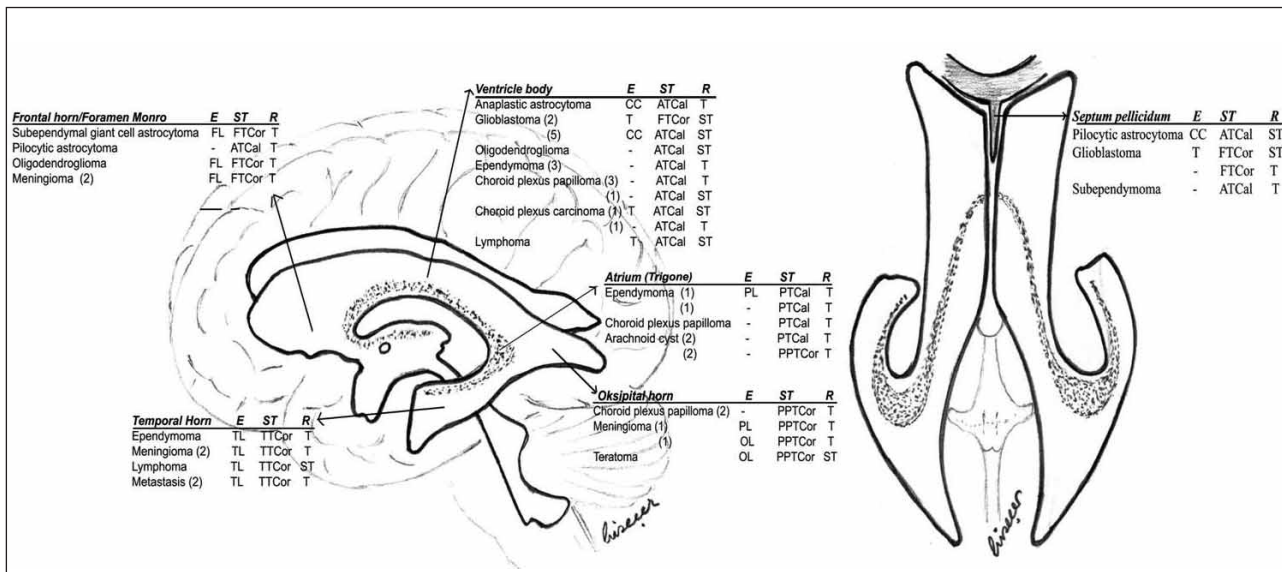

Figure 1: Tumor locations, expansion, surgical techniques and resection of the lateral ventricle tumors [E (expansion), ST (surgical techniques), R (resection), FL (frontal lobe),CC (corpus callosum), T (thalamus), TL (temporal lobe), PL (parietal lobe), OL (occipital lobe), FTCor (frontal transcortical), TTCor (temporal transcortical), PPTCor (posterior parietal transcortical), ATCal (anterior transcallosal), PTCal (posterior transcallosal).

for the excision of tumors in the ipsilateral anterior horn, and the anterior body of the lateral ventricle. This corridor was used in 8 patients for resection the tumors. Four of them had transependymal anterosuperior, and superolateral expansion in the anterior portion of the lateral ventricle. We preferred this approach in four glioblastomas that were located in the anterior ventricular body (n=2), and anterior septum pellicidum (n=2) at the dominant hemisphere, and expanded to the thalamus. Two meningiomas that had a large size and were located in the frontal horn were resected easily by this approach. The principles of internal decompression and than resection of the tumor capsule were followed routinely. More than half of the tumors that were operated with the frontal transcortical approach could be resected totally (Figure 1).

Temporal Transcortical Approach

The temporal horn and the occipital horn region were accessed through the posterior portion of the middle temporal gyrus. The transcortical approach to the temporal horn is the primary method for removing tumors in this region or with a lateral transependymal extension. The approach provided a short trajectory to the lesions. Early control of the anterior choroidal vessels can be obtained, making tumor slightly less challenging. Because meningioma is the most common tumor found in this ventricle, any branch of the choroidal artery can feed the tumor. This approach had the potential to produce associated language deficits on the dominant hemisphere. This approach was used in 6 patients. All the tumors were located at the temporal horn of the lateral ventricle on the non-dominant hemisphere, and expanded to the temporal lobe. These were meningiomas (n=2), metastasis (n=2), ependymoma (n=1), and a lymphoma (n=1). Except for lymphoma, all tumors were excised totally (Figure 1).

Parietal Transcortical Approach

The parietal transcortical approach is one of the best approaches for removing tumors of the atrium, tumors of the posterior body of the lateral ventricle, and the glomus of the choroid plexus. A posterior parietal craniotomy was centered on the superior parietal lobe, and the cortical incision was made high enough to avoid the optic radiations. This approach was especially well suited for large masses, and tumors with a superior development,

but it is more risky in the dominant hemisphere. Because the vascular supply to the tumor is deep, this approach did not provide for access to vascular control before tumor removal. This corridor was used in 7 patients for resection the tumors. These tumors were located in the occipital horn (n=5), and atrium (n=2). Two meningiomas and a teratoma had transependymal superior and posterior expansion. These tumors were meningioma (n=2), (Figure 2A,B, C,D,E,F) teratoma (n=1), choroid plexus papilloma (n=2), and arachnoid cyst (n=2). Except for teratoma, the tumors were excised totally (Figure 1).

Anterior Transcallosal Approach

The anterior transcallosal approach is suitable for lesions in the frontal horn, septum pellicidum and body of the lateral ventricle. The transcallosal approach is easier to perform than the transcortical, if the ventricles are normal in size or minimally enlarged. The transcallosal approach has the advantage of avoiding a cortical incision, but has the disadvantage of sacrificing a significant part of the corpus callosum.

Intraventricular surgery requires the surgeon to work in a small space and to manipulate a tumor several centimeters from the brain surface. The prevent misidentification of normal anatomy; it is helpful to orient the dissection according to reliable anatomical landmarks. The course of the choroid plexus and thalamostriate vein to the foramen of Monro, where the septal vein and the vein of the caudate join it to form the internal cerebral vein can be used to guide the surgeon for localization of the fornix, thalamus, and septum pellicidum.

The anterior transcallosal approach was used in 20 patients to reach tumors of the body, septum pellicidum, and anterior horn of the lateral ventricles (Figure 1). This approach was preferred in patients with small tumors and purely intraventricular localization, or superior corpus callosum expansion. This approach was preferred only in one patient with thalamic expansion of lymphoma for decompression and pathologic definition of the tumor.

Posterior Transcallosal Approach

The posterior transcallosal approach was used in 5 patients to reach tumors of the atrium, mainly of a small size (Figure 1). The posterior transcallosal approach is best suited to lesions that extend upward from the atrium of the lateral ventricle. Opening the arachnoid below the falx exposes the distal branches
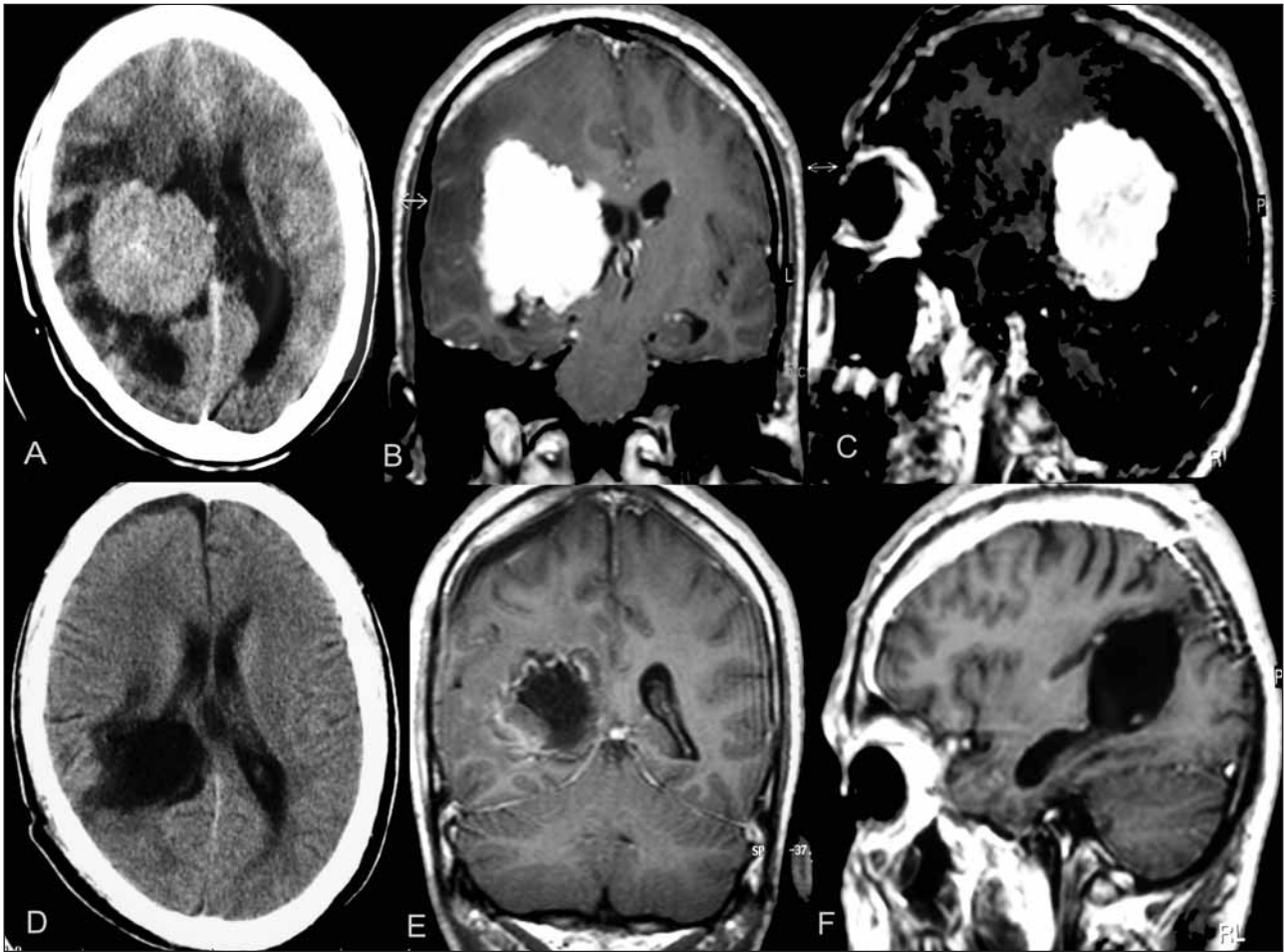
Figure 2: Images obtained in a 52-year-old-man with a meningioma originating from atrium of the right lateral ventricle, A: Preoperative axial post-contrast CT image, B and C: Preoperative coronal and sagittal T1-weighted post-contrast MR images, D: Postoperative axial post-contrast CT image, E and F: Coronal and sagittal T1-weighted post-contrast MR images after total removal of the tumor, using the posterior parietal transcortical route

of the anterior cerebral arteries and occasionally the splenial branches of the posterior cerebral arteries on the surface of the corpus callosum. The junction of the internal cerebral veins with the great veins comes into view below the splenium and above the pineal gland. The posterior part of the corpus callosum is incised in the midline. This callosal incision opens the lateral ventricle, which deviates laterally at this point. The opening through the lateral part of the splenium into the atrium exposes the crus of the fornix, bulb of the corpus callosum, pulvinar, and choroid plexus. These small tumors are excised totally by this way. (Figure 3A,B,C,D)

RESULTS

Surgical results regarding the extent of tumor removal and approach used according to tumor origin and development are shown in figure 1.

According to the histological analysis, total tumor resection was achieved in most of the benign or low-grade tumors, and subtotal resection was performed mainly in patients with malignant tumors.

Histological diagnosis was glioblastoma in 9 cases, choroid plexus papilloma in 7, ependymoma in 6, meningioma in 6, subependymal giant-cell astrocytoma in one, anaplastic astrocytoma in one, pilocytic astrocytoma in 2, oligodendroglioma in 2, subependymoma in one, choroid plexus carcinoma in 2, lymphoma in 2, teratoma in one, metastasis in one, and arachnoid cyst in 4 cases. (Table III) Presenting symptoms and signs were high intracranial pressure syndromes in most of the patients (52,17%), headache in 23 (50%), sensorial deficits in 17 (36,95%), motor deficits in 16 (34,78%), mental disturbance in 5 (10,87%), seizures in 4
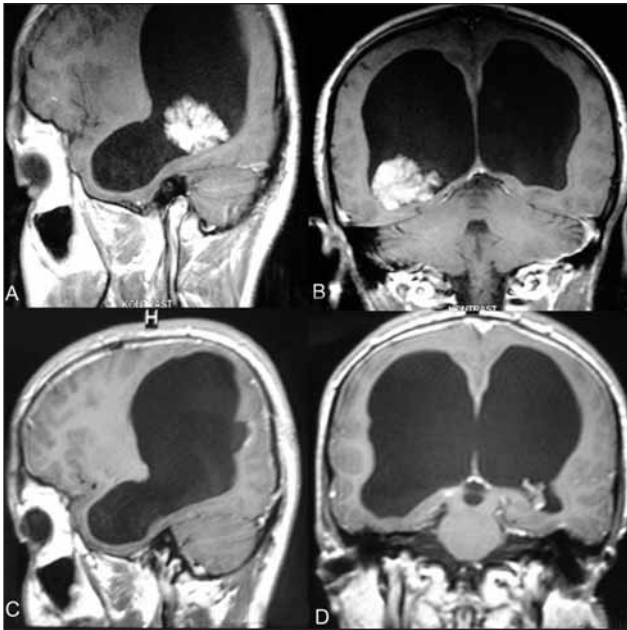
Figure 3: *Images obtained in a 21-year-old-man with a choroid plexus papilloma originating from atrium of the right lateral ventricle, A and B: Preoperative coronal and sagittal T1-weighted post-contrast MR images, C and D: Coronal and sagittal T1-weighted post-contrast MR images after total removal of the tumor, using the posterior transcallosal route.*

(8,70%), language disturbance in 2 (4,35%), and visual deficits in 2 (4,35%).

One patient with glioblastoma died one month after the operation because of hepatic encephalopathy and intraventricular hemorrhage developing 7 days after the operation. The postoperative complications, additional treatments, follow-up times and recurrences were noted in table III. Additional neurological deficits were seen 4 patients. Two of them had glioblastoma, and one had lymphoma located in the ventricular body. Postoperative seizure occurred in one patient with oligodendroglioma in the frontal horn. Two patients with glioblastoma and choroid plexus carcinoma, and no preoperative hydrocephalus developed postoperative ventricular dilatation that required ventriculo-peritoneal shunting. A thick epidural hematoma, which required reoperation at the convexity, developed in one patient. A rim epidural hematoma and subdural hematoma occurred in two patients, and required no treatment. A temporoparietal subdural hematoma occurred in one patient who was operated by the parietal transcortical route to remove a plexus papilloma,

located in the occipital horn in the dominant hemisphere. This patient was reoperated and the hematoma was drained. Severe brain edema was seen in two patients, and only conservative treatment was performed for these patients. 25 of 46 patients received postoperative radiotherapy, and 7 of them received adjuvant chemotherapy. Radiotherapy was performed at the spinal axis with the brain in one patient with ependymoma, who had spinal metastases. Cysto-peritoneal shunt was required in one patient with arachnoid cyst nine months after surgery. No additional visual defects were seen.

The mean duration of postoperative evaluation was 38,37 months (range, 1-110 months). 5 patients with glioblastoma died after 12 to 28 months. One patient with choroid plexus carcinoma of the ventricular body died after 14 months due to cardiac arrest. One patient with metastatic carcinoma died after 20 months due to multi-organ metastases. Two patients with meningioma, two patients with arachnoid cyst, one patient with choroid plexus papilloma, and two patients with ependymoma were out of the follow up period during 23 to 65 months. At the end of the follow-up, there were no recurrences or increased the tumor sizes in subependymal giant-cell astrocytoma, anaplastic astrocytoma, subependymoma, choroid plexus papilloma, meningioma, teratoma, arachnoid cyst, and metastatic carcinoma. The maximum recurrences and increased tumor sizes were seen in lymphoma and glioblastoma. We did not reoperate any patients due to recurrence or increase in the size of the tumors (Table III).

DISCUSSION

Ten percent of all central nerve system neoplasms present within or in proximity to the ventricular system while fifty percent of all adult intraventricular tumors and twenty five percent of pediatric intraventricular tumors occur in the lateral ventricle (18). The histopathological diagnosis of the lateral ventricle tumors reported in younger children were often choroid plexus tumors, whereas in older children the tumors tended to be gliomas (7,11). Histopathological diagnoses varied with the age of the patients in the literature (9,11,17,26,31). In this study the number of the males and females were approximately equal in all tumor categories, except for glioblastoma multiforme where male dominancy

Table III: Postoperative complications, additional treatments, follow-up period, and recurrence or increased size of the tumor

Tumors	Number of patient	Postoperative Complications and Additional Treatments (n=number of patients)	Follow-up Period (months)	Recurrence or increased tumor sizes
Subependymal giant cell astrocytoma	1	No complication, Radiation therapy(1)	36	-
Anaplastic astrocytoma	1	Epidural hematoma, Reoperation, Radiation therapy (1)	24	-
Pilocytic astrocytoma	2	No complication, Radiation therapy (2)	20/31	-/+
Glioblastoma	9	Death with intraventricular hemorrhage and hepatic encephalopathy(1), Additional neurological deficits (2), Ventriculo-peritoneal shunt application (1), Radiation therapy (8), Chemotherapy with temazolomid (3)	1/12/14/19/ 21/21/28/ 27/33	-/-/-/-/ +/+/+/+
Oligodendroglioma	2	Seizure (1), Radiation therapy(2)	32/18	-/+
Ependymoma	6	Severe brain edema (1), Radiation therapy to brain (6), and spinal axis (1)	9/25/39/49/50/52	-/-/+/-/-/-
Subependymoma	1	No complication, No additional therapy	41	-
Choroid plexus papilloma	7	Subdural hematoma (1)	6/28/44/65/98/99/110	-/-/-/-/-/-/-
Choroid plexus carcinoma	2	Ventriculo-peritoneal shunt application (1)	14/39	-/+
Meningioma	6	Epidural hematoma (1), Severe brain edema (1)	23/32/36/65/69/97	-/-/-/-/-/-
Lymphoma	2	Additional neurological dfeicits (1), Radiation therapy(2), Chemotherapy (2)	13/16	+/+
Teratoma	1	No complication, Radiation therapy (1)	55	-
Arachnoid cyst	4	Cysto-peritoneal shunt application (1)	21/39/63/98	-/-/-/-
Metastasis	2	No complication, Radiation therapy (2), Chemotherapy (2)	13/20	-/-

was seen. The natural age grouping of ependymoma and choroid plexus papilloma is 0-30 years, and of meningioma is over 30 years.

A wide range of tumors occur within the lateral ventricles. Neoplasms that originate in the ventricular wall and its lining are considered primary ventricular tumors either with or without transependymal development, and those that arise in the adjacent brain structures but with more than two-thirds exophytic growth within the ventricle are considered secondary ventricular tumors with transependymal development (18). The majority of these tumors are benign or low-grade lesions (4,20,22). The most commonly reported lateral ventricle tumors were astrocytoma, choroid plexus papilloma, meningioma, and ependymoma (5,7,9,14,18,26). In this report, the most frequent tumor types were glioblastoma (19,57%), choroid plexus papilloma (15,22%), ependymoma (13.04%), and meningioma (13.04%).

The incidence of tumor localization within the lateral ventricle was reported in descending order of frequency as the atrium, body and frontal horn (19). In another series, the most common localizations of lateral ventricle tumors were the atrium, frontal horn, temporal horn and septum (14). Gökalp et al reported 112 lateral ventricle tumors in their series, and the most common sites of the tumors were the frontal horn, foramen of Monro, body and the atrium (9). In our series the tumor localizations were the ventricular body (41,3%), atrium (15,2%), temporal horn (13%), occipital horn (10,9%), frontal horn and foramen of Monro (10,9%), and septum pellicidum (8,7%).

The choice of approach to the tumors of the lateral ventricles depends on several factors. These are the localization of the tumor within the ventricle, the expansion side of the tumor, whether the hemisphere involved is dominant or not, the size of the tumor, the origin of the vascular feeding branches, the venous drainage, and the relationship between the choroid plexus and the internal cerebral veins, and the histopathological features. The ideal surgical approach is the shortest distance to the

lesion with a perpendicular field of view that requires minimal retraction of the brain, avoids trajectory through important structures, and provides clear visualization of the vascular feeding branches (32). Surgical approaches to the lateral ventricle are divided into 3 routes: (1) anterior approaches: anterior transcortical, anterior transcallosal, (2) posterior approaches: posterior transcortical, posterior transcallosal and (3) inferior posterior frontotemporal, temporal and subtemporal transventricular approaches (33).

Most neurosurgeons prefer the frontal transcortical approach for lesions involving the anterior two-thirds of the lateral ventricles. The transcortical midline frontal gyrus approach was used in 8 patients for resection of tumors in the ipsilateral anterior horn, the anterior body, and septum pellicidum of the lateral ventricle in this study. Tumors of the frontal horn can become very large and cause obstruction of the foramen of Monro with ventricular dilatation. The anterior transcortical approach is facilitated when the lateral ventricles are enlarged. Sometimes the tumors change the location of the lateral ventricle, and it is difficult to find the lateral ventricle. In these cases, it is important to locate the foramen of Monro to avoid the damage of the fornix. The principles of internal decompression and then resection of the tumor capsule were performed routinely. The total tumor resection rate was approximately 60% in this group of our cases. All the tumors, operated with frontal transcortical approach, were resected totally except three glioblastoma multiformes, located at the vertebral body and septum pellicidum.

The transcortical approach to the temporal horn is the primary method to remove the tumors in this region. There are three cortical incisions that provide access to the temporal horn of the lateral ventricle: the middle temporal gyrus, the lateral temporoparietal junction, and the transtemporal horn occipitotemporal incision, with or without modified temporal lobectomy (7). This approach provided a short trajectory to the lesions. We used the middle temporal gyrus approach to remove the lesions on the non-dominant hemisphere in our cases. In the non-dominant hemisphere, this is a very acceptable route, causing minimal morbidity. In the dominant hemisphere, the danger posed to the language cortex becomes an issue and requires refinement in technique. In dominant hemisphere

lesions, the risk of causing language deficit is most effectively prevented by cortical stimulation and mapping.

The superior parietal route is one of the best approaches for reaching the posterior part of the body, atrium, and the glomus of the choroid plexus (2,7,9). Postoperative cortical damage manifested by a visual field cut can occur if the medial wall of the atrium adjacent to the calcarine cortex is injured. However, the cortical incision was made high enough to avoid the optic radiations. The superior parietal transcortical was especially well suited for large masses and tumors with a superior development, but it is more risky in the dominant hemisphere. Because the vascular supply to the tumor is deep, this approach did not provide for access to vascular control before tumor removal. The risk includes apraxia, acalculia, visual spatial distortions, and the Gerstmann syndrome (20). The operation can be performed safely in the dominant hemisphere when performed using minimal retraction of the relatively small tumors, located in the occipital horn and atrium. We used this route to remove the plexus papilloma, located in the occipital horn in the dominant hemisphere in two cases. Subdural hematoma occurred in one of them as a complication. The patient was reoperated, and the hematoma was drained.

The transcallosal approaches to the lateral ventricle lesions offer an important surgical option. There are several advantages of these approaches over the transcortical routes. The surgeons can reduce the risk of brain injury with appropriate brain relaxation and minimal retraction. Taking care to preserve medial draining veins prevents venous infarction. Partial sectioning of the callosum leads to minimal long-term consequences, unless additional brain injury is induced. In the anterior transcallosal approach, the callosal section must spare the genu of the corpus callosum, especially near the rostrum and the anterior commissure anteriorly, and the posterior part of the sectioned callosum must not go beyond the interparietal commissure. Section of the corpus callosum by preserving the splenium does not result in appreciable adverse neurological deficits, but either anterior or posterior interhemispheric dissection may result in injury to the bridging veins, or the posterior occipital veins (25,29). Transcallosal approaches reduce the risk of postoperative seizures, porencephalic cyst formation, and subdural

hygroma compared with the transcortical approaches (21). As reported in the literature, the large tumors of the occipital horn and atrium were not suitable for posterior transcallosal removal, as the tumor itself prevented the hemispheric retraction that is required to achieve tumor removal, and for proper choroidal vessel control (23). The anterior transcallosal approach was used in 20 patients, and the posterior transcallosal approach was used in 5 patients to reach tumors, mainly of a small size.

The authors have reported that the removal of lateral ventricle tumors at the dominant hemisphere, via a transcortical middle frontal gyrus approach can cause speech and facial apraxia in patients, because of forniceal damage (24). This approach was performed in two cases with lateral ventricle tumors in the dominant hemisphere, and we have not seen speech or facial apraxia.

The reported risk of postoperative seizures after transcortical approaches ranges from 19% to 75% (8,13,21). The true incidence of cortical incision-related postoperative seizure is hard to determine as there are many factors that can contribute to a seizure disorder, including the tumor's histological type, presence of preoperative seizures, residual tumor, subdural effusion, and electrolyte imbalance. In our experience, postoperative seizure that required treatment occurred in one patient with oligodendroglioma in the frontal horn, operated using the frontal transcortical approach. Four cases already had seizures preoperatively.

Postoperative ventriculomegaly is common. Not all patients will require placement of a shunt, however, because the intracranial pressure measured by the ventricular catheter may be normal or even low after a large tumor is excised. The number of patients requiring a shunt will vary based on different factors. Approximately 10 to 50% of patients will ultimately require CSF diversion (6,21). In our series, we performed shunt application in two cases: one had choroid plexus carcinoma and the other had glioblastoma, operated by the anterior transcallosal approach.

In the last series, the authors have recorded mortality rates far lower than 10%. The deaths in the microsurgical era are usually secondary to catastrophic postoperative hemorrhage or pulmonary emboli (9,10,21). In this series, one patient died in the early postoperative period due to severe intraventricular hemorrhage and hepatic encephalopathy.

CONCLUSIONS

Lateral ventricle tumors are relatively rare, slow growing and can become large before causing symptoms. The nature, size, site, location, expansion, and vascularization of intraventricular tumors are fundamental elements influencing the choice of surgical approaches. Complete resection of many, but not all, of these lesions is possible via the transcortical or transcallosal route. Subtotal resection is preferred when the tumor is malignant and attached to eloquent structures. There were no differences in complications between the transcortical and the transcallosal approaches. Surgeons might evaluate all the factors of the tumor, vascular feedings, and eloquent structures nearby the tumor, and prefer the short and safe way to remove it.

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