PRIMARY TUMORS OF THE LATERAL VENTRICLES OF THE BRAIN

Leon Dănăilă
National Institute of Neurology and Neurovascular Diseases Bucharest, Romania
Clinic of Neurosurgery

Background: The lateral ventricles are located in the center of the brain. Each ventricle lies in contact with five critical neural structures: the caudate nucleus, the thalamus, the fornix, the corpus callosum, and the genu of internal capsule. The authors reported their experience in primary tumors of the lateral ventricles of the brain by analyzing the symptomatology, the surgical treatment, the complications and the postoperative results.

Objective: To determine the importance of the surgical technique on the morbidity and the recurrence of the lateral ventricles tumors.

The total surgical resection followed by radiotherapy and/or chemotherapy had been the main objective in the cases of anaplastic tumors.

Methods: This retrospective study makes reference to 202 primary tumors of the lateral ventricles operated by Leon Danaila between 1982 and 2012.

The respective analysis is based on the operative approaches and on the extent of resection. The surgical access routes had been the interhemispheric transcallosal approach and the transcortical approach.

Results: A number of 177 (87%) of the primary tumors of the lateral ventricles had been benign (low grade lesions), while 25 (12.37%) of them had been anaplastic. The most frequent tumors had been ependymomas, astrocytomas, subependymomas, choroidal plexus papillomas and meningiomas.

Out of the total of 202 tumor cases, 164 (81.18%) had been discharged with very good and good results, 35 (17.32%) had been left with neurological deficits, and 3 (1.48%) had died.

A significant proportion of the patients undergoing surgery develop cerebrospinal fluid outflow obstruction, and this fact had made necessary the postoperative mounting of a number of ventricular shunts.

Conclusion: The majority of these tumors had been benign, with a relatively slow growth rate. Owing to this fact, the preoperative dimensions of the tumors had been of several centimeters.

The average age of the patients had been lower than that of those with similar lesions located intraparenchymatously. The symptoms had been determined by the ventricular outflow obstruction and by the affectation of the periventricular structures. The interhemispheric transcallosal and transcortical approaches had been the best surgical access routes.

Key words: Lateral ventricle, Microsurgery, Primary tumors.

Introduction

In 1854, Shaw provided one of the earliest reports of a patient with a lateral ventricular tumor (Abbott and Courville, 1942). He described a 63-year-old man who had suffered from right leg paresis, aphasia and seizures for 27 years.

The autopsy revealed an irregular, globular, fibrous tumor situated in the left lateral ventricle. Abbott and Courville's analysis reached the conclusion that this tumor had been most likely a meningioma (Abbott and Courville, 1942).

Subsequently, Dandy estimated that such lesions constituted only 0.75% of the intracranial tumors. In Cushing's series of 2000 brain tumors, only 9 had occurred within the lateral ventricle (De la Tore et al., 1963; Pendl et al., 1992).

Pendl et al. (1992) observed 55 tumors of the lateral ventricle among 4289 tumors of the brain.

The lateral ventricles are paired C-shaped structures located deep within the telencephalon. Each ventricle has five areas: the frontal horn, the body, the atrium, the occipital horn and the temporal horn.

The respective tumors had affected a multitude of anatomical structures involved in the accomplishment of the functions of conscience, memory, emotion and personality, balance, etc.

The majority of the tumors of the lateral ventricles are benign or low grade lesions. Because of their relatively slow growth rate, these lesions may reach sizes of several centimeters before they require medical attention.

The regions of the lateral ventricles can be accessed through either transcallosal, or transcortical dissection.

For each access route there are multiple options for patient positioning, scalp incision and craniotomy.

However, each procedure must be customized according to the disposition of the tumor in each individual case.

The anatomic landmarks which are normally used to provide orientation may be distorted by the lesion itself, by the surgical configuration and by the degree of ventricular dilatation.

The careful review of the patient's preoperative imaging studies and the clinical presentation will highlight the salient features and help the surgeon anticipate the operative findings.

Although commonly benign, the tumors of the lateral ventricle pose a formidable challenge to the neurosurgeons, because their deep location makes every intervention potentially difficult. All surgical approaches to this region require the transection or the retraction of neurological structures such as the corpus callosum, the cingulate gyrus, the parietal cortex, the temporal cortex or the fornix.

Furthermore, once inside the ventricle, it may be necessary to manipulate or ablate deep arterial or venous structures such as the internal cerebral veins, the anterior choroidal artery, the medial posterior choroidal artery, or the lateral posterior choroidal artery (Amar et al., 2004).

Patients and methods

Beginning with 1982 and until 2012, Leon Danaila had operated in The Neurosurgery II Clinic in Bucharest a number of 25,035 cerebral tumors, of which 202 (0.80%) had been located in the lateral ventricles. The most frequently affected age group had been that between 15 and 40 years old (69.30%).

The average age of the patients at the moment of surgery had been 41 years old (range 15 to 69).

We had found 109 (53.96%) tumors in women, while 93 (46.03%) had been in men (Table 1).

Therefore, the lateral ventricular tumors appear to have a propensity for the young patients and for the females.

The localization, that in some of the cases had been only approximate, is shown in Table 2. The extensive tumors are represented by lesions which include two or more regions of the lateral ventricles.

The symptoms encountered in our patients with tumors of the lateral ventricles had been both general and localized.

The symptoms from the first category had been much more frequent than those from the second one. I will present hereinafter the general symptoms together with the number of affected patients (Table 3). The most frequent symptom had been the acute and subacute headache, often accompanied by nausea and vomiting, which had been encountered in 124 (61.38%) patients, followed by memory disorders (98 – 48.51%), epilepsy (47 – 23.26%), behavioral and cognitive deficits (34 – 16.83%) and gait and balance disorders (19 – 9.40%).

The unilateral localized symptoms had been relatively rare. Their type and frequency are presented in Table 3. According to this, the hemiparesis had been encountered in 18 (8.91%) patients, aphasia in 12 (5.94%), hemihypoesthesia in 11 (5.44%) and the homonymous hemianopsia in 3 (1.48%). Generally, the localized symptoms had a moderate intensity.

Thus, the tumors of the lateral ventricle tend to generate general symptoms such as headache, memory deficit, epilepsy, behavioral and cognitive deficits, as well as gait and balance disorders. They uncommonly result in focal neurological deficits. Changes in the recent memory (short term memory) and behavior, particularly an increasing apathy, can occur in the absence of increased intracranial pressure.

However, the patients presenting with intraventricular tumors pose a threat of acute deterioration from occlusion of CSF pathways.

Before discussing the surgery of these tumors, we shall present several notions of the anatomy of the lateral ventricles.

Surgical anatomy

The goal of this part is to review the relevant surgical anatomy elements, pathological conditions and operative strategies that apply to the lesions of the lateral ventricles, with a special emphasis on the transcallosal approaches.

The lateral ventricles are paired, C-shaped structures located deep within the telencephalon. Each ventricle has five areas: the frontal horn, the body, the atrium, the occipital horn and the temporal horn.

The frontal horn consists of the portion lying anterior to the foramen of Monro and are bounded laterally by the head of the caudate, anteriorly by the posterior aspect of the genu and the rostrum of the corpus callosum, superiorly by the anterior part of the body of the corpus callosum and medially by the septum pellucidum who separate the anterior horns of the two ventricles (Ono et al., 1984; Danaila, 2012).

The lateral and the third ventricles communicate with each other through the foramen of Monro, named after Alexander Monro who had described it in 1783.

The frontal horn contains no choroid plexus, but has on its wall two important veins that help with the surgical orientation. On its medial border, the septal veins lead into the medial foramen of Monro, where it enters the velum interpositum of the roof of the third ventricle to join the internal cerebral vein. Laterally, the anterior caudate vein runs medially to join the thalamostriate vein near the foramen of Monro (Patel et al., 2012).

The internal capsule lies in direct contact with the lateral ventricle. Its genu forms part of the lateral wall at the level of the foramen of Monro, just posterior to the head of caudate (Timurakynak et al., 1996).

The body of the lateral ventricles lies within the frontal and parietal lobes and extends from the posterior aspect of the foramen of Monro to the anterior border of the splenium of the corpus callosum, an area where septum pellucidum tapers off. The bodies of the lateral ventricles are separated by the septum pellucidum, which contains the columns of the fornices in this lower edge.

The body of the ventricle is covered superiorly by the corpus callosum and laterally by the body of the caudate nucleus.

Inferiorly, the junction of the lateral wall and the floor of the body of the ventricle is demarcated by the striothalamic sulcus, which separates the caudate from the thalamus. Between the thalamus and the caudate nucleus there is a groove which is occupied by the stria terminalis and by thalamostriate vein which travels along the posterior margin of the foramen of Monro. Separating the thalamus from the body of the fornix is the choroidal fissure. The choroidal plexus occludes the choroidal fissure and covers part of the thalamus and fornix.

There are two sets of veins that travel on the lateral wall of the body: the more anterior thalamocaudate and the posterior caudate vein, which drains either into the thalamostriate or directly into the internal cerebral vein through the velum interpositum.

The medial posterior choroidal artery, which enters the ventricular system just lateral to the pineal and travels anteriorly in the roof of the third ventricle in the velum interpositum, can be seen in the lateral ventricle as it ascends through the foramen of Monro and bends posteriorly to run in the direction of the choroid plexus.

The body of the lateral ventricle widens posteriorly to become continuous with the posterior and inferior horns at the collateral **trigone, or atrium**. Thus, the atrium of the lateral ventricles is a confluence of the body and the temporal and occipital horns.

The atrium begins as a continuation of the body at the posterior edge of the thalamus and ends further posteriorly, as the corpus callosum blends into the occipital lobe. The splenium (superiorly) and the tapetum of the corpus callosum (more posteriorly) make up the roof of the atrium. The floor consists of the upward protrusion of the collateral sulcus, forming the collateral trigone.

More anteriorly, the caudate tail covers the lateral wall as it curves downward, on its way toward the temporal lobe. The anterior boundary of the atrium starts just medial to the caudate tail with the pulvinar eminence. Medial to the pulvinar, covered by choroid, is the crus of fornix.

The medial wall of the atrium has two prominences.

The upper prominence consists of the forceps major fibers and is called the bulb of the corpus callosum. The lower prominence is called the calcar avis and is simply the ventricular protrusion of the calcarine sulcus.

The fornix forms part of the floor of the lateral ventricle. It originates from the fimbria of the hippocampus within the temporal lobe and travels around the thalamus. The crus of the fornix runs beneath the splenium of the corpus callosum in the floor of the atrium. The paried crusa merge at the level of the body of the lateral ventricle to form the body of the fornix. The fornix continues forward and diverges along the anterior and medial border of the foramen of Monro as it descends to meet the mamillary body.

Within the atria and he occipital horms lie the medial and lateral atrial veins. These vessels merge just lateral to the choroidal fissure to form the common atrial vein. They may have major branches that drain into the internal cerebral vein, the vein of Galen, or the basal vein of Rosenthal (Ono et al., 1984).

At the atrial level of the choroid plexus, there can often be seen two choroidal arteries, one curving medially with the choroid, the anterior choroidal artery, which can enter into the body of the ventricle.

More laterally, the lateral posterior choroidal artery, which may have several branches, runs to supply the atrium and body of the choroid. The triangular enlargement of the chororid plexus at the trigone is called the glomus.

The occipital horn is a posterior extension of the atrium. Medially, the wall consists of the same structures that make up the atrial medial wall, namely, the forceps major superiorly and, inferiorly, the calcar avis. Likewise, the collateral trigone forms the floor of the occipital horn. The roof and lateral wall blend into one and are both covered by the tapetum. There is no choroid in the occipital horn (Patel et al., 2012).

The temporal horn, the largest compartment of the lateral ventricle, extends forwards into the temporal lobe and ends in the amygdaloid nucleus. It curves round the posterior aspect of the thalamus, passes downwards and posterolaterally, and then curves anteriorly to end within 2.5 cm of the temporal pole, near the uncus. At the surface of the hemisphere, it corresponds to the superior temporal sulcus (Crossman, 2008).

The floor displays two prominences: (1) laterally, the collateral eminence formed by the underlying deep collateral sulcus, and (2) medial to that, the hippocampus, which protrudes prominently into the floor (Patel et al., 2012). The roof of the temporal horn is formed mainly by the tapetum of the corpus callosum, but also by the tail of the caudate nucleus and the stria terminalis, which extend forward to terminate in the amygdala (Crossman, 2008). The lateral wall, which angles into the roof of the temporal horn, is lined by the tapetum.

The temporal extension of the choroid plexus fills the choroid fissure and covers the outer surface of the hippocampus.

The primary veins of the temporal horn include the inferior ventricular vein, the amygdalar vein, and the transverse hippocampal veins. The inferior ventricular vein runs in the roof of the temporal horn and joins the basal vein near the lateral geniculate body of the thalamus (Amar et al., 2004).

The amygdalar vein runs over the amygdala and often drains into the aforementioned inferior ventricular vein. The transverse hippocampal veins travel across the hippocampal formation to enter the ambient cistern and drain into the longitudinal hippocampal veins (Wen et al., 1998).

The internal cerebral veins provide the major venous drainage of the lateral ventricles. Most neurosurgeons consent that the occlusion of the internal cerebral vein will result in the venous infarction of the diencephalon (Smith et al., 1998). The ability to withstand to the occlusion of the internal cerebral vein is entirely dependent on the existence of the collateral venous drainage. However, it is not always possible to determine preoperatively whether such connections exist.

The arterial input to the lateral ventricular region is supplied predominantly by the anterior, posterior, and medial choroidal arteries.

The anterior choroidal artery enters the choroidal fissure at approximately the inferior choroidal point and courses posteriorly in the plexus.

After entering the choroidal fissure, it supplies the choroidal plexus of the atrium and the temporal horn. It also provides blood to parts of the globus pallidus, the genu of the internal capsule, the posterior limb of the internal capsule, the amygdala, the hippocampus, the uncus, the tail of the caudate, the optic radiation, the cerebral peduncle, the mesencephalon, and the thalamus (Timurkaynak et al., 1986).

The lateral posterior choroidal arteries arise from the posterior cerebral arteries as they pass through the ambient cistern. They supply blood to the choroid plexus of the temporal horn, the body and the atrium of the lateral ventricles. In addition, they may send a branch through the foramen of Monro to the contralateral ventricle. They also provide blood to the thalamus, the geniculate ganglion, the fornix, the cerebral peduncle, the pineal body, the posterior commissure, the caudate nucleus, the splenium, the temporal cortex and the ventral mesencephalon (Amar et al., 2004; Danaila, 2001).

The medial posterior choroidal arteries arise from the posterior cerebral arteries in the interpeduncular cistern. They travel around the midbrain and ascend to enter the roof of the third ventricle. These arteries travel in the velum interpositum along with the internal cerebral vein and provide blood to the choroid plexus in the roof of the third ventricle.

They may also supply the cerebral peduncle, the geniculate bodies, the tegmentum, the superior and inferior colliculi, the pulvinar, the pineal body, the posterior commissure, the habenula, the occipital cortex and the thalamus (Amar et al., 2004; Danaila, 2001). The choroidal vessels often provide the blood supply to the intraventricular tumors, and they are commonly enlarged in the presence of such lesions (De la Torre et al., 1963; Fornari et al., 1981; Jun, 1985).

To achieve the control of the feeding choroidal arteries, the surgeon must strike a delicate balance among the devascularization of the lesion and the avoidance of the ischemia of the deep structures of the brain.

The neural and vascular anatomy of the lateral ventricles demonstrates that the surgical management of the intraventricular tumors carries a significant potential of morbidity.

Hereinafter we present the surgical options for each segment of the lateral ventricles.

Surgical options

The frontal horn tumors

We had a number of 55 tumors of the frontal horn, of which 19 had been approached using the transcallosal interhemispheric route, and 36 through the anterior transcortical route.

The transcallosal approach was most suitable for the lesions within the frontal horn, especially when the ventricle was of normal size. This route affords access to both the lateral and medial sides of the ventricle. The bone flap should cross the superior sagital sinus to allow the complete exposure of the interhemispheric fissure. The bridging veins must be preserved. The retractor blade is progressively advanced in the interhemispheric fissure to expose the cingulate gyrus, and then the pericallosal arteries. The small anastomoses between the left and right arterial complex may be coagulated and divided.

Some surgeons advocate the performing of the dissection ipsilateral to the lesion, but for the lesions within the dominant hemisphere it may be possible to perform the approach from the contralateral side in order to minimize the retraction on the dominant frontal lobe (Nehls et al., 1985; Lawton et al., 1996). However, the **transcallosal** corridor allows especially the resection of the tumors of the median line (Figures 1, 2, 3, 4) without excessive retraction.

After the performance of the corpus callosotomy and the entrance in the ventricle, there can be identified landmarks such as the foramen of Monro and the thalamostriate vein.

However, the callosotomy limited to the genu and the anterior body of the corpus callosum is generally well tolerated and without neurological sequelae (Nehls et al., 1985; Lawton et al., 1996; Bogen, 1998; Danaila, 2012).

The anterior transcortical approach provided access to the ipsilateral frontal horn tumors (Figure 5). The exposure is performed over the middle frontal gyrus which is incised, and the underlying white matter is divided to access the frontal horn. It is performed a 2 to 3 cm gyral incision which is then developed down into the ventricle.

It is difficult to access the contralateral frontal horn unless significant hydrocephalus is present. After the ventricular chamber is opened, it is used the operative microscope. The tumor removal is achieved by maintaining the tumor interface with the ependymal surface.

In the cases with very big tumors which expand in the frontal horn and in the body of the ventricle, it can be performed a combined trans-sulcal and **transcallosal** approach because each exposure has its own limits.

The ventricular approach across the corpus callosum provides us the access to the ventricular horn only after an excessive retraction.

The trans-sulcal exposure limits the access to the posterior part of the body of the ventricle.

Consequently, for the tumors which occupy the lateral ventricle, the decompression performed through a trans-sulcal corridor leads to the relaxation of the hemisphere and makes possible the interhemispheric dissection.

The opening of the transcallosal corridor allows the resection of the tumor without an excessive retraction(Patel et al., 2012).

Tumors of the body

We had a number of 37 tumors of the body of the lateral ventricles, of which 9 that had been developed both in the body and in the hydrocephalic frontal horn had been approached using the transcortical route.

The rest of 28 tumors of the body of the lateral ventricle had been approached using the transcallosal interhemispheric route (Figures 6, 7 and 8).

However, these tumors developed within the body of the lateral ventricle had been best accessed through the anterior transcallosal route.

The big tumors which had crossed the septum pallucidum and had invaded both lateral ventricles had been resected either through a single approach, either using a combined, transcallosal and transcortical one and/ or in several stages.

In the presence of hydrocephalus, the tumors of the body of the lateral ventricles had been also accessed across the frontal horn, using the transcortical route.

The anterior transcallosal approach. For this approach route, the main obstacle is represented by the draining cortical veins which lead to the superior sagittal sinus. For this reason, the cerebral angiogram or the magnetic resonance venograms are important in the preoperative planning.

Often, the cortical draining veins enter the dura before reaching the midline. These veins may be preserved by opening the dura on all sides around the veins andleaving the dura covering the venous access to the sagittal sinus intact (Patel et al., 2012). If exuberant arachnoid granulations are encountered, they can be divided by sharp dissection and using the bipolar cautery.

Furthermore, the ventricular venous and arterial structures can be distorted by the tumor and should be ascertained preoperatively.

When we reach the median line, we go in depth following the falx, and then we use the operative microscope. The high magnification is helpful in identifying the anatomy and the vascularization.

At the inferior edge of the falx there can be encountered small cingulate gyrus veins as they drain into the inferior sagittal sinus. These veins may be sacrificed. The arachnoid below the falx may be adherent, and this arachnoid must be sectioned carefully, to avoid the injury to the cingulate gyrus on either side (Omay et al., 2006). Next, the frontal lobe is retracted laterally and the callosum midline is often demarcated by a very small callosal artery (Fuji et al., 1980).

Once the corpus callosum is reached, the two pericallosal arteries are visualized and the ventricular access between them helps to prevent vascular injury. To gain access to the body of the lateral ventricle, the callosotomy can be started just posterior to the genu and developed 3 cm posteriorly.

By performing the callosotomy off the midline and toward the ventricle of interest it can be avoided the opening of the contralateral ventricle.

According to Bellotti et al. (1991), Ehni and Ehni (1998) and Patel et al. (2012), occasionally, when the opposite lateral ventricle is accessed, the orientation is achieved by locating the choroid plexus, the septal vein and the thalamostriate vein running to the foramen of Monro. If the vein is to the right of the choroid plexus, the surgeon is in the right ventricle, if the vein is to the left of the choroid plexus, the surgeon is in the left ventricle (Patel et al., 2012).

During the resection of the intraventricular tumor, it must be identified and maintained the interface between the tumor and the ependyma.

Since many lateral ventricular tumors can reach a very large size, the resection begins by first performing the internal debulking, followed by the isolation of the tumor capsule away from the surrounding ventricular structures (Shucart and Stein, 1978; Geffen et al., 1980; Fuji et al., 1980; Sugita et al., 1982; Timurkaynak et al., 1986; Sass et al., 1988; Bellotti et al., 1991; Ehni and Ehni, 1998; Hellwing et al., 2003; Omay et al., 2006; Patel et al., 2012).

Tumors of the atrium

We had 23 tumors of the atrium and 17 which had involved both the atrium and the occipital horn.

The majority of these tumors, namely 31 of them, had been approached using the posterior transcortical route.

In general, the tumors involving the atrium and the occipital horn can be approached and excised using the posterior **transcallosal approach, or** transcortically, across the superior parietal lobulee.

The posterior transcallosal approach. This route gains access to the roof and medial part of the atrium of the lateral ventricle, and has the advantage of sparing the visual pathways, as well as areas of the parietal lobe that may subserve speech function (Ojeman, 1979; Ojeman and Mateer, 1979; Danaila, 2012).

However this approach is achieved at the expense of spliting the splenium of the corpus callosum and is contraindicated for patients with preoperative right homonymous hemianopsia because of the risk of alexia.

Preoperatively, it is required to perform a magnetic resonance venogram or a cerebral angiogram which will help us in the accurate positioning of the craniotomy by visualizing the cortical draining veins. The craniotomy exposes the superior sagittal sinus and extends laterally 3 to 4 cm. At the sectioning and the medial reflection of the dura mater, great care should be taken for the preservation of the large draining veins.The parietal lobe is retracted approximately 2 cm from the falx. Once the arachnoid adhesions are opened, the distal pericallosal arteries and the splenium are identified. Below, the internal cerebral veins join to form the Galen's vein, and these can be seen once the splenium is cut. The splenium is incised with a bipolar cautery, and this incision must be made lateral to the midline because the atrium of the lateral ventricle deviates laterally (Omay et al., 2006).

The lateral ventricles diverge at the level of the splenium.

Consequently the dissection must be continued laterally after the splenium is divided, which result in an impaired view of the lateral portion of the atrium (Amar et al., 2004).

However, the division of the splenium itself carries many physiological risks. The distal branches of the anterior cerebral artery and the splenial branches of the posterior cerebral arteries may also be injured with this approach (Perlmutter and Rhoton, 1978). Therefore, the tumors which are not positioned in the medial part of the atrium will be hard to resect through this route, and the surgeon should consider the posterior transcortical approach for the lateral tumors of the atrium (Ono et al., 1984; Timurkaynak et al., 1986; Bellott et al., 1991; Piepmeier et al., 1993; Oppel et al., 1998; Amar et al., 2004; Patel et al., 2012).

One of the contraindications for the transcallosal surgery is the crossed dominance, a condition in which the hemisphere controlling the dominant hand is opposite the hemisphere mediating language and speech (Piepmeier, 1996; Desai et al., 2002; Danaila, 2012). The crossed dominance can occur when there is evidence of extracallosal dysfunction, particularly after a cerebral injury during childhood resulting in the relocation of the functions.

These patients may be at risk of writing and speech deficits after the callosal sectioning.

The posterior transcortical approach. This route is preferred for the atrium of the lateral ventricle and it allows access to both the medial and the lateral tumors of the atrium (Figures 9, 10, 11), as well as to those in the occipital horn (Figure 12). The patient is positioned in the three-quarter prone position with the parietal area of interest at the highest point in the field.

The craniotomy does not cross the midline. After the craniotomy, the superior parietal lobule is identified and incised.

A preoperative magnetic resonance venogram or a cerebral angiogram is helpful in determining the position of major draining veins. Once the cortical incision is made, the dissection proceeds along the interparietal sulcus.

A cortical window measuring 1.5 by 2 cm provides the best trajectory to the region of the atrium, while minimizing the retraction and the brain distortion remote from this corridor.

Once the ventricle is entered, the surgeon can visualize the thalamus anteriorly, the choroid plexus more medially, the crus of fornix and the optic radiation who define the lateral wall of the atrium. The surgeon should avoid manipulation of that area. Then, the vascular pedicle of the tumor should be identified and coagulated at the earliest possible time to avoid the excessive bleeding (Ono et al., 1984; Nagata et al., 1988; Bellotti et al., 1991; Oppel et al., 1998; Amar et al., 2004; Patel et al., 2012). The egress of cerebrospinal fluid promotes the shifting of the critical brain structures, limiting the utility of the guidance systems referenced to the preoperative images.

The atrium lesions extending into the occipital lobe may be accessed through the occipital pole cortex. If the tumor extends into the temporal horn, an approach through the posterior portions of the middle and inferior temporal gyri may be considered (Amar et al., 2004). When the tumor compresses the lateral wall of the atrium, the tumor should be decompressed before separating it from this lateral ependymal surface.

For the tumors positioned laterally in the atrium, it can be used the **posterior temporal approach**. The posterior temporal region is immediately above the transverse sinus. After the sectioning of the dura mater at the level of the non-dominant side, an incision along the axis of the gyrus, into the posterior middle or inferior temporal gyrus will gain access to the atrium. Extreme care should be taken not to injure the vein of Labbé.

Once the ventricle is accessed, the tumor is removed piecemeal and separated away from surrounding ependyma (Patel et al., 2012). Care should be taken to avoid blood pooling in the ventricles, which lead to postoperative obstructive hydrocephalus.

At the level of the dominant hemisphere it must be avoided the injury of the speech area.

After the removal of the inferior temporal bone and of the mastoid air cells, we can achieve the access to the subtemporal area, where we incise the cortex at the level of the occipitotemporal gyrus. By using this route, which requires a more accentuated retraction of the temporal lobe, we can avoid the injury to the optic radiation and the speech cortex. The vein of Labbé must also be preserved, while the mastoid air cells should be closed.

The Tumors of the temporal horn

We had 42 tumors of the temporal horn, of which 28 had been excised through the middle temporal gyrus (Figure 13), 6 through the inferior temporal gyrus, and 8 through the resection of the temporal tip.

Thence, the temporal horn of the lateral ventricle may be accessed by making a cortical incision in the inferior or middle temporal gyrus, traversing the middle temporal sulcus, or by resecting the temporal tip. The former approach allows the visualization along the lateral-to–medial axis. In contrast, the resection of the temporal pole exposes the anterior-posterior view line and may be preferable for the tumors of the temporal horn with a significant posterior extension (Timurkaynak et al., 1986). However, in this cases, the craniotomy is extended inferiorly to the level of the zygoma.

For the middle gyrus approach, a horizontal cortical incision is made along its anterior portion. The temporal horn is commonly encountered at 3.5 cm posterior to the temporal tip and the sphenoid ridge.

Thus, if rendered in this fashion, the middle gyrus approach avoids the vein of Labbé and the optic radiation (Amar et al., 2004).

When we operate on the dominant lobe, it is necessary to have a very good knowledge of the map of the temporal cortex which varies from one individual to another (Ojeman, 1979; Danaila, 2012).

The more inferior temporal approaches are often used for lesions residing in the temporal horn or in the lateral atrium of the dominant hemisphere.

After the opening of the dura mater, the pia mater is cauterized along the inferior and middle temporal gyruses, with a vertical orientation. The resection is performed along the superior edge of the middle temporal gyrus, towards the temporal pole. The dissection is then continued medially, towards the temporal horn. The decompression of the tumor is followed by the dissection away from the surrounding ependyma (Bellotti et al., 1991).

It is important to preserve the vein of Labbé at the posterior limit of the dissection.

The resection of the anterior 5 cm of the temporal lobe provides a larger field of exposure than the middle gyrus route (Amar et al., 2004).

Treatment

Because intraventricular surgery requires manipulation deep within the hemispheres, the proper patient positioning, the adequate tumor exposure and the brain relaxation are fundamental requirements for a successful tumor removal.

There are several published alternative surgical approaches that have been utilized for accessing the ventricular system (interhemispheric, transcortical, trans-sylvian fissure). All the surgical approaches are designed to minimally displace or disturb the normal anatomy. While these alternative approaches may have some merit, Patel et al. (2012) consider them to be of limited value for the vast majority of the intraventricular tumors. For this reason, Patel et al. (2012) pleads in favor of using methods which maximize the tumor removal with minimal morbidity.

These include the anterior transcallosal approach, the anterior trans-sulcal approach, the combined approaches, the posterior trans-sulcal approach, the posterior transcallosal approach, the posterior temporal approach and the inferior temporal approach.

All the patients in the present series underwent surgical treatment. Our main goal had been that of removing the tumor in its entirety, with the lowest mortality.

We had chosen the surgical approach depending on the exact location of the tumor, the tumor's size and the anatomical knowledge.

The tumor excision had been performed using the standard microsurgical technique through two major approaches: the interhemispheric transcallosal route in 78 (38.61%) patients, and the transcortical route in 124 (61.38%) patients. The tumor had been removed in its entirety in 174 (86.13%) of the patients. The total or partial removal of the tumor was considered depending on its size and the anatomic location.

The adequacy of a subtotal resection is a matter of judgment and experience. Beyond the diagnosis, the possible goals of the subtotal procedure include the cytoreduction in preparation for adjuvant therapy, the relief of the mass effect and the re-establishment of the CSF circulation (Amar et al., 2004).

In 38 (18.81%) of the patients, the onset clinical symptoms were dominated by signs of internal hydrocephalus. In all these cases, ventricular drainage was performed prior to surgery. In 5 (2.47%) patients, we had performed an external ventricular drainage which was removed at time of surgery. For the rest of 33 (16.33%) patients, we had performed a ventriculoperitoneal shunting in 29 (14.35%) cases, and a ventriculoatrial shunting in 4 (1.98%) cases.

The patients appear to tolerate the manipulation of one fornix; however, injury to both fornices and the nearby thalamic nuclei may result in significant memory impairment (Damasio et al., 1998).

The corpus callosum forms a major boundary for the lateral ventricles. The sectioning of the anterior third of the corpus callosum can generally be performed without significant neurological sequellae.

The division of the posterior corpus callosum may result in a left hemialexia and other potentially debilitating deficits. The concurrent splenial section and injury to the dominant occipital lobe may result in alexia without agraphia (Bogen, 1998; Danaila, 2012).

There have been no reports concerning the endoscopic resection of the tumors of the lateral ventricle, although this is likely to be a promising approach for this entity, as the surgeons become more familiar with the benefits and limitations of this technique.

Histology

The histology of the lesions affecting the lateral ventricle encompassed a wide range of neoplastic processes. The majority of the tumors of the lateral ventricles are benign or low-grade lesions.

Therefore, 177 (87.62%) of our primary tumors of the lateral ventricles had been benign or low-grade lesions, while 25 (12.37%) had been malignant. Because of their relatively slow growth rate, the respective tumors had arrived in our clinic when they had reached large or very large sizes.

The most frequent tumors had been ependymomas, astrocytomas and subependymomas, choroid plexus papillomas and meningiomas (Table 5) (Danaila et al., 2001; 2005).

Our primary, or intra-axial, tumors had arisen directly from the structures within the lateral ventricle itself, such as the ependyma, the subependymal glia, the choroid plexus and embryologic remnants. Therefore ependymomas, astrocytomas, subepedymomas, neurocytomas, meningiomas, choroid plexus papillomas, choroid plexus carcinomas, epidermoids, teratomas, cavernomas, oligodendrogliomas are examples of primary tumors of the lateral ventricles (Danaila et al., 2001; 2005).

The neurocysticercosis is a the most common infection that may manifest as an intraventricular mass in 15% to 50% of cases, with larger percentages noted in the series that routinely use the magnetic resonance imaging (Apuzzo et al., 1984; Amar et al., 2000). The secondary, or extra-axial, tumors arise from structures adjacent to the lateral ventricle and subsequently grow into it by either gentle extension or frank invasion. The periventricular white matter, the caudate nucleus, the internal capsule, the thalamus and other structures lying in close proximity to the lateral ventricle are often the site of origin. The tumors that may develop from these sites and secondarily involve the ventricle include gliomas (astrocitoma, oligodendroglioma, glioblastoma multiple) and vascular lesions, such as cavernous hemangiomas or arteriovenous malformations. However, we had not included the secondary tumors in the present study.

According to Jelinek et al. (1990), sixty-four percent of their 47 patients had benign tumors, including subependymoma and subependymal giant cell astrocytoma. Five percent had intermediate-grade lesions, and the remaining 21% had malignant tumors, including primitive neuroectodermal tumor, lymphoma, and teratoma.

Pendl et al. (1992) had observed benign tumors in 56% of their patients; they included neurocytomas, meningiomas, choroid plexus papillomas, cavernous, and arachnoid casts. Only 13% of their patients had malignant lesions.

The oligodendrogliomas developed in the lateral ventricles are rare. We had 2 (0.99%) cases of such tumors situated in the frontal horn of the right lateral ventricle. Both patients had been females, with the ages of 24 and 32 years old. In one of the cases, the oligodendroglioma had been low grade, while in the other patient it had been anaplastic (WHO grade III).

Our case is the fourth report in the literature to describe a patient with anaplastic intraventricular oligodendroglioma (IVO). In this case, the simple histological staining was insufficient to confirm the diagnosis of IVO. For example, the oligodendroglioma and the central neurocytoma appear quite similar on the routine smear and at the cryostat microscopic examination (Yuen et al., 1992; Danaila et al., 2001; 2005). There had been used specific immunohistochemical staining methods and electron microscopy to confirm the diagnosis.

The staining for GFAP and synaptophysin had been crucial in differentiating the IVOs from other types of gliomas and central neurocytomas.

The staining for markers such as neurofilament protein, chromogranin and synaptophysin is positive in the central neurocytoma, whereas it remains negative in oligodendroglioma. GFAP is positive in oligodendroglioma, yet negative in neurocytoma (Yuen et al., 1992).

Likewise, Hasuo et al. (1987) noted that IVOs can also be differentiated from neurocytomas based on electron microscopy, because the latter have mature neuronal cells with well-formed synapses. It also needs to be considered the possibility of the presence of another type of intraventricular tumor (central neurocytoma, clear cell meningioma, metastatic lesion, subependymoma, astrocytoma, ependymoma, germ cell tumors, and ganglioglioma).

The oligodenrogliomas originating primarily within the ventricular system have been reported to account for approximately 8% to 10% of all oligodenrogliomas (Earnest et al., 1950).

The first description of an oligodentroglioma occurring primarily within the ventricular system was made by Dickson in 1926.

Between 1926 and 2009 there had been reported 70 cases of patients with intraventricular oligodendroglioma (IVO).

Twenty seven (68%) of the 40 cases of IVO with available data had been reported to occur within the lateral ventricle (Zada et al., 2009). Of these cases, IVO were more than twice as likely to develop in the right lateral ventricle than in the left one.

Of the 26 patients with available data concerning the degree of the surgical resection, 15 were reported to have undergone a subtotal resection, whereas 9 were reported to have undergone a gross total resection. Most of the surgical procedures for the resection of oligodendrogliomas originating in the lateral ventricles have been performed using the transcortical transventricular approaches. (Markwalder et al., 1979; Maiuri et al., 1982; Kikuchi et al., 1985; Martinez-Lage et al., 1986; Garza-Mercado et al., 1987; Lee and Kelly, 1990; Tekkok et al., 1992; Yuen et al., 1992; Natale et al., 2005; Zada et al., 2009).

Nioka et al. (1987) and Romero et al. (1986) have used the interhemispheric transcallosal approach, especially when the third ventricle was involved. Morita and Kelly (1993) described the use of a stereotactic approach for the resection in 2 cases of oligodendrogliomas confined to the lateral ventricles.

All the patients with anaplastic lesions had experienced recurrence.

Among these cases, most have been reported as low-grade neoplasms. The anaplastic (WHO grade III) IVO is an extremely rare entity with only 3 previous cases reported in the literature (Packer et al., 1984; Natale et al., 2005; Zada et al., 2009).

The precise origin of the IVO remains unclear. Maiuri et al. (1982) postulated that these tumors originate in the subependymal region, and are actually of neuronal origin. Sakai et al. (1980) reported that these lesions originate from a precursor that is common to both the oligodendroglial cells and the ependymal cells.

The electron microscopic studies have demonstrated that these lesions have microtubules measuring 20 to 25 nm in diameter, dense-cored vesicles measuring 100 to 200 nm in diameter, and simple maculae adherents, yet no well-formed synapses (Hasuo et al., 1987). They have thus referred to these lesions as intraventricular neurocytomas, to more accurately reflect the neuronal origin of these neoplasms. On the other hand, Zuen et al. (1992) reported that IVOs do not have neurotubules or neurosecretory granules.

Dupuy et al. (1970) had reported a patient with a voluminous calcified oligodendroglioma situated in the left lateral ventricle.

Significant advances in the treatment of oligodendrogliomas have been madethe recent years, based primarily on the molecular subtyping of the lesions.

The deletions resulting in the loss of heterozygosity of the 1p and 19q segments of the intratumoral chromosomes have correlated closely with a favorable response to chemotherapy. The standard chemotherapeutic regimen for such lesions includes now procarbazine, lomustine, and vincristine (Zada et al., 2009).

However, the outcomes for the patients with intraventricular anaplastic oligodendroglioma remain poor.

The treatment based on targeted chemotherapy, perhaps using an intrathectal route, remains a possibility for the patients diagnosed with these lesions (Zada et al., 2009).

The inflammatory pseudotumor of the lateral ventricle is an extremely rare lesion, with an uncertain etiology in most of the cases. Or case pertains to a female patient aged 58 years old who had begun 10 years ago to exhibit rhythmical movements of the head, repeated dental abscesses, bilateral maxillary sinusitis operated by an otolaryngologist, and in the last 8 months, headaches and vomiting.

The computed tomography disclosed a solid tumoral mass with maximal dimensions of 3.5 cm, located in the right lateral ventricle, accompanied by hydrocephalus (Figure. 14). I had performed the removal of the tumor through a transcortical transventricular approach. It had been totally removed an ill-defined fibrous and granulomatous lesion that was tightly attached to the choroid plexus.

The histological examination had revealed diffuse infiltrates with small lymphocytes, plasma cells, and eosinophils, with interstitial vascular proliferation. The cuboidal epithelial cells had indicated the presence of the choroid plexus within this formation.

These histological findings in the brain lesion were identical to those observed in the maxillary sinus.

The steroid treatment had been necessary to control this inflammatory lesion. After the surgery, the general health condition and the neurological status had been good, with the exception of the persistence of some slow movements of the head.

The intraventricular inflammatory pseudotumors (IP) are very rare lesions that may be present at various ages in either sex (A-Sarraj et al., 1995; Hausler et al., 2003).

Their correct diagnosis depends on the histological evaluation. With respect to the differential diagnosis, there must be made the distinction between lymphomas, lymphoplasma cell-rich meningiomas, Rosai - Dorfman disease, and intracranial fibromatosis (Pimentel et al., 1993; Bramwit et al., 1997; Hauser et al., 2003).

The inflammatory pseudotumor shows heterogeneous features that explain this variety of synonymous expressions (Hausler et al., 2003; Nishioka et al., 2009). Primary intraventricular IP has been reported in 7 cases, 5 of which were presumably derived from the choroid plexus (Chang et al., 1991; Pimentel et al., 1993; Al-Sarraj et al., 1995; Bramwit et al., 1997).

The absence of the blood-brain-barrier, as well as the richly vascularized secretory epithelium in the choroid plexus may serve as a portal for the entry of the pathogens into the central nervous system, a target for various systemic disorders or a reflector of various diseases that affect the brain and meninges (Guermazi et al., 200; Nishioka et al. 2009).

Albert et al. (1995), Fukunaga et al. (1998) and Nishioka et al. (2009) suggested that the Epstein-Barr virus infection plays a role in a significant number of IP cases. It is considered that many factors such as systemic (auto) immune responses and infection are involved in the development of IPs (Al-Sarraj et al., 1995; Arber et al., 1995; Hausler et al., 2003).

Chang et al (1991) reported a case of IP of the choroid plexus associated with Sjogren's disease.

Results

A favorable outcome (GSO 5 and 4) at discharge had been seen in 164 (81.18%) of the 202 patients who had been subjected to surgery. From the rest of 38 patients, 5 (2.47%) had entered in a coma immediately after the surgical intervention, and 3 (1.48%) of them had died.

The coma had been caused in 2 patients by the postoperative hematomas, by the deep brain softening in another 2 0.99%), and to the pulmonary embolism in 1 (0.49%) patient.

The other 35 (17.58%) patients had survived with the following deficits: 2 (1%) with homonymous hemianopsia, 3 (1.50%) with memory disorders, 6 (3.01%) with aphasia, 10 (5.02%) with disconnection syndrome, 13 (7.53%) cu hemiparesis, and 1 (0.55%) in vegetative state.

One year follow-up was possible for 173 (86.93%) of the patients. The outcome analysis at the time of the follow-up had recorded neurological impairments (hemiparesis, aphasia, visual field deficit, memory deficits, and disconnection syndrome) in 21 (12.13%) of the patients. At the one year follow-up had been recorded two (1.15%) new deaths related to the tumor re-growth and the negative state. The overall recorded mortality for whole series of 202 patients was 2.47% (5 patients).

At the one year follow-up there were 158 (91.32%) patients with good neurological evolution or mild neurological deficits. They were considered with reference to their social independence (Table 6). However, since the cognitive deficits are the most commonly encountered preoperative signs of an intraventricular lesion, the persistent postoperative cognitive liabilities and hydrocephalus deserve a closer attention.

Recurrences

One year follow-up was possible for 173 of the patients. There had been recorded recurrences of the tumors in 21 (12.13%) patients who had survived more than a year after the first surgery.

The imaging (CT or MRI) follow-up performed at discharge demonstrated the partial resection of the tumor in all this 21 patients, of whom 13 had been operated through the interhemispheric thranscallosal route and 6 using the transcortical route.

In conclusion, in all the patients with recurrences it had been performed the partial resection of the tumor.

Eighteen of them underwent re-operation, with good neurological evolution in 88.88% of the cases (16 patients out of 18 patients).

Discussion

The most common clinical manifestations of the tumors of the lateral ventricles include headache, loss of memory and the cognitive and gait disorders (Asgari et al., 2003).

Pendl's group observed chronic or subacute headaches in 47% of their patients (Pendl et al., 1992), and Nishio's group found the headaches to be the presenting simptom in 58% of their patients (Nishio et al., 1990). The other signs and symptoms caused by these tumors are dependent on the localization and the extent of the brain infiltration. Those developed in the frontal horn cause subtle behavioral manifestations and headaches. At he level of the dominant hemisphere, they cause various degrees of speech disorders. The lesions developed more posteriorly cause hemiparesis and occasionally discrete sensory deficits.

The tumors in the occipital horn lead frequently to the development of visual field deficits.

The tumors of the lateral ventricles can be approached using the transcortical route or the interhemispheric thranscallosal route. The cortical incisions can lead to the emergence of epileptic seizures. Fornari et al. (1981) had reported the incidence of this complication in 29% of their patients in whom it had been used the transcortical approach through the parieto-occipital fissure.

According to Kempe and Blaylock (1976), Ehni (1984) and Jun and Nutik (1985), the transcallosal route may reduce the risk of postoperative seizures. Ehni observed seizures in only 2% of his patients who had been managed using an interhemispheric transcallosal approach.

Lawton et al. (1996) reported no postoperative seizures among their 32 patients treated using a contralateral interhemispheric approach. They did not report any clinically significant neurological deficits among their patients related to the division of the anterior corpus callosum. However, the anterior callosotomy can not always be performed with impunity.

Sass et al. (1990) found that the epileptic patients with crossed cerebral dominance were at risk of developing significant language impairments after partial or complete callosotomy. Four of them had crossed cerebral dominance, with ether right-handedness and right hemisphere speech dominance, or left-handedness and left hemisphere speech dominance. However, the anterior callosotomy appears to be an otherwise safe and effective way to approach the tumors of the lateral ventricle (Amar et al., 2004).

In contrast, the division of the posterior portion of the corpus callosum inevitably results in some form of neurological deficit that may or many not be disabling.

After the surgical approach of an atrial meningioma, Jun and Nutic (1985) had observed the postoperative development of various deficits concerning the processing of the tactile information which had not been linked to the disconnection of the sight, hearing or tactile areas.

The division of the posterior third of the corpus callosum may result in language impairment as well. The dissection of the fibers located in the splenium really demonstrated that the inferior fibers which are located in the splenial area go towards the striate region and form the major forceps (Danaila, 2012).

The superior splenial fibers go towards the occipito-temporal and temporal regions and form the tapetum.

Sass et al. (1990) had identified three distinct syndromes following the posterior callosotomy.

The first is manifested by a paucity of the spontaneous speech, impaired spelling and reading comprehension, as well as dysgraphia.

The second is characterized by mutism and buccofacial apraxia.

The third is manifested by isolated dysgraphia.

The section of the splenium of the corpus callosum may also cause left hemialexia (Bogen, 1998). Frequently, none of these deficits is disabling.

The manipulation of the fornices during surgery may result in postoperative memory impairment, especially if these structures were compromised preoperatively by the tumor itself (Hirsch et al., 1979).

Classically, the syndrome of interhemispheric disconnection or the callous syndrome consist of a series of symptoms in which there can be included the transfer defects of elementary sensorial information, dysfunctions of the elaborate cognitive functions (speech, praxias), and even psychiatric symptoms with a dissociative character (Danaila, 2012).

The patients with tumors of the lateral ventricle may develop hydrocephalus and ultimately require a permanent CSF shunt. In the series of Lena et al. (1990), 78% of all the children with intraventricular choroid plexus tumors underwent permanent shunt placement.

The same surgeons advocate the preoperative placement of a permanent shunt in the patients with tumors of the lateral ventricle and hydrocephalus (Lena et al., 1990).

In contrast, Amar et al. (2004) prefer to place a ventriculostomy at the time of the surgery whenever hydrocephalus is present. This allows the surgeon to achieve excellent interhemispheric exposure while minimizing the relation of the cortex. In addition, a significant number of the patients will recover the CSF circulation after the removal of the tumor and this reduces dramatically the need for a permanent shunt (Amar et al., 2004).

Lawton et al (1996) used ventriculostomy catheters preoperatively and reserved the shunts for the patients who continued to have impaired CSF circulation after surgery. In their series, the ventriculoperitoneal shunts were required in only 12.5% of the patients.

Other complications that can develop after the surgical interventions on the lateral ventricles include hemiparesis, aphasia, coma, infections and death.

In this respect, Lawton et al. (1996) had observed transient hemiparesis in 6% of their patients and aphasia and hemiparesis in 3% of them after the transcallosal approach of the tumors in the lateral ventricles.

Ehni (1984) had reported that the postoperative hemiparesis had been present in 9% of the patients with tumors of the lateral ventricles for which it had been used the interhemispheric transcallosal approach.

The injuries of the deep arteries and veins during the excision of the tumors in the lateral ventricles can lead to the development of devastating complications.

In 1963, De La Torre et al. had reported a surgical mortality of 50%. The deaths among the pediatric patients had been due the excessive blood loss during the surgical procedure.

In the modern series, the mortality ratio had been reduced further due to the use of the operative microscope and the refinement of the techniques of neuroanesthesia.

In 1984, Ehni had reported one postoperative death in the 23 patients with tumors of the lateral ventricles.

Pendel et al (1992) had a surgical mortality ratio of 5%. Two of their patients had died because of the intracerebral hemorrhage, while another because of the cerebral edema.

Nishio et al (1990) had not registered any postoperative deaths, but 10% of their patients had been left with important neurological deficits.

In the 11 children with choroid plexus tumors of the lateral ventricles, Lena et al. (1990) had not registered any postoperative deaths.

Among the 32 patients operated by Lawton et al (1996) there had not been registered any postoperative deaths, but 2 of them had transient neurological deficits.

Conclusions

The average age of the patients with primary tumors of the lateral ventricles of the brain is generally younger than that described for the patients harboring intraparenchymal lesions.

These patients had presented with clinical symptoms and signs of ventricular outflow obstruction and elevated intracranial pressure.

The short-term memory loss had been encountered in our patients, as well as in others with tumors originating in the septum pellucidum, which had been considered to be secondary to the fornical compression and/or invasion.

The interhemispheric transcallosal and the transcortical routes remain the best surgical approaches for the tumors of the lateral ventricles, but other factors, including the tumor's localization, the surrounding neural and vascular anatomy, the patient's medical condition and the surgeon's familiarity with the various techniques must be taken into consideration.

The attempted gross total surgical resection remains the main method of treatment, followed by adjuvant radiotherapy and/or chemotherapy.

A significant proportion of the patients undergoing treatment for the tumors of the lateral ventricles will develop cerebrospinal fluid outflow obstruction and will require perioperative ventricular shunting.

Table 1

The age and gender of the 202 patients with primary tumors developed in the lateral ventricles.

The patient age group in years	Number of patients	Patients' gender	
		Male	Female
15 – 20	29 (14.35%)	13	16
21 – 30	57 (28.21%)	27	30
31 – 40	54 (26.73%)	25	29
41 – 50	35 (17.32%)	15	20
51 – 60	19 (9.40%)	9	10
61 – 70	8 (3.96%)	4	4
Total	**202**	**93 (46.03%)**	**109 (53.96%)**

Table 2

The localization of the 202 tumors of the lateral ventricles.

The localization of the tumors	Numberof patients
Frontal horns tumors	55 (27.22%)
Tumors of the body	37 (18.31%)
Atrium tumors	23 (11.38%)
Occipital horn tumors	17 (8.41%)
Temporal horn tumors	42 (20.79%)
Extended tumors	28 (13.86%)
Total	**202**

Table 3

The symptoms encountered in the 202 patients with tumors of the lateral ventricles.

General symptoms	Number of patients
Headaches	124 (61.38%)
Memory disorders	98 (48.51%)
Epilepsy	47 (23.26%)
Behavioral and cognitive deficits	34 (16.83%)
Gait and balance disorders	19 (9.40%)
Localized symptoms	
Hemiparesis	18 (8.91%)
Aphasia	12 (5.94%)
Hemihypoesthesia	11 (5.44%)
Homonymous hemianopsia	3 (1.48%)

Table 4

The surgical approach methods used in the 202 patients with tumors of the lateral ventricles.

The localization of the tumors	Number of patients	The surgical approach	
		The interhemispheric transcallosal route	The transcortical route
Frontal horn tumors	55	19	36
Tumors of the body	37	28	9
Atrium tumors	23	5	18
Occipital horn tumors	17	0	17
Temporal horn tumors	42	0	42
Extended tumors	28	26	2
Total	**202**	**78 (38.61%)**	**124 (61.38%)**

Table 5

The histology of the 202 primary tumors in the lateral ventricles

Histology	**Number of patients**
Ependimoma	57 (28.21%)
Anaplastic ependimoma	11 (5.44%)
Astrocitoma low-grade	27 (13.36%)
Anaplastic astrocytoma	8 (3.96%)
Subependymoma	14 (6.93%)
Neurocytoma	6 (2.97%)
Meningioma	13 (6.43%)
Choroid plexus papilloma	18 (8.91%)
Choroid plexus carcinoma	5 (2.47%)
Epidermoid cysts	6 (2.97%)
Teratoma	1 (0.50%)
Cavernoma	4 (1.98%)
Oligodendroglioma WHO grade I-II	1 (0.50%)
Oligodendroglioma WHO grade III	1 (0.50%)
Inflammatory pseudotumor	1 (0.50%)
Cysticercosis	29 (14.35%)
Total	**202**

Table 6

The general outcome at discharge and at one year follow-up

Outcome	**At discharge**	**At one year**
GOS 5 (good recovery)	116 (57.42%)	135 (78.03%)
GOS 4 (moderate disability)	52 (25.74%)	23 (13.29%)
GOS 3 (severe disability)	30 (14.82%)	13 (7.51%)
GOS 2 (vegetative state)	1 (0.49%)	0
GOS 1 (death)	3 (1.48%)	2 (1.15%)
Total	202	173

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FIGURES

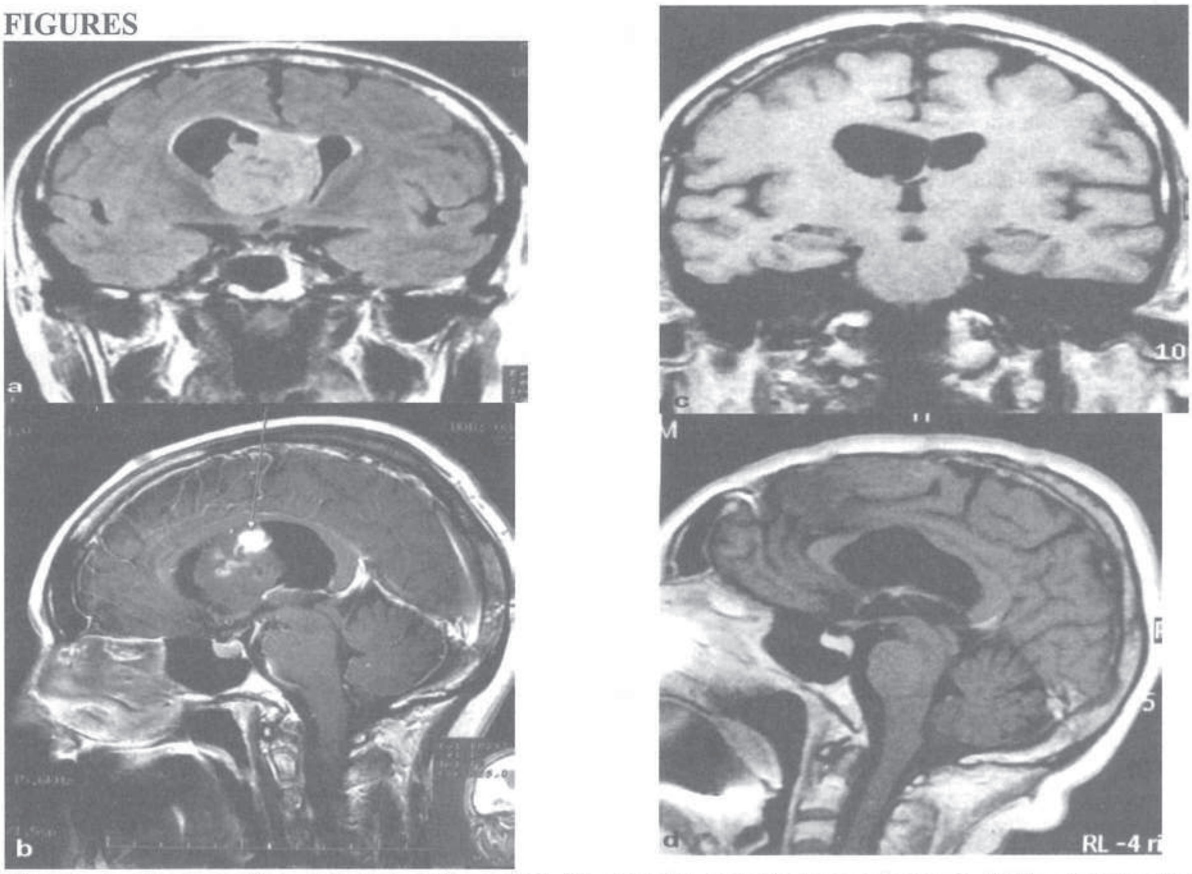

Figure 1. Preoperative coronal and sagital T1-weight gadolinium-enhanced MRI, demonstrating a subependymoma arising from the left lateral ventricle and extending into the right ventricle and into the third ventricle (a, b). Images c and d had been obtained after the complete removal with excellent results. The excision had been accomplished through an interhemispheric transcallosal approach (surgeon Leon Danaila).

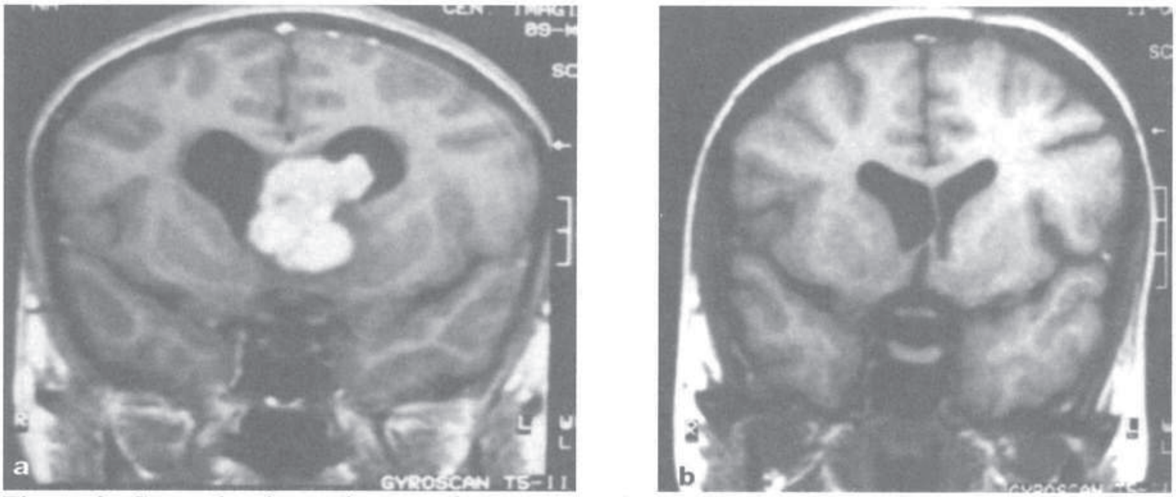

Figure 2. Coronal enhanced magnetic resonance imaging of a subependymoma arising from the left lateral ventricle (the frontal horn) and extending into the third ventricle (a). Image b was obtained after the complete removal of the tumor through interhemispheric transcallosal approach, with excellent results (surgeon Leon Danaila).

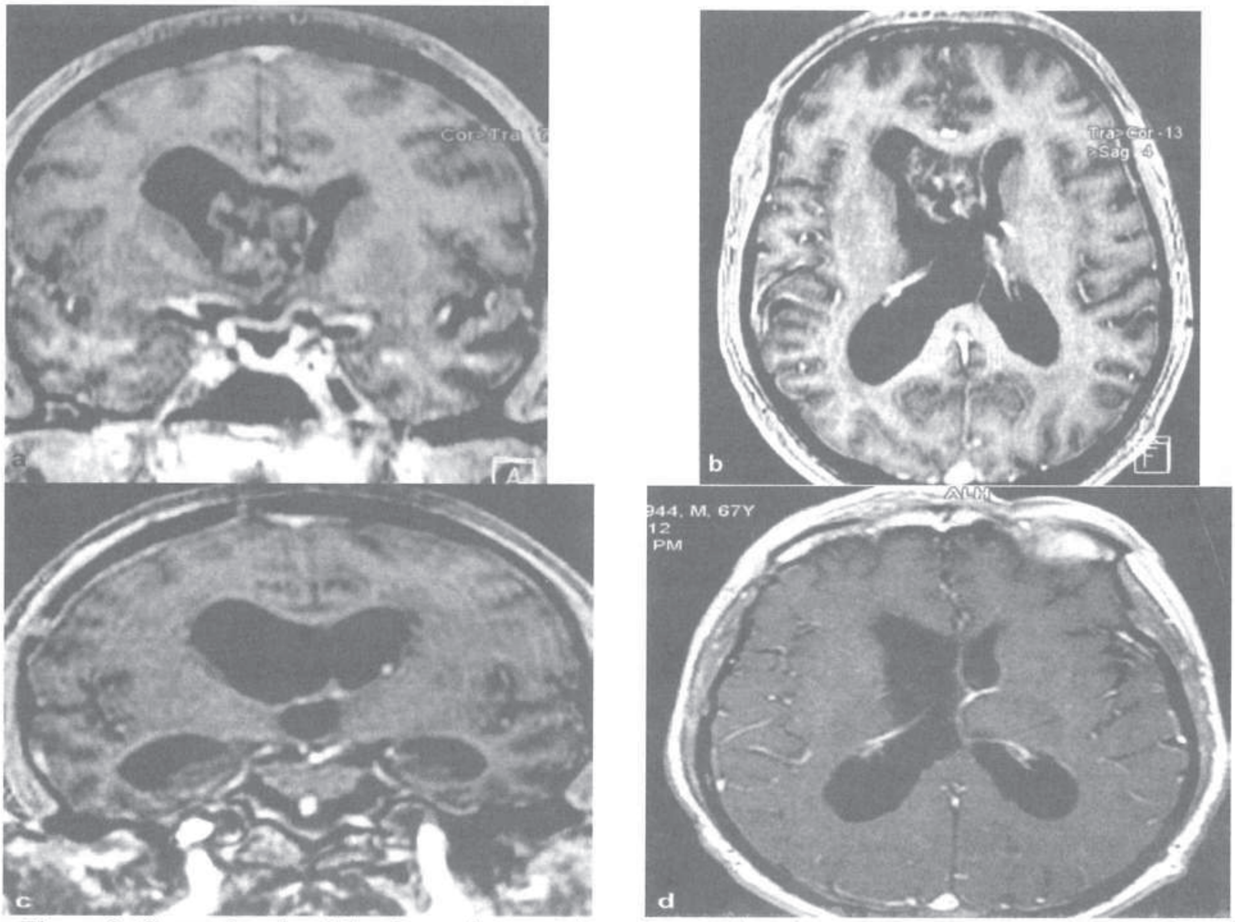

Figure 3. Coronal and axial enhanced magnetic resonance imaging of an astrocytoma arising from the right frontal horn of the lateral ventricle (a, b). Images c and d had been obtained after the complete removal of the tumor through the interhemispheric transcallosal approach, with very good results (surgeon Leon Danaila).

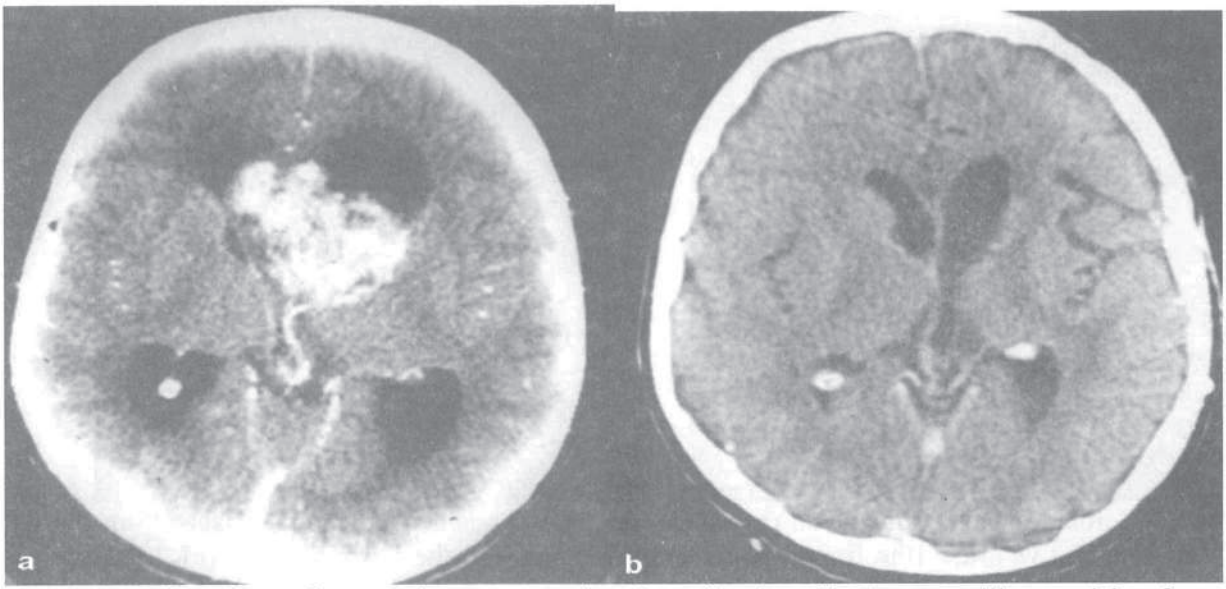

Figure 4. Axial enhanced magnetic resonance imaging of a choroid plexus papilloma arising from the left lateral ventricle (a). Postoperative MRI after the complete anterior transcallosal resection of the tumor (b), with very good results (surgeon Leon Dănăilă).

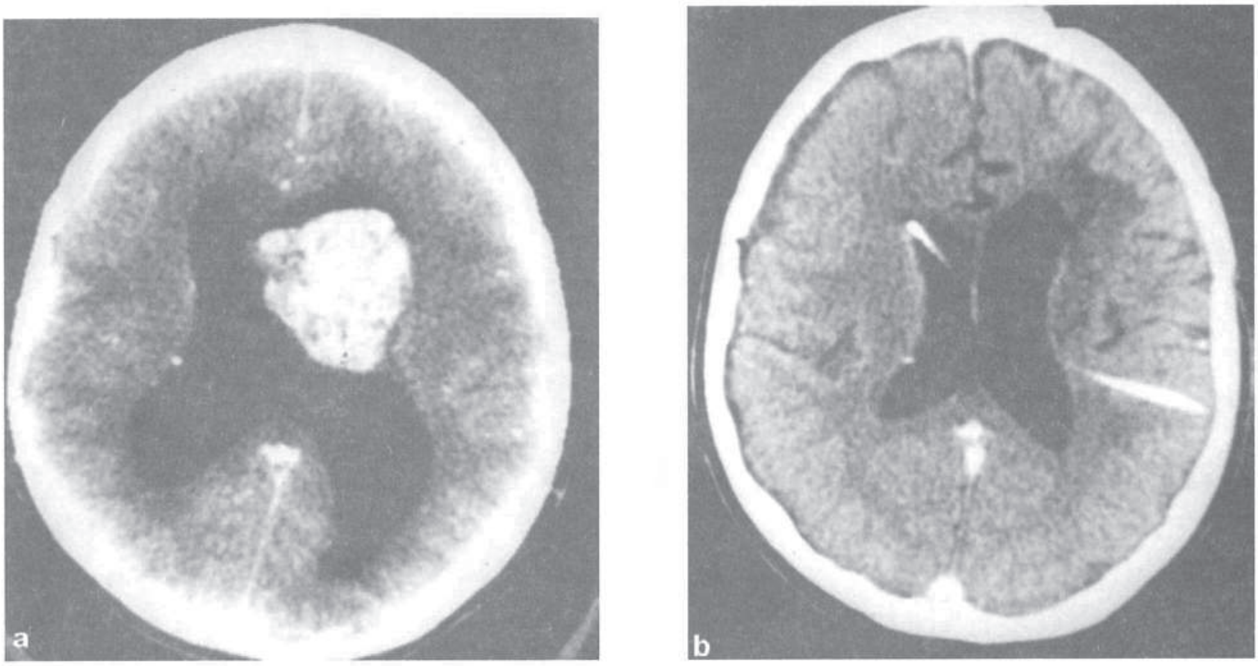

Figure 5. Axial enhanced magnetic resonance imaging of an astrocytoma filling the left frontal horn of lateral ventricle (a). Postoperative MRI after the complete transcortical resection of the tumor with very good results (b) (surgeon Leon Dănăilă).

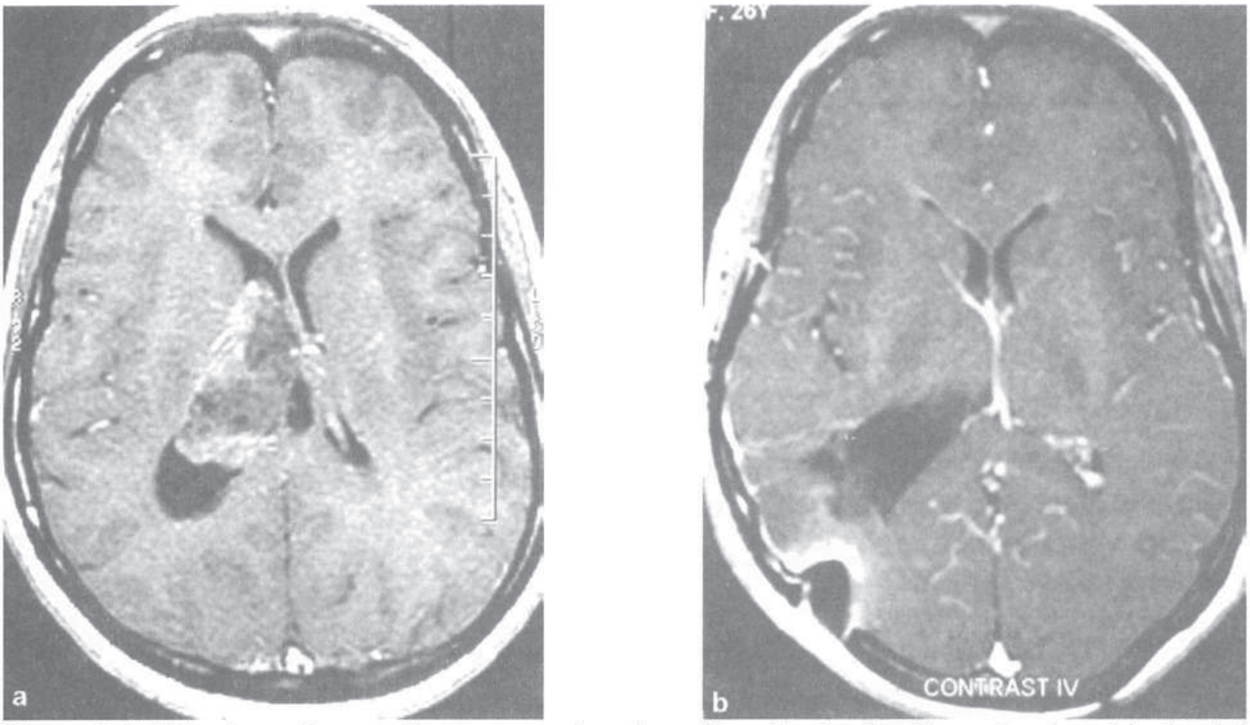

Figure 6. Axial enhanced magnetic resonance imaging of an oligodendroglioma developed in the right body of the lateral ventricle (a). The complete excision was accomplished through an interhemispheric transcallosal approach (b) (surgeon Leon Dănăilă). Postoperatively, the patient had remained in a very good health condition.

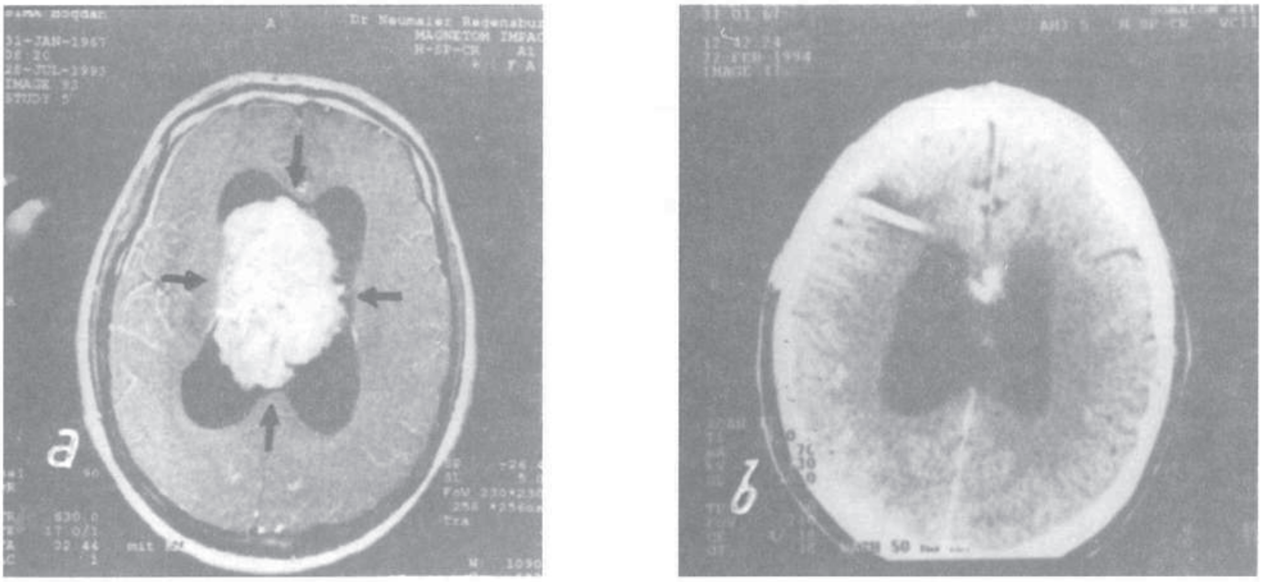

Figure 7.Contrast-enhanced axial CT scan of a central neurocytoma filling the right body of the lateral ventricle and extending into the left one, with ipsilateral obstruction (a). The complete excision had been accomplished through an interhemispheric transcallosal approach, with very good results (b) (surgeon Leon Danaila).

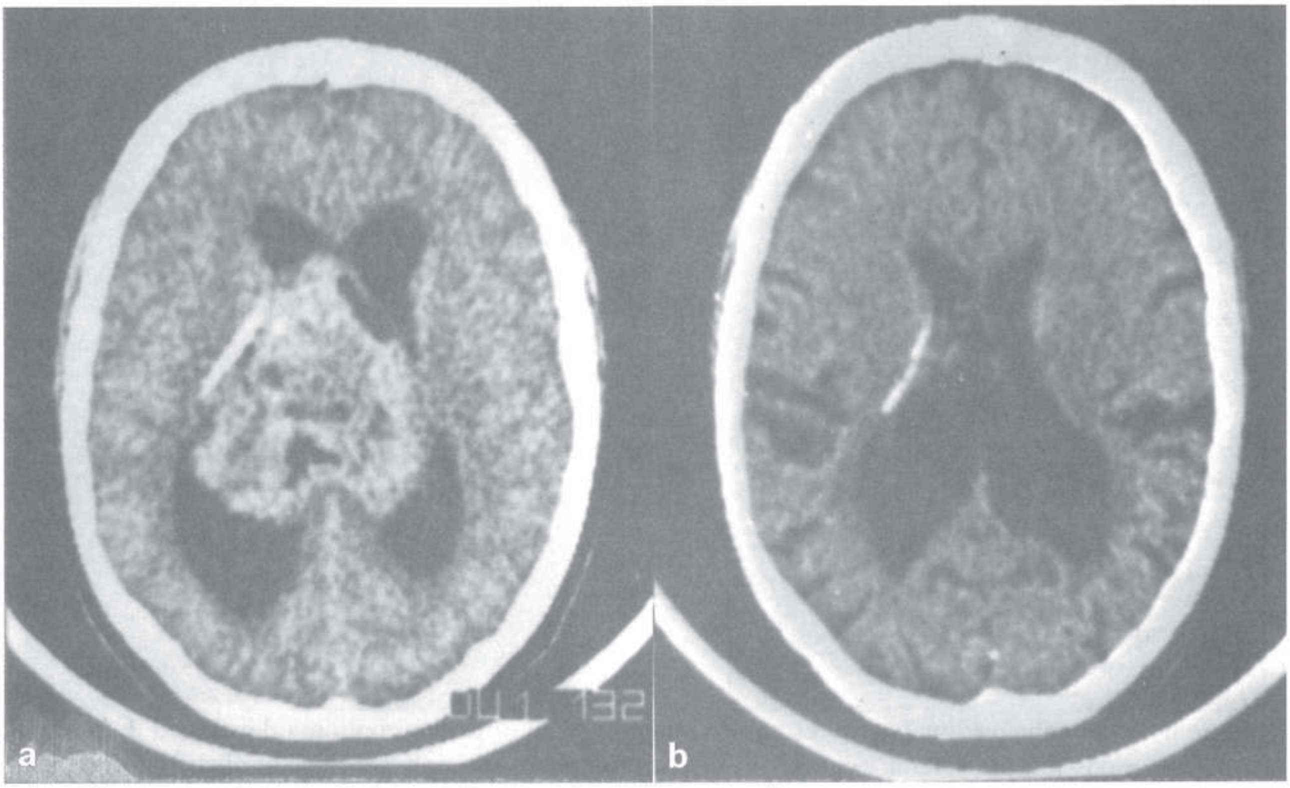

Figure 8. Contrast-enhanced axial CT scan of an astrocytoma filling the right and the left body of the lateral ventricles (a). The patient underwent craniotomy and interhemispheric transcallosal approach. The postoperative CT scan demonstrates the resection of the tumor (b) (surgeon Leon Dănăilă).

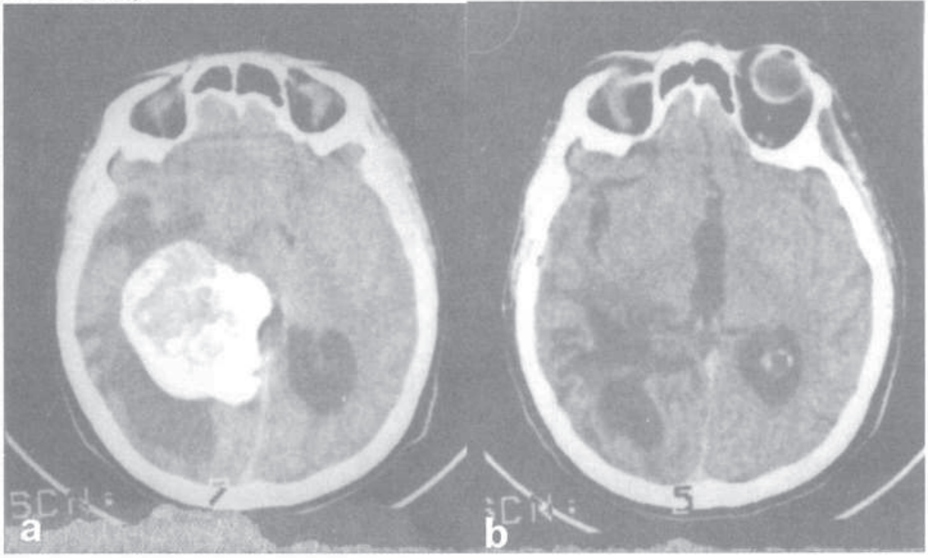

Figure 9.Axial computed tomography of a meningioma developed in the atrium of the right lateral ventricle (a). Postoperative CT scan after the resection of the meningioma through the posterior transcortical route (b) (surgeon Leon Dănăilă).

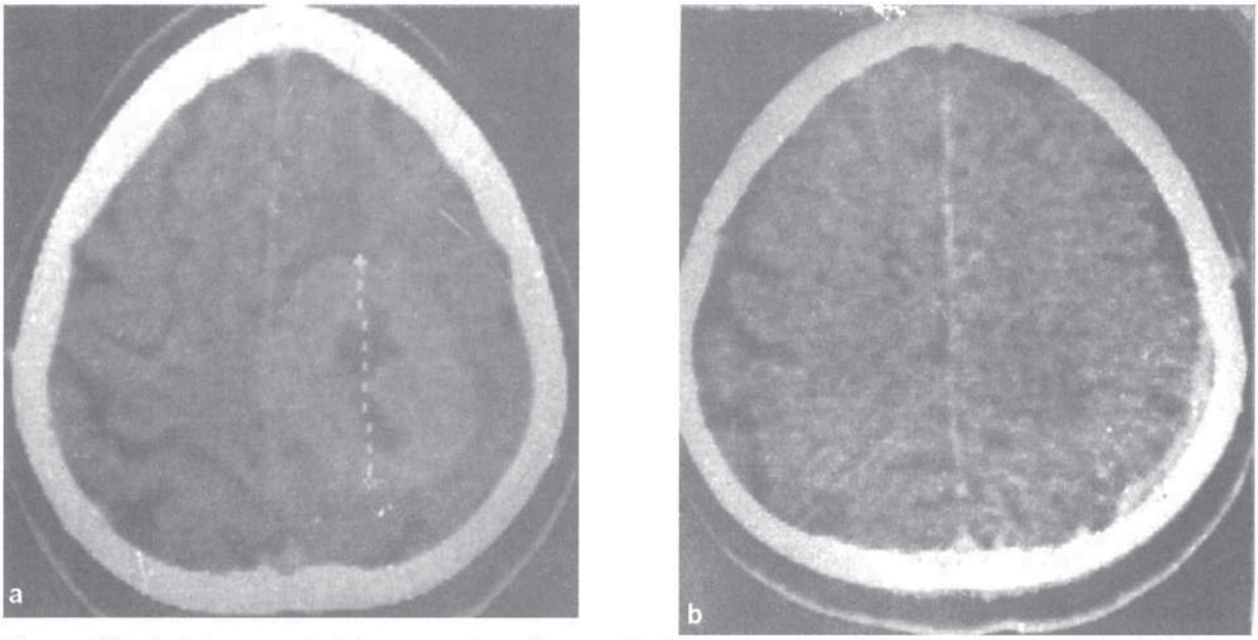

Figure 10. Axial computed tomography of a meningioma developed in the atrium of the left lateral ventricle (a). Postoperative CT scan after the resection of the meningioma through the posterior transcortical route (b), with very good results (surgeon Leon Dănăilă).

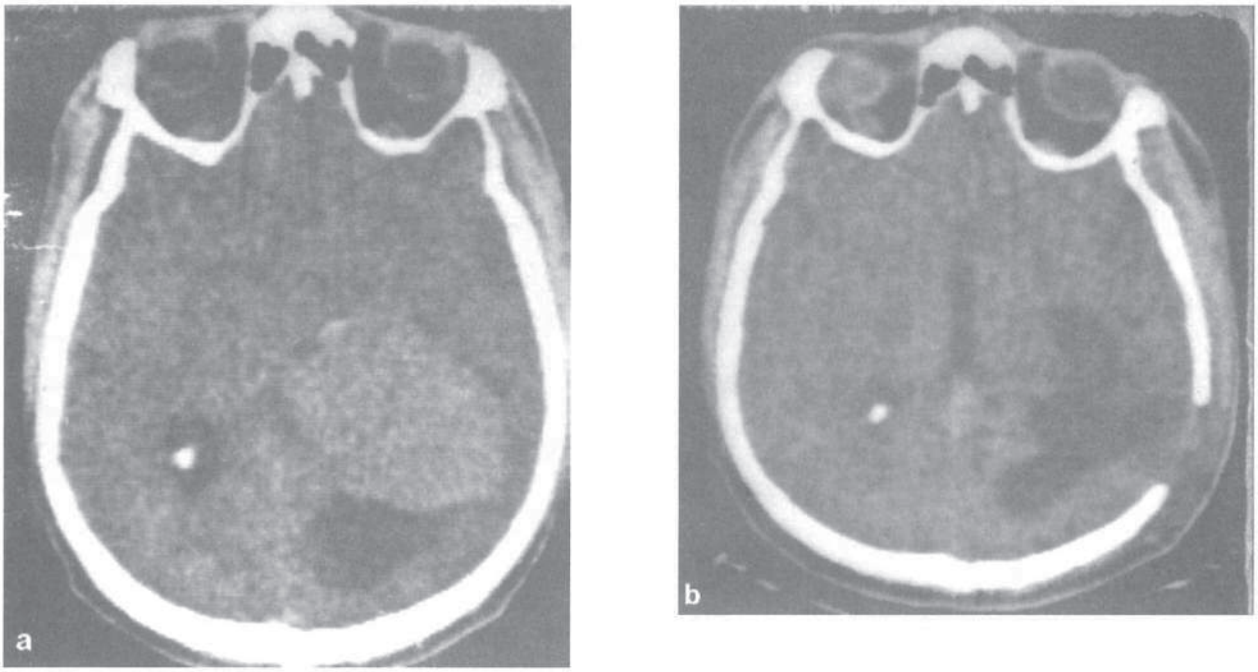

Figure 11. Computed tomography (CT) scan that shows a large meningioma in the left atrium (a). The excision was accomplished through a posterior transcortical approach, with very good results (b) (surgeon Leon Dănăilă).

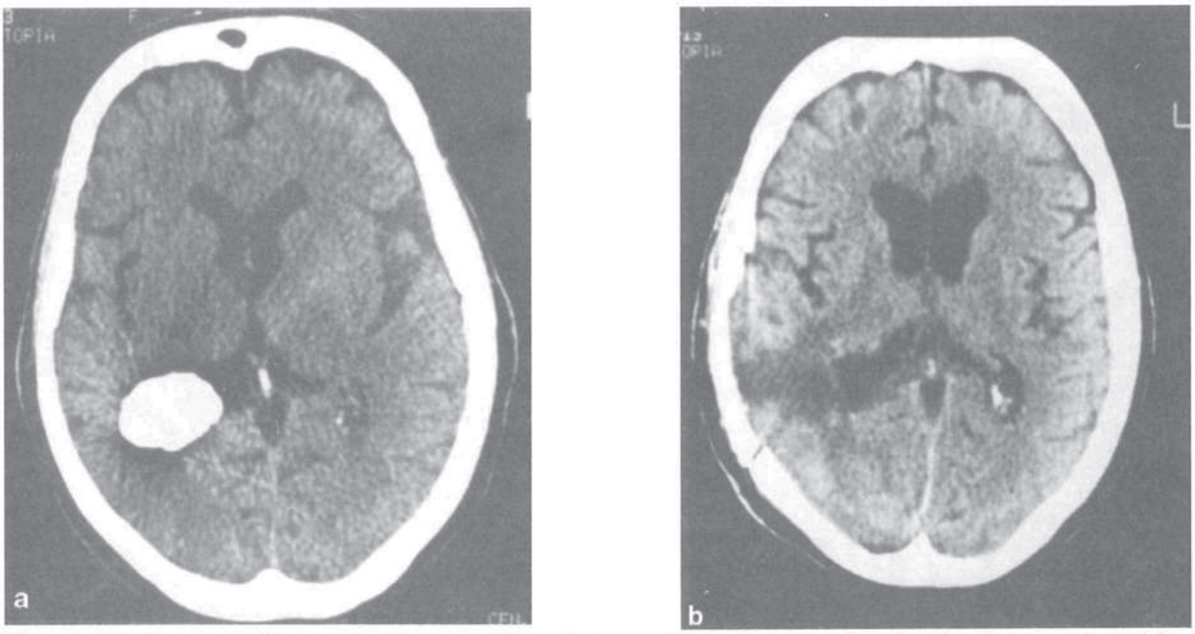

Figure 12. Computed tomography scan that shows a large meningioma in the right occipital horn (a). The excision was accomplished through a posterior transcortical approach, with very good results (b) (surgeon Leon Dănăilă).

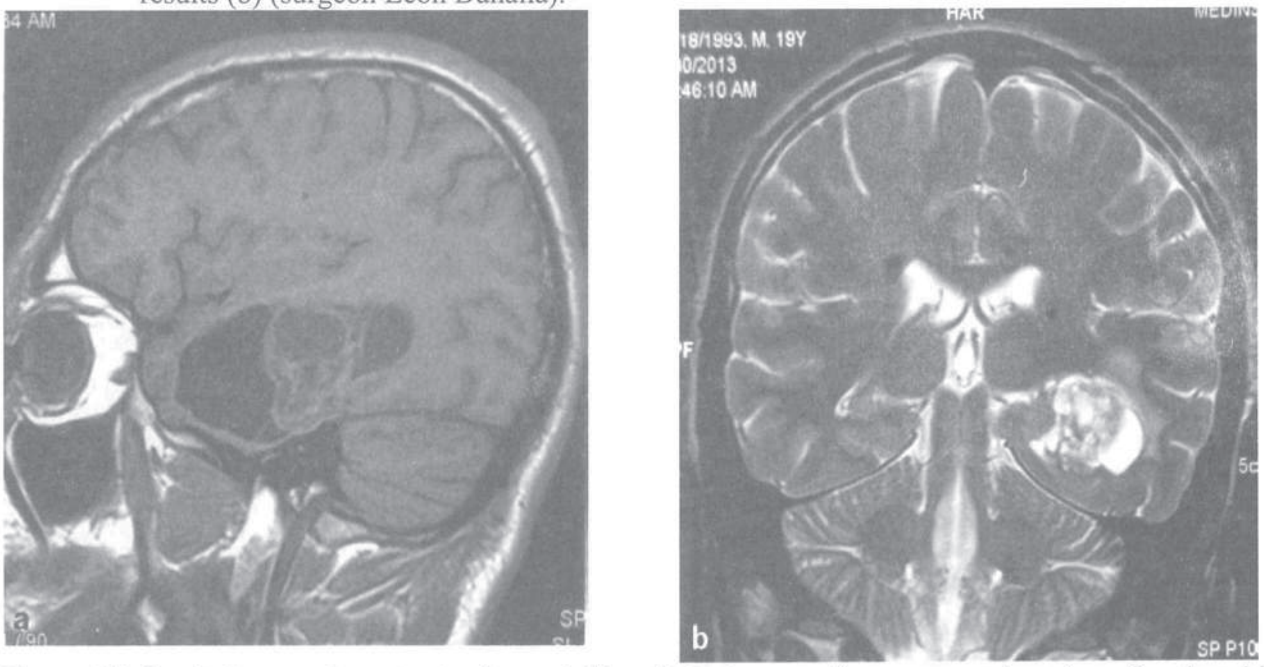

Figure 13. Sagittal coronal contrast-enhanced T1-weighted magnetic resonance imaging of a choroid plexus carcinima developed in the left temporal horn of the lateral ventricle (a, b).

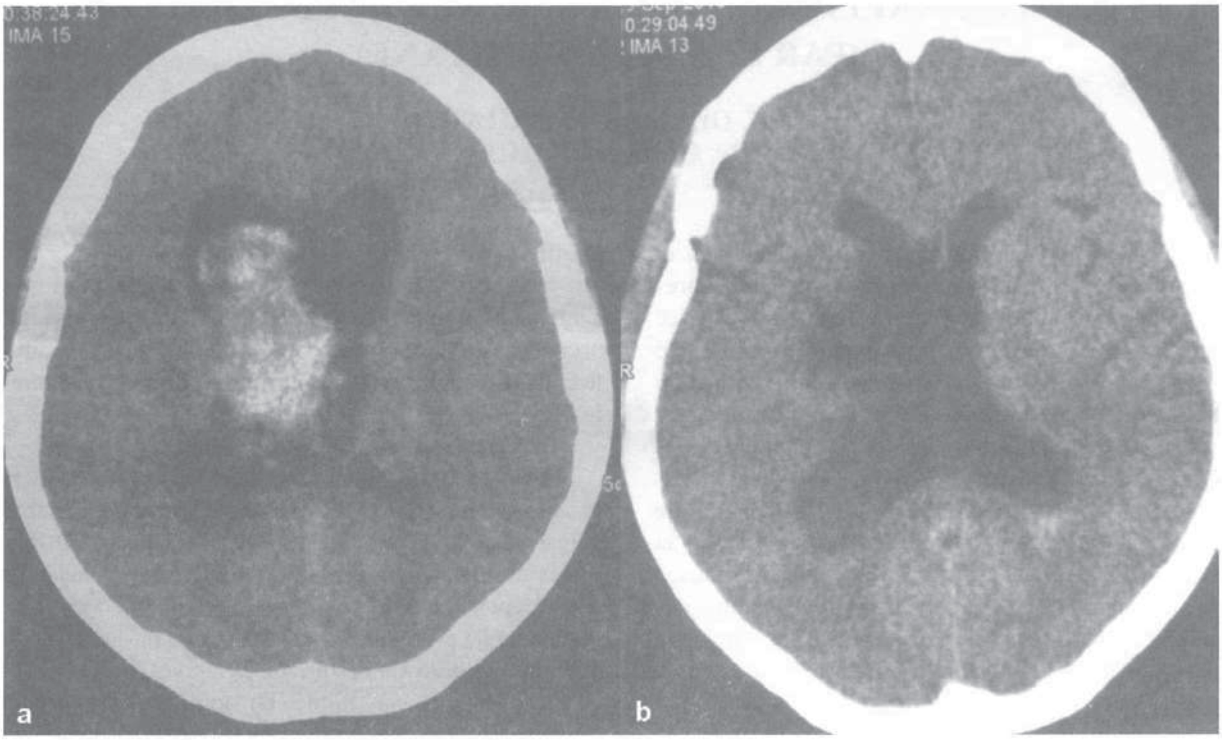

Figure 14. A 58-year-old woman presented with rhythmical movements of the head, headaches and vomiting. The CT scan demonstrated a solid tumoral mass with maximal dimensions of 3.5 cm, located in the right lateral ventricle (a). The postoperative CT scan demonstrated the complete excision (b) (surgeon Leon Dănăilă). The histological examination had revealed that it had been an intraventricular inflammatory pseudotumor.