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ORIGINAL ARTICLE

Trigonal and peritrigonal lesions of the lateral ventricle—surgical considerations and outcome analysis of 20 patients

Fernando Ruiz Juretschke · Erdem Güresir · Gerhard Marquardt · Joachim Berkefeld · Steffen Rosahl · Joachim Klisch · Andreas Raabe · Volker Seifert · Rüdiger Gerlach

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Abstract The aim of this study is to review the results and clinical outcome of patients with surgically treated lesions within the trigone of the lateral ventricle. This is a retrospective case series of 20 (eight male, 12 female) patients with lesions of the trigone of the lateral ventricle operated between 1998 and 2008. All lesions were removed via the transcortical temporal and transcortical parietal route. Surgical complications and outcome were assessed using the modified Rankin Scale (mRS). There were four children and 16 adults with a mean age of 42±22 years (min=1, max=74). Eight (40%) lesions grew within the trigone of the dominant hemisphere. In 17 cases, the lesion was purely intraventricular, and in three cases, a slight paraventricular extension was seen. The mean size was 4.5 cm of maximal diameter. Surgical removal was achieved via the transcortical parietal route in 13 cases (65%) and the transcortical temporal route in seven cases (35%). In all cases, complete resection was possible. According to the mRS, 13 patients improved, five remained the same, and two were lost to follow-up. One patient had an increased visual field deficit postoperatively and new hemiparesis and aphasia, but returned to the preoperative level within a few weeks. In one patient, an acute myocardial infarction occurred due to previous cardiac stent placement and in-stent stenosis. Even large trigonal lesions can be resected with low morbidity using a transcortical approach depending on the peritrigonal extension of the tumor.

Keywords Trigone · Lateral ventricle · Surgical approach · Tumor

S. Rosahl · R. Gerlach (✉)
Department of Neurosurgery, Helios Klinikum Erfurt,
Nordhäuser Str. 74,
99089 Erfurt, Germany
e-mail: ruediger.gerlach@helios-kliniken.de

F. R. Juretschke · E. Güresir · G. Marquardt · A. Raabe · V. Seifert · R. Gerlach
Department of Neurosurgery, Goethe University Frankfurt/Main,
Schleusenweg 2-14,
60528 Frankfurt/Main, Germany

J. Klisch
Neuroradiological Institute, Helios Klinikum Erfurt,
Erfurt, Germany

J. Berkefeld
Neuroradiological Institute, Goethe University Frankfurt/Main,
Frankfurt/Main, Germany

Introduction

Tumors and non-neoplastic lesions of the lateral ventricle account for less than 1% of all brain tumors [9, 10, 18]. The ventricular trigone (VT) is the most frequent location for lateral ventricular masses [12, 17]. Most of these lesions have a non-specific clinical manifestation and a late diagnosis. Surgical removal of lesions within the atrium of the lateral ventricle remains a challenging procedure because of the lesions' big size, deep location and relationship to the vascular structures, e.g., choroidal arteries and the deep venous system. Moreover, eloquent cortical areas such as precentral gyrus, dominant hemispheric angular region and the thalamus, as well as the course of subcortical tracts, require an exact planning of the approach to avoid neurological deficits. The highest risk is the violation of the optic radiation, which covers the entire lateral aspect of the temporal horn and atrium as it extends to the occipital horn [10]. Various surgical approaches have been proposed for masses arising at the VT [6, 7, 10, 14, 15, 22]. Although the atrium of the lateral ventricle is not an

uncommon site of neoplastic and vascular lesions, there are only a limited number of series dedicated to these lesions [1, 8, 12]. Therefore, the aim of this retrospective case series is to review a series of 20 patients with various pathologies in the atrium of the lateral ventricle which were removed via two transcortical approaches—the posterior parietal and middle temporal gyrus approach. Surgical considerations concerning these two strategies are discussed.

Patients and methods

Between 1998 and 2008, a total of 57 patients underwent surgery for tumors and tumor-like lesions of the trigone of the lateral ventricle at the Department of Neurosurgery of the University Hospital of Frankfurt am Main, and were registered in the data base. We performed a retrospective review of intraventricular or paraventricular lesions confined to the trigone without extension to the neighboring structures, thus excluding malignant gliomas and lymphomas, and found 18 cases which fulfilled these criteria. After the senior author moved to another institution, two patients with trigonal lesions were operated at the Helios Klinikum Erfurt and included in this series. The clinical data on 20 cases of trigonal lesions were collected from medical charts, surgical records imaging studies and follow-up records. All cases had been operated with microsurgical technique through a transcortical approach.

The surgical outcome was established with the modified Rankin Scale (mRS) measured at admission and postoperatively at the last follow-up.

Results

Twenty patients (eight males and 12 females) with lesions located at the VT were identified and analyzed. For patients' characteristics, see Table 1. The mean age was 42±22 years (min=1, max=74). Four of the 20 patients were children. The most frequent symptom was headache (70%) as a sign of intracranial hypertension. Motor disturbances were seen in 45% of the patients, and visual field disturbances were present in 30% of the patients, whereas only 15% had some kind of cognitive impairment. No preoperative seizures were reported. Most patients had a non-specific slow onset of symptoms with a course before diagnosis of more than 1 month in 65%.

All patients underwent CT and MRI. There were 12 right-sided and eight left-sided lesions of which 17 were pure primarily ventricular lesions and three were paraventricular masses with invasion of the ventricle. All cases showed some degree of contrast enhancement. The size was estimated by the maximal diameter. There were two small lesions (<3 cm), 11 medium-sized lesions (3–5 cm) and seven large lesions (>5 cm). The mean size was 4.5 cm. Hydrocephalus or trapped posterior or temporal horns were present in ten cases (50%). A digital substraction angiography was performed in 40% of the cases showing a vascular supply by the anterior choroidal artery in all cases.

Histology of the lesions is shown in (Table 1). Meningioma was the most common finding in seven patients (35%). All of the children harbored a plexus papilloma (Fig. 1). Interestingly, we had two cavernomas. One of the cases had a large extension and an associated developmental venous anomaly (Fig. 2).

Patients were placed in a lateral position or a three-quarter prone position in 18 cases (90%). One papilloma in a 1-year-old child was operated in a prone position, and one ependymoma in a 29-year-old female was operated in a semi-sitting position, both using a posterior parietal approach. A preoperative external ventricular drainage was placed in 50% of the cases through a frontal burr hole. This drainage could be removed within the first 5 days in all cases but one which developed a postoperative ventricle enlargement that required a shunt. Intraoperative localization was performed with a BrainLAB Neuronavigation System (BrainLAB, Heimstetten, Germany) in 13 cases (65%) and with the aid of ultrasound in two cases (10%). All lesions were approached after a small cortical incision (1.5–2 cm) was performed. The posterior parietal transcortical approach (P1) was chosen in 13 cases (65%). A posterior middle temporal gyrus transcortical access (T2) was performed in seven cases (35%). In all cases, a complete tumor removal was achieved by using a microsurgical technique, which was demonstrated by postoperative CT and MRI. A piecemeal excision was carried out in 18 lesions (90%) using the cavitron ultrasonic aspirator (CUSA, Integra LifeSciences Corp., NJ) for debulking in 56% of the cases. There were two cases where the small size of the lesion (<3 cm) allowed a total “en bloc” removal, one incidental plexus papilloma and one cavernous angioma. Intraoperative monitoring of somatosensory evoked potentials (SSEPs) and muscle motor evoked potentials (MMEPs) was used in 65% of the cases (in five of the dominant hemispheric lesions). The median hospital stay was 18 days (7–46 days).

There was no surgical mortality.

Morbidity was reported in 7 patients (33%) (Table 2). Preoperative hemianopia was present in five patients, four of them had been studied by an ophthalmologist, and remained unchanged or slightly improved. There were two cases of new postoperative visual field disturbance documented on campimetry, one in a right-sided meningioma approached trough a P1 route and one in a left-sided meningioma with a T2 approach. This last patient who had only a slight right hemiparesis prior to surgery also

Table 1 Clinical and histological characteristics of 20 patients with lesions in the trigone of the lateral ventricle

No.	Age	Side	Size (maximal diameter, cm)	Pathology	Approach	mRS preop	mRS postop
1	1	Right	5.4	Plexus papilloma	T2	2	1
2	72	Left	6.4	Meningioma	P1	2	0
3	57	Right	6.0	Ependymoma	T2	4	4
4	50	Right	3.8	Meningioma	T2	1	0
5	60	Left	3.0	Hemangiopericytoma	T2	1	1
6	48	Right	4.4	Pilocytic astrocytoma	T2	3	2
7	1	Left	2.2	Plexus papilloma	P1	1	LFU
8	9	Right	8.1	Plexus papilloma	T2	3	2
9	29	Right	4.3	Ependymoma	P1	1	0
10	50	Right	2.3	Cavernoma	P1	0	0
11	37	Left	6.7	Meningioma	P1	1	1
12	60	Left	4.0	Meningioma	T2	1	1
13	69	Right	5.5	Metastasis	P1	2	1
14	44	Right	5.2	Meningioma	P1	1	0
15	47	Left	3.7	Meningioma	P1	2	1
16	38	Right	4.2	Metastasis	P1	2	1
17	36	Left	4.2	Cavernoma	P1	1	0
18	50	Left	4.5	Meningioma	P1	1	LFU
19	8	Right	3.5	Plexuspapilloma	P1	1	0
20	74	Right	3.3	Metastasis	P1	2	1

The outcome of the patients is assessed using the mRS. Surgical resection was performed via the P1 and T2 approaches

LFU lost to follow-up

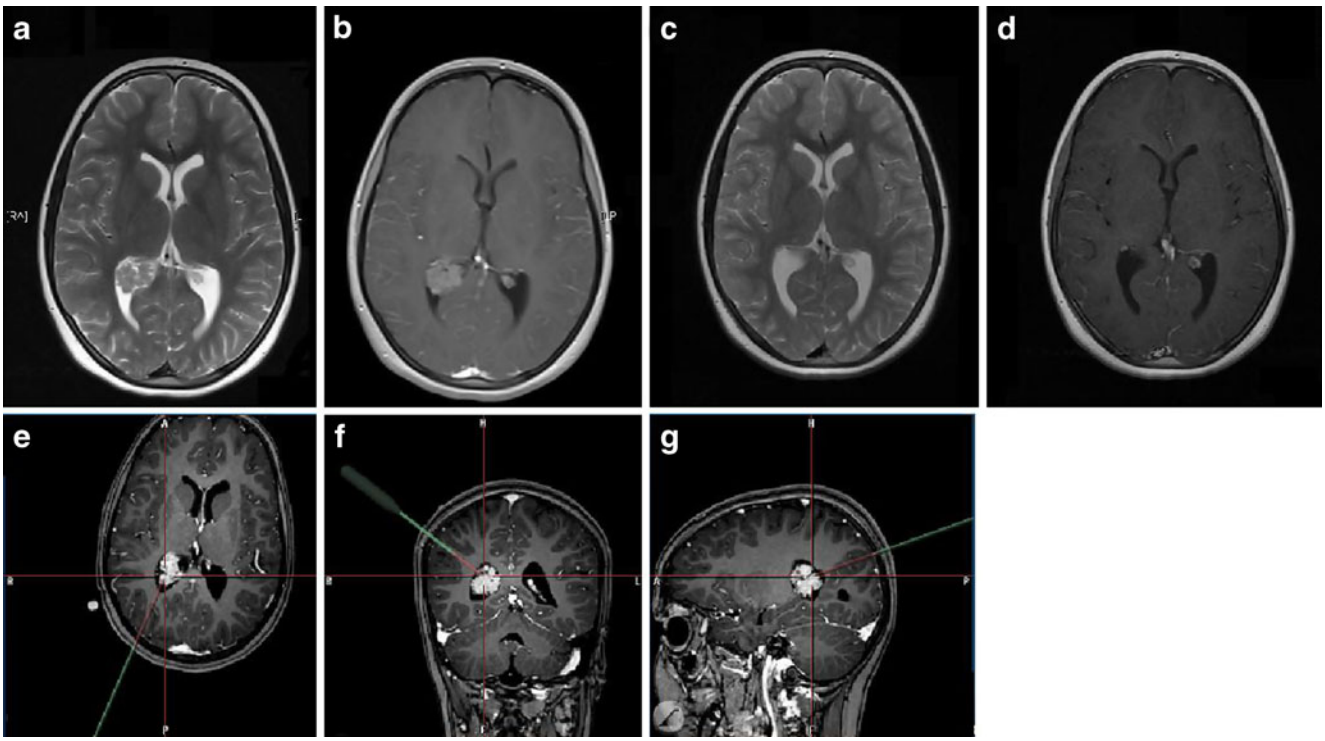

Fig. 1 Axial MRI of a right trigonal plexus papilloma in an 8-year-old female [fluid attenuated inversion recovery (FLAIR)] T2 (**a**) and contrast-enhanced T1 (**b**). Same sequences 3 months later after complete removal through a transcortical transparietal approach (**c**, **d**). Intraoperative planning of the transparietal approach using the BrainLAB Neuronavigation System (Heimstetten, Germany) (**e**–**g**)

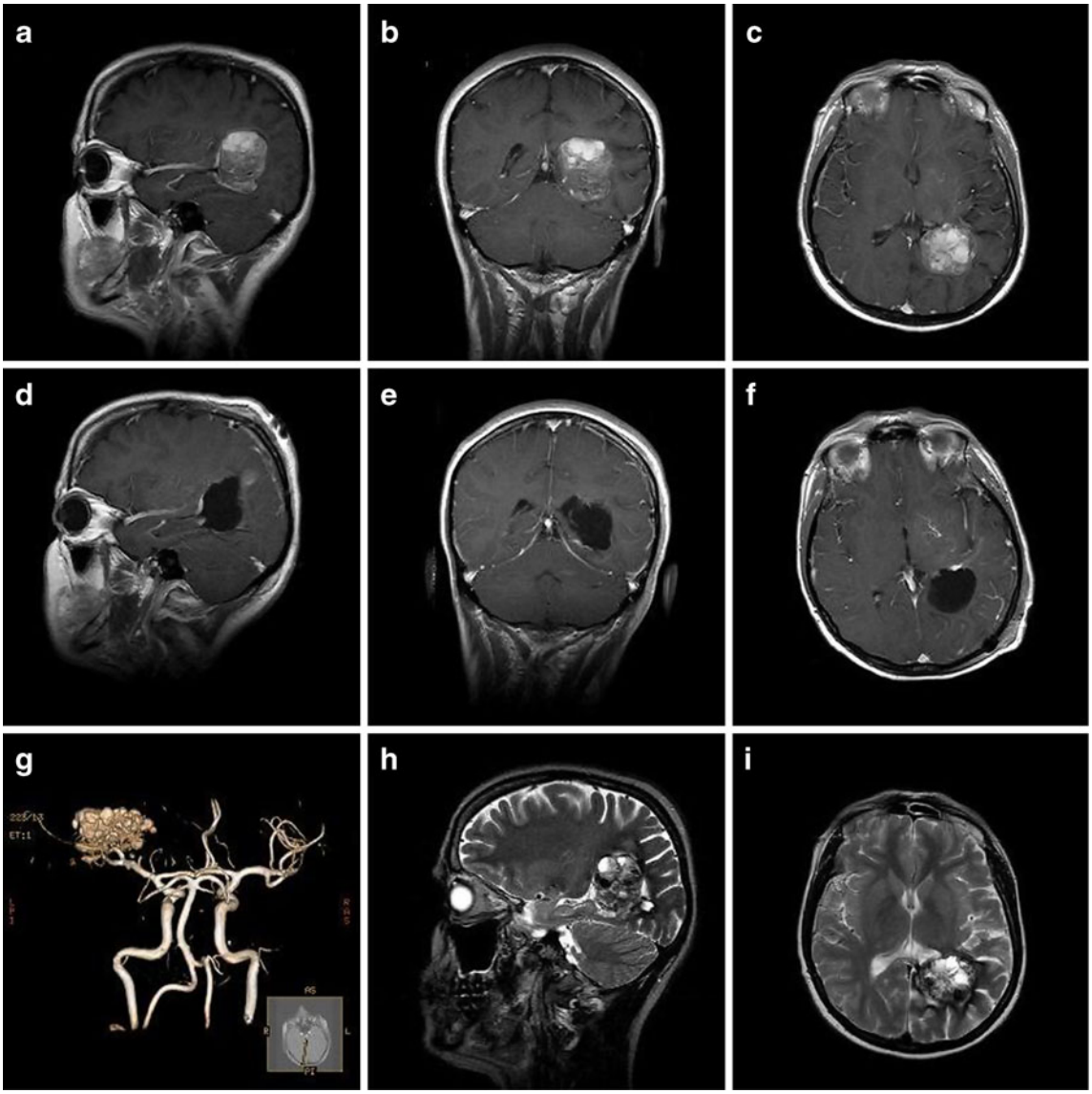

Fig. 2 Contrast-enhanced T1-wieghted MRI: sagittal (**a**), coronal (**b**) and axial (**c**) preoperative images of a left trigonal cavernoma with associated deep venous anomaly in a 36-year-old female. Postoperative images after a transcortical transparietal approach, sagittal (**d**), coronal (**e**) and axial (**f**), show a complete resection. MR-angiography in a posterior view of the left trigonal cavernoma (**g**). T2-weighted images of the same case: sagittal (**h**) and axial (**i**)

developed transient worsening of the motor deficit and transient dysphasia which returned to almost normal before discharge. A case of permanent hemiparesis occurred in a right-sided grade I astrocytoma operated through a T2 route. The patient had already a left-sided weakness before surgery. Postoperative bleeding appeared in a 4-month-old child with a left-sided plexus papilloma who developed an epidural hematoma in the first hours after surgery. The hematoma was surgically evacuated without neurological deficit. Three patients (16%) developed seizures that required long term treatment.

The median follow-up was 27 months (1–80 months). The neurological status according to the mRS improved in 13 patients and remained the same in five patients. Two patients were lost to follow-up (Fig. 3). Of the 20 patients studied, 19 had no or only mild disability (mRS, 0–2) after surgery, and were not affected in their daily living. Only one patient, who was wheelchair-bound due

Table 2 Complications

Epidural hematoma (required surgery)	1 (6%)
Seizures	3 (16%)
Hydrocephalus	1 (6%)
Visual field disturbance (new or worsened)	2 (11%)
Hemiparesis	2 (11%)
Dysphasia	1 (6%)
Acute myocardial infarction	1

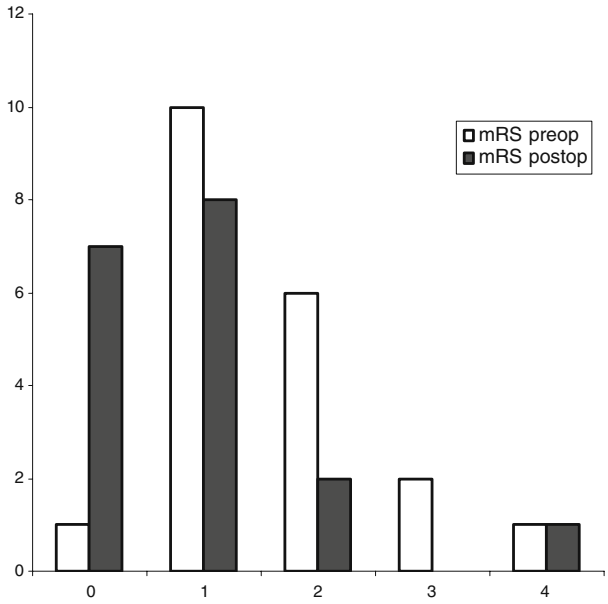

Fig. 3 The mRS assessed pre-operatively at admission and postoperatively at the first outpatient visit (mean time= 1 month)

Modified Rankin Scale

0. No symptoms

1. No significant disability despite symptoms, abele to carry out all usual activities

2. Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance

3. Moderate disability; requiring some help, but able to walk without assistance

4. Moderate severe disability; unable to walk without assistance and unable to attend own bodily needs

5. Sever disability; bedridden and requiring constant nursing care

6. Dead

to a recurrent trigonal ependymoma with spinal metastasis, remained moderately disabled after surgery. One patient with a renal cell carcinoma metastasis in the right trigone had a myocardial infarction 2 days after discharge, leading to readmission and cardiological treatment of an in-stent stenosis. All pediatric patients had a normal development.

Discussion

The VT is the preferred location of tumors and tumor-like lesions affecting the lateral ventricles in most series [8, 12, 18] especially in the series of meningiomas, which are some of the most frequent tumors of the lateral ventricles. There was a report of a very high incidence at the VT ranging from 69% to 90% [4, 5, 17, 21].

There are only a few series describing only lesions limited to the area of the VT. Most of the larger series include infiltrating tumors such as low- and high-grade gliomas and lymphomas that may extend diffusely into the white matter of the parietal and temporal lobe [1, 6, 9, 12, 19]. These lesions cannot be considered as purely intra- or paraventricular, and therefore, we focused on clearly circumscribed lesions like meningiomas, metastasis and cavernomas. In our series, we describe the transcortical approach as a surgical pathway, which allows a safe and effective management of these lesions.

The P1 approach (Fig. 4) is started with a linear corticotomy along the superior parietal gyrus, which can be prolonged into the parieto-occipital sulcus [21]. The dissection is carried downward entering the roof of the posterior part of the lateral ventricular body and the trigone. The ventricle can be punctured with a ventricular needle or catheter, which is referenced to the neuronavigation system for proper orientation. This allows decompression of a trapped ventricle and location of the tumor [5, 9]. Once the ventricular wall is reached, self-retaining blade retractors are placed, always trying to put on as little pressure as possible. This approach runs medial to the majority of optic radiations [12, 14]. The anterior choroidal artery enters the temporal horn through the choroidal fissure near the choroidal point and then runs along the plexus which courses in the inferior and lateral aspect of the VT. The posterior choroidal arteries reach the lateral ventricle behind the

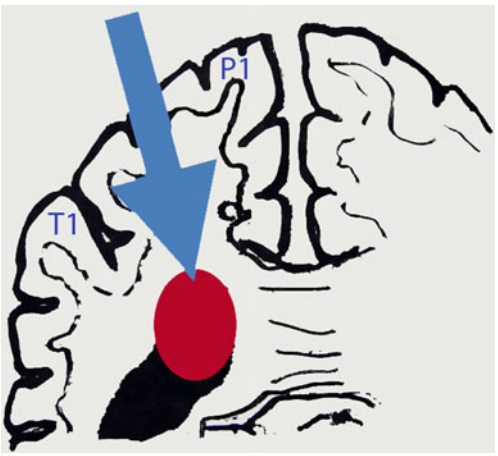

Fig. 4 Schematic view of the P1 approach

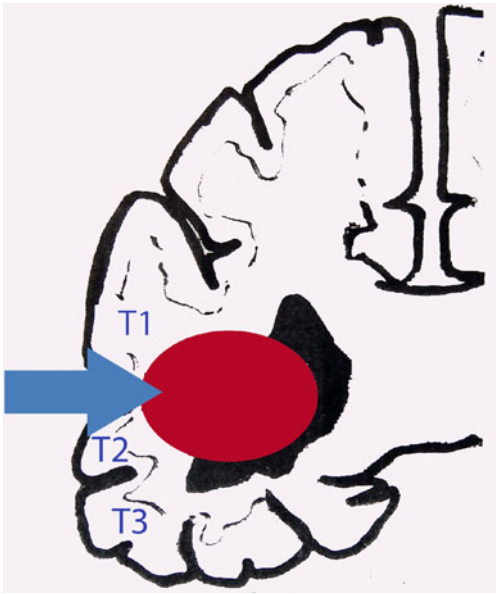

Fig. 5 Schematic view of the T2 approach

anterior choroidal artery and give frequent feeders to tumors at the VT [14]. The opening of the VT happens away from the choroidal arteries which usually course underneath the tumor, thus preventing an early vascular control.

The T2 approach (Fig. 5) opens the posterior part of the middle temporal gyrus providing access to the temporal horn and VT. The craniotomy centered with neuronavigation should expose the posterior part of all three temporal gyri [9]. This incision runs parallel and superior to the visual projection fibers in order to minimize the risk of postoperative hemianopia [5]. The lateral opening of the VT exposes the choroidal fissure offering a relatively early control of the intraventricular segment of the anterior choroidal artery, unless it is displaced medially by the tumor which can occur in about half of the cases [6, 10]. There is a risk of aphasia, agraphia and alexia in the dominant hemisphere and visuospatial apraxia in the nondominant hemisphere because of injury to language-related areas in the superior temporal gyrus [21].

In our series, the preference for one of both transcortical approaches depended mainly on the location and extension of the lesion. Those lesions located more superiorly at the VT and extending into the parietal lobe were approached through the P1 route whereas those that extended laterally into the temporal lobe were approached through T2, but other factors were also taken into account. In four cases, the angiography or MR-angiogram showed vascular feeders reaching the medial aspect of the lesion, and a P1 approach was favored. Of the eight left-sided lesions, only two were approached through T2 in order to avoid speech deficits. In one patient with a left-sided meningioma and a preoperative dysphasia, the speech deficit improved after removal of the tumor through a P1 approach. One patient with a left-sided meningioma that is approached through T2 developed a transient dysphasia. This supports our conception that the T2 approach is less suited for left-sided lesions.

In our experience, piecemeal removal allows safe debulking without excessive bleeding in most cases until the tumor can be mobilized to expose and coagulate the feeding vessels. Attempts to gain early control of the feeding arteries before starting the tumor resection can often imply more extended approaches that compromise functional areas and result in postoperative morbidity. Therefore, risks and benefits of both transcortical approaches have to be considered (Table 3). The transcortical route is, for most lesions of the VT, the shortest way without damage to functional areas. Intraoperative monitoring has proven to be an important aid for deep brain dissection. Changes in MMEPs accurately predict transient and permanent injuries to motor pathways [20]. It was used in 65% of our cases and helped to minimize the damage caused by brain retraction.

Most recent series of transcortical approaches to lateral ventricular tumors report a low mortality rate with permanent morbidity ranging from 0–20% [9, 17, 19]. There was no mortality in our series. The most frequent morbidity associated with transcortical approaches to the

Table 3 Surgical considerations for transcortical approaches to the trigone

	P1	T2
Visual field defect	Low risk to optic radiations Risk for calcarine cortex if too medial	Risk to optic radiations
Motor deficit	Low risk if behind postcentral sulcus	Risk of hemiparesis by retraction
Language deficit	Low risk if no lesion of angular gyrus	Risk in dominant hemisphere
Cognitive deficit	Visuospatial apraxia and Gerstmann syndrome on dominant hemisphere	Low risk
Vascular control	Late	Early if not medially displaced
Bridging veins	Low risk	Low risk

VT is visual field deficit consisting in homonymous hemianopia or quadrantanopia [9]. In our series, five patients with previous visual field defects had experienced no worsening or had slightly improved. The two cases of new hemianopia occurred after one P1 and one T2 approach. The latter was a patient with a postoperative motor and speech deficit, both of which improved in a matter of days. Another hemiparesis was seen after a T2 approach in a patient with previous deficit, and it also showed progressive improvement. It has been argued that transient motor disorder is a result of excessive retraction during surgery when approaching through the middle temporal gyrus [9]. This lateral approach may also cause language disorders in the dominant hemisphere when dissection is carried out too superiorly and cranially affecting the T1 gyrus or if too much pressure is put on retraction. A lower incision between the middle and inferior temporal gyri has been proposed for tumors in the left trigone in order to avoid language areas, but this incision obliges to direct the dissection very cranially to reach the ventricle leaving a small working space [19]. A significantly higher risk of seizures has been reported after transcortical approaches ranging from 6% to 70% in comparison to interhemispheric approaches where seizures are uncommon [2, 6, 12, 23].

Alternative approaches to the P1 route are mainly the posterior transcallosal approach, the parieto-occipital interhemispheric parasplenial approach and the occipital interhemispheric transcortical approach. The posterior transcallosal approach described by Kempe and Blaylock reaches the posterior part of the corpus callosum which is opened at the midline to enter the lateral ventricle giving access to the superior and medial aspects of the VT [15]. This technique offers an early access to the posterior choroidal vessels and has lower risk of seizures and visual field disturbances. But all interhemispheric approaches bridging veins are at risk and may limit the exposure of larger and more lateral lesions. The section of the corpus callosum may cause mutism, aphasia, and a verbal–visual disconnection syndrome if the splenium is affected [10, 11, 16]. These complications may be avoided with the interhemispheric parasplenial approach that is also directed to the superior aspect of the VT entering lateral to the splenium [3, 13, 22]. The occipital interhemispheric transcortical approach reaches the splenium along the falcotentorial junction and then enters the medial occipital cortex. It may be useful for lesions at the medial aspect of the VT and the occipital horn, but again it has the limitation of bridging veins, and excessive retraction of the occipital lobe can cause hemianopia [6, 12]. An alternative to the T2 route is the subtemporal approach which opens the inferior temporal or occipito-temporal gyrus and then reaches the VT through the temporal horn providing an early control of the anterior choroidal artery. This approach has less risk of speech and visual field disturbances and may be a useful alternative for lesions in the dominant hemisphere [14, 19, 21]. The main complication can be an excessive retraction of the temporal lobe and injury of the vein of Labbé which can cause venous infarction and edema.

Conclusions

Even large trigonal lesions can be resected with low morbidity using a tailored approach depending on the expected pathology and peritrigonal extension of the tumor. With careful planning of the approach, the risk of violation of the optic radiation is low. Neuronavigation and intraoperative electrophysiology are helpful tools for deep-seated lesions. Only a few series with a reasonable number of patients address the approach and outcome after surgery of trigonal lesions.

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Comments

Christopher Nimsky, Marburg, Germany

Lesions in the trigonal region require a profound anatomical knowledge to decide the optimal surgical approach to avoid neurological sequelae. All patients were either operated on a transcortical temporal or transcortical parietal approach; postoperative neurological deficits were low. The series of 20 patients spans a long period of 10 years, so that the influence of modern navigation techniques cannot be estimated. It will be interesting to see in the future on whether the application of sophisticated navigation techniques allowing the identification of eloquent cortical and subcortical brain structures, such as the speech areas and pathways, as well as the optic radiation, will further influence the decision making on the optimal approach and, at all, be able to further improve the good neurological outcome.

Dietmar Krex, Dresden, Germany

This is a carefully elaborated series of tumors located in the trigonal and peritrigonal region of the lateral ventricle which have been operated by two different approaches. Those less frequent lesions are associated with potential risks to harm the visual tract, the precentral gyrus, the thalamus, the vascular supply of the choroidal arteries and the deep venous system, the speech and angular region in the dominant hemisphere and the corpus callosum depending on the approach. The authors present their good results by either using the transcortical temporal or transcortical parietal route, respectively. In addition, alternative routes are described and discussed leading to one important message of the paper. Those deep-seated and frequently large lesions should not be underestimated. Of course, the presented two routes are not the solution for every situation and the decision will be affected also by personal experience, but in any case, an individual, thoroughly tailored approach is mandatory to avoid the above mentioned sequelae. This is important to remember just for those lesions which do not occur on a daily basis.