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Clinical Articles

Thalamic Astrocytomas: Surgical Anatomy and Results of a Pilot Series Using Maximum Microsurgical Removal

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Summary

Deep-seated astrocytomas within the basal ganglia and the thalamus are considered unfavourable for microsurgical removal since the circumferential neighbourhood of critical structures limits radical resection. On closer assessment, the thalamus has a unique configuration within the basal ganglia. Its tetrahedric shape has 3 free surfaces and only the ventrolateral border is in contact with vital and critical functional structures, e.g. the subthalamic nuclei and the internal capsule. The purpose of the present study was to investigate the feasibility of maximum microsurgical removal in a series of intrinsic thalamic astrocytomas.

14 patients with intrathalamic astrocytomas grades 1 to 4 as diagnosed by previous stereotactic biopsy or intra-operative frozen section were selected for maximum microsurgical removal. The infratentorial supracerebellar approach from the contralateral side was used for 4 limited neoplasms of the pulvinar. For the other 10 larger and more extensive processes a parieto-occipital transventricular approach was chosen.

Final histology gave the result of astrocytoma grade 1 or 2 in 4 patients, and of astrocytoma grade 3 or 4 in 10 patients. Postoperative MRI confirmed reduction of the tumor mass by 80 to 100% in 11 of 14 cases. Regional ancillary radiotherapy with 60 Gy was administered postoperatively for astrocytomas grades 3 and 4. Two patients operated on via the posterior transventricular approach had new postoperative partial hemianopia. Five of the 14 patients finally needed a ventriculo-peritoneal shunt. During the follow-up time of 6 to 52 months, tumor progression/recurrence was observed in 6 of the 10 high grade and none of the low grade neoplasms.

The present pilot series demonstrates the feasibility of the microsurgical concept. Comparison with other treatment modalities, such as brachytherapy, requires future consideration.

Keywords: Astrocytoma; microsurgery; microsurgical anatomy; thalamus.

Introduction

Deep-seated tumors of the basal ganglia and the thalamus are generally considered a marginal object for microsurgical removal [1–4, 6, 10, 13, 18, 19]. Particularly in the case of infiltrating astrocytoma, the omnidirectional neighbourhood to critical structures limits gross total resection and renders the long-term benefit questionable. Kelly and coworkers as well as the group of Drake introduced the concept of computer assisted volumetric resection [7, 14, 17]. However, the unsolved problem of brain shift was recognized as a limiting factor for radical resection based on preoperative imaging. Therefore at the present time, it remains an open question whether attempted radical resection of infiltrating tumors located centrally within the basal ganglia improves the generally poor survival time of approximately 1 year in the case of grade 3 or 4 astrocytomas treated solely by external radiation therapy and/or chemotherapy [4, 9, 15].

The thalamus differs from putamen and pallidum in several anatomical respects. The thalamus can be seen as a tetrahedron with 3 free surfaces, where only the ventrolateral border touches critical structures such as the internal capsule and the vital subthalamic structures. Therefore thalamic astrocytomas have a tendency for exophytic growth into the lateral and the third ventricle. Moreover, in contrast to putamen and pallidum, there is substantial evidence that total or subtotal surgical removal is one of the principal positive prognostic factors for survival in the case of thalamic infiltrative astrocytomas [4, 15]. However, at the present time surgical approaches to the thalamus are not well standardized. Transcallosal approaches compete with anterior and posterior transventricular ways of access, each of these having its own risks of complications and morbidity. The purpose of the present study was to standardize the approach to the thalamic astrocytomas and to analyze the results of a pilot series of patients treated accordingly.

Microsurgical Anatomy and Approaches

Microsurgical Anatomy

Since traditionally thalamic anatomy and physiology are principally relevant for functional neurosurgery and particularly the treatment of movement disorders and central pain states, specific knowledge in humans focuses on these aspects while knowledge of the other thalamic areas in humans is sparse [21]. Most recent studies in neuro-anatomy and neurophysiology were performed in primates [8, 16, 22, 25, 28, 29, 32]. The present nomenclature is based on the atlases of Olszewski and Baxter, Schaltenbrand and Wahren, and Tailarach and Tournoux [20, 27, 31].

The thalamus is principally subdivided into anterior, central, and ventral nuclear complexes as well as the pulvinar (see Fig. 1). The anterior and central nuclei are retrogradely connected to the frontal cortical areas [8, 25, 28], and ischemic lesions in these areas are reported to result in delirium and frontal like syndromes [5, 33]. The ventral nuclei are subdivided into a motor and a sensory component. The motor thalamus, that is the ventrolateral subnucleus and the anterior part of the ventro-postero-lateral subnucleus, is reciprocally connected to the motor cortex and the globus pallidus [21, 22, 32]. At the same time these areas receive input from the contralateral cerebellum by the way of the brachium conjunctivum and from the red nucleus. The remainder of the ventroposterior complex is the principal sensory relay connecting sensory information to the parietal area. Sensory representation in the ventroposterior nucleus is somatotopically organized with the lower extremities represented laterally, and the upper extremities and the head medially. The medial and lateral geniculate bodies, the main relay stations for auditory and visual information, form the logical continuation of the thalamic nuclear arrangement in that they project to the most posterior areas of the cortex. The pulvinar is finally reciprocally connected to the temporal and parietal association areas. These connections are considered important for language functions [23].

As mentioned, the ventrolateral border of the thalamus consists of critical structures which need to be spared by all means during surgery. Laterally the posterior end of the internal capsule forms the boundary. The internal capsule lies underneath the caudate nucleus. The groove between the thalamus and the caudate, which also carries the terminal vein, marks quite reliably the position of the internal capsule. This landmark is still useful in case of considerable displacement by large tumor masses. At the ventral border of the thalamus, the adjacent midbrain structures are critical. At the oral end of the medial longitudinal fascicle, the interstitial nucleus of Cajal and the rostral interstitial nucleus are the supranuclear centers for gaze control. The interstitial nucleus of Cajal projects to the contralateral oculomotor nucleus through the posterior commissure [29]. Damage of the posterior commissure by tumor compression or surgical injury interferes with this pathway thus causing Parinaud's syndrome. Within the lateral aspects of the posterior commissure, the olivary nucleus is situated acting as a relay for the pupillary light reflex [29]. The level of the posterior commissure needs to be respected as ventral limit of resection. More anteriorly the level of the interthalamic adhesion should not be transgressed into the ventral direction unless when resecting solid tumor mass.

There are several nerve fiber bands involved in memory circuits that are in close topographical relationship. The first is the crus fornicis covering the thalamus. This structure is at risk with transventricular approaches to the thalamus. The other structures are the central diencephalic fiber tracts, e.g. mamillothalamic tract, and the tractus retroflexus (Meinert).

Surgical Approaches and Methods

For small tumors arising from the pulvinar or the habenula a modification of the infratentorial supracerebellar approach was chosen. In order to center the pulvinar within the limited field of access between the two basal veins of Rosenthal, a paramedian approach from the contralateral side was developed (Fig. 2). For more extensive tumors exceeding the limit of the pulvinar laterally, a parieto-occipital transcortical transventricular approach was used (Fig. 3). A small corticotomy was placed approximately 8 cm above the inion and 4 cm paramedially. A neuronavigator (Vectovision, Brainlab, Heimstetten, Germany) was used for targeting the transventricular approach. With the transventricular approach the crus fornicis and the choroid plexus overlying the tumor usually had to be removed in order to gain access to the lesion. As it

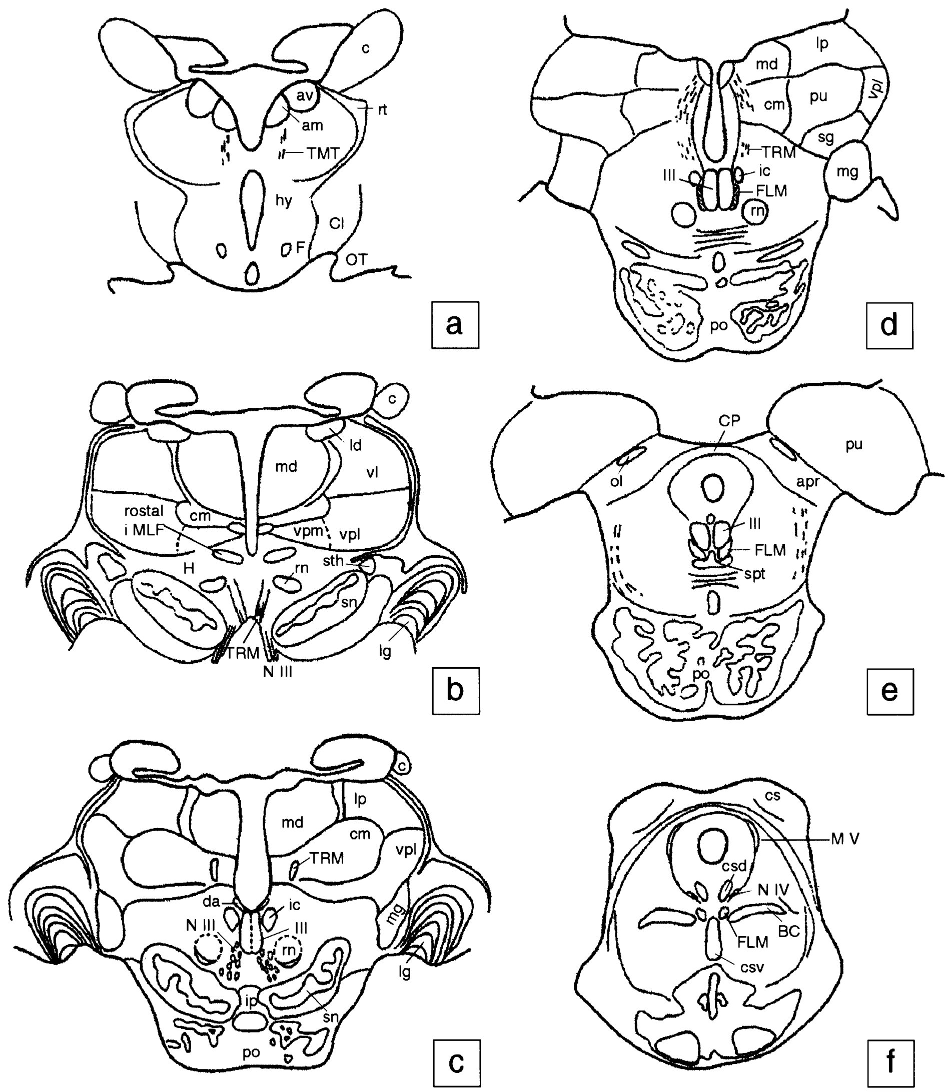

Fig. 1. Anatomical relations of thalamic nuclei and adjacent structures. a to f): coronal sections from rostral to caudal. The critical subthalamic structures lie below the aqueduct and the third ventricle, respectively. The posterior commissure and the pretectal area are also critical for consciousness and gaze control. Laterally the internal capsule situated below the caudate nucleus limits surgical resection. *am* Nucleus anterior medialis thalami; *apr* area praetectalis; *av* nucleus anterior ventralis thalami; *BC* brachium conjunctivum; *c* nucleus caudatus; *CI* capsula interna; *cm* centrum medianum; *CP* commissura posterior; *csd* nucleus centralis superior, pars dorsalis; *csv* nucleus centralis superior, pars ventralis; *da* nucleus Darkschewitsch; *F* fornix; *FLM* fasciculus longitudinalis medialis; *H* campus Foreli; *hy* hypothalamus; *ic* nucleus interstitialis (Cajal); *ip* nucleus interpeduncularis; *ld* nucleus lateralis dorsalis thalami; *lg* corpus geniculatum laterale; *lp* nucleus lateralis posterior thalami; *md* nucleus medialis dorsalis thalami; *mg* corpus geniculatum mediale; *MV* tractus mesencephalicus trigemini; *N III* nervus oculomotorius; *N IV* nervus trochlearis; *ol* nucleus praetectalis olivaris; *OT* tractus opticus; *po* griseum pontis; *pu* nucleus pulvinaris; *rn* nucleus ruber; *rostral iMLF* rostral interstitial nucleus of the medial longitudinal fascicle; *rt* nucleus reticularis thalami; *sg* nucleus suprageniculatus thalami; *sn* substantia nigra; *spt* nucleus supratrochlearis; *sth* nucleus subthalamicus (Luysi); *TMT* tractus mamillo-thalamicus; *TRM* tractus retroflexus (Meynert); *vl* nucleus ventralis lateralis thalami; *vpl* nucleus ventralis posterior lateralis; *vpm* nucleus ventralis posterior medialis thalami; *III* nucleus oculomotorius

turned out, the crus fornicis most often had already been destroyed and infiltrated by the larger tumors.

Electrophysiological monitoring was used routinely and tailored according to the specific needs. For larger tumors approached via the lateral ventricle, somatosensory and acoustic evoked potentials were recorded while for smaller medial tumors approached by the infratentorial route, eye muscle EMG was monitored to allow functional control of the oculomotor system.

Since 1997 resection of malignant gliomas has been supported by 5-aminolevulinic acid fluorescence [30]. A special operating microscope equipped with an ul-

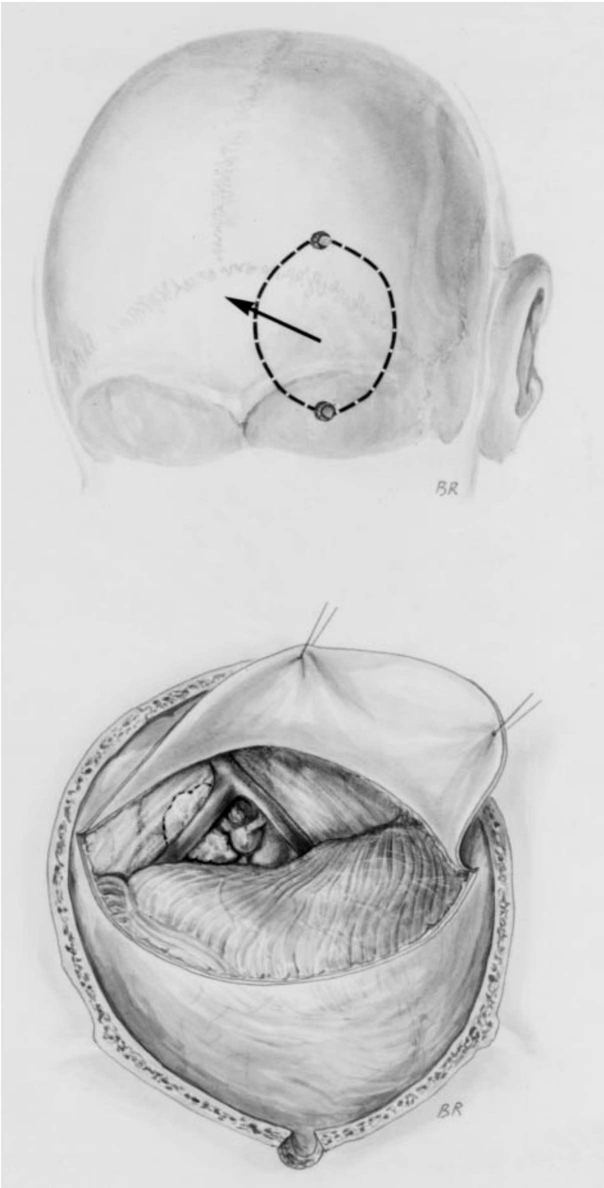

Fig. 2. Artist's view of the contralateral infratentorial supracerebellar approach to a partially exophytic tumor of the pulvinar thalami. With the contralateral approach the medial aspect of the pulvinar is within the center of the surgical field between the veins of Rosenthal. The pineal gland usually needs to be removed to gain access to the pulvinar

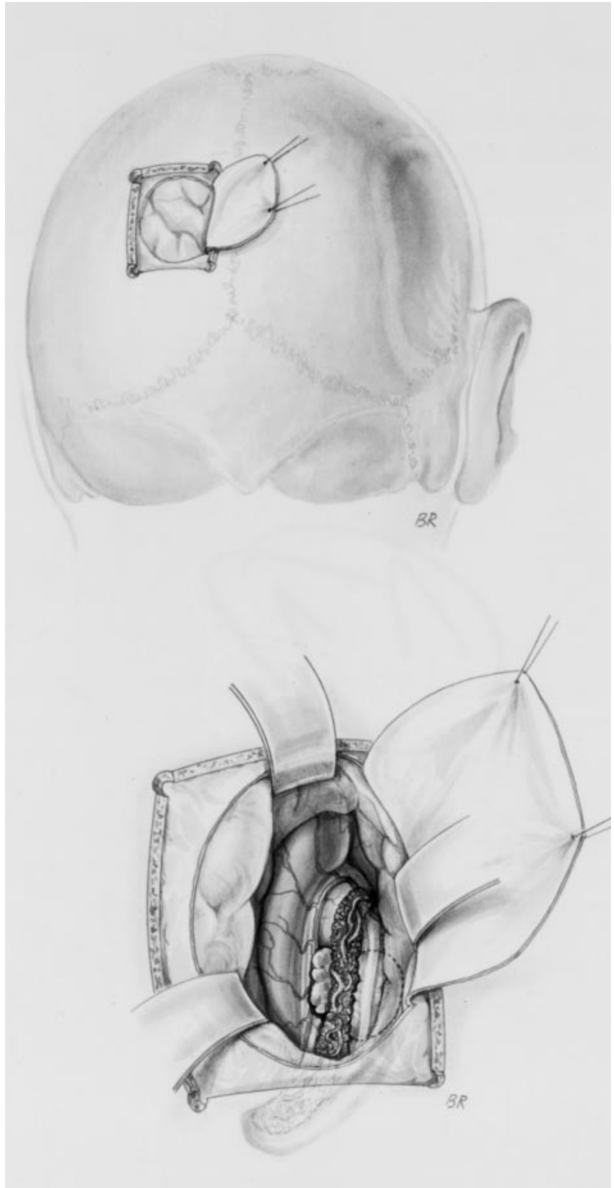

Fig. 3. Artist's view of the parieto-occipital transventricular approach. The crus fornicis lies medial to the choroid plexus. The crus fornicis is commonly infiltrated or thinned out by bulging exophytic tumors. The terminal (thalamo-striate) vein identifies the lateral border of the thalamus and the posterior limb of the internal capsule

traviolet light source allows identification of tumor tissue by its red fluorescence.

Postoperatively, control MRI was routinely performed within 48 hours.

Summary of Cases and Results

The key data of the 14 patients and the treatment results are summarized in Table 1. The age of the 9 female and 5 male patients ranged between 4 and 64 years with an average of 30 years. The tumor diameters ranged from 2 to 5 cm. Four tumors were approached via the supracerebellar infratentorial (Fig. 4) and 10 through the posterior transventricular route (Fig. 5). Histological diagnosis was pilocytic astrocytoma in 3 cases, astrocytoma grade 2 in 1, astrocytoma grade 3 in 7, and glioblastoma in 3 cases.

Postoperatively a new partial hemianopia was noticed in 2 patients operated on via the posterior transventricular approach (cases 3 and 7). Decompensating hydrocephalus needed shunt treatment during the early postoperative period in 4 patients. Pre-existing

Table 1. *Case Summaries*

	Patient ID	Age	Side	Tumor ∅	Histology	Approach and % removal	Postoperative complications	Events during follow-up	Follow-up time
1.	GH	4 ys	right	4.5 cm	pilocytic astrocytoma	transventricular 100%	–	–	52 months
2.	HH	6 ys	right	4 cm	anaplastic astrocytoma	infratentorial 80%	hydrocephalus, VP-shunt	–	16 months
3.	NA	25 ys	left	3.5 cm	astrocytoma II	transventricular 90%	partial hemianopia	–	10 months
4.	KG	54 ys	left	4 cm	glioblastoma	transventricular 70%	–	progression, death at 4 months	–
5.	KC	30 ys	right	5 cm	pilocytic astrocytoma	transventricular 90%	–	–	21 months
6.	AS	16 ys	left	3 cm	pilocytic astrocytoma	transventricular 100%	hydrocephalus, VP-shunt, transient disturbed consciousness	–	34 months
7.	SJ	30 ys	left	5 cm	glioblastoma	transventricular 95%	partial hemianopia	–	6 months
8.	HF	48 ys	right	4 cm	anaplastic astrocytoma	transventricular 70%	–	progression, hydrocephalus, shunt	14 months
9.	SM	32 ys	right	3.5 cm	anaplastic astrocytoma	transventricular 70%	hydrocephalus, VP-shunt	progression	25 months
10.	ID	31 ys	right	2.5 cm	anaplastic astrocytoma	infratentorial 100%	hydrocephalus, VP-shunt	–	15 months
11.	HI	9 ys	left	5 cm	anaplastic astrocytoma	transventricular 95%	–	progression	16 months
12.	RS	64 ys	left	2 cm	anaplastic astrocytoma	infratentorial 100%	–	progression	10 months
13.	DZ	10 ys	right	2 cm	anaplastic astrocytoma	infratentorial 100%	–	progression, hydrocephalus, death at 22 months	22 months
14.	IT	51 ys	right	5 cm	glioblastoma	transventricular 90%	–	–	10 months

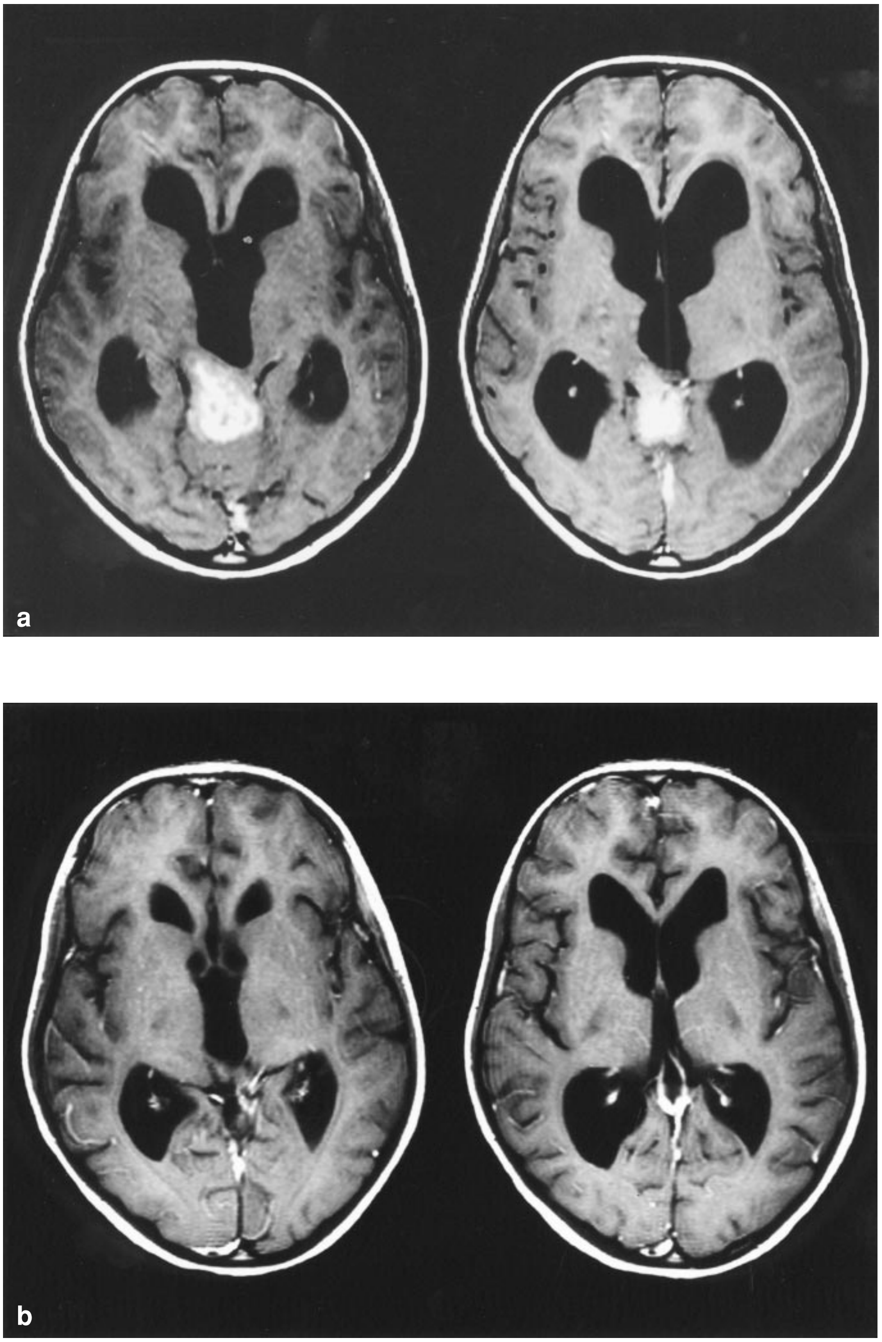

Fig. 4. Pre- and postoperative MRI of a 2 cm measuring anaplastic astrocytoma of the right pulvinar thalami in a 10-year old girl (case 13). (a) The preoperative contrast study shows an exophytic, contrast enhancing tumor originating from the habenular insertion. (b) Postoperative contrast MRI showing complete removal of the tumor after an infratentorial supracerebellar approach

hemiparesis worsened after surgery in 1 patient (case 14). Aphasia or frank memory disturbances did not occur.

Malignant tumors were postoperatively treated with ancillary radiotherapy using 60 Gray tumor dose. In 6 of the 10 patients harboring high grade tumors, progression was documented during the follow-up time of 6 to 52 months. At that time various regimen of ancillary chemotherapy were instituted. So far 2 of the high grade tumors have progressed to death (cases 4 and 13).

In addition to the four patients needing shunt treatment during the early postoperative period, two further patients needed ventricular shunting procedures after documented tumor progression (cases 8, 13) during follow-up.

Illustrative Case Report (Case 7)

This 30-year old female immigrant from former Yugoslavia was admitted with a 3-week history of nausea, vomiting and vertigo. According to a neurological examination there were no focal deficits

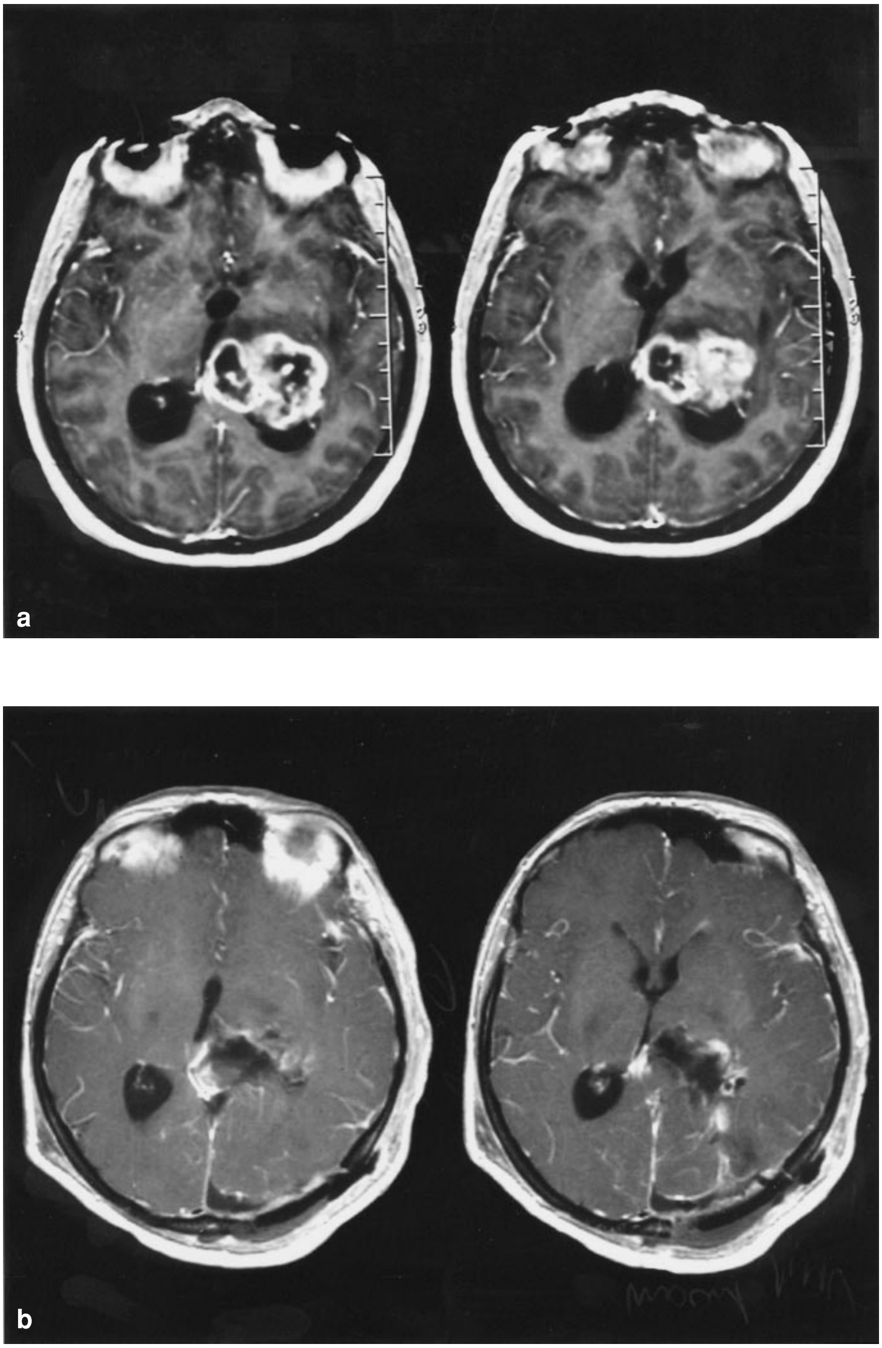

Fig. 5. Pre- and postoperative MRIs of a 5 cm left thalamic glioblastoma in a 30-year old female patient (case 7). (a) Preoperative axial contrast study showing a large centrally necrotic tumor mass with anterolateral displacement of the internal capsule. The lateral ventricles are slightly dilated. (b) Postoperative contrast image showing almost complete tumor removal by transventricular approach and normalization of ventricular size. This patient had a new partial hemianopia after surgery

of cranial nerves or extremities. MRI showed an approximately 5 cm centrally necrotic tumor originating from the left pulvinar thalami whith considerable displacement of the posterior end of the internal capsule into the anterolateral direction (Fig. 5). There was moderate perifocal edema. Some enlargement of the supratentorial ventricular system was noticed.

Stereotactic biopsy was performed and provided the histological diagnosis of glioblastoma. A multimodal treatment including surgical tumor reduction was recommended to the patient. The tumor was approached by the parieto-occipital transventricular route. The neuronavigation system was used for planning the procedure as described before. Electrophysiological monitoring was set up for surveillance of somatosensory evoked potentials. With the patient in a prone position, a 4×4 cm sized craniotomy centered 7.5 cm above the inion and 4 cm paramedially was fashioned. The trigone of the lateral ventricle was approached and opened using the neuronavigation system. The bulging superior aspect of the tumor was readily identified. The overlying crus fornicis appeared to be largely destroyed by the infiltrating tumor. After initial debulking of the tumor with an ultrasonic aspirator, 5-aminolevulinic acid fluorescence was used as a guide [30]. In preparation for this instrument 5-aminolevulinic acid at a dose of 20 mg/kg body weight had been given to the patient 4 hours prior to induction of general anesthesia. A special ultraviolet light source integrated in the surgical microscope allowed for identification of malignant astrocytic tumor tissue by a characteristic red fluorescence. Removal of the solid tumor mass resulted in opening the lateral wall of the third ventricle. Resection was limited laterally at the thalamo-striate vein and ventrally at the level of the posterior commissure and the interthalamic adhesion. At the end of resection no solid tumor fluorescence could be identified any more. However, light fluorescence indicating tumor infiltration persisted toward the posterior limb of the internal capsule.

The postoperative course was uneventful except for a new partial hemianopia. There were no memory disturbances or aphasic deficits. Postoperative control MRI at 48 hours confirmed the essentially complete removal of the enhancing tumor (Fig. 5). The preoperative hydrocephalus had normalized by that time. Ancillary radiotherapy using 60 Gy tumor dose was added to the postoperative regimen. No tumor recurrence/progression has been noticed so far during the follow-up time of 6 months.

Discussion

Indications for Surgical Removal of Thalamic Gliomas

Thalamic astrocytomas together with basal ganglia astrocytomas are usually considered within the group of deep-seated tumors. The literature with regard to surgical treatment of deep-seated infiltrative astrocytomas is limited. The group of Kelly developed the concept of computer-assisted volumetric resection [14, 17]. They strongly suggested aggressive surgical removal of deep-seated astrocytic tumors. They also point out that these tumors grow and that the mass effect finally leads to deterioration of the neurological condition. A similar philosophy was adopted by Drake and coworkers, who used a combination of a stereotactic system and a Puma 200 robot to volumetrically remove deep-seated astrocytomas in a small series of pedriatric patients [7]. Radical excision was carried out in all six reported patients with minimal morbidity and no mortality. Nonetheless, these authors emphasized the limitation of stereotactically guided volumetric resection caused by the brain shift during the course of surgery.

Analyzing the natural history of 70 patients with low grade astrocytoma of the basal ganglia and the thalamus after histological diagnosis obtained by serial stereotactic biopsy, Franzini and co-authors reported that 43% of their patients had died within 3 years after diagnosis [9]. Based on their data, these authors also suggested a more aggressive cytoreductive treatment in deep brain tumors as strategy for the future. The only results which allow some statistical conclusions with regard to the outcome after resection of thalamic astrocytomas come from the analysis of Krouwer and Prados [15]. These authors reported on 57 patients with infiltrative thalamic astrocytomas analyzed retrospectively. 20 patients underwent stereotactic biopsy and 23 patients were submitted to an open procedure with extended biopsy or subtotal resection. The ancillary therapy consisted of conventional radiotherapy, combined with adjuvant chemotherapy in some patients. Among the prognostic factors for a favorable outcome, histological diagnosis of low grade astrocytoma, age under 18 years, and an open surgical procedure could be identified with statistical significance. The median survival time of the entire collection was 73 weeks. The benefit of radiotherapy could not be shown with statistical significance. The value of radiotherapy is controversially discussed by other authors [4, 10, 11, 24]. Based on these data it appears likely that surgical tumor reduction provides some benefit for deep-seated astrocytomas which can be approached and removed with a small risk as defined by the adjacent functional structures. As outlined in the introduction, the thalamus certainly has a special position among the deep-seated ganglia since the critical border zone consists only of the ventrolateral border of the thalamus, while the posterior, the medial, and the superior aspects of the thalamus are essentially free surfaces, not touching critical structures. This exquisite position predisposes the thalamus for surgical removal of intrinsic tumors.

Approaches and Correlative Anatomy

In this series we have used either the parieto-occipital transcortical transventricular approach or an infratentorial supracerebellar route from the contralateral side. In general the infratentorial way of access is less invasive because it is completely extra-axial. However, the window between the two basal veins of Rosenthal is limited, and processes with a lateral extent to more than approximately 1 cm from the midline cannot be removed by this route. Thus this approach, which is a modification of the common approach used for tumors of the pineal region, is sufficient for small tumors originating from the habenula or the medial aspect of the pulvinar thalami. The pineal gland usually needs to be removed, which apparently does not have any negative consequences.

For tumors extending more laterally, a parieto-occipital transventricular approach was chosen in the present series. In our opinion, the parieto-occipital transventricular approach is the most suitable of all transventricular ways of access, and we consider it superior to an anterior transfrontal transventricular or a transcallosal approach. However, there are some problems even with the posterior transventricular route caused by the adjacent optic radiation and the crus fornicis covering the thalamus. In the present series two patients suffered an additional visual field deficit after the posterior transventricular approach. The crus fornicis on the affected side was uniformly more or less displaced, thinned out or infiltrated by the tumor growth. The crus fornicis was not even identifiable consistently. However, there were no apparent memory deficits in any instance.

During tumor removal, orientation with regard to the ventrolateral critical structures was maintained primarily based on anatomical landmarks. The terminal (thalamo-striate) vein was respected strictly as an anterolateral border for resection except when removing solid tumor. With regard to the ventral extent, the plane of the posterior commissure and the interthalamic adhesion was not transgressed except in cases of obvious solid tumor. In our opinion this plane serves as a useful limit to prevent danger to the subthalamic critical structures.

Morbidity and Mortality of Thalamic Microsurgery

In the present series we did not have any mortality. One patient recovered slowly with a decreased level of consciousness lasting for 7 days following surgery. In two instances as mentioned before, incomplete hemianopia resulted from the posterior transventricular approach. Pre-existing hemiparesis worsened in one patient. In no case were new aphasia, hemiparesis or gaze palsies seen. This experience corresponds to the report of Drake and co-workers who stated a minimal morbidity in their small series [7]. They reported transient disphasia in one patient. Aphasic problems are certainly a risk with thalamic operations on the dominant side. This problem is also known from thalamotomies for movement disorders [23]. However, these disturbances appear to be quite rare and usually transient. The most likely source for speech disturbances is the pulvinar since it represents the site of the neurons projecting to the peri-sylvian language centers.

Disturbances of the state of consciousness and frontal like syndromes are known to occur with ischemic lesions of the anterior and central thalamic nuclei [5, 12, 33]. Prior to the actual series we had used transfrontal or transcallosal approaches for thalamic lesions. With these modalities we had seen several instances of such frontal like syndromes, and it appears likely that damage to the anterior and central nuclei of the thalamus was responsible. With the currently favored posterior approaches such deficits seem to be less of a problem.

Long-Term Outcome

The long-term outcome was primarily determined by the histology of the infiltrating tumor. During the follow-up time of 6 to 52 months, progression was noted in 6 of 10 malignant tumors and none for the low grade tumors. Although the series is too small for statistical analysis, these results compare favorably with other reports using less radical treatment [4, 9, 15, 26]. However, it appears noteworthy that a considerable proportion of our patients finally needed a ventriculoperitoneal shunt for hydrocephalus. Therefore it must be concluded that our surgical management was not constantly sufficient to guarantee a normal CSF circulation. In the future some efforts will certainly be required to establish an enduring connection between the third and the fourth ventricle.

Conclusions

The present preliminary results indicate that thalamic gliomas can be surgically removed with an acceptable risk. The particular anatomical situation of the thalamus suggests that the long-term benefit might be comparable to surgery for cortical gliomas.

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Comments

The authors should be commended for presenting a very useful subject of microsurgical treatment of malignant intra-axial deep-seated tumors. It is a real relief for me personally, because, throughout the last 20 years, I have been doing the maximum microsurgical removal of all kinds of intra-axial tumors. Constantly I was criticized on the grounds that this kind of surgery of deep-seated intra-axial tumors is the wrong approach. It is well known that stereotactic biopsy was very much in favor, in combination with the complementary radio- and chemotherapy. The microsurgical resection of the intra-axial deep-seated tumorous lesions was considered as old fashioned, even useless treatment with which the patient is exposed to additional dangerous conditions. In my opinion, an open microsurgical approach to these lesions does offer much more than just biopsy. Subtotal tumor removal provides enough tumorous material for histological studies and good control of hemorrhage. The complementary treatment can then be appropriate and more efficient.

The authors have presented a very detailed and absolutely necessary description of the anatomical details of which one should be aware while tacking these kind of deep-seated lesions. Neuronavigation can be very useful, especially in small lesions, but is not absolutely necessary in larger lesions. Very helpful also is the use of the fluorescence effect for identification of malignant cells at the border of the tumor. It is clear that we cannot be 100% radical in malignant tumors; however, in pylocitic astrocytoma, for instance, complete excision is possible. The main aim is to remove the large bulk of the malignant tumor as well. The figs 4a and 4b, as well as 5a and 5b, are very convincing evidence of the usefulness of this kind of treatment. However, the reader would appreciate it even more if these two sets of images were further completed by the sagittal (in particular) and the coronal planes.

Personally, I am reluctant to approach these tumors transcortically, where there may possibly be a different approach (interhemispheric). The retraction of the occipital lobe in a medial direction is more dangerous than retraction from the medial to the lateral direction. In my personal series (several hundreds of these tumors), I have always used the sitting or semisitting position and interhemispheric occipital approach (for these lesions). In none of those cases on either side were there any additional postoperative visual defects. For smaller tumors, as presented in fig 4a, the occipital supratentorial transtentorial approach may be used (in most of our cases) and good exposure of all the veins entering the vein of Galen is possible; all these veins should be preserved – including the vermian veins, which are usually sacrificed while using the suboccipital infratentorial supracerebellar approach. What is most important in direct microsurgical removal of these kinds of tumor is to remove the bulk of the tumor and not to exaggerate "the completeness" of the resection of the tumorous lesions, at the frontiers of the lesion; this will help to preserve the vascularisation of the surrounding brain tissue and avoid damage to (equally important) the draining veins. If one adheres to these guidelines one can operate also without having all the sophisticated monitoring equipment, which is welcome, but not absolutely indispensable, except in very few cases – e.g. when dealing with the lesions in the vicinity of the brainstem or in the brainstem proper. My sincere belief is that in future the microsurgical treatment of malignant intra-axial tumors will regain the appropriate value among the modalities of treatment of these fatal lesions of the central nervous system.

V. Dolenc

Steiger *et al.* present their experience with the surgical removal of 14 thalamic tumors. The authors indicate that they were able to achieve 80–100% resection in the majority of their cases, however, the methodology used in assessing post-operative extent of resection data scoms unclear. The illustrated case presented in figures 4A and 4B, based on the axial images provided, appears more likely to be a pineal region tumor rather than a thalamic one.

Thalamic gliomas represent a distinct anatomic and clinical entity. Their morphologic characteristics just like other gliomas, as previously described by the senior commentator (Prof. M. G. Yasargil), are based on compartmentally segmental confinement, circumscribed borders, expansive compression rather than infiltrative spread. In the experience of the senior commentator, in the surgical resection of thalamic gliomas ($n = 49$), all cases underwent radical removal. The majority of these patients (51%) had a good outcome, and their condition mostly improved after surgery enabling them to live independent lives (58%). There were no surgical mortalities (illustrated cases 18.2, 18.3, 18.6 in Ref 1) [1].

Yasargil – Abdulrauf

Reference

1. Yasargil MG (1996) Microneurosurgery, volume 4B. Microneurosurgery of CNS tumors. George Thieme Verlag, Stuttgart, pp 299–307

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