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Surgical treatment and prognosis of adult patients with brainstem gliomas

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ABSTRACT

The paper presents 47 adult patients who were surgically treated due to brainstem gliomas. Thirteen patients presented with contrast-enhancing Grades III and IV gliomas, according to the WHO classification, 13 patients with contrast-enhancing tumours originating from the glial cells (Grade I; WHO classification), 9 patients with diffuse gliomas, 5 patients with tectal brainstem gliomas and 7 patients with exophytic brainstem gliomas. During the surgical procedure, neuronavigation and the diffusion tensor tractography (DTI) of the corticospinal tract were used with the examination of motor evoked potentials (MEPs) and somatosensory evoked potentials (SSEPs) with direct stimulation of the fundus of the fourth brain ventricle in order to define the localization of the nuclei of nerves VII, IX, X and XII. Cerebellar dysfunction, damage to cranial nerves and dysphagia were the most frequent postoperative sequelae which were also the most difficult to resolve. The Karnofsky score established preoperatively and the extent of tumour resection were the factors affecting the prognosis. The mean time of progression-free survival (14 months) and the mean survival time after surgery (20 months) were the shortest for malignant brainstem gliomas. In the group with tectal brainstem gliomas, no cases of progression were found and none of the patients died during the follow-up. Some patients were professionally active. Partial resection of diffuse brainstem gliomas did not prolong the mean survival above 5 years. However, some patients survived over 5 years in good condition.

1. Introduction

Brainstem gliomas account for only 1–2% of all adult gliomas and are characterized by poor prognosis. In particular, unfavourable prognosis is related to patients with enhancing high-Grades III and IV gliomas (WHO classification) and diffuse brainstem gliomas. However, in the latter group the prognosis is better than in children [1–3]. A 5-year survival was reported in 58% of adult patients with diffuse brainstem gliomas, which

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is significantly longer than in children [1–3]. Good prognosis is expected after surgical intervention in patients with focal and exophytic tumours [4–9].

Diagnosis of brainstem gliomas was based on the characteristic MRI features [7,8,10–13]. Another significant factor is the use of neuronavigation to determine tumour location and the localization of the corticospinal tract within the neuronavigation system based on the diffusion tensor tractography (DTI) examination. The use of corticospinal tract tractography decreases the frequency of postoperative limb paresis [14]. Frequency of limb paresis is also decreased due to the examination of motor evoked potentials (MEPs) with transcranial electrical stimulation (TES) of the brain [14–16]. The direct electrical stimulation (DES) of cerebral peduncles in tumours of the ventral part of the midbrain or the pyramids of the medulla oblongata enables us to find the corticospinal tract. From the practical point of view, it is vital to localize the nuclei of cranial nerves VII, IX, X and XII on the basis of DES of the fundus of the fourth brain ventricle during the surgical procedure [15].

The aim of the present study is the analysis of surgical treatment results in adult patients with brainstem gliomas. Attention was paid to the following questions:

- what affects the prognosis of these patients;
- what are the benefits of surgical treatment;
- what is the frequency of serious postoperative sequelae and what is their tendency to resolve;
- whether the prognosis depends on tumour location or histological findings;
- whether patients with diffuse brainstem gliomas should undergo surgery;
- what radiological and electrophysiological examinations should be used during surgery to obtain the best surgical outcome.
- Experience of other surgeons in this respect is of great importance. They presented surgical treatment results of brainstem gliomas and discussed significant prognostic factors [2,7,8,14–17,20–24,26–28,30,32].

2. Clinical material and methods

Forty seven patients underwent surgery for brainstem gliomas between 1998 and 2014. 26 of the patients were female and 21 were male (age range 18–74 years; mean age 38.7 years). The follow-up period ranged from 3 months to 16 years (mean follow-up 4.04 years). Table 1 presents surgically treated types of brainstem glioma. The classification was based on the division presented by Botero [17] with some modifications by the authors of this paper.

As it is shown in Table 1, patients with contrast-enhancing malignant and non-malignant brainstem gliomas constituted the largest group ($n = 26$). Nine patients presented with diffuse brainstem gliomas, 7 patients with exophytic brainstem gliomas and 5 patients with focal tectal brainstem gliomas.

Head MRI with PWI, DWI, DTI, 1 HMRS was performed. All the surgical procedures were performed with the use of the neuronavigation system, which was applied to determine tumour location and the course of the corticospinal tract (DTI tractography). In order to preserve the continuity of the corticospinal tract, MEP recording obtained with transcranial electrical stimulation (TES) was used. The localization of the nuclei of nerves VII, IX, X and XII within the fundus of the fourth ventricle was established by DES. Somatosensory evoked potentials (SSEPs) were monitored.

Table 1 – MRI-based radiological classification of brainstem gliomas.

	Cases	
	No	%
1. Adult diffuse intrinsic low-grade brainstem gliomas	9	19
2. Contrast-enhancing malignant brainstem glioma	13	28
3. Contrast-enhancing non-malignant intrinsic glioma	13	28
4. Focal tectal brainstem gliomas	5	11
5. Exophytic brainstem gliomas	7	14
Total	47	100

The extent of resection was confirmed by contrast-enhanced MRI performed within one month after the surgical procedure. The extent of resection was defined either as a gross total resection (when in the follow-up contrast MRI the removal of over 80% of tumour mass was confirmed) or as a partial resection (resection of less than 80% of the baseline tumour mass) [18]. The choice of the surgical approach was determined by tumour location and the result of the course of the corticospinal tract as measured by DTI.

The following surgical approaches were used to remove the brainstem lesions: suboccipital – 22 (47%); subtonsilar telovelar – 8 (17%); far-lateral – 4 (6%); infratentorial, supracerebellar – 4 (6%); retrosigmoid – 4 (6%); temporal-posterior – 3 (5%); subtemporal, transtentorial – 1 (4%); paramedian supracerebellar – 1 (4%). The surgical approach related to surgical treatment of brainstem gliomas was previously described in our paper in 2005 [19].

After the surgical procedure, patients were transferred to the Intensive Care Unit. Two outcome measures were assessed: (1) progression-free survival (PFS), defined as the time from surgery to the increase in tumour size on follow-up FLAIR imaging and/or demonstration of gadolinium enhancement on follow-up imaging or malignant degeneration; (2) overall survival (OS), defined as the time between initial surgery and death.

3. Methodology of statistical analysis

Statistical analysis was performed using STATISTICA 10 software. Survival probability (OS, PFS) was calculated using the Kaplan–Meier method. Differences between the courses of the curves of the impact of the analyzed variables on survival time (OS, PFS) were compared by the log-rank test and the equivalent to the log-rank test for variables with many categories (more than 2).

4. Results

The following were the symptoms reported by patients on admission to the Department of Neurosurgery: instability of

gait – 36 subjects (77%); sensory disturbances – 16 (33%); headache – 15 (31%); visual disturbances – 12 (25%); limb weakness – 12 (25%); vertigo – 10 (21%) and dysphagia – 8 (16%).

At 3 months postoperatively patients complained of gait disturbances – 15 subjects (32%); diplopia – 10 (21%); sensory disturbances – 9 (19%); visual disturbances – 8 (17%); headache – 6 (13%); limb weakness – 6 (13%) and dysphagia – 4 (8%).

On admission, neurological examination revealed the following neurological deficits: gait disorders – 31 (66%); decreased cerebellar function – 24 (51%); hemiparesis – 12 (25%) and cranial nerve palsy – 10 (21%).

Based on the presented data, on admission patients mostly complained of gait disorders, impairment of superficial sensation in the trunk and limbs, headache and vertigo. Decreased muscular strength of the limbs and dysphagia were frequently observed.

At 3 months postoperatively, headache frequently resolved and vertigo was less common. Dysphagia resolved and the improvement in limb movement was observed.

In patients who underwent surgery for brainstem gliomas, some new neurological deficits were observed postoperatively and some symptoms exacerbated compared to their preoperative status. These complications are listed in Table 2. They were compared with those during the last follow-up.

The most frequent postoperative sequelae were ataxia in the lower or upper limbs and balance disorders (60%). These disorders showed no tendency to resolve in comparison with the last follow-up (55%). A relatively frequent postoperative sequela was the damage to cranial nerves, in particular nerves III, IV, VII, IX and X (40%). Postoperative dysfunction of the cranial nerves did not show a tendency to resolve (45%). However, in 2 patients we observed the resolution of eyelid ptosis after brainstem surgery [14]. In 36% subjects, hemiparesis occurred. Moreover it showed a tendency to resolve over time (19%). Dysphagia is a dangerous complication related to surgical treatment of gliomas of the medulla oblongata (26%). These patients required gastric tube feeding and intravenous hydration. These symptoms resolved in half of the patients (13%). Two patients failed to breathe spontaneously and, as a result, were artificially ventilated for several weeks. In all patients, spontaneous breathing returned. Also pulmonary oedema, observed in 3 patients, resolved. Postoperative mortality was 4.2%. Pulmonary embolism was the cause of death of 1 patient despite antithrombotic treatment. Another patient was in bad condition after the surgical procedure due to cardiopulmonary insufficiency and died after 2 months.

Histological examination confirmed the following types of brain glioma: pilocytic astrocytoma – 17 (36.2); anaplastic astrocytoma – 11 (23.4%); astrocytoma: fibrillary, protoplasmic, gemistocytic – 11 (23.4%); multiform glioblastoma – 2 (4.3%); ependymoma – 3 (6.4%); oligodendroglioma – 1 (2.1%); subependymoma – 1 (2.1%); ganglioglioma – 1 (2.1%).

The characteristics of patient groups is presented below.

4.1. *Adult diffuse intrinsic low-grade brainstem gliomas (n = 9)*

Nine patients with diffuse brainstem gliomas underwent surgery in accordance with the criteria specified by Botero [17]. The majority of patients were below 40 years of age. The pons was the most common tumour location (67%). Histological assessment of all tumours confirmed low-grade gliomas (Grade II; WHO classification). MRI examination revealed that tumours did not enhance after contrast administration. Tumour resection was partial in the majority of cases (89%). Tumour progression defined as an increase in tumour volume was observed in 67% patients. According to the Glasgow Outcome Scale, mortality was confirmed in 4 (45%) patients, severe disability in 3 (33%), whereas moderate disability in 2 (23%).

4.2. *Contrast-enhancing intrinsic malignant glioma (n = 13)*

Thirteen subjects with contrast-enhanced malignant brainstem gliomas underwent surgery. In the majority of cases, patients were over 40 years of age (79%). Tumours were most frequently located in the pons. Gross total resection was performed in 15%, whereas in 85% of the patients partial resection was done. Histological diagnosis revealed anaplastic astrocytoma in 85% and multiform glioblastoma in 15% cases. In the follow up period 8 (61%) of the patients died and progression was observed in 9 (69%) subjects.

4.3. *Contrast-enhancing non-malignant intrinsic glioma (n = 13)*

Thirteen patients presented with contrast-enhanced non-malignant brainstem gliomas. These tumours were most frequently located in the midbrain (38%) and in the medulla oblongata (38%). Histological assessment most often revealed pilocytic astrocytoma (92%). Gross total resection was performed in 5 patients (38%), whereas partial resection was done in 8 patients (62%). Four patients underwent revision surgery, of whom 3 had delayed total resection. In the follow-up period, 3 patients died (23%), and progression was observed in 5 subjects (38%).

The case of a patient with pilocytic astrocytoma located in the pons and the midbrain pre- and postoperatively is presented below (Fig. 1).

Table 2 – Postoperative sequelae.

	Immediate	During the last follow-up
Decreased cerebellar function	28 (60%)	17/31 (55%)
Cranial nerve palsy	19 (40%)	14/31 (45%)
Hemiparesis	17 (36%)	6/31 (19%)
Dysphagia	12 (26%)	4/31 (13%)
Lack of spontaneous breathing	2 (4%)	0
Neurogenic pulmonary oedema	3 (6%)	0

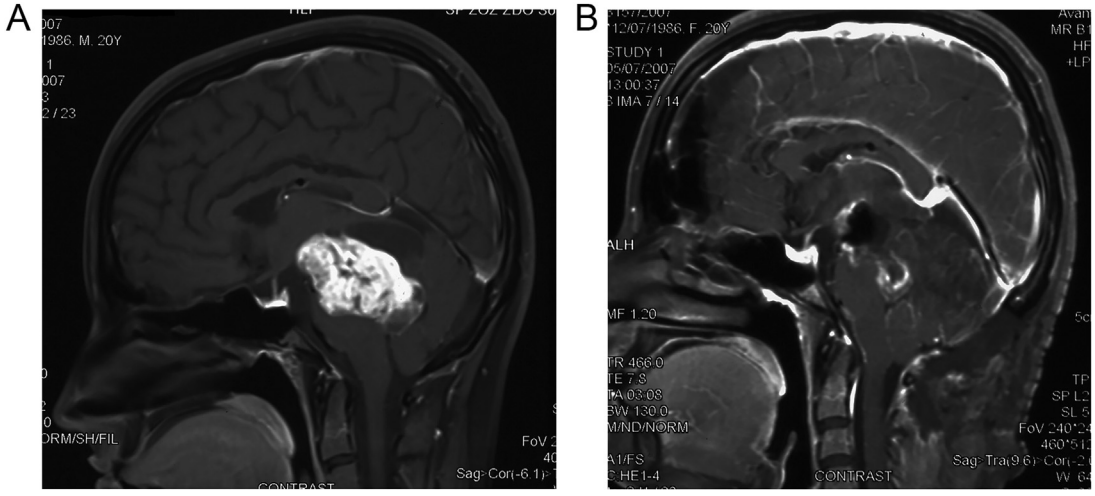

Fig. 1 – (A and B) MRI of a patient with a tumour of the mesencephalon and the pons (sagittal section) before and after surgery. Total tumour resection.

4.4. *Focal tectal brainstem gliomas* (n = 5)

Five patients with focal tectal midbrain gliomas underwent surgery. These were only the cases with an increase in tumour volume or the exacerbation of neurological deficits in the follow-up. Gross total resection was achieved in 60% cases. After the surgery, the majority of patients were in good condition (80%). No tumour progression was observed. However, prognosis of a patient with malignant ependymoma Grade III (WHO criteria) remains uncertain.

4.5. *Exophytic brainstem gliomas* (n = 7)

The patients over 40 constitute the majority of the group. In 6 subjects the tumour was located in the dorsal part and in 1 subject in the ventral part of the medulla oblongata. These tumours enhanced after contrast administration. Total resection was performed in 4 patients (57%). Tumour progression was observed only in 1 subject with anaplastic astrocytoma. This patient died in less than 20 months after the diagnosis of tumour progression. Other patients, even with partial tumour resection, were in good condition or presented with some discrete neurological deficits such as deficits of exteroception and proprioception.

The case of a patient with exophytic brainstem tumour of the anterior part of the medulla oblongata is presented in the figure below (Fig. 2A and B). It is obligatory to use MEPs during surgery because of the vicinity of the corticospinal tract with the tumour.

The analysis of the correlation between the patient age and prognosis was performed. No statistical significance was found. The Table 3 below illustrates this analysis.

Then the prognosis was assessed preoperatively, according to the Karnofsky score (Table 4).

The Table 4 below illustrates this analysis.

The figure illustrating the above correlation is presented below (Fig. 3)

There was a significant difference in survival time among patients with a different Karnofsky score assessed on the day of admission ($p < 0.05$). Patients who had a higher score on admission (i.e., 90 or 100) had the best prognosis.

Then the prognosis was established, depending on the extent of resection (Table 5). The Table 5 illustrates this analysis.

Patient prognosis depended significantly on the extent of tumour resection ($p < 0.05$). The majority of progression cases occurred when partial tumour resection was done.

The Table 6 below illustrates the prognosis established based on the Glasgow Outcome Scale depending on the location and type of brainstem glioma. Due to a small number of cases of midbrain tectal tumour and exophytic tumours, these groups were analyzed together for the purposes of statistical analysis (Table 6).

A statistically significant correlation was observed between the type of the brainstem tumour and the prognosis established based on the Glasgow Outcome Scale ($p < 0.05$). The best prognosis was observed in patients with tectal brainstem tumours and exophytic tumours of the medulla oblongata.

The Table 7 below illustrates the prognosis established based on the Glasgow Outcome Scale depending on the histopathological investigation. Division of gliomas was done according to the WHO classification. Due to a small number of cases Grade III and IV of gliomas were analyzed together for the purposes of statistical analysis.

A statistically significant correlation was observed between the results of histopathological investigation and the prognosis established based on the Glasgow Outcome Scale ($p < 0.05$). In the group of patients with pilocytic astrocytoma and ganglioglioma, the patient condition was most commonly diagnosed as GR + MD. The highest mortality was observed in the group of patients with anaplastic astrocytoma and glioblastoma multiforme.

Table 8 presents patients with postoperative progression.

A statistically significant difference was observed between various groups of patients with respect to PFS ($p < 0.05$). Patients with tectal brainstem tumours had the highest chances of PFS. The shortest mean time to progression was observed in patients with malignant brainstem gliomas.

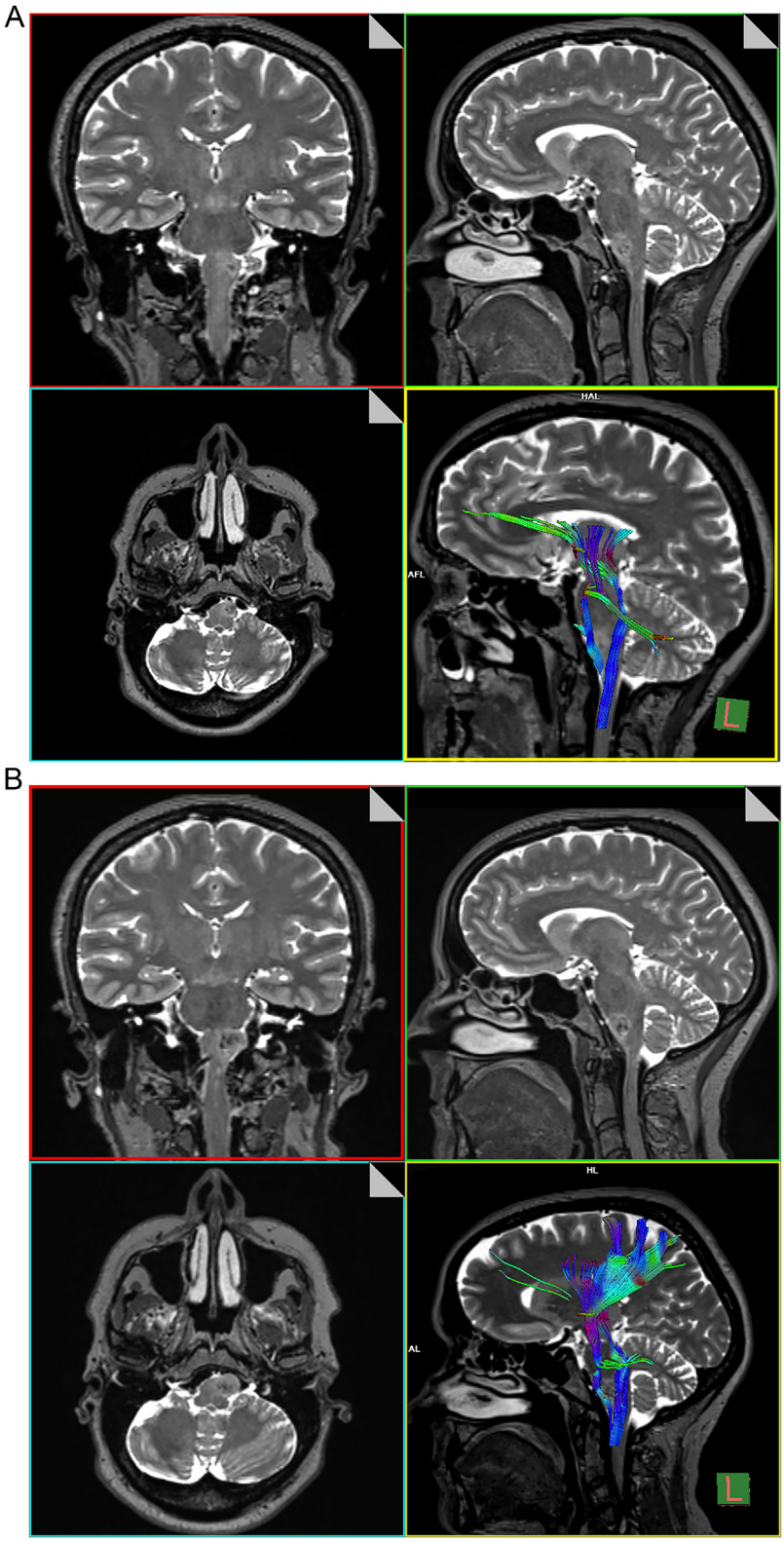

Fig. 2 – (A) Preoperative MRI of a patient with an exophytic tumour of the pyramid of the medulla oblongata (frontal, sagittal and axial sections). (B) Postoperative MRI. Subtotal tumour resection. The corticospinal tract was spared. The patient without limb paresis. Histological investigation revealed pilocytic astrocytoma.

Table 3 – Death rate and age of the patients.

Patient's age	Below 40	Over 40
Number of deaths	9 (56%)	7 (44%)
Number of subjects in observation	24 (51%)	23 (49%)

Table 4 – Survival of patients presenting on admission with different score in Karnofsky performance scale.

Karnofsky score	Mean survival period (months)
60	23
70	48
80	46
90	60
100	80

Fig. 4 presents this correlation.

Also a 5-year postoperative PFS was calculated and it was 48%, which means that fewer than half of all patients will survive without progression (in more than half of the patients, the progression will occur within 5 years after brainstem surgery).

Then the mean postoperative survival time was calculated for patients who underwent surgery due to various types of brainstem gliomas (Table 9).

A statistically significant difference was observed between various groups of patients in respect to the postoperative survival period ($p < 0.05$). Patients with enhancing malignant gliomas (anaplastic astrocytoma, glioblastoma multiforme) had the worst prognosis. The best prognosis was observed in patients with the tectal tumour (mesencephalic tectum).

Fig. 5 presents the graphic illustration of this correlation.

Also a 5-year survival after brainstem surgery was calculated and was 76%, which means that the majority of patients will survive at least 60 months postoperatively.

The quality of life of patients was assessed at 3 months postoperatively. We considered independence of patients in performing everyday activities. As much as 68% of the patients could run independent life. 40% of patients were in good condition or presented with moderate disability. At 12 months postoperatively, we examined whether any of the subjects resumed employment. It was confirmed in 4 of 12 patients with tectal and exophytic gliomas.

5. Discussion

On admission to the Neurosurgery Clinic, the major complaints of surgical patients with brainstem gliomas were related to gait disorders, impaired exteroception, visual disturbances and headaches. These symptoms also occurred in patients with brainstem tumours whose treatment was discussed by other neurosurgeons [3,20–22]. The neurological assessment of such patients revealed most frequently balance and gait disorders, limb ataxia, hemiparesis and the damage to cranial nerves. We also observed the occurrence of alternating neurological symptoms. Reyes–Botero pointed to similar results of the neurological assessment of adult patients with diffuse brainstem tumours [17].

Neurological condition of the patients used to deteriorate after surgery. The worst symptoms included dysphagia, neurogenic pulmonary oedema and lack of spontaneous breathing. In 36% subjects, hemiparesis occurred. The last two symptoms gradually resolved whereas dysphagia persisted in 13% of patients. Hemiparesis which occurred after operation in most of the patients resolved. We reported resolution of hemiparesis in our subjects in the paper from 2005 [14].

Cerebellar symptoms and the damage to cranial nerves did not show a tendency to resolve either. Mursch reported that

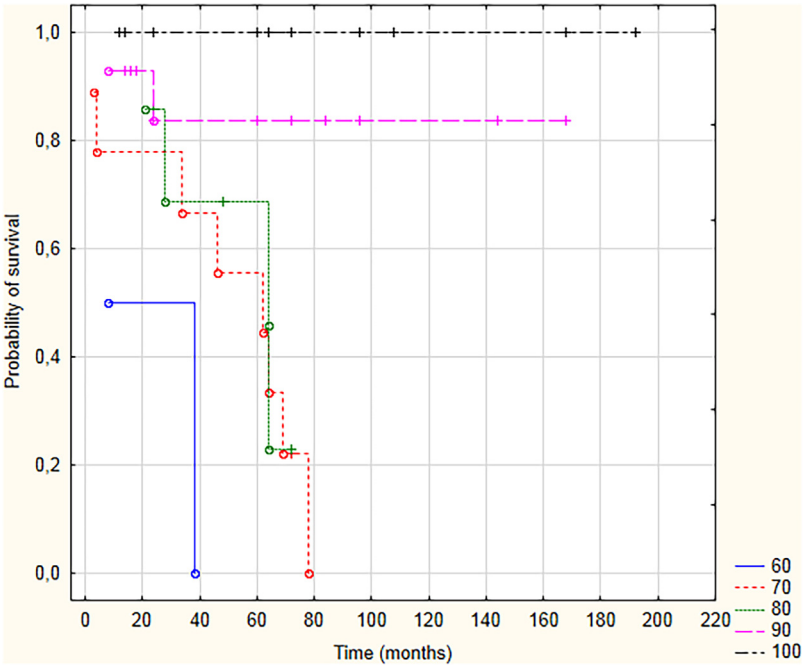

Fig. 3 – Kaplan–Meier graph of survival by score in the Karnofsky scale of initial performance.

Table 5 – Effect of the extent of resection on progression and survival.

	Cases	Progression	Median PFS	Median survival time
	N	N (%)	Months	
Gross Total resection	14	5(36%)	43	47
Partial resection	33	16(48%)	23	37

Table 6 – Glasgow Outcome Scale according to MRI-based radiological classification.

	GR + MD	SD	DEATH	Cases
1. Adult diffuse intrinsic low-grade brainstem gliomas	2 (22%)	3 (33%)	4 (45%)	9 (100%)
2. Contrast-enhancing malignant brainstem gliomas	1 (8%)	4 (31%)	8 (61%)	13 (100%)
3. Contrast-enhancing non-malignant gliomas	7 (54%)	3 (23%)	3 (23%)	13 (100%)
4. Focal tectal and exophytic brainstem gliomas	9 (75%)	2 (17%)	1 (8%)	12 (100%)
Cases in total	19 (40%)	12 (26%)	16 (34%)	47 (100%)

Table 7 – Glasgow Outcome Scale according to histopathological investigation.

	GR + MD	SD	DEATH	Cases
GI: pilocytic astrocytoma, ganglioglioma	11 (61%)	3 (20%)	4 (19%)	18 (100%)
GII: astrocytoma:fibrillary,protoplasmic,gemistocytic, ependymoma, oligodendroglioma, subependymoma	7 (46%)	5 (31%)	4 (23%)	16 (100%)
GIII + GIV: anaplastic astrocytoma, multiform glioblastoma	1 (7%)	4(31%)	8 (62%)	13 (100%)
Cases in total	19 (40%)	12 (26%)	16 (34%)	47 (100%)

Table 8 – The rates of progression among patients with different types of gliomas.

Tumour type	Patients with progression	Mean time of progression-free survival (months)
Adult diffuse brainstem glioma	6 (67%)	38
Malignant brainstem glioma	9 (69%)	14
Non-malignant brainstem glioma	5 (38%)	42
Exophytic tumour	1(14%)	13
Tectal tumour	0	–

neurological deficits exacerbated immediately after surgical treatment of brainstem gliomas and showed a very small tendency to resolve. In particular, this situation was connected with dysphagia and hemiparesis [23]. Sinha reported that after surgery of brainstem tumours, postoperative complications were observed in 19% of patients while the postoperative mortality was 5% [22]. Other authors observed complications immediately after surgery of brainstem gliomas in adult patients in 51.6% subjects [24]. However, in a longer follow-up, condition of patients improved and neurological deficits persisted only in 12.9% cases [24].

Authors report different extent of resection of brainstem gliomas. We performed total resection in 14 patients (30%) and partial resection in 33 patients (70%). The extent of resection in our study had a significant influence on patient survival. Elhamady performed total or subtotal resection in 64% of patients from a group of 31 adult subjects with brainstem tumours [24]. Some other authors reported that they performed total resection in patients with brainstem gliomas in 12.5%. This was related to patients with Grades I and II astrocytoma (WHO classification) and Grade II ependymoma. Subtotal resection was performed in 9 cases and partial in 3 cases [23]. According to the above authors, the following were the causes of limited resection: arterial hypertension of 250–300 mmHg or bradycardia (30–40 beats per minute), a decrease in SSEPs observed during surgery or no distinction between the tumour and a healthy brainstem tissue [23]. Also in some of our patients tumour resection could not be continued due to incidents of hardly controllable hypertension approaching 300 mmHg. The disorders of SSEP recordings, as a rule, were of transitory nature. Abnormal MEPs correlated with limb paresis occurring postoperatively. The lack of a clear distinction between the tumour and the healthy tissue in our study material was related to intrinsic tumours, i.e., pilocytic astrocytoma and Grade II astrocytoma (WHO scale).

Our results indicate that the prognosis is heavily influenced by patient's performance on admission, as expressed by the score in Karnofsky performance scale. A similar observation was made by Kesari et al. [3]. Guillamo, in a group of adult patients with brainstem tumours, reported better prognoses in patients, who had more than 70 points in the Karnofsky score on admission [20].

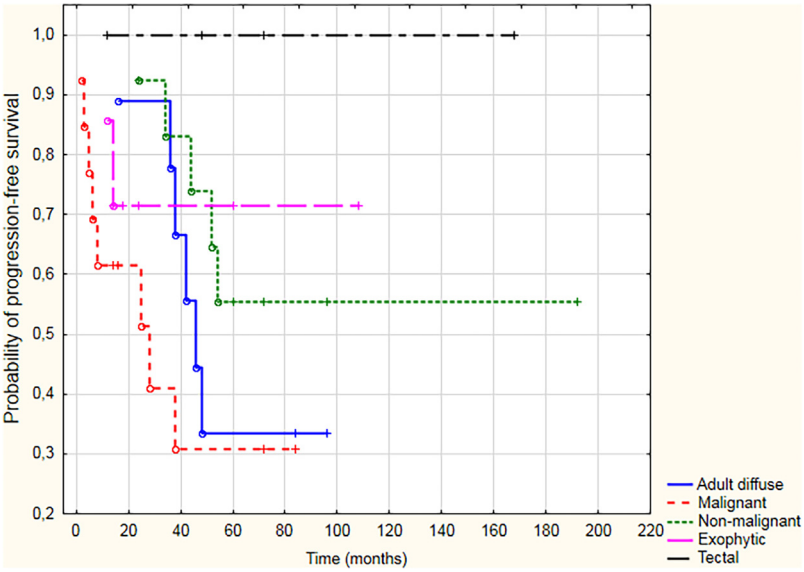

Fig. 4 – Kaplan–Meier graph of time to progression in different types of brainstem gliomas.

Table 9 – Survival after surgery in different types of brainstem gliomas.

Type of cancer	Number of deaths	Mean time period between the surgical procedure and death (months)	Mean follow-up period (months)
Adult diffuse brainstem glioma	4 (44%)	58	72
Malignant brainstem glioma	8 (62%)	20	32
Non-malignant brainstem glioma	3 (23%)	66	78
Exophytic tumour	1 (14%)	24	39
Tectal tumour	0	–	72

The international papers are dominated by a view of non-resectability of low-grade diffuse brainstem gliomas in adult patients, in particular when the tumour is located in the pons [3,17]. Radiation is the proposed therapy and surgery is related only to a biopsy or the elimination of the existing hydrocephalus [20,25–27]. Elhamady proposed surgical treatment of patients with limited diffuse brainstem gliomas [24]. The decision to perform surgery must be accompanied with an effort to perform radical resection. This would mean a longer period of patient survival. However, radical resections result in neurological deficits and lower quality of life. In our patients with diffuse brainstem gliomas, partial resection of tumours

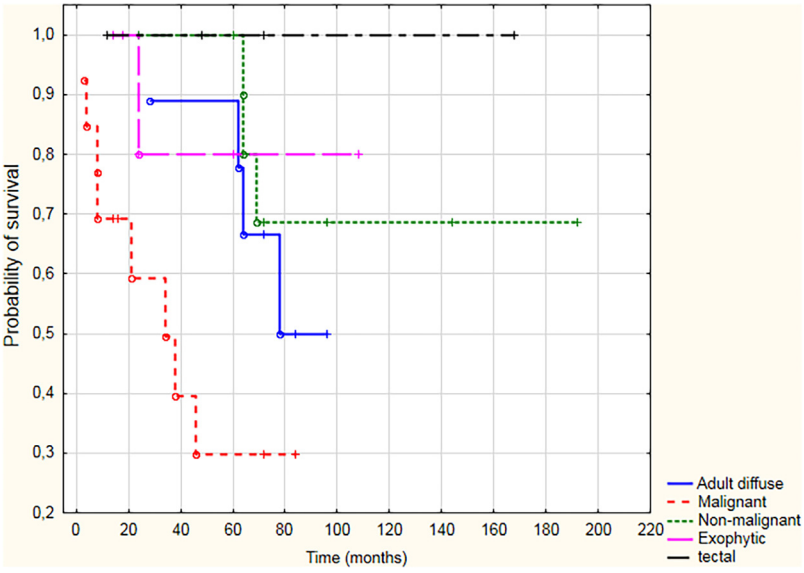

Fig. 5 – Survival of patients with different types of brainstem glioma.

was most often performed. However, partial resection of low-grade gliomas in 9 patients did not prolong the mean survival above 5 years. The studies conducted in Europe and in the United States revealed the mean survival of patients with diffuse brainstem gliomas who did not undergo surgery from 4.9 to 7.3 years [20,28]. In our study group, the mean survival of patients with diffuse brainstem gliomas was 4.8 years.

In our patients, the prevalence of malignant brainstem gliomas was 28%. A similar prevalence (30%) of this type of glioma in adult patients was reported by Duverneuil [29]. Most frequently these tumours occurred in patients over 40 years of age. This observation was confirmed by other researchers who observed an increased prevalence at older age [20,28]. These types of tumours are characterized by a very short survival period – the mean survival was about 12 months [3]. Other studies report that overall mean survival time in patients diagnosed with anaplastic astrocytoma and glioblastoma multiforme was 25.8 months [30]. In our patients, the mean survival was 20 months.

A large group of patients operated on for brainstem tumours in our Neurosurgery Clinic consisted of subjects with a histological diagnosis of pilocystic astrocytoma (cases of intrinsic tumours). The majority of authors report good prognosis of patients with total resection of this type of tumour [22,31,32]. However, total resection was very difficult to perform due to the size of tumours. During the resection, we observed disorders of heart rate abnormalities and the decrease in SSEPs. Sometimes that was the reason why surgical procedure was discontinued. This group of patients also presented with abnormal respiratory rates. Therefore, in 4 patients we performed delayed revision surgery after the diagnosis was obtained. Deterioration and death occurred in patients with partial resection or in those who after radical resection presented with severe disability. Ye J.M. reported that the prognosis of patients with tumours of pilocystic astrocytoma depends on tumour location. The worst prognosis is related to patients with intrinsic pilocytic astrocytoma. The prognosis in such cases depends on the resection size [32].

In our study material, the prevalence of the midbrain tectal tumour was 11%. In other studies, the prevalence of this tumour among brainstem tumours of adult patients was 8% [17]. Patients with tectal midbrain tumours underwent surgery only in the case of an increase in neurological symptoms caused by the tumour such as vision disorders or increasing balance disorders. Surgical procedures were also performed in patients in whom the size of the tumour was increased. In our patients we did not observe any increase in hydrocephalus as these tumours were growing exophytically upwards without any pressure on the cerebral aqueduct. During the postoperative follow-up we did not observe tumour progression and none of our patients died. Tumours with this location diagnosed in children offer good prognosis [33,34] and the course of the disease is stable. In MRI examinations, these tumours in children did not exceed 2 cm, neither did they enhance after contrast administration [33]. In the majority of children, it was necessary to treat hydrocephalus [34]. As in the case of other surgeons, we also found such tumours as pilocytic astrocytoma, fibrillary astrocytoma and oligoastrocytoma in this location [20,35].

Exophytic brainstem tumours are very rare among adult patients [17,20,28]. This tumour most frequently arises exophytically in the 4th brain ventricle [22]. In our subjects, there were 6 cases of this tumour on the dorsal part and 1 case on the ventral part of the medulla oblongata. In the case of surgery of a tumour of the pyramid of the medulla oblongata, it is necessary to use DES, which illustrates the relationship between the tumour and the adjacent fibres of the corticospinal tract. Pilocytic astrocytoma was diagnosed in almost 50% of cases. It must be borne in mind, however, that it is probable that some malignant tumours enhancing after contrast administration might also be found in this location, which was observed in one case in our centre. In this patient, anaplastic astrocytoma was diagnosed and after partial resection, the tumour growth was observed, which resulted in death of the patient at a further stage of the disease.

Considering all the cases, the progression of tectal tumours and exophytic tumours was the longest. The most rapid progression was observed in patients with Grades III and IV gliomas as per WHO classification. Kesari et al. made similar observations [3]. The shortest survival period was observed in patients with malignant brainstem tumours. A 5-year survival after brainstem surgery in our patients was 76%, which means that the majority of patients will survive at least 60 months postoperatively. The mean follow-up was 4.04 years. Kesari, in a group of 101 patients with brainstem gliomas observed a 5-year survival in 58%, and a 10-year survival in 48% patients [3]. The mean survival was 3.9 years. However, the majority of these patients were not surgical subjects. Guillamo et al. observed a 3-year survival in 66% cases in a group of 48 adult patients with brainstem gliomas [20]. The mean follow-up was 5 years. In this group, 25% patients were under surgical treatment (with the exception of biopsy).

Mursch observed a 5-year survival in 25% of patients in a group of 16 surgical patients with brainstem gliomas [23]. The follow-up period was 6.7 years.

In conclusion, it should be stressed that brainstem glioma patients in good condition should undergo surgery. Headache and vertigo decrease postoperatively. In half of the patients improvement in the movement of arms and legs was observed. Dysphagia often resolved. Patients mainly complained of dysfunction of the cerebellum and cranial nerve paresis. Good recovery or moderate disability was noted in 40% of patients. Some patients with exophytic tumour of mesencephalic tectum and the dorsal part of the medulla oblongata were professionally active.

6. Conclusions

1. The prognosis of patients with brainstem gliomas was affected by their general health condition as assessed on hospital admission using the Karnofsky performance score and by the extent of tumour resection.
2. Among the symptoms less likely to resolve postoperatively are cerebellar dysfunction and defects of cranial nerves.
3. The best prognosis (as assessed with the Glasgow Outcome Scale) was observed in patients with tectal tumours and exophytic tumours of the medulla oblongata and

in patients with gliomas–GI according to the WHO classification.
4. Tumour progression and the highest mortality were observed in patients with Grades III and IV gliomas (WHO classification).
5. Reduction of tumour mass in patients with diffuse gliomas fails to extend mean survival time beyond 5 years.
6. Surgery of brainstem tumours adjacent to the corticospinal tract requires the use of tractography as well as transcranial direct electrostimulation to elicit motor evoked potentials.

Conflict of interest

None declared.

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