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ORIGINAL ARTICLE

Intraoperative monitoring of foramen occipitalis magnum meningiomas surgery significantly improves the preservation of neurological functions

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Abstract

OBJECTIVE: Evaluate the results of surgical treatment of foramen occipitalis magnum meningiomas.
METHODS: The article presents analysis of 20 cases of foramen occipitalis magnum meningiomas surgery. All the patients were operated using suboccipital approach.
RESULTS: Total removal of tumor was made in 14 (70%) cases; subtotal – in 5 (25%) cases, partial – in 1 (5%). There were no lethal outcomes.
CONCLUSIONS: Transcondyllar approach is not necessary at meningiomas of foramen occipitalis magnum. There is some risk of instability in occipito-cervical junction. There were no cases of tumors relapse after suboccipital approach during the long-term follow up.

Introduction

Meningiomas represent a high percentage of all intracranial neoplasms and can be seen in almost any section of intracranial cavity, although they are rare for some regions (Cao *et al* 2015). Foramen occipitalis magnum is the one (1.8–3.2% of intracranial meningiomas) (Arnautovic *et al* 1997, 2001; Cao *et al* 2015). Anatomical borders of this region are located within the limits of the lower 1/3 of clivus and to the upper edge of the body and arches of C2 vertebra, between jugular tubercle, to the top of C2 spine to the rear (Arnautovic *et al* 2001). Special interest to foramen occipitalis magnum meningiomas is caused by certain difficulties in clinical diagnostics, complexity of anatomic correlations and high sensitivity of surrounding structures to surgical manipulations, thus recently giving rise to a new wave of discussion with regard to surgical treatment of such neoplasms.

Foramen occipitalis magnum meningiomas are lesions with original growth zone (matrix) located within the aforementioned anatomic borders and invading neoplasms with matrix proliferating to the limits of the foramen (Boulton & Cusimano 2003). Initial tumors are classified according to their orientation in space (Figure 1). Most of foramen occipitalis magnum meningiomas (68–98%) (Arnautovic *et al* 2001) are anterolateral, rarely – posterolateral, even more rarely – posterior and the rarest is the anterior position showing 70.1% of anterior tumors, 21.2% of anterolateral tumors and 8.8% of posterior tumors (George 1991; David & Spetzler 1997; George *et al* 1997; Mantovani *et al* 2014). The size of neoplasms with regard to the dimensions of foramen occipitalis magnum has the following grades: small – less than 1/3 of foramen occipitalis magnum transverse diameter, medium – from 1/3 to 1/2, big – more than 1/2 of the transverse diameter.

Material and methods

We performed the surgery of foramen occipitalis magnum meningiomas in 20 patients within the period from 1989 to 2010. It comprises about 1.6% of the general number of patients with primary symptomatic intracranial meningiomas. The patients were distributed in the following groups according to the tumor position within the limits of foramen occipitalis magnum: anterior – 1 (5%), posterior – 2 (10%), lateral and anterolateral – 17 (85%). We should mention that their size was small in 5 (25%), medium in 7 (35%) and big in 8 (40%) patients. Neoplasms invading foramen occipitalis magnum from the region of cerebellopontine angle were excluded. There were 6 men and 14 women aged 48.8 years in average (from 18 to 68 years). All the patients were followed up post-surgically till 2014.

Neurological symptoms are presented in Table 1. In all cases without any exceptions the first symptom of the disease was pain in the cervico-occipital region increasing during head nods. Concomitant dizziness was observed in 12 people (60%). Classic foramen occipitalis magnum syndrome is described as progressing monoparesis and sensory disorders in homolateral arm, then in homolateral leg, then in contralateral leg and, finally, in contralateral arm seen in all the examined patients with various manifestation rates. Pyramid disorders in the arm could lead to interdigital muscle atrophy (Boulton & Cusimano 2003; Bassiouni *et al* 2006). The events related to cerebellar ataxia were observed in 10 (50%) patients. 14 (70%) patients reported on the disorders of caudal cerebral and hypoglossal nerves functions at the later stage. Atrophies of trapezius and sternocleidomastoid muscle were seen in 6 (30%) patients. 12 (60%) patients focused attention on temperature-related dysesthesia and anesthesia in C1–C2 dermatomas, however only pain, motor disorders and ataxia were of medical significance. Papilledema was observed in 11 (55%) patients, in 3 cases (15%) the disease manifested itself by occlusive crises, thus demonstrating the significant size of the neoplasm. Clinical manifestation took from 3 to 32 months, 9.5 months on average.

In all the patients the diagnosis was made using CT and/or MRI methods, thus providing the possibility of surgical approach planning. Meningiomas on MRI scans often were of hyperintensive and rarely isointensive or hypointensive. T2-weighted images demonstrated a peritumoral subarachnoid liquor fissure thus always pointing at the nature of a neoplasm (Figure 2). Perifocal changes in the adjacent brain sections were considered to be a sign of meningioma invasion to arachnoid matter in 4 (20%) patients. It is considered that axial CT slice due to clear differentiation of bone and soft-tissue lumps provide the possibility to plan the amount of bone resections for surgical approach to tumor (Cantore *et al* 1994; Banerji *et al* 1999; Babu *et al* 2001; Pirotte *et al* 2010). However, we did not see any reason for this during our research.

In all the patients neoplasms were removed through a traditional suboccipital approach with C1 laminectomy. Surgical window provided sufficient view and required no significant shift of neural structures with the exception of the case of anterior tumors. Partial unilateral resection of atlanto-occipital joint to hypoglossal canal was carried out in 5 (25%) of cases (the latter was never opened). Total meningioma removal in a common sense (Simpson 1–2) performed in 14 (70%) cases. However, only in two cases full resection of tumor matrix on dura mater was achieved. Due to close adhesion of tumorous tissue with vertebral artery and neural lumps in 5 (25%) cases the subtotal tumor removal was carried out, and in 1 case (5%) – partial removal.

One of total tumor removal surgeries was carried in two stages. It was caused by the fact that during the first

Tab. 1. Neurological symptoms of foramen occipitalis magnum meningiomas.

Clinical symptom	Number of events (%)
Headache (in cervico-occipital region)	20 (100%)
Dizziness	12 (60%)
Pyramidal disorders	20 (100%)
Motion coordination disorders	10 (50%)
Neuropathies of cerebral nerves	14 (70%)
IX, X, XI	10 (50%)
XII	4 (20%)
Neuropathies of C1-C2 roots	12 (60%)
Atrophy of sternocleidomastoid muscle and trapezius muscle	6 (30%)
Papilledema	11 (55%)
Occlusive crises	3 (15%)

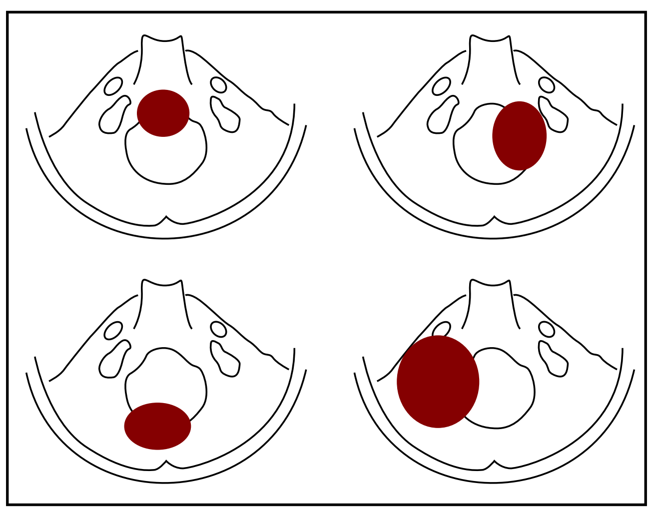

Fig. 1. Position of foramen occipitalis magnum meningiomas (chart): 1)anterior; 2) lateral; 3) posterior; 4) in-growth to foramen occipitalis magnum.

Fig. 2. MRI scans of lateral meningioma of foramen occipitalis magnum.

surgery crude stem disorders were observed accompanied with blood pressure decrease below 60 mmHg and bradycardia, that's why the surgery was stopped. 5 months later the tumor was finally removed during the second stage.

Results and discussion

The peculiarities of microsurgical anatomy of foramen occipitalis magnum are nowadays carefully studied and described in literature (Arnautovic *et al* 1997, 2001; George *et al* 1997; Rhoton 2000). This is the place where some very important neural and vascular organs are located: tonsils and lower sections of vermis, aperture of forth ventricle, caudal sections of medulla with IX—XII pairs of cerebral nerves, rostral sections of spinal medulla with upper cervical roots C1 and C2 and vertebral arteries and their branches (David & Spetzler 1997). Cerebrospinal denticulate ligament separates anterior and posterior sections of foramen occipitalis magnum area.

The clinical picture of foramen occipitalis magnum meningiomas is carefully studied and provided in many publications (Sen & Sekhar 1991; Fine *et al* 1999; Couce *et al* 2000; Boulton & Cusimano 2003). Our data fully comply with those from the literature sources. It should be noted that in patients with foramen occipitalis magnum meningiomas severe dysfunctions of accessory nerve, and the presence of such disorders can indicate some other disease or other tumor localization. Tongue deviation and folds are the signs of later stages of hypoglossus irreversible paralysis (Boulton & Cusimano 2003). We observed such disorders only in 4 cases (20%), although during the surgery in 17 cases (85%) shifted according to the upper and anterior pole of the tumor and in 3 cases (15%) – to the anterior pole.

There are anterior, lateral and posterior approaches to foramen occipitalis magnum. Each of them has its advantages and disadvantages. Anterior transoral approach to intradural lumps at the level of foramen occipitalis magnum is rarely used due to the problems with dura mater plastics and the risk of post-surgery liquorrhea and related meningitis (Boulton & Cusimano 2003). Suboccipital resection or osteoplastic craniotomy with laminectomy to the level of the lower tumor pole is a classic approach to foramen occipitalis magnum meningiomas. Suboccipital approach provides a good visualization of vertebral artery, brain stem, caudal cerebral nerves and tumors in its bed; it is easy and time saving. Its disadvantage lies in the fact that the tumor surface is frequently covered by brain stem, cerebral nerves and artery. Anteromedial meningiomas are fully covered by these structures during the suboccipital approach, that is why their traction is required being harmful from the functional point of view (Boulton & Cusimano 2003). In most cases foramen occipitalis magnum meningiomas are of anterolateral position and during their growth the stem sections of brain are located to the rear and contralaterally. It is considered that using retraction it is possible to create an adequate surgical window to remove the most of such tumors (Sen & Sekhar 1991; Arnautovic *et al* 1997). However in our research we abstained from manipulations with retractors when possible.

The surgical window is an opening between the lateral edge of medulla and medial edge of occipital condyle during removal of foramen occipitalis magnum meningiomas (Boulton & Cusimano 2003). It is considered to be narrow if the opening width is less than 1.0 cm, of optimal width if it is 1.0–2.0 cm and broad if its width is more than 2.0 cm. The most of symptomatic foramen occipitalis magnum meningiomas with dislocated medulla provide an adequate surgical approach. In our study none of surgical windows exceeded 1.5 cm, however the optical increase in 15 cases (75%) provided the adequacy of manipulations and possibility of tumor total removal. In 5 cases (25%) in order to extend the surgical window the partial resection of posterior sections of atlanto-occipital joint without the opening of hypoglossal canal was performed. It is considered that such manipulation leads to instability of occipito-cervical joint (Vishteh *et al* 1999). What concerns the resection of vertebral arches, during the surgery we performed only C1 resections and those tumor sections located below were successfully removed without partial or full resection of C2 vertebral arch.

Many authors in order to secure a more reliable and efficient approach to anterior neoplasms recommend using a transcondylar approach (Cantore *et al* 1994; Banerji *et al* 1999; Babu *et al* 2001; Pirotte *et al* 2010). In case of condylar resection (50% and more) it is recommended to apply occipital cervical stabilization (Vishteh *et al* 1999). However say that during their work (114 cases) they performed no resections of atlanto-occipital joint (Nedzelski *et al* 2008; Plowman 2000). We must say that no one randomized estimation of two fundamental surgical approaches was carried out, that is why it is impossible to prefer one of them.

The potential risk of surgical complications during the removal of foramen occipitalis magnum meningiomas is rather high. The special attention should be paid to caudal cerebral nerves (Sen & Sekhar 1991; Boulton & Cusimano 2003). Pre-surgery loops of functions of any manifestation rate assume nerve compression and possible commitment of nerve trunk vessels, thus making nerves more sensitive to surgical manipulations. Cerebral nerves IX and X form the arc of pharyngeal reflex. That is why the acute loop of their function can lead to lethal outcome due to aspiration pneumonia. According to literature data, tube feeding and early tracheostomy should be performed in case of swallowing dysfunction detection in the post-surgery period (Boulton & Cusimano 2003). In our study tracheostomy was required in none of the cases.

Brainstem infarctions should be firstly mentioned as the main reason of mortality among the surgery-based complications (Sen & Sekhar 1991). We had no lethal outcomes during our study; however the mortality rate after the removal of meningiomas near brainstem is 4.7% according to the literature data. Post-surgery stem disorders in 7 patients (35%) were of transient nature and regressed in 5–7 days after the surgery. Functional improvement was observed significantly later. 19 of operated patients (95%) faced it in 4–15 months. No significant change of condition was observed in 1 patient (5%). Post-surgery progressive hydrocephaly developed in 1 case (5%) in 68-year old patient after total tumor removal. Ventricular-jugular shunting in two months after the initial surgery removed this problem.

No relapses after the total or subtotal removal of neoplasms were observed. Patients after partial tumor removal were followed up for 48 months; no progressing of meningioma size or worsening of neurological symptoms was observed.

The preservation of cerebral nerves and vascular formations is the integral task of surgical removal of foramen occipitalis magnum meningiomas. The fundamental principle of skull base surgery is: bone resection shall guarantee the total removal of tumor without the traction of neural formations. There is an opinion that meningioma switches off in a "parasitic" way in some part of the blood supply of the meninges. Taking this into account the coagulation of small arterial vessels on tumor surface can seem to be rational, however it is not allowed in the surgery of foramen occipitalis magnum meningiomas due to the hazard of brainstem ischemia due to small perforating branches damage. That is why even small arteries on tumor surface should remain in intact arachnoid meninges (David & Spetzler 1997; Bassiouni *et al* 2006; Rhoton 2000; Pirotte *et al* 2010). During our study no cases of brainstem infarction in the post-surgery period were observed.

Intraoperative monitoring significantly improves the preservation of neurological functions. After surgery, patients showed weakened dizzy spells, disappearance of headaches, improvement in spatial orientation and coordination of movements. The recorded changes can point at the potentially hazardous manipulations that can be avoided or implemented in some other way (Cantore *et al* 1994; George *et al* 1997; Pirotte *et al* 2010). Assess the quality of life in operated patients as normal (KPS, 80–100) in 59 cases (63.4%). In our study we had KPS 70–100 in 19 patients (95%) and KPS 50–60 – in 1 (5%). The possibility of radiotherapy should be considered if there are contraindications for surgical treatment. Due to complex anatomical correlations within the limits of foramen occipitalis magnum and small tumor size (usually not more than 3.0 cm) the focused gamma-knife surgery is preferable (Plowman 2000).

Thus, the suboccipital approach with C1 laminectomy without additional resection of C2 arch is sufficient to perform the adequate microsurgical removal of foramen occipitalis magnum meningiomas providing the high quality of life during the post-surgery period.

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