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Meningiomas of the anterior portion of the craniovertebral junction: immediate and late outcome following surgical removal using a partial transcondylar approach

Bezpośrednie i odległe wyniki leczenia oponiaków przedniej części pogranicza czaszkowo-szyjnego z wykorzystaniem dostępu przezkłykciowego częściowego

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Abstract

Background and purpose: The partial transcondylar approach (PTA) is an alternative to the suboccipital approach in the surgical treatment of meningiomas of the anterior portion of the craniovertebral junction (APCVJ). The purpose of this study is to present our results of treatment of these meningiomas using PTA.
Material and methods: Fourteen patients (11 women, 3 men) with meningioma of the APCVJ were included in the study. Neurological status of the patients was assessed before and after surgery as well as at the conclusion of the treatment. The approximate volume of the operated tumour, its relation to large blood vessels, cranial nerves and brainstem, along with its consistency and vascularisation were assessed.
Results: The symptom duration ranged from 1 to 36 months (median: 11 months). In 79% of patients, motor deficits of the extremities were predominant symptoms. Less frequent symptoms included headache, cervical pain and sensory deficits of cervical nerves C2 to C5. Approximate volume of the tumours ranged from 2.5 mL to 22.1 mL (mean: 11.7 mL). Gross total or subtotal resection was achieved in 86% of patients. The postoperative performance status improved in 57%, did not change in 36% and deteriorated in 7% of the patients.
Conclusions: The PTA is a useful technique for removal of meningiomas expanding intradurally of the APCVJ without significant compression of the medulla. The results of treatment were good in most patients.

Streszczenie

Wstęp i cel pracy: Dostęp przezkłykciowy częściowy (DPC) jest alternatywą dla dostępu podpotylicznego w operacyjnym leczeniu oponiaków przedniej części pogranicza czaszkowo-szyjnego (PCPCS). Celem niniejszej pracy jest przedstawienie własnych wyników leczenia powyższych oponiaków z wykorzystaniem DPC.
Materiał i metody: Analizie poddano grupę 14 chorych z oponiakami PCPCS, wśród których było 11 kobiet i 3 mężczyzn. Ocenie podlegał stan neurologiczny chorych przed rozpoczęciem leczenia, po operacji i po zakończeniu leczenia oraz zmiany ich aktywności życiowej. Określano przybliżoną objętość operowanych guzów, ich stosunek do dużych naczyń, nerwów czaszkowych i pnia mózgu, jak również konsystencję i stopień unaczynienia.
Wyniki: Długość wywiadu wahała się od 4 miesięcy do 36 miesięcy (mediana: 11 miesięcy). W 79% przypadków wiodącym objawem był niedowład kończyn. Rzadziej występowały bóle głowy i karku oraz zaburzenia czucia korzeniowego C2 do C5. Przybliżona objętość usuniętych guzów wahała się od 2,5 cm^3 do 22,1 cm^3 (średnia: 11,7 cm^3). W 86% przypadków przeprowadzone wycięcia były doszczętne lub z niewielkimi pozostałościami guzów. Aktywność życiowa leczonych w 57% się poprawiła, w 36% nie zmieniła się, w 7% nastąpił jej spadek.
Wnioski: Dostęp przezkłykciowy częściowy stanowi dogodną drogę usuwania oponiaków rozrastających się wewnątrzopo-

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nowo w PCPCS, bez konieczności wywierania znacznego ucisku na rdzeń przedłużony i rdzeń kręgowy. Wyniki leczenia są u większości chorych dobre.

Słowa kluczowe: otwór potyliczny wielki, tętnica kręgowa, oponiak, mikrochirurgia, chirurgia podstawy czaszki.

Introduction

The partial transcondylar approach (PTA) supplements suboccipital craniectomy and cervical laminectomy with partial resection of the occipital condyle and corresponding lateral part of the atlas thus enabling a wider view into the anterior portion of the craniovertebral junction (APCVJ). This modification imposes posterior reposition of the suboccipital part of the vertebral artery that winds around the occipital condyle. The PTA is designed for the removal of intradural tumours located in the APCVJ. Predominant tumours in this location, meningiomas, are classified as anterior and antero-lateral. For the former, the approach described above determines tumour resection. For the latter, indications for its implementation are relative, particularly depending on the tumour relation to the vertebral artery. The aim of the following paper is to present our results of the surgical treatment of APCVJ meningiomas using the PTA.

Material and methods

The PTA has been used in the Clinical Department of Neurosurgery in Sosnowiec since 1999. A retrospective analysis of 14 cases of APCVJ meningiomas (11 women, 3 men, aged 19 to 71 years) was performed. Our cohort consisted of 6 meningothelial, 4 fibrous, 3 transitional and 1 angiomatous meningioma. In addition to the aforementioned group of meningiomas, the authors implemented PTA in the treatment of three neuromas, two neurofibromas and two chordomas related to the APCVJ. All these cases were excluded from our cohort owing to their diversity.

Neurological status of the patients before and after surgery and at the conclusion of the treatment (Table 1 and 2) along with the changes in the functional capacity of patients assessed with the Karnofsky performance scale (Table 3) were analysed. The volumes of the tumours were approximated with the formula for a rotational ellipsoid (*volume* $= \Pi/6\ (x\,y\,z)$), based on magnetic resonance imaging (MRI), while the extent of resection was assessed with the Simpson scale. Next, the relationship of tumours to large vessels, cranial nerves and brainstem along with their consistency and vascularity were analyzed. 'Soft' (feasible for suction), 'compact' (feasible for blunt dissection or cavitron ultrasonic aspiration) and 'hard' tumours that necessitated cleavage with scissors or bone tools were distinguished. While analyzing tumour vascularity, cases that sporadically required haemostasis during resection were described as 'weak' while 'considerable' required frequent haemostasis and 'prominent' required haemostasis on each attempt of resection.

Average times of catamnesis, postoperative follow-up or tumour volumes distributions were analysed with the Shapiro-Wilk test. Variables with distribution that did not meet criteria for normality were described by the median and upper and lower quartile. Variables with normal distribution were presented as the mean with standard deviation (SD).

Results

The time of catamnesis in our group varied from 4 months to 36 months (median 11 months, interquartile range 9-12 months). The most common clinical sign, found in 11 patients (79%), was variable level of extremities' paresis. Headache, neck pain and sensory losses within C2 to C5 somatosensory segments were less frequent – 10 (71%) and 7 (50%) cases, respectively. All the signs and symptoms along with changes in the clinical course of the disease following treatment are summarized in Table 1.

All of the patients presented with intradural tumours that were confined to the posterior fossa and spinal canal. Half of the tumours were localized in the anterior part of the craniovertebral junction, i.e. displaced medulla oblongata and spinal cord posteriorly (Figs. 1-4). Four cases (29%) had antero-lateral localization and displaced medulla oblongata and spinal cord posteriorly and partially to the side. In the other 3 cases (21%), the tumour had latero-anterior location. It shifted the medulla oblongata and spinal cord mostly laterally and only partially posteriorly (Fig. 5). The predominant part of the tumour was associated with the lower part of the clivus in 12 cases (86%), i.e. these were cases of cranio-vertebral tumours in contrast to 2 cases (14%) of vertebro-

Table 1. Neurological abnormalities present prior to the surgical treatment in 14 patients

Neurological abnormality	Examination on admission *n* (%)	Examination on discharge *n* (%)	Follow-up examination *n* (%)
Headache and neck pain	10 (71.4%)	0	0
Cerebellar ataxia	5 (35.7%)	5 (35.7%)	4 (28.5%)
Disequilibrium	4 (28.5%)	3 (21.4%)	2 (14.2%)
Glossopharyngeal and vagus nerve paresis	2 (14.2%)	2 (14.2%)	2 (14.2%)
Accessory nerve paresis	3 (21.4%)	3 (21.4%)	3 (21.4%)
Hypoglossal nerve paresis	1 (7.1%)	1 (7.1%)	0
Upper limb paresis	6 (42.8%)	6 (42.8%)	2 (14.2%)
Tetraparesis	2 (14.2%)	1 (7.1%)	0
Hemiparesis	3 (21.4%)	1 (7.1%)	1 (7.1%)
C2-C5 dysaesthesia	7 (50.0%)	7 (50.0%)	5 (35.7%)

Table 2. Neurological abnormalities and complications that occurred as a side effect of the surgical treatment of 14 patients

Neurological abnormality	Examination on admission *n* (%)	Examination on discharge *n* (%)	Follow-up examination *n* (%)
Respiratory disturbances	1 (7.1%)	0	0
Glossopharyngeal and vagus nerve paresis escalation	3 (21.4%)	2 (14.2%)	1 (7.1%)
Accessory nerve paresis escalation	5 (35.7%)	4 (28.5%)	4 (28.5%)
Hypoglossal nerve paresis escalation	1 (7.1%)	1 (7.1%)	0
Liquorrhoea from surgical wound	2 (14.2%)	0	0

Table 3. Assessment of the functional capacity of patients according to Karnofsky performance scale

	Examination on admission	Examination on discharge	Follow-up examination
Patient 1	70	80	90
Patient 2	70	70	90
Patient 3	80	80	90
Patient 4	80	80	80
Patient 5	90	80	90
Patient 6	70	60	80
Patient 7	80	70	80
Patient 8	90	80	100
Patient 9	70	50	60
Patient 10	80	70	80
Patient 11	70	70	90
Patient 12	80	90	90
Patient 13	80	80	90
Patient 14	90	90	90

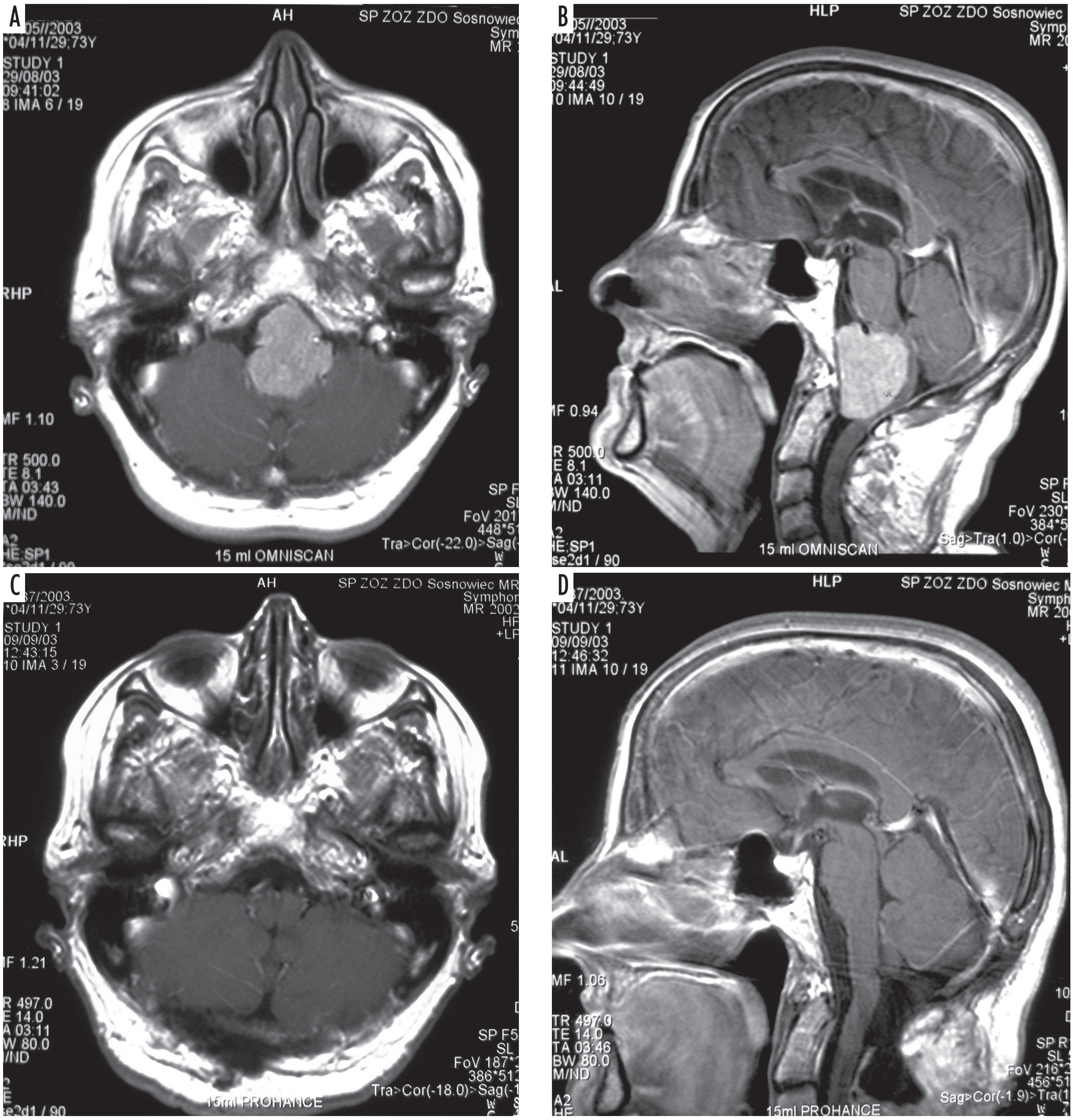
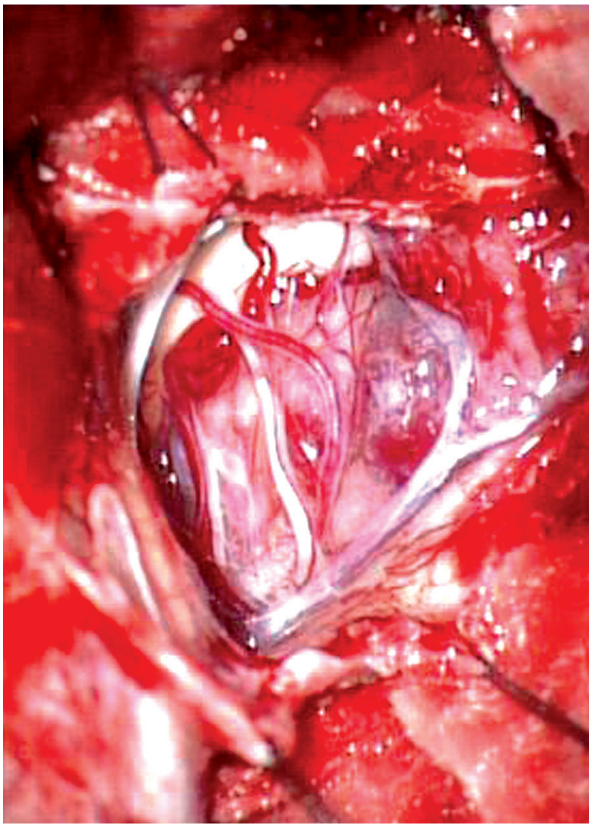


Fig. 1. Meningioma (20.3 cm^3) of the anterior portion of the craniovertebral junction (patient 2). Due to the large size of the tumour an access that enabled completion of the resection was achieved during its removal; A) a tumour seen in the axial plane on preoperative MRI, B) a tumour seen in the sagittal plane on preoperative MRI, C) status after removal of the tumour seen in the axial plane on postoperative MRI, D) status after removal of the tumour seen in the sagittal plane on postoperative MRI

cranial tumours with the predominant part of the tumour associated with the anterior boundaries of the spinal canal. Average volume of tumours varied from 2.5 to 22.1 cm^3 (mean 11.7 cm^3, SD 6.9 cm^3).

Tumours displaced the medulla oblongata and spinal cord in all of the cases but only 2 cases presented with pial infiltration. Despite the fact that in both of these cases pieces of the tumour indigenous to the ventral part of the medulla oblongata remained untouched, one of the patients presented transient postoperative respiratory disturbances that required artificial ventilation. Tumours were adjacent to the lower group of the cranial nerves in the cerebellopontine angle and upper cervical roots in 6 (43%) cases. Accessory and hypoglossal nerves along



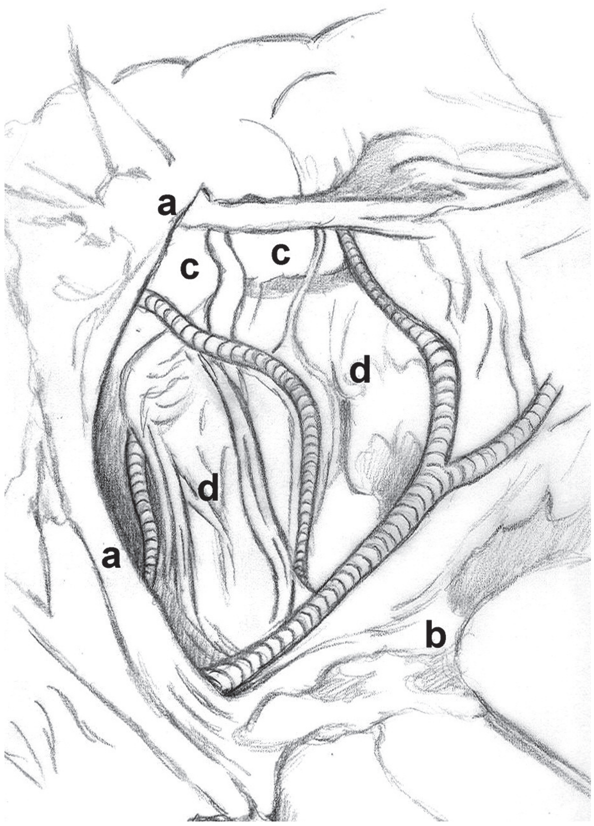


Fig. 2. Status prior to the resection of the meningioma of the anterior portion of the craniovertebral junction (patient 2) seen from the left; a – suboccipital dura, b – dural flap ajar, c – brainstem, d – tumour entangled in nerves and vessels

with the first cervical roots were usually involved. In another 5 cases (36%), tumours were indigenous to the aforementioned nerves while in another 3 (21%) nerves were completely encased in the tumour. For half of the cases, the tumour was adjacent to cranial nerves on both sides. Concretion or encasement of nerves within a tumour led to technical difficulties in preservation of nerves' continuity during resection. It was particularly relevant to the spinal root of the accessory nerve and to a lesser extent to the glossopharyngeal, vagus and hypoglossal nerve. Postoperatively, 8 patients (57%) showed signs of cranial nerve dysfunction. In 2 cases (14%), we observed postoperative consciousness disturbances subsequent to internal hydrocephalus found on postoperative computed tomography. In one case it subsided spontaneously owing to the retreat of posterior fossa oedema. The other case required implantation of a ventriculo-peritoneal shunt. All neurological sequelae and complications subsequent to surgical treatment are summarized in Table 2.

Direct contact between the tumour and vertebral artery was found in 3 (21%) cases, adhesions in 5 (36%) cases, while the vertebral artery was encased in the tumour in 6 (43%) cases. The relationship of the posterior inferior cerebellar artery to the tumour depended on tumour size and individual variability of the posterior, inferior cerebellar artery origin on the vertebral artery. In 8 cases (57%), the tumour was adjacent to vertebral arteries bilaterally, but none of the cases showed bilateral adhesion to or bilateral encasement of the arteries in the tumour. All of the patients whose preoperative MRI had suggested encasement of the vertebral artery in a tumour underwent angiography in order to assess flow and find possible signs of arterial wall's infiltration by the tumour. None were found, which was confirmed intraoperatively. Nonetheless, angiographic studies proved that pathological vascularisation of the tumours usually originated from the ascending pharyngeal artery and meningeal branches of the vertebral artery. Eight tumours (57%) had considerable vascularisation that required frequent haemostasis during resection. Five other cases (36%) had weak vascularisation; one angiomatous meningioma in our series had prominent vascularisation. In 4 cases (29%), tumours were soft with the majority of tumour feasible for suction. Half

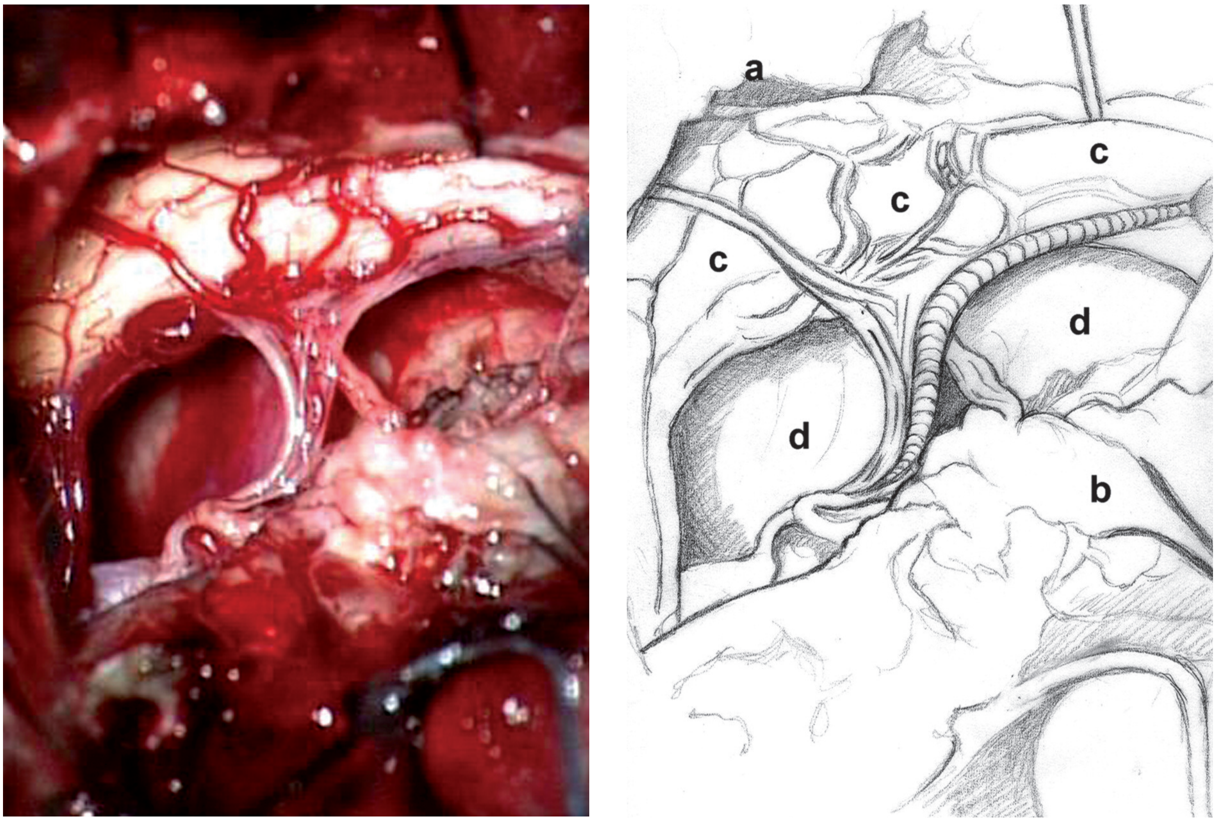


Fig. 3. Status after resection of the meningioma of the anterior portion of the craniovertebral junction (patient 2) seen from the left; a – suboccipital dura, b – dural flap ajar, c – brainstem, d – dura of the lower clivus and anterior arch of the atlas

of the tumours had mixed consistency (partially soft and partially compact) while two cases (14%) were hard, which made resection particularly difficult in the narrow space provided by the selected approach.

Resections were complete in 12 cases (86%) but only in 4 cases did handling of the dural attachment of the tumour allow Simpson grade I classification of radicalness. In the remaining 8 cases we achieved Simpson grade II radicalness. In 2 cases (14%), lack of radicalness was related to the fact that pieces of the tumour indigenous to the ventral part of the medulla oblongata were electively left untouched. Follow-up for one of the cases is 40 and 35 months for the other one; still we have found no signs of progression of the remaining parts of the tumour. The other patients had postoperative MRI that confirmed completeness of the resection and have presented no signs of recurrence so far. Follow-up times varied from 10 months to 103 months (mean 55 months, SD 31 months).

Comparison of functional capacities according to Karnofsky performance scale (Table 3) on admission and during follow-up proved that 57% of patients improved after surgery, in 36% of them their activity remained unchanged while in 7% of cases it deteriorated. Importantly, half of the patients among 8 who ultimately improved at the completion of the treatment and rehabilitation were discharged from the hospital in a worse condition than on admission.

Discussion

Classification of APCVJ tumours into extradural and intradural finds its substantiation in different surgical modalities necessary for their treatment as well as in their histopathological distinction [1-3]. Tumours of the APCVJ, if they are to be approached laterally and are located extradurally, require a complete transcondylar approach which consequently necessitates cranio-vertebral junction stabilization. Tumours of the anterior part of the cranio-cervical junction that are located intradurally usually require PTA [1]. The histopathological range of tumours within this region is wide and encompasses chordomas, neuromas, benign and malignant tumours of bony, cartilaginous, fibrous or vascular origin and meta-

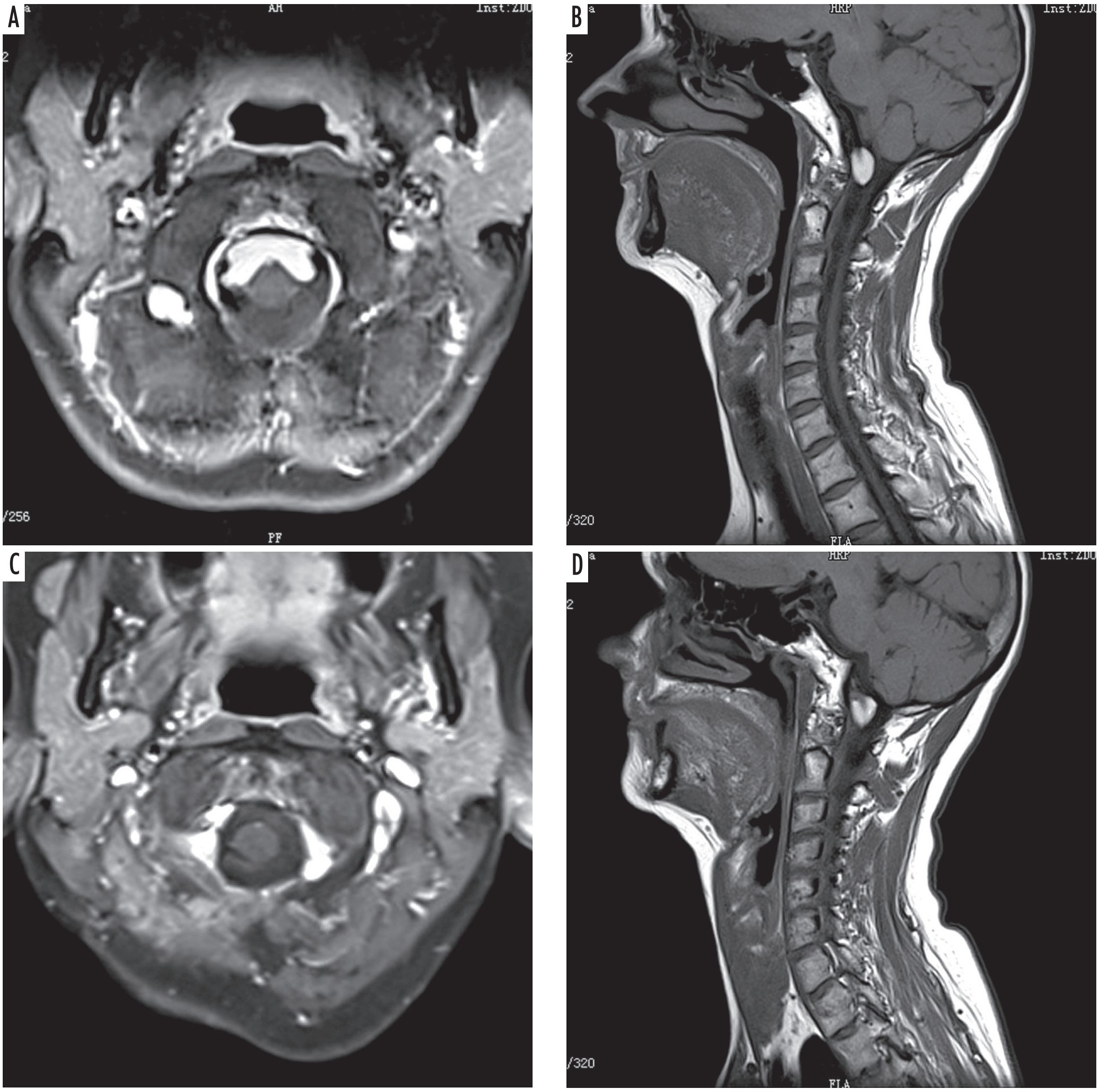


Fig. 4. Meningioma (2.8 cm^3) of the anterior portion of the craniovertebral junction (patient 11). Due to the small size of the tumour no access that would enable completion of the resection was achieved during its removal; A) tumour seen in the axial plane on preoperative MRI; B) tumour seen in the sagittal plane of the right vertebral artery on preoperative MRI; C) status after removal of the tumour seen in the axial plane on postoperative MRI; D) status after removal of the tumour seen in the sagittal plane of the right vertebral artery on postoperative MRI

static tumours, as well [1,2]. Among the intradural tumours of cranio-cervical junction, 25% constitute neuromas and only sporadically other lesions [3-7]. Meningiomas are the most common in this location and comprise 75% of them [3]. Nonetheless, Borba and Colli [8] report that they constitute only 1.8% to 3.2% of all meningiomas. These authors describe segmentation of the foramen magnum into an anterior and posterior part based on denticulate ligament location. Fifteen percent of meningiomas have their attachment in the anterior part, 70% in the antero-lateral part, 10% in the postero-lateral part and 5% in the posterior part of the foramen. Pirotte *et al*. [9] divide meningiomas with an attachment to the anterior part of the foramen into anterior right- or left-sided, those that barely cross the midline, and anterior bilateral ones that extend from one denticulate ligament to the other. All cranio-cervical junction meningiomas are adjacent to the foramen magnum, while

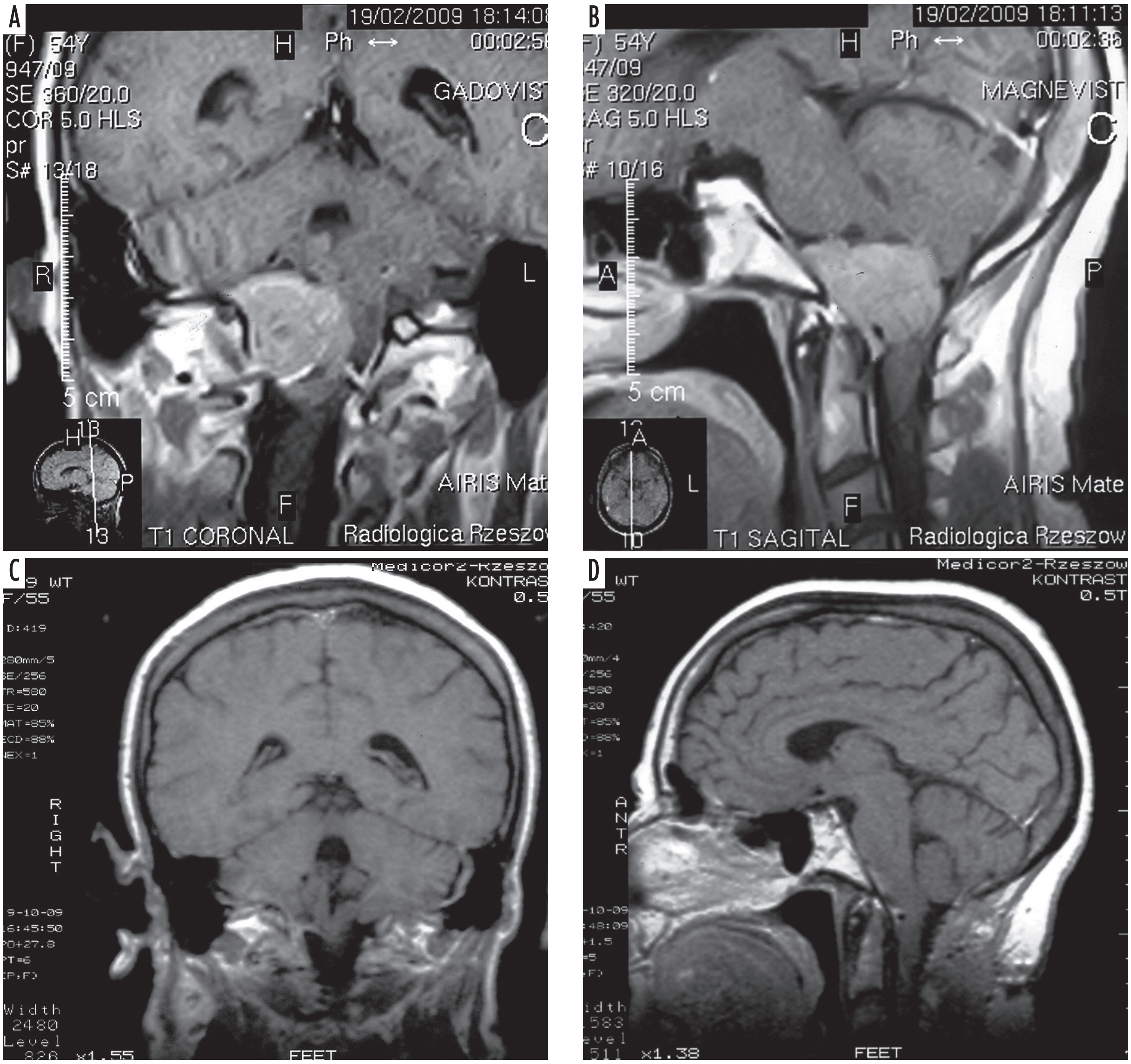


Fig. 5. Antero-lateral meningioma of the anterior portion of the craniovertebral junction on the right (patient 13). Right vertebral artery encased in the tumour; A) tumour seen in the coronal plane on preoperative MRI; B) tumour seen in the sagittal plane on preoperative MRI; C) status after removal of the tumour seen in the coronal plane on postoperative MRI; D) status after removal of the tumour seen in the sagittal plane on postoperative MRI

their rostral and caudal extent is variable. Borba and Colli [8] quote Cushing and Eisenhardt, who divided the tumours in question based on the direction and the extent of growth into vertebro-cranial and cranio-vertebral. Five growth combinations repeat in the literature [4,7,10]: from the mid-clivus to half of the height of the odontoid process; from the lower part of the clivus to half of the height of the odontoid process; from the mid-clivus to the base of the odontoid process; from the mid-clivus to the body of the axis; and from the foramen magnum to the body of the axis.

Preoperative assessment of the attachment location in those tumours based on the neuroimaging studies is difficult. Nonetheless, it is important to pay attention to its location for it determines the tumour's growth direction as well as its topographic relations to the adjacent structures. In our experience, tumours with an attachment in the APCVJ usually displace the spinal cord posteriorly and vertebral arteries laterally. The more laterally the attachment is, the higher the likelihood of contralateral spinal cord displacement and the higher the probability of vertebral artery encasement on the attachment side.

Based on the above observation we classified tumours that displaced the medulla oblongata and spinal cord posteriorly as anterior tumours of the APCVJ. Tumours that displaced the spinal cord postero-laterally or latero-posteriorly were defined as anterolateral or latero-anterior APCVJ tumours, respectively. It seems that the proportions between anterior and lateral portions of the tumour depend on the degree of the tumour attachment displacement either in the lateral or anterior direction. Sagittal planes that cross medial aspects of the vertebral arteries upon their entry into the dura might serve as a reference point for demarcation between anterior and posterior parts of the craniocervical junction and its lateral parts. The given approach along with foramen magnum division into an anterior and posterior part based on location of denticulate ligaments that was cited above allows precise separation of anterior, posterior, antero-lateral and postero-lateral parts in the cranio-cervical junction.

Time from the first symptoms to the diagnosis and treatment in APCVJ tumours averages a year and a half [6]; in our cohort it slightly exceeded a year. It is usually prolonged by the absence of characteristic first symptoms [11]. They include pain of the posterior part of the head and neck, pareses of extremities that arise from uni- or bilateral pyramidal tract compression, paresis or paralysis of the cranial nerves of the lower cerebellopontine angle group, and cerebellar disturbances [1,4,5,7,10,12]. Meyer *et al.* [11] in their study that analysed catamnesis of 102 patients with benign tumours of the foramen magnum proved that, prior to a proper diagnosis, 25% were treated as cervical spondylosis, 18% as multiple sclerosis, 17% as syringomyelia, 15% intramedullary tumour and 5.5% as Arnold-Chiari malformation or even as a carpal tunnel syndrome. Motor deficits evoked by the tumour primarily involved the upper extremity on the tumour side, next the lower extremity on the same side, and subsequently the other side's extremities.

The results of surgical treatment of APCVJ meningiomas that we present in our study are encouraging. Complete resection was achieved in the majority of the cases without any mortality and with only sporadic, additional neurological deficits. It allowed us either to preserve satisfactory quality of life or to improve it. The relatively small group that we analysed does not allow us to draw any far-reaching conclusions; still, our remarks are in concert with others [1,4,5,7,10]. It is worth stressing, however, that the treatment was well tolerated by elderly patients [6]. Topography of the cranial nerves related to the cranio-cervical junction results in the highest risk of iatrogenic injuries to the spinal root of the accessory nerve [13]. We report intensification of the deficits of this nerve in 36%. On the other hand, postoperative complications of APCVJ meningioma treatment include liquorrhoea from the surgical site or internal hydrocephalus [1,8]. We observed no liquorrhoea in our group, but 14% of patients developed hydrocephalus. Borba and Colli's data [8] proved that radical resection could be achieved in 82% for the meningiomas in question. On the other hand, only 4 out of 14 treated patients in our group achieved grade I in the Simpson scale while 8 achieved II. Still, Al-Mefty [14] asserts that difficult topographic conditions do not obviate attempts to achieve Simpson grade I resection. We did not achieve complete resection of the tumours in 2 patients owing to their adhesion to the brainstem. These patients are being systematically followed up with control MRI; notably, the remaining parts of the tumours have not grown so far. The authors will recognize any enlargement as an indication for stereotactic radiotherapy. In general, stereotactic radiotherapy constitutes an alternative to surgical treatment whenever it cannot be implemented due to the general condition of the patient and/or lack of his or her consent; still the tumour should not exceed 30 mm in any of its diameters [15,16].

Classification of intradural APCVJ tumours into anterior and antero-lateral or latero-anterior allows the refinement of indications for PCA. Absolute indications for this approach include intradural tumours that displace the spinal cord posteriorly, i.e. tumours that are completely concealed by the medulla oblongata when approached posteriorly. This is particularly relevant for small tumours. Tumours that are partially visible lateral to the medulla oblongata via a posterior approach, either due to their large size, antero-lateral location or both, have relative indications for PCA. *En plaque* expansion and vertebral artery encasement favour this approach as well [14,17]. Foramen magnum shape is individually variable, which in turn might influence surgical accessibility of its anterior limits [18]. Some patients have an oval foramen with antero-posterior diameter predominant over lateral. This shape of the foramen strengthens indications for PCA [19].

A number of surgical concepts exist that constitute an alternative to PCA in the treatment of intradural APCVJ tumours. They contemplate various possible approaches to this region from posterior, lateral or anterior directions. A classical approach to the posterior fossa, i.e. paramedian suboccipital craniectomy that encompasses the posterior border of the foramen magnum and approaches the occipital condyle, opens the list. This is usually considered as a possible way to approach APCVJ tumours posteriorly [20]. Goel *et al.* [21] described 17 cases of intradural, antero-lateral tumours of APCVJ treated with this approach. Tuite and Crocard [22], Kasprzak *et al.* [23], and George *et al*. [2,24,25], who call it the postero-lateral approach, have described its implementation as well.

Another two approaches, alternative to transcondylar approaches, are lateral approaches. The first one, described by George *et al.* [24,25], is an antero-lateral approach. It consists of posterior translocation of the sternocleidomastoid muscle and subsequent visualization of the accessory nerve, internal jugular vein and transverse process of the atlas. Removal or deviation of cranio-cervical junction muscles facilitates identification of the V3 segment of the vertebral artery. This approach provides access to the areas anterior and posterior to the occipital condyle and lateral part of the atlas. The other lateral approach alternative to transcondylar approaches consists of jugular tubercle resection proposed by Perneczky [26]. Salas *et al.* [1] describe this approach as one of the variants of the far-lateral approach, stressing its value in the treatment of selected aneurysms of the vertebro-basilar circulation. Matsushima *et al*. [27] developed the idea of jugular tubercle resection and suggested an approach that encompasses resection of the condylar fossa milieu in combination with suboccipital craniectomy and resection of the posterior arch of the atlas. Measurements performed by Spektor *et al.* [28] proved the importance of jugular tubercle resection for a proper view into the foramen magnum area. Rhoton [29], however, stresses that even with extradural jugular tubercle resection glossopharyngeal, vagus and accessory nerves might get injured.

Another large group of approaches, alternative to transcondylar approaches, are anterior approaches. They include transoral approaches with splitting of the soft palate and posterior wall of the pharynx [30-35], sometimes extended by opening of the hard palate and maxillary sinuses [36], as well as those that involve the lower lip and mandible split [37]. Anterior approaches also incorporate cervical approaches directed laterally to the larynx and pharynx and medially to the neurovascular bundle [38], often with associated mandible split [39]. However, even Crocard [31], an advocate for the most common of the anterior approaches, i.e. the transoral approach, admits that while being useful in the treatment of extradural, midline lesions it has no advantages over lateral approaches in cases with intradural lesions that are located laterally. The two most common disadvantages of the transoral approach are liquorrhoea that arises from difficulties in watertight dural closure and infections caused by bacterial flora present in the course of the access [9,14,40,41]. Moreover, during APCVJ tumour dissection via any of the anterior approaches a surgeon has no control over the tumour margin in relation to the brainstem [9,14,41], and if tumour dissection results in instability that requires cranio-cervical stabilization, a separate procedure with a different incision and approach is required [41].

Conclusions

1. The partial transcondylar approach facilitates removal of meningiomas of the APCVJ that are located intradurally, without any need for brainstem or spinal cord dislocation.
2. The partial transcondylar approach allows a view of the borderline between the tumour and the ventral part of the brainstem within the APCVJ and enables simultaneous control over the vertebral artery and its branches along with the lower group of cranial nerves in the cerebellopontine angle and upper cervical roots.
3. Surgical treatment of meningiomas that qualify for PTA usually does not result in deterioration of existing neurological deficits, and its side effects are limited or subside completely. The discussed approach does not lead to craniovertebral junction instability.

Disclosure

Authors report no conflict of interest.

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