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# Postoperative complications following resection of extramedullary tumors of the craniovertebral junction region

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**ABSTRACT**
Surgical treatment of extramedullary tumors of the craniovertebral junction (CVJ) remains a difficult task due to adjacent important neurovascular structures. International data indicate high incidence of postoperative complications following surgical intervention alone.
**Objective. T**o analyze postoperative complications following resection of CVJ extramedullary tumors.
**Material and methods.** A retrospective study of treatment outcomes in 64 patients with CVJ tumors was performed between 2013 and 2024. Neurological status in pre- and postoperative period was assessed depending on location, histological variant of tumor and surgical approach. Surgical, neurological and somatic complications were specified.
**Results.** Postoperative complications occurred in 23 (38%) patients. For meningiomas, complications occurred in 38.4% of cases, for schwannomas — in 23.5%, for neurofibromas — in 57.1% of cases. Lateral and median approaches had similar complication rates (35.7% and 33.3%, respectively). Surgical complications occurred in 11 (21.8%) patients, and infectious complications were the most common (meningitis in 6 (9.3%) patients). Neurological complications were detected in 13 (20.3%) patients, and dysfunction of bulbar nerves prevailed (7 (10.9%) patients). Somatic postoperative complications occurred in 8 (12.5%) patients, fatal outcomes — in 1 (1.5%) case.
**Conclusion.** Our results demonstrate high incidence of postoperative complications after surgical treatment of extramedullary CVJ tumors.

***Keywords:*** *postoperative complications, craniovertebral junction, craniovertebral meningiomas.*

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## Abbreviations

CVJ — craniovertebral junction
CSF — cerebrospinal fluid
ICP — intracranial pressure
VPS — ventriculoperitoneal shunt
FEDSS — Fiberoptic endoscopic dysphagia severity scale

## Introduction

CVJ tumors are located between the lower third of the clivus and inferior border of C2 vertebra [1—4]. Among them, meningiomas account for up to 77% [1, 3, 4, 6, 8], neurinomas — about 30% including intra- and extradural tumors (15—25%) [2, 3, 9]. There are also paragangliomas, arachnoid cysts, dermoid tumors, lipomas, teratomas, intradural chordomas and metastases [9]. Total resection of CVJ tumors is associated with high risk of neurological disorders. The incidence of postoperative complications ranges from 9.7% to 29.4% [1, 2, 5, 6, 8], mortality varies from 1.8% to 16.6% [1, 2]. Complications described in the literature are not systematized [1, 2, 6, 8] and typically assessed according to surgical classifications (Clavien-Dindo, 2004; F.A. Ibanez, 2011; K. Houkin, 2009) [1, 2, 6, 8, 10]. There are ongoing discussions about what should be considered

a surgical complication and what is a consequence of disease. Incidence of specific complications typical for CVJ tumors is interesting.

The purpose of this study was to analyze postoperative complications associated with resection of extramedullary CVJ tumors.

## Material and methods

A retrospective study included 64 patients with CVJ tumors between 2013 and 2024. There were 23 men and 41 women.

Inclusion criteria: extra- and intradural extramedullary CVJ tumors, histological confirmation of diagnosis and patients undergoing primary surgery.

Exclusion criteria: intramedullary tumors, tumor extension beyond CVJ, concomitant injuries, systemic diseases (rheumatoid arthritis), CVJ anomalies, bone and soft tissue tumors, combination of several histological types of brain tumors, multiple CVJ tumors.

We assessed pre- and postoperative neurological status, as well as caudal cranial nerve function. Dysphagia was assessed using 3-swallow test according to the FEDSS scale. MRI of the head and cervical spine was evaluated before and after surgery. Complications were categorized as surgical, neurological and somatic. We analyzed complications depending on histological type of tumor and surgical approach. Postoperative complications were studied using the Clavien-Dindo classification [10].

## Results

Meningiomas ($n$=39, 61%) and C1 spinal root schwannomas ($n$=17, 26.5%) predominated **(Table 1)**.

**Surgical approaches.** In patients with tumors at the lower third of the clivus and foramen magnum, we used posterolateral approach in 42 (65.6%) cases including partial (<1/3) resection of occipital condyle in 6 (14.2%) patients. For C1—C2 tumors with midline configuration and tumor matrix below foramen magnum, we performed midline suboccipital approach in 18 (28.2%) patients. Retrosigmoid approach was used in 4 (6.2%) cases to remove meningiomas with rostral extension and matrix within the lower clivus. Complication rates were comparable depending on approach **(Table 2)**.

Postoperative complications developed in 23 (38%) patients. Nine ones experienced combination of multiple complications.

Surgical complications developed in 14 (21.8%) patients. Of these, surgical site complications were the most common: CSF cysts (3 cases, 4.6%), wound CSF leaks (3 cases, 4.6%), and infectious meningitis (6 cases, 9.3%, death in one case) **(Table 3)**.

Surgical complications Clavien-Dindo grade 3b with necessary surgery under general anesthesia occurred in 6 cases **(Table 3)**. Surgical site CSF cyst developed in 3 cases. In the first case, the patient presented one month after surgery with progressive limb weakness, moderate impairment of consciousness and tetraparesis (3 points). CSF cyst at the level of foramen magnum and occlusive hydrocephalus were detected. Third ventricle drainage was followed by VPS. Another patient presented one year after surgery with complaints of headaches and dizziness. MRI revealed surgical site CSF cyst. Drainage and excision of cyst walls were performed.

Wound CSF leakage developed in 3 cases. Each case required redo surgery with dura mater reconstruction using auto- or allografts. Combination of CSF leakage with postoperative wound suppuration required surgical site debridement, dura mater defect closure and insertion of irrigation system.

One patient with CVJ meningioma developed C0-C3 hematoma in early postoperative period with spinal cord compression and hemotamponade of the fourth and third ventricles. Impaired consciousness and occlusive hydrocephalus necessitated external ventricular drainage and subsequent exploration. The cause of bleeding

***Table 1.*** **Number of complications in various histological types of extramedullary CVJ tumors**

| Histological variant | Number of patients, *n* (%) | Number of patients with complications, *n* (%) |
|---|---|---|
| Meningiomas | 39 (61) | 15 (38.4) |
| Schwannomas | 17 (26.5) | 4 (23.5) |
| Neurofibromas | 7 (10) | 4 (57.1) |
| Metastasis of adenocarcinoma | 1 (1.5) | — |

***Table 2.*** **Complication rates for different surgical approaches**

| Surgical approach | Number of patients, *n* (%) | Number of patients with complications, *n* (%) |
|---|---|---|
| Far lateral | 42 (65.6) | 15 (35.7) |
| Midline | 18 (28.2) | 6 (33.3) |
| Retrosigmoid | 4 (6.2) | 2 (50) |

***Table 3.*** **Surgical somplications**

| Complication | Clavien—Dindo grade | Number of patients, *n* |
|---|---|---|
| Surgical site infection with wound CSF leakage | 3b | 1 |
| Meningitis | 2 | 6 |
| Wound CSF leakage | 3b | 2 |
| CSF cyst | 3a | 1 |
| | 3b | 2 |
| Surgical site hematoma | 3b | 1 |
| Posthemorrhagic anemia | 2 | 1 |
| Death | 5 | 1 |

*Table 4.* **Neurological complications in early postoperative period**

| Complication | Clavien—Dindo grade | Number of patients, *n* |
|---|---|---|
| Stroke | 4 | 2 |
| Bulbar syndrome | 3a | 4 |
| | 3b | 2 |
| Hypoglossal nerve palsy | 1 | 1 |
| Facial nerve palsy | 2 | 1 |
| | 3a | 1 |
| Progressive ipsilateral paresis | 1 | 2 |

*Table 5.* **Somatic complications of early postoperative period**

| Complication | Clavien—Dindo grade | Number of patients, *n* |
|---|---|---|
| Thromboembolism of small pulmonary arteries | 2 | 1 |
| Endobronchitis | 2 | 4 |
| Deep vein thrombosis | 2 | 3 |

was not identified, hematoma was evacuated, and hemostasis was achieved. VPS was established after 3 weeks. Somatic and neurological status returned to baseline.

Neurological complications were identified in 13 (20.3%) patients. In early postoperative period, cranial nerve dysfunction was observed in 9 (14%) patients. Tracheostomy was necessary in 2 (3.1%) cases **(Table 4)**.

Early postoperative bulbar syndrome developed in all patients with tumors of inferior clivus contacting with caudal cranial nerves. In four cases, bulbar symptoms were caused by direct surgical trauma following nerve detachment from tumor surface. In two cases, bulbar symptoms were due to circulatory disturbances in caudal brainstem on the first postoperative day. Appropriate foci of ischemia were confirmed by DWI. Intraoperatively, anatomical integrity of caudal nerves was not compromised in any case. Caudal cranial nerve damage corresponded to FEDSS score 1—3. Symptoms of bulbar syndrome partially regressed in 3 (4.6%) patients after rehabilitation and persisted at discharge in 4 (6.2%) patients. The most serious complications (focal ischemic damage to the brainstem with severe disability) occurred in 2 (3.1%) patients with ventral meningiomas and tumor matrix at the lower third of the clivus **(Table 4)**.

Somatic complications (thromboembolic and infectious) were noted in 8 (12.5%) patients. Type 2 complications, requiring conservative treatment, were the most common **(Table 5)**. Endobronchitis developed under bulbar syndrome in all cases.

## Discussion

Surgical approach is one of the main factors in aggressive resection of CVJ meningiomas. To minimize complications, it is necessary to take into account tumor location (M. Bruneau et al., 2008), sufficient angle of attack and adequate control of neurovascular structures [4]. Midline approach is widespread and associated with low risk of complications in patients with posterior tumors [1, 4]. Up to 80% of meningiomas are located anteriorly and laterally [4, 6]. Lateral access with drilling of foramen magnum and occipital condyles minimizes brainstem retraction. However, there is a risk of damage to V3 segment of vertebral artery or veins of vertebral plexus [4, 8]. Involvement of vertebral artery is significantly associated with higher incidence of complications [5]. Manipulations near accessory nerve can lead to its dysfunction, while those near sympathetic trunk can lead to transient Horner's syndrome [4].

**Bulbar disorders.** The incidence of new bulbar syndrome or deterioration of baseline symptoms ranges from 6.2% in schwannomas [2] to 22.2% in meningiomas [1, 5, 8]. About 8.3—31.6% of disorders require tracheostomy [1, 5]. Functional recovery is observed in 50% of patients throughout more than 1-year follow-up [8]. Dysfunction of caudal cranial nerves is more common in meningiomas of foramen magnum, ventral (anterior) neoplasms and tumor matrix at the lower clivus [5—7]. In our series, the incidence of bulbar complications was consistent with international data. Correct surgical manipulations are recommended to reduce the likelihood of caudal cranial nerve dysfunction: dissection from intact structures to damaged ones (from bottom to top); preservation of arachnoid sheath of the nerve and no intersection of transverse fibers connecting longitudinal nerve bundles. It is important to minimize cauterization for dissection and intracapsular resection of tumor. In case of vein damage, one should use hemostatic materials for hemostasis [11]. We recommend intraoperative neurophysiological monitoring in all interventions for CVJ tumors. Combined treatment may be advisable in case of dense adhesion of tumor to nerves or vessels (subtotal or partial resection with sufficient CVJ decompression followed by radiotherapy for residual tumor) [1]. Stereotactic radiosurgery opens up opportunities for safer irradiation minimizing early and delayed radiation reactions of surrounding tissue, such as neuropathy [6]. Combined treatment is preferable because it does not affect disease-free survival and allows for preservation of baseline functional status with fewer complications due to less surgical aggressiveness [1, 6].

Stroke is the main cause of postoperative mortality in surgery for posterior cranial fossa meningioma [1, 6]. Stroke may be caused by vascular cauterization, sinus damage or traction injury. Increased unilateral perfusion parameters in patients with meningiomas of posterior cranial fossa indicate restructuring of blood flow in areas adjacent to neoplasm and higher risk of postoperative pathological reactions [12].

**Wound CSF leakage, CSF cysts.** The incidence of postoperative CSF leakage ranges from 4% to 32%. The prob-

ability of CSF space infection in among patients with CSF leakage is up to 66%. This complication is most common in PCF surgery and lesions near foramen magnum (up to 33.3%) [13]. Risk factors of CSF leakage include inability to align dura mater edges, leaky suturing and crossovers on suture line. Several CSF flow pathways within surgical site contribute to CSF leakage. The main methods for preventing this complication are hermetic dura mater suturing with autograft and post-resection dead space filling with autologous fat [13]. Early lumbar drainage is recommended for wound CSF leakage after PCF surgery. The main problems of lumbar drainage are excessive CSF drainage and drainage-associated meningitis. If drainage is ineffective, redo intervention is necessary for additional sealing of dura mater defects. Continuous lumbar drainage is recommended for up to 5 days to maintain normal ICP in postoperative period and to ensure good adhesion of the graft [14]. A systematic review enrolled 2976 patients, and incidence of persistent hydrocephalus after resection of PCF tumors was 13.63%. The main etiologic factor is mechanical block of CSF flow at the level of foramen magnum due to local edema, hemorrhage in tumor bed and CSF cysts [15]. Lumbosacral or ventriculoperitoneal shunt is recommended for patients with uncorrectable CSF leakage and hydrocephalus [13, 15].

**Infectious complications.** The incidence of infectious complications in different studies ranges from 0.5% to 20%. The most common one is meningitis (0.3—9.5%) [16]. According to the literature, significant factors contributing to meningitis are blood albumin< 3.5 mg/dL, skull base tumors, blood loss > 400 ml, surgery time > 3 hours, placement of drains (ventricular, lumbar) and wound CSF leakage [16, 17]. In our sample, mean surgery time in patients with meningitis was 5 hours 15 minutes, blood loss — 425 ml, and lumbar drains were inserted in 4 out of 6 patients. Drainage infection occurs in 1.2—19% of cases. It is associated with high mortality risk [15]. Basal meningitis is particularly dangerous. Indeed, infectious focus (CSF cyst, plastic material for dura mater closure or filling dead space) in skull base forms a surrounding zone of inflammation and encapsulation with chronic infection [17].

Mortality rate in patients with infectious complications ranges from 3% to 15% [16, 17]. In our sample, this value was 1.5%.

## Conclusion

Histological type of tumor, its location and relationship with neurovascular structures are essential for postoperative complications after resection of CVJ tumor. Dysfunction of caudal nerves and occlusive CSF flow disturbances are specific complications. These data may be used to predict postoperative period and to adjust surgical tactics in favor of combined treatment. It is important to focus treatment of CVJ tumors in hospitals with extensive surgical experience. This will reduce the incidence of complications and increase extent of safe resection. Appropriate data allow us to develop a special classification of complications after interventions for CVJ lesions.

**Author contribution:**
Concept and design of the study — Rzayev D.A., Kubetsky Yu.E., Stepanenko V.V.
Collection and analysis of data — Labzina E.E., Kosimshoev M.A.
Statistical analysis, writing and editing — Labzina E.E.

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## COMMENT

Postoperative complications are important for neurosurgeons. CVJ is one of the most difficult areas for resection of extramedullary tumors. The article is rich in recent literature data, including data from Russian authors. Postoperative complications developed in 23 (38%) patients. In our opinion, this is a truly high percentage (according to the literature, the incidence of postoperative complications ranges from 9.7% to 29.4%). Nevertheless, the authors openly discuss their problems and methods for addressing them. They compare own data with complications reported in meta-analyses. This analysis and structuring of complications may be useful for determining surgical strategy and predicting postoperative course in patients with extramedullary CVJ tumors.

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