# SURGICAL TREATMENT OF PRIMARY SPINAL TUMORS: TACTICS AND RESULTS*

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**Objective.** To study the efficacy of differentiated surgical treatment for primary spinal neoplasms based on estimation of clinical condition of a patient, survival rate, and early postoperative complications.
**Material and Methods.** Surgery was performed in 55 out of 68 patients with primary spinal tumors involved in the study. The primary examination included CT and MRI study of the affected area of the spine. In some cases, a biopsy was performed.
**Results.** According to histological structure, spinal tumors were identified as aggressive hemangioma, chondrosarcoma, aneuyrismal bone cyst, plasmocytoma, chordoma, giant-cell tumor, or eosinophilic granuloma. Neurological status was characterized by local pain in 18 (38 %), and by pain combined with nerve conduction disorders in 20 (40 %) patients. In accordance with the spine instability neoplastic score (SINS), most patients had stable destructions of vertebra. Evaluation of neurological status did not reveal severe deficiency: 65 % of patients had grade D or E on Frankel scale.
**Conclusion.** Patients with tumors of the spine require careful choice of a multidisciplinary treatment. Increasing the life expectancy of patients with malignant tumors and improving the quality of life in patients with tumors of different histological structure are decisive factors in the choice of tactics and dictate the variability of approaches to treatment.
**Key Words:** spinal tumors, hemangioma, chondrosarcoma, aneuyrismal bone cyst, plasmocytoma, chordoma.

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The development of surgical techniques, based on the seminal work by Boriani et al. [5, 6] and advances in imaging techniques enabled the use of basic oncology principles in treatment of primary spinal tumors. This option sets them apart from metastatic spinal tumors, which in recent years have been requiring increasingly tailored choice of treatment due to significant variability of secondary lesions of the same histological nature [8, 9]. To a large extent, the lack of common standards for treatment of primary spinal tumors can be attributed to highly specialized approaches employed by oncologists, orthopaedists and neurosurgeons and contradictory concepts used by different professionals involved in treatment of this particular nosology. Creation of "spinal surgery" specialization might address the issue of optimization of treatment principles for vertebral neoplasms.

The common approach to spinal tumors treatment is based on the principles of bone oncology, in particular on resection of parts of the musculoskeletal system developed by Enneking [7]. The existing principles of en-block resection of primary and metastatic spinal neoplasms require taking into account a number of aspects that distinguish oncovertebrological problems from problems encountered, e.g., in disarticulation of affected limbs.

The purpose of research is to study the efficacy of differentiated surgical treatment for primary spinal neoplasms based on evaluation of post-operative clinical condition, survival rates of patients and incidence of intra- and early postoperative complications.

## Material and Methods

The study included 68 patients with primary spinal neoplasms. The average age was 43.8 years (34 to 68 years) and 64 % of the patients were male. The distribution of patients by tumor histology is shown in Table 1.

This study examined only the outcomes of surgical treatment delivered by the authors. In all cases, the decision to perform a surgery was made by an inter-institutional oncological council, after a biopsy, and was based on oncology principles and WBB, SOSG recommendations, as well as a few national guidelines [2, 3, 5, 10]. Thus, this paper analyzes the outcomes of treatment of 55 patients with primary spinal neoplasms for whom surgery was chosen as the main stage of pathognomonic treatment. The material was collected and the outcomes were evaluated over 5 years.

The most common clinical manifestation of a neoplasm was local pain. In our study, the incidence of isolated back pain as the main complaint upon admission was equal to the incidence of pain combined with nerve conduction disorders, paresis of varying degree of severity (Table 2).

Distribution of patients by severity of motor impairment is shown

in Fig. 1. Frankel scale was used for evaluation. The majority of patients had no or minimal motor impairment.

The primary examination included CT of the affected section of the spine, which allowed evaluation of the degree of cortical layer destruction and tumor calcification [20]. Relevant information was also derived from MRI of the spine and included assessment of the following diagnostic symptoms:

– soft-tissue component in the bone structure;

– changes in the surrounding paraspinal tissues;

– compression of neural structures;

– infiltration of the spongy substance of the vertebrae;

– epidural component.

In a large proportion of cases (ca. 75 % of cases) the use of these diagnostic tools allowed putative elucidation of histological nature of the primary neoplasm with high degree of certainty. In 10% of cases, assumptions about histological nature of the tumor, in the absence of definite diagnosis, allowed performance of the surgery without prior biopsy due to the risk of dissemination of the tumor. The biopsy was not performed in case of pronouncedly vascular character of the neoplasm and high risk of bleeding (especially in case of penetration of the tumor into the spinal canal) (Fig. 2).

Four different biopsy techniques were used (a combination of methods was used in the absence of a reliable result):

– Fine needle aspiration biopsy, primarily cytological study (4 cases);

– Trephine biopsy, thick need biopsy with collection of bone marrow sample in one piece (42 cases);

– Open incision biopsy, collection of the neoplasm's fragment through an incision (18 cases);

– Total resection of the neoplasm with a biopsy, excisional biopsy (10 cases) [13].

For patients with differential diagnosis of only primary benign spinal neoplasms, based on imaging studies, excisional biopsy was an adequate option for the pfinal diagnosis and treatment. However, since the probability of local tumor spread in open incisional and excisional biopsies is quite high, trephine biopsy was performed in all cases of uncertain histological nature of the tumor. Upon identification of a highly malignant neoplasm, the channel excision along the course of a biopsy needle was performed according to the recommendations [23]. It requires planning of the progress of biopsy needle course. In our series, nearly 30 % of trephine biopsies were unproductive, and in 25 % of cases the histological diagnosis did not match the final one, based on examination of the tumor as a whole.

Instability was evaluated using instability score [10, 11]. The scale (spine instability neoplastic score, SINS), developed by members of Spine Oncology Study Group in 2010, contains the main criteria defining the stability of the spine: pain, a type of bone lesion, radiographic signs of spinal alignment, vertebral body collapse, posterolateral involvement of spinal elements. The maximum numerical value for the instability is 18 points. According to the researchers, the values up to 6 may indicate conditional stability of the spine and do not require additional fixing measures (Fig. 3).

The average value in our group of patients was 5.78 points (4.08 to 11.0), i,e. most patients had stable destructions of vertebra. It should be noted that, according to the literature [7], the average SINS value in spinal metastases exceeds 9 and characterizes more destructive metastatic lesions compared to primary tumors.

Surgical resection was performed in case of signs of compression of neural structures and instability. In case of radiosensitive tumors, surgical treatment was often limited to removal of vertebral body fragments displaced into the

**Table 1**

Distribution of patients with primary spinal neoplasms by histological nature of the tumor, n

| Nature of the tumor | Overall number of patients | Patients who underwent a surgery (levels of the lesions) |
|---|---|---|
| Aggressive hemangioma | 12 | 11 ($C_2$, $T_8$, $L_2$) |
| Chondrosarcoma | 9 | 9 ($C_1$, $T_3$, $L_6$) |
| Aneurysmal bone cyst | 8 | 8 ($C_5$, $T_3$) |
| Plasmacytoma | 9 | 4 (T) |
| Lymphoma | 7 | 2 (T, L) |
| Chordoma | 8 | 8 ($C_5$, $T_1$, $L_2$) |
| Giant-cell tumor | 5 | 5 ($C_1$, $L_4$) |
| Hemangioendothelioma | 1 | 1 (Th) |
| Osteosarcoma | 1 | 1 (L) |
| Ewing's sarcoma | 2 | 1 (C) |
| Fibrous cell dysplasia | 2 | 2 (L) |
| Chondroma | 2 | 2 (Th, L) |
| Eosinophilic granuloma | 2 | 1 (C) |
| TOTAL | 68 | 55 |

**Table 2**

Incidence of various neurological symptoms and combinations thereof, n (%)

| Clinical symptoms (complaints) | Incidence |
|---|---|
| Local back pain | 18 (38) |
| Pain combined with segmental disorders | 6 (22) |
| Pain combined with nerve conduction disorders | 20 (40) |

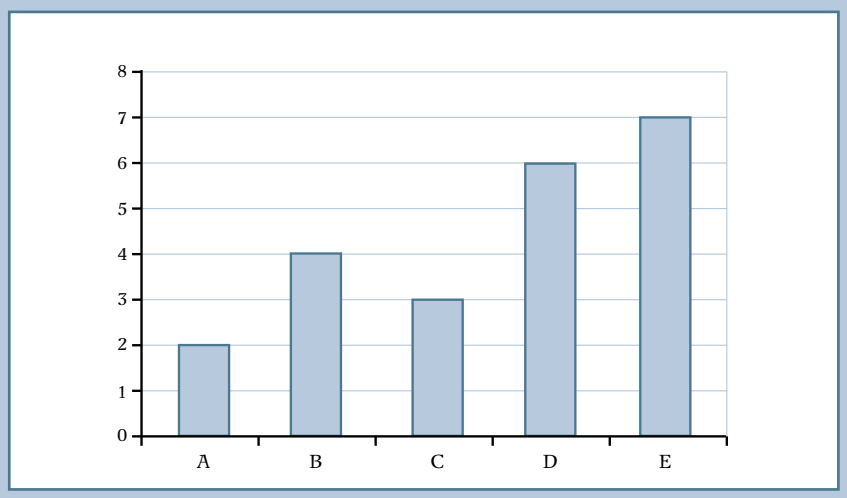


**Fig. 1**
Distribution of patients with motor impairment on Frankel scale

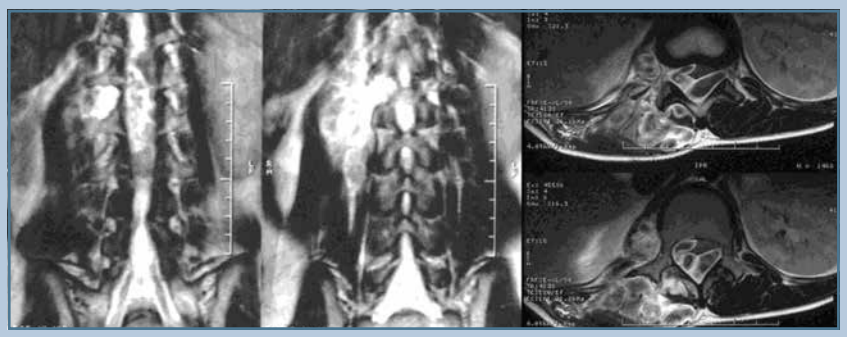

**Fig. 2**
MRI of a patient with cavernous angioma at the level of $L_2$ vertebra on the right: different modes suggest liquid component of the tumor in the spinal canal and soft tissues

**Fig. 3**
MRI of a patient with chondrosarcoma at $Th_{12}$: despite of the transition level of damage, SINS score of 5 characterizes a stable segment

spinal canal after pathological fracture (34 %; retropulsion). In the case of post-radiation collapse of radiosensitive neoplasms in the vertebral body, decompression of the spinal canal was supplemented with vertebroplasty and instrumental stabilization of the affected segments. Since the development of instability and compression of the spinal canal was, essentially, caused by the radiotherapy, the surgeon's task was not the complete resection of the tumor node, which would had been technically difficult and dangerous for a patient due to size and location, but rather the separation of nervous structures and bone neoplasms to optimize further radiation exposure (Fig. 4).

A group of tumors with average sensitivity to adjuvant therapy included patients with sarcomas; the most common primary childhood neoplasm is Ewing's sarcoma (Fig. 5). There were 12 cases among our patients. These neoplasms can be successfully managed by conservative therapy as a pre-operative stage. However, one should keep in mind a potential cytotoxic effect of radiochemotherapy, which complicates the surgical wound healing and reduces a patient's resistance to infection. Despite aggressive tactics against sarcomas (preoperative therapy followed by en-block resection), the prognosis for this group of tumors is poor with 5-year survival rate of less than 50 % [18].

A group of tumors that are not responsive to chemo-radiotherapy includes chordomas and chondrosarcomas (18 patients). The only treatment option for these primary neoplasms is en-block resection [1]. The existing evidence on the effectiveness of proton therapy and neoadjuvant therapy may be useful, if total removal of the tumor is impossible. Tumor excision to prevent its penetration into the surrounding tissues defines life expectancy of the patients, which does not depend on distant metastases, but mostly on local recurrence (Fig. 6).

Surgical options for removal of primary spinal tumors in the described series of cases include the following:

– intratumoral curettage (18 patients);
– wide excision by morcellation (21 patients);
– en-bloc resection (12 patients).

In two cases, the operation included isolated vertebroplasty, and in two other cases, in combination with removal of the tumor fragments. Wide resection involved larger, compared with intratumoral, access with visualization of adjacent structures and the need to remove the tumor up to the area which is free from neoplasm (negative edge). En-block removal of the tumor includes removal of the neoplasm as a single intact unit or as two units according to Tomita [21] (Fig. 7).

En-block resection is the most efficient operation (in our series of 12 patients) in terms of preventing recurrence; however, technically it is much more difficult than intratumoral removal [17]. The rate of postoperative neurological complications of en-block is much higher than in other resection options due to the need to cross neurovascular entities involved in the tumor.

Postoperative adjuvant therapy was conducted in specialized oncological institutions, and its effectiveness was not assessed in this study. Control of local recurrences of the primary tumor was achieved by radiation therapy in 22 (88 %) patients with malignant primary tumors. Proton therapy as a monotherapy or in combination with radiotherapy was used as a postoperative management option for primary malignant spinal neoplasms. In case of proton therapy, the possibility of achieving the maximum dose with a pronounced gradient near the nerve structures helped to avoid post-radiation complications [22].

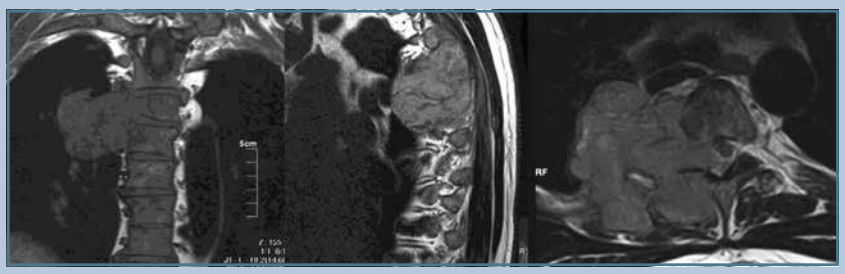

**Fig. 4**
MRI of a patient with a solitary plasmacytoma: tumor size, nature of its spread, and its histological structure do not suggest a total resection and require only decompression of neural structures

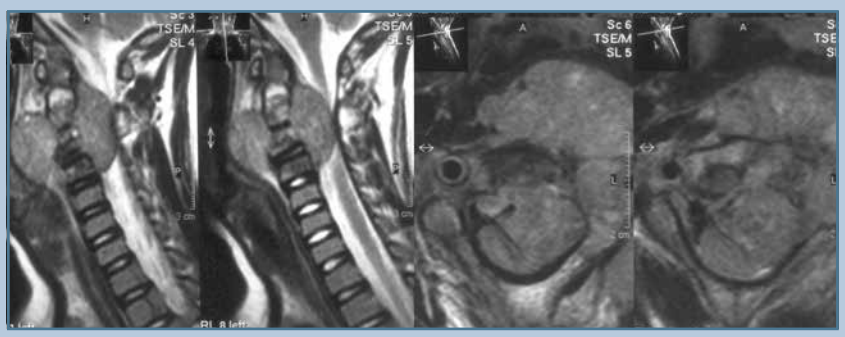

**Fig. 5**
MRI of a patient with Ewing's sarcoma in upper cervical vertebrae: the pattern of its growth and size prevent the total removal

## Results and discussion

The choice of surgical tactics is dictated by the spread of the tumor, its morphological structure and presence of metastases. The authors of this study identified two major objectives

**Fig. 6**
MRI and CT of a patient with chondrosarcoma of mesothoracic spine: the characteristic form of the tumor is confirmed by a combination of studies

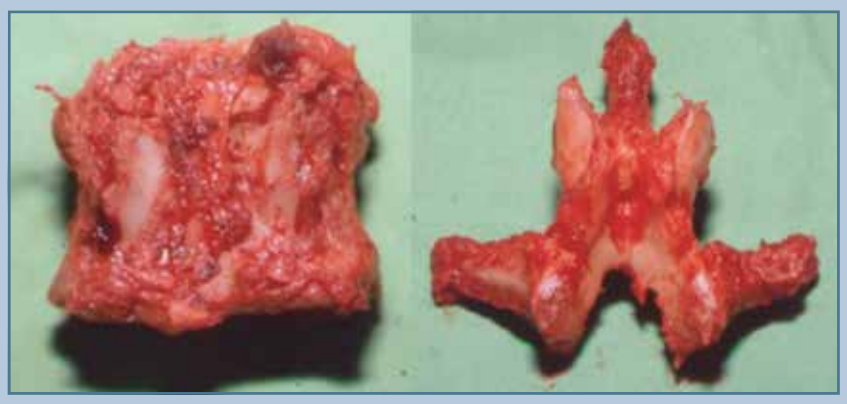

**Fig. 7**
Fragments of the vertebral bodies from the thoracic spine removed during en-block resection according to Tomita [21]

of surgical treatment: removal of the neoplasm and recovery of support ability of the spine. Enneking Staging System for spinal lesions [7] was used to justify the nature and scope of surgical resection (Table 3).

Our series included 2 cases of S1 (aneurysmal bone cysts and hemangioendothelioma) and 25 cases of S2 (aggressive hemangioma and giant-cell tumors, as well as eosinophilic granulomas and chordomas). The most prevalent group among malignant tumors was IIB category (24 (43 %) patients).

Feasibility of en-block resection of the tumor is defined by the presence and condition of the tumor capsule and pseudocapsule. According to classical concepts by Roy-Camille [15], en-block resection of tubular bones involves removal of the neoplasm, including pseudocapsule, within healthy tissue with involving all adjacent structures and tissues. Due to particular structural features of the spine and the presence neuro-vascular entities in the tumor, this tactic was not always feasible, even though it was preferred. Broad en-block resection is also indicated in case of dissemination into the surrounding tissues due to intraoperative damage to the neoplasm or in case of preoperative biopsy, involving the spread of the tumor into the adjacent tissue. The technical feasibility of the resection and the degree of involvement of adjacent organs and tissues is considered after the stage of the tumor is determined and the type of surgical treatment is agreed upon. Ingrowth into adjacent organs, especially in the case of sarcomas, is the main reason why the total removal of neoplasms was impossible. En-bloc resection algorithm used in this paper is shown in Fig. 8.

If en-block resection was feasible, the surgical access included the resection of the neoplasm without damage to the capsule. The most common complicating factor of en-block resection of the neoplasm was its location next to the spinal cord. Ventral location of the tumor (in the vertebral body) required a fairly broad lateral dilation that allows bypassing the spinal cord without injury. The involvement of the vertebral arches and pedicles in the process made broad en-block resection impossible. Tumor

**Table 3**
The choice of treatment based on the degree of tumor spread

| Tumor | Stages | Description | Treatment |
|---|---|---|---|
| Benign | S1 (latent): no growth | Well pronounced capsule | Nonsurgical (except for situations where the required decompression / stabilization) |
| | S2 (active): slow growth | Thin capsule, reactive pseudocapsule | Intratumoral curettage |
| | S3 (aggressive): rapid growth | Indistinct capsule, wide reactive pseudocapsule | Marginal en-block resection |
| Malignant | Low level (I):<br>IA (inside the vertebra)<br>IB (paravertebral spread) | Wide pseudocapsule | Wide en-block resection |
| | High degree (II):<br>IIA (inside the vertebra)<br>IIB (paravertebral spread) | Pseudocapsule infiltrated by a tumor | Wide en-block resection and adjuvant therapy |
| | The high degree of metastases (III) | Distant metastases | Palliative surgery and adjuvant therapy |

damage to the ring, forming the spinal canal, required the removal of the neoplasm en-block from the intact side of the ring.

It is generally believed that en-block resections are more technically challenging if performed from the caudal to the cranial end. In particular, sacretomies (especially of the lower and middle third) may be performed from single posterior access without additional stabilization (Fig. 9).

The en-bloc resection at the lumbar level should take into account the location of the nerve roots, ureter, parts of the colon and often requires instrumental 360° reconstruction in the area of resection [19]. Thoracic neoplasms involve reconstruction of the chest wall and the support ability of the spine. The involvement of subaxial cervical spine into the tumor process requires taking into account innervation of the diaphragm and the upper extremities and relationship with the vertebral artery, esophagus and trachea. Accesses to upper cervical vertebrae are the most difficult ones since they require transoral/transmandibular access. The general algorithm for selection of treatment method for the spinal tumors is shown in Fig. 10.

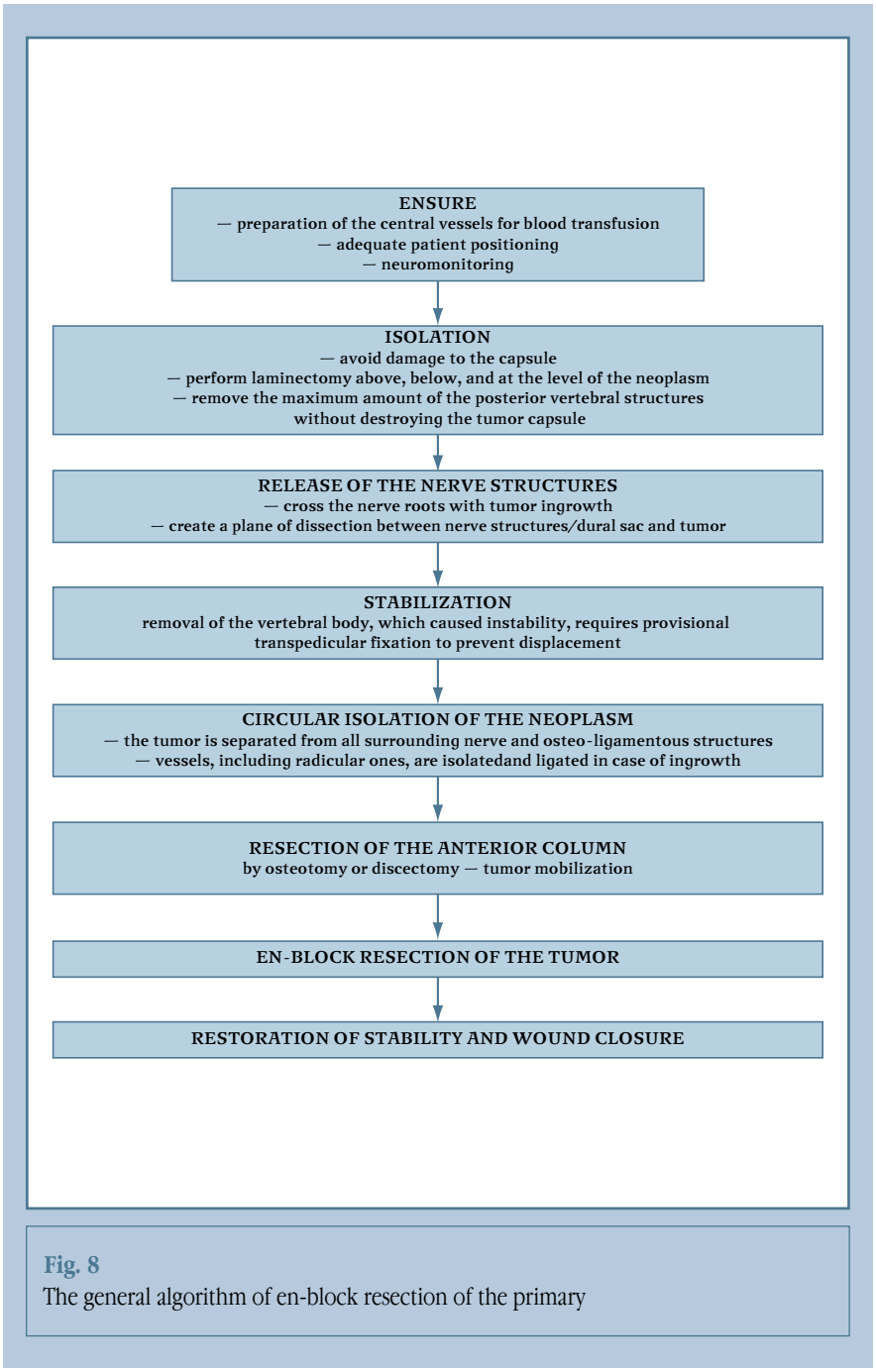


**Fig. 8**
The general algorithm of en-block resection of the primary

Monitoring and early detection of local recurrence is the most important task in the postoperative period. About 80 % of Ewing's sarcoma, for example, recurs in case of intratumoral resection. However, detection of distant metastases involves conducting radiotherapy and chemotherapy of the primary neoplasm concurrently to the resection, regardless of the nature of the surgery. Therefore, it should be kept in mind that survival of patients with primary malignant spinal tumors depends on onset of local recurrence rather than on detection of distant metastases.

For spinal tumors, surgical treatment outcomes depend mostly on incidence and management of intraoperative and early postoperative complications. A total of 8 (15 %) patients in our group experienced surgical complications. There were no lethal complications.

Five patients had hemorrhagic complications during the surgery. In 3 cases, they accompanied en-block resection of chondrosarcomas (sacrum (2); $Th_{12}$ vertebrae (1), in 1 case the bleeding from the vertebral artery in aggressive $C_2$ hemangioma was stopped intraoperatively by endovascular embolization followed by prolonged neurological recovery. Preoperative endovascular embolizations were performed in 8 (14.5 %) patients due to presumably vascular nature of the tumors. Blood loss during hemorrhagic complications averaged 5.5 liters. The average blood loss during primary spinal tumors resection amounted to 1.12 liters (0.6 to 3.5). In all cases, preparation for surgery involved the use of autotransfusion and transfusion of blood/plasma of the same blood type.

The second most frequent complication was deep wound infection (2 cases) in sacrum chondrosarcomas (post-

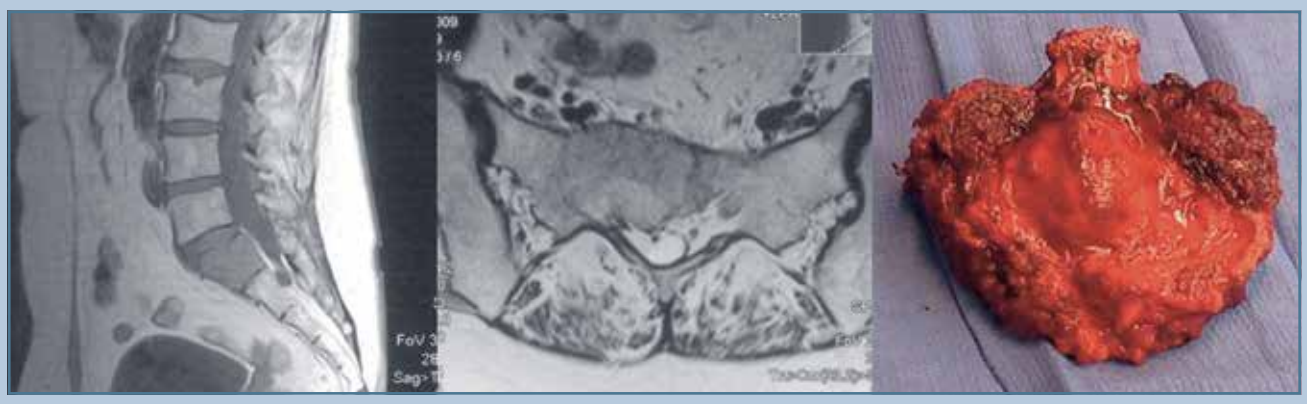

**Рис. 9**
En-block resection of sacral chordoma from the posterior access

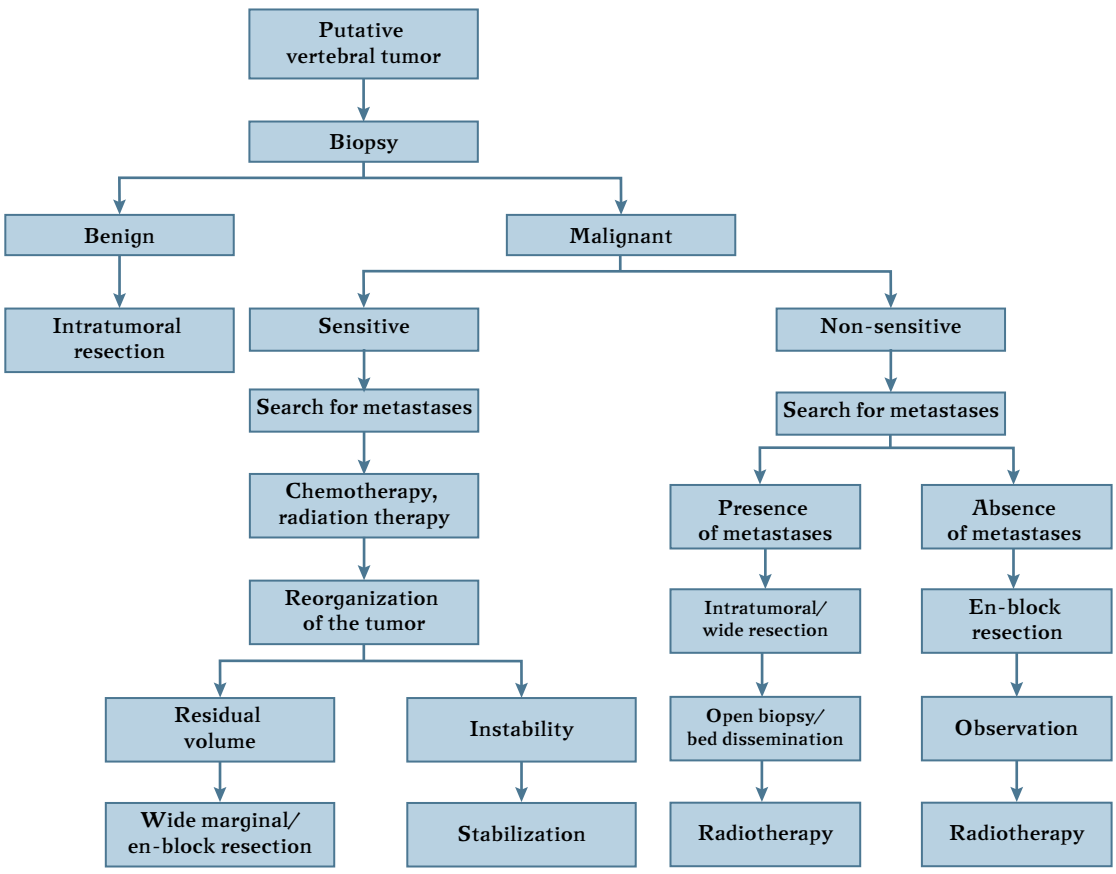


**Fig. 10**
En-block resection of sacral chordoma from the posterior access

operative complications). In both cases there were plastic skin defects after the total resection of the sacrum, requiring repeated interventions to transplant skin graft, including the closure of the bone defect using fat graft from the anterior abdominal wall. In the latter case, the closure of the skin defect and complete cure of infection has not been achieved. The patient died of tumor recurrence 8 months after the primary surgery.

Complications associated with postoperative liquorrhea (2 cases) were managed by lumbar drainage. Overall, according to different researchers the incidence of intraoperative and early postoperative complications ranges from 12 to 20 % [4], which indicates that our study is in agreement with international standards for similar series of primary spinal tumors.

Since 20 (40 %) patients had nerve conduction disorders at admission, we assessed the nature and degree of recovery of neurological functions. The spinal decompression reduced severity of neurological disorders by an average of one step on the Frankel scale for half of the patients. Therefore, neurological disorders were observed in 15 patients after the surgery and are represented in Fig. 11.

Due to the diverse tumor histologies and postoperative treatment in specialized oncology institutions, reliable follow-up information is available for only 40 (72 %) patients. The review of follow-up data for the patients revealed survival and local recurrence rates as presented in Table 4.

Despite the short time of follow-up (12–36 months) and lack of follow-up data for one third of the patients, the treatment outcomes demonstrate the advantages of en-blok resection in case of primary malignant neoplasms: 5 (50 %) patients with chondrosarcoma and chordoma had no relapse for more than 2 years. Studies by a number of scientists have shown that en-block resection of primary malignant tumors (chondrosarcoma, chordoma) reduces recurrence rate from 100 to 22 % [16]. Since, in contrast to metastatic spinal tumors, primary tumors account only for 5% of cases [4], early diagnosis of the primary spinal tumors and late onset of metastasis, as well as high proficiency in total resection, allow a doctor to completely cure a patient. Early diagnosis and treatment are crucial for these patients prognosis. Proper conduct of biopsy without dissemination of the tumor followed by differentiated wide resection of the tumor can ensure recovery of patients. The histological type of tumor, evaluation of its spread and severity of pain syndrome and neurological deficit make it possible to plan adequate combination of treatment options to avoid complications.

Local pain in the spine, often aggravated at night, is a common clinical manifestation of primary spinal tumors. The nighttime pain can be attributed to periosteal tension due to stromal tumor edema. The pain can also be caused by instability. The symptoms associated with compression of the neural structures are less common [5, 17].

The stability of the spine is affected in 15 % of patients with spinal tumors. Surgical treatment of primary spinal tumors results in 84 % recovery rate for vertebral column support ability whereas in the group of patients with isolated radiotherapy the stability was preserved only in 50 % of the cases [14].

We should not forget about percutaneous techniques (vertebroplasty, kyphoplasty) in treatment of primary spinal lesions that are not accompanied by neural compression [12]. In combination with radiotherapy (ablation, cryosurgery) and, in the case of instability, with percutaneous vertebral stabilization, they can serve as an effective minimally invasive surgical strategy.

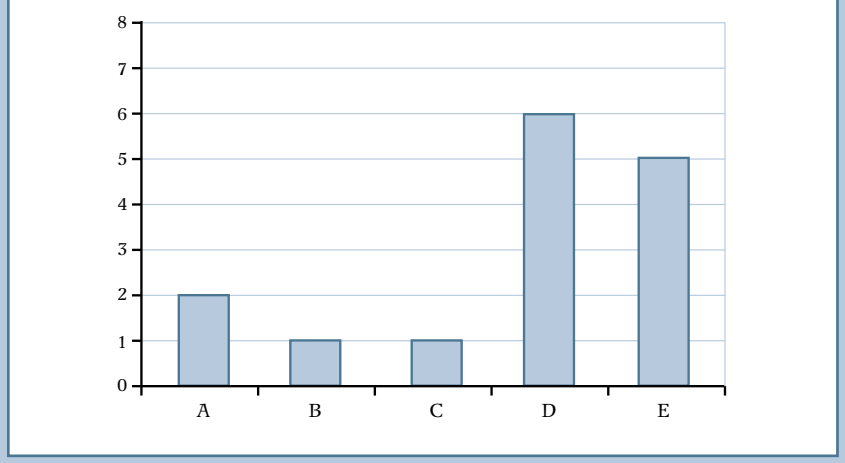


**Fig. 11**
Post-surgery dynamics of motor impairment at Frankel scale

## Conclusion

Development of treatment strategies for primary spinal tumors should take into account palliative surgery options, which include decompression of neurovascular entities. Capabilities of the modern radiopharmacotherapy of malignancies enable long-term control of the tumor growth, even when the total resection is impossible [24].

Patients with tumors of the spine require careful choice of a multidisciplinary treatment. Increasing the life expectancy of patients with malignant tumors and improving the quality of life in patients with tumors of different histological structure are decisive factors in the choice of tactics and dictate the variability of approaches to treatment.

Table 4
Analysis of the differentiated treatment outcomes in patients with primary spinal tumors

| Histological nature of the tumour | Patients (n) and the type of surgery | Outcome of the primary spinal tumor |
|---|---|---|
| Osteosarcoma | 1; intratumoral resection (palliative) | Death after 6 months |
| Chondrosarcoma | 4; en-block resection | 1 – deep infection and death within 8 months; 1 relapse |
| | 6; wide resection | 4 relapses; 2 unknown |
| Chordoma | 6; en-block resection | 2 relapses within a year; 1 death after 2 years |
| | 2; wide resection | 1 relapse; 1 unknown |
| Plasmacytoma | 4; wide resection, radiation chemotherapy | 1 relapse, death after 10 months. |
| Lymphoma | 2; intratumoral resection, radiation therapy | Unknown |
| Giant-cell tumor | 2; en-block resection | 1 relapse within 2 months |
| | 3; wide resection | 2 relapses |
| Aggressive hemangioma | 4; vertebroplasty | 2 relapses |
| | 7; vertebroplasty + wide resection | 1 relapse with radiation therapy |
| Aneurysmal bone cyst | 6; wide resection | 2 relapses |
| | 2; intratumoral resection + vertebroplasty | Unknown |
| Hemangioendothelioma | 1; wide resection | – |
| Fibrous cell dysplasia | 2; wide resection | No relapse for 1 year |
| Chondroma | 2; wide resection | No relapse for 18 months |
| Eosinophilic granuloma | 1; intratumoral resection + chemotherapy | No relapse for 3 years |

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