



SPINAL TUMORS: A CONCEPT OF INTEGRATED ASSESSMENT IN RELATION TO EMERGENCY CONDITIONS

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A modern concept of assessing tumor lesions of the spine, NOMS, adapted to the conditions of emergency care is presented as a part of a systematic review of the literature. Principles of neurological, oncological, mechanical and system analysis of spine lesions in primary and metastatic spinal tumors, which are the basis for step-by-step tactical decisions, as well as methods for analyzing each component are described.

Key Words: spinal tumors, urgent healthcare, NOMS, SINS.

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Primary spinal tumors in adults are quite rare: in this age group, most spinal tumors are of metastatic origin, and the spine itself is the most frequent localization of bone metastases whose growing incidence is due to an increasing life span and, correspondingly, a growing proportion of elderly people in the population [1, 3, 17]. According to the American Academy of Orthopedic Surgeons (AAOS), spinal metastases occur in approximately 20 % of oncologic patients, with 5 to 10 % of these lesions being accompanied by compression of the spinal cord. However, insufficient prophylaxis and medical culture may lead to the fact that emergency condition becomes the first disease manifestation. For example, according to the Saint-Petersburg Dzhanlidze Research Institute of Emergency Medicine data (2012), 47.8 % (11 of 23) of patients with metastatic spine lesions had no oncologic history at primary admission to spinal departments [2].

The goal of treating spinal metastases usually reduces to control of pain intensity, preservation or restoration of neurological functions, local control of tumor growth, preservation of spinal motion segment stability, and improvement of the patient's quality of life. Improvements in chemotherapy, radiotherapy,

and hormonal therapy have significantly increased survival of oncologic patients [18], and their expectations about the quality of life have become an important factor for making tactical and therapeutic decisions. For this reason, emergency conditions in spinal tumors include not only aggravating compressive myelopathy or caudopathy, a particular variant of which is epidural spinal cord compression (ESCC) [33], but also pronounced pain (VAS score ≥ 7) caused by either spine instability or compression of the spinal structures and roots, which is managed only by narcotic analgesics.

The most common sources of metastatic spinal lesions are breast, lung, kidney, prostate, and thyroid gland tumors as well as melanoma, myeloma, lymphoma, and colorectal cancer [1, 20, 21]. At the same time, according to modern principles of cancer care, chemotherapy or radiotherapy can not be performed without histological confirmation of the diagnosis. Histological examination of bone tissue usually takes at least 7 days from the time of material sampling, and the patient has no antitumor treatment during this period. In these cases, in the presence of compression myelopathy, therapeutic delay may dramatically reduce the chance of motor function recovery. It should be remembered that

metastatic lesions usually mean that the process is no longer at an early stage: these patients are initially weakened due to high tumor burden, which addresses the issue of an adequate amount of possible surgery.

Decompression surgery without spine stabilization, which was previously used in neoplastic spinal cord compression, led to unsatisfactory results, often worsening the patients' quality of life, which gave rise to the opinion that radiotherapy is a more preferable treatment for these patients [10, 34, 40, 43]. Later, the modern surgical tactics including decompression of the neural structures and stabilization of the spine was demonstrated to provide better results in patients than radiotherapy alone, including a higher quality of life, even though its expected duration may be less than two years [20, 27, 34, 38, 41]. That is why surgery should not reduce quality of the survival period, and the risk of postoperative complications, whose rate may reach 20–30 %, should be compared with potential benefits [9, 16, 35]. This is especially true for complex extensive en bloc resections that are associated with a higher risk of complications compared to procedures such as curettage [25, 32, 36, 37].

Surgeries for emergency conditions are often not radical, but improve the

patient's quality of life and increase the life span by reducing the tumor mass volume and tumor intoxication. This also applies to ESCC patients in whom the risk of hypostatic complications (congestive pneumonia, pressure sores, PATE) is abruptly reduced in the case of improvement/recovery of the motor status.

According to the AAOS recommendations, surgery should be performed only if the patient's life expectancy exceeds 3 months because this period is necessary for recovery from spinal surgery (National Collaborating Center for Cancer, 2008). This estimate is usually made by oncologists; but in emergency situations, the decision is made by the surgeon who should assess the potential risks and benefits of surgery and understand what factors may be used to predict the quality and longevity of life, from which he must decide on the need for an emergency operation.

To objectify making tactical decisions in the case of metastatic spinal lesions, the Memorial Sloan-Kettering Cancer Center (MSKCC) developed the NOMS framework, whose name is an abbreviation of the first letters of the four main evaluation criteria: neurological (N), oncological (O), mechanical (M), and systemic (S).

In this review, we present the modern evaluation criteria for each of the components of this system.

Neurological evaluation

A standardized assessment of neurological disorders in patients with spinal tumors is based on analysis of the severity of epidural spinal cord compression (ESCC) and its structures. To objectify this indicator, the Spine Oncology Study Group (SOSG) adopted a classification system [5] based on analysis of axial T2-weighted MRI scans at the site of the most severe compression (Fig., Table 1). In the absence of mechanical instability, grades 0, 1a, and 1b are considered as indications for radiotherapy as an initial treatment option; grades 2 and 3 are considered as high-grade epidural compression requiring surgical treatment before the course of radiotherapy, except cases of high tumor sensitivity. The role of surgical and radiosurgical techniques at

the compression grade 1c has remained uncertain: the introduction of high-dose hypofractionated radiation enables the use of stereotactic surgery as an optimal method of reducing toxicity for the spinal cord structures. In cases of indolent instability and the absence of histological verification of the diagnosis, the amount of specialized care may be limited only to targeted trepanation biopsy.

Oncological evaluation

Currently, radiation therapy remains the most effective and least invasive method for controlling local tumor growth. Perhaps, for this reason, oncological evaluation of spinal tumors is largely reduced to assessment of their radiosensitivity.

Tumors are differentiated into radiosensitive and radioresistant ones based on their response to conventional External Beam Radiation Therapy (cEBRT) delivered by one or two beams without the use of precise conformal techniques. The fraction dose that can be delivered using cEBRT is significantly limited when the spinal cord is close to the irradiation area. In this case, the histological type of tumor is unambiguously defined as the main factor of its sensitivity to radiation therapy: lymphoma, seminoma, and myeloma are the most sensitive tumors; radiation therapy is recommended for their vertebral metastases, regardless of the grade of ESCC or neurological deficit [15, 24].

Solid tumors have a wide spectrum of radiosensitivity. Radiosensitive neoplasms include breast, prostate, and ovarian cancers and neuroendocrine tumors; radioresistant tumors are kidney carcinoma, thyroid carcinoma, hepatocellular carcinoma, non-small cell lung tumors, sarcoma, and melanoma. In the case of highly radioresistant tumors, local control is achieved by means of stereotactic radiosurgery; in this case, the radiation dose and fractionation can vary depending on the purpose of radiotherapy. A short course (800 cGy*1 and 400 cGy*5) provides a short-term palliative effect; a long course of radiotherapy with a higher total dose enables longer local control of tumor growth [8, 28].

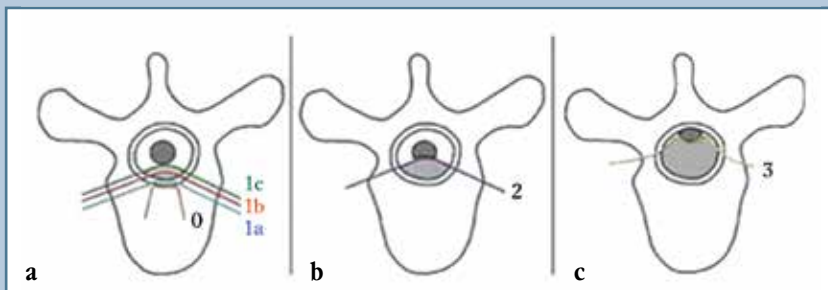
Many authors support the use of cEBRT for tumors with high sensitivity to radiation therapy even in the case of high-grade ESCC because it is able to cause mitotic catastrophe and a subsequent reduction in compression without significant damage to the spinal cord and meningeal structures [6, 24].

Radioresistant tumors without high-grade ESCC signs. In most cases, these tumors are favorable for performing stereotactic radiosurgery (SRS). Gerszten and co-authors [15] reported a positive clinical and radiation response to high-dose SRS in 85% of cases, regardless of the histological type of tumors; in 85–92% of cases, the technique was effective for pain control [13, 14, 29, 30]. Among 413 patients treated with SRS at a dose of 24 Gy, the 4-year recurrence rate was only 2.1%, regardless of the histological type of tumor [42].

Therefore, in the case of a verified diagnosis and absence of instability signs, managing of patients with spinal tumors at an emergency medicine hospital is hardly advisable; in these cases, it is more reasonable to refer the patient to a center providing SRS.

Radioresistant tumors with high-grade ESCC signs. Patients with metastatic spinal lesions and grade 2 or 3 ESCC require surgical decompression and stabilization before image-guided radiation therapy (IGRT). Patchell and co-authors [27] demonstrated that surgical decompression followed by cEBRT provided a significantly better result in terms of survival, general ability to motion, preservation and recovery of the ability to move, preservation of pelvic functions, and the need for narcotic analgesics compared to that of cEBRT alone. However, the authors did not obtain significant differences in the duration of hospital stay among compared groups.

The main task of surgery is preservation or restoration of mechanical stability and circulatory decompression of the dural sac/spinal cord, which are aimed at preserving neurological functions, creating conditions for radiotherapy, and achieving adequate local control of tumor growth. The performed analysis revealed that all treatment failure cases

**Fig.**

Classification of the epidural spinal cord compression (ESCC) severity based on the SOSG criteria [5]: **a** – grade 0 and 1; **b** – grade 2; **c** – grade 3

Table 1

Classification of the epidural spinal cord compression (ESCC) severity based on the SOSG criteria [5]

Grade 0	Bone involvement only
Grade 1a	Epidural impingement without deformation of the dural sac
Grade 1b	Deformation of the dural sac without signs of spinal cord abutment
Grade 1c	Deformation of the dural sac with spinal cord abutment
Grade 2	Spinal cord compression but CSF visible
Grade 3	Spinal cord compression but no CSF seen

had a dose of less than 15 Gy in some part of the planning target volume [23]. If the tumor margin is not delimited from the spinal cord structures, a dose of 15 Gy can not be delivered throughout its entire border without the risk of injury to the spinal cord structures. Given this fact, at least small (2 mm) separation between the tumor and the spinal cord structures is required to avoid insufficient exposure of all parts of the planned target. On this basis, it was concluded that surgery may be recommended for patients with radioresistant tumors with high-grade ESCC, and the term “separation surgery” was introduced to describe interventions where minimal surgical tumor resection is performed only to separate the tumor margin from the spinal cord for further use of SRS.

Therefore, comprehensive neurological and oncological assessment enables identification of groups of spinal tumors that require immediate radiation therapy or surgical decompression. Based on the

recommendations, surgical decompression should be performed before radiation therapy for radioresistant tumors with grade 2 or 3 ESCC. The absence of histological verification in grade 2 or 3 ESCC necessitates decompression surgery with an operative biopsy. However, we could not find information on the need for cytoreductive intervention in patients with high-grade ESCC in the absence of a verified diagnosis.

Mechanical evaluation

Radiation therapy and decompression of the spinal cord provide certain local control of tumor growth, but do not affect mechanical stability, and in some cases may exacerbate it [31]. Mechanical instability in neoplastic diseases is considered as an independent indicator in the planning of surgery, which does not depend on the grade of ESCC and tumor sensitivity to radiation therapy and, according to the SOSG definition, is loss of structural spinal integrity, which leads to movement-associated pain, symptom-

atic or progressive deformity, and/or neural compromise under physiologic loads [11]. The mechanical stability is evaluated based on clinical and radiological findings.

Pain due to mechanical instability of the spine should be differentiated from tumor-associated pain of a biological nature. Clinically, pain due to mechanical instability is associated with movement and manifests in the area corresponding to the lesion. Pain of a biological nature is time-dependent (manifests in the evening and morning) and, in contrast to mechanical pain, regresses on the background of corticosteroid and radiation therapy.

Tumor growth and infiltration of the vertebral body and facet joint cause failure of support function and may lead to collapse of the radicular foramen in the vertical position and compression of the corresponding root. Patients with obvious manifestations of mechanical instability require surgical stabilization. At the same time, if there is no gross mechanical instability or significant involvement of the posterior supporting column, painful pathological compression fractures in the setting of tumor can be treated with cement vertebroplasty or kyphoplasty procedures [4, 7, 19]. Furthermore, the systematic SOSG review strongly recommends the use of these procedures for symptomatic osteolytic tumors [26].

For quantitative objectification of tumor-related instability of the spine, an 18-point Spinal Instability Neoplastic Score (SINS) scale was developed [11, 12], which includes six parameters: the level and location of the lesion, pain features, spinal deformity, destruction nature (osteolysis), vertebral body collapse, and posterior spinal element involvement (Table 2).

Lesions with a low SINS score (0 to 6) are usually stable and do not require surgical fixation, whereas a high score (13–18) indicates the need for surgical intervention to restore mechanical stability. Intermediate SINS scores (7–12) require further examination both to determine the need for surgery and to address the need for vertebroplasty and kyphoplasty.

Systemic evaluation of spinal tumor patient condition

All decisions related to the choice of management for the patient are based on the patient's ability to tolerate an appropriate procedure, which, in particular, depends on dissemination of the tumor process, its histological type, and concomitant somatic pathology. Since the patient's life span is directly related to the histological tumor type, the optimal amount of surgery should be chosen in cooperation with the oncologist. Non-small cell lung cancer, colon cancer, and carcinomas with unspecified primary localization have a mean survival rate of about 4 months since the time of surgery [39]; aggressive interventions that may require long recovery are not recommended in these patients. If concomi-

tant somatic pathology excludes surgical intervention, radiation and medical therapeutic means are recommended for use even at the late stages of cancer.

Table 3 presents a NOMS-based algorithm for making a tactical decision.

Conclusion

In emergency situations, a specialist lacking oncological background should make tactical decisions based on analysis of simple and clear signs. Regarding neoplastic spinal lesions, the NOMS strategy appears to be the essential analytical tool, application of which enables eliminating an unreasonably prolonged therapeutic pause and choosing the treatment tactics that best suits the patient's interests.

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Table 2

SINS scale for assessing spinal instability due to tumor lesions [11, 12]

SINS component	Score
Location:	
– junctional areas: occipital bone – C2, C7–T2, T11–L1, L5–S1;	3
– mobile spine: C3–C6, L2–L4;	2
– semirigid area: T3–T10;	1
– rigid area: S2–S5	0
Pain is reduced in a lying position, and/or pain is associated with movement or with load on the spine:	
– yes;	3
– no (occasional pain, but not mechanical);	1
– pain-free lesion	0
Bone lesion:	
– lytic;	2
– mixed;	1
– blastic	0
Spinal alignment:	
– subluxation, translation;	4
– <i>de novo</i> deformity (kyphotic/scoliotic);	2
– normal alignment	0
Vertebral body collapse:	
– > 50 %;	3
– < 50 %;	2
– no collapse with > 50 % body involved;	1
– none of the above	0
Posterolateral involvement of spinal elements (joints, pedicles, or costovertebral joint injury or replacement with tumor):	
– bilateral;	3
– unilateral;	1
– none of the above	0

Table 3

NOMS algorithm

Neurological criteria (N)	Oncological criteria (O)	Mechanical criteria (M)	Systemic criteria (S)	Decision making
Low-grade ESCC + no myelopathy	Radiosensitive	Stable	—	cEBRT
	Radiosensitive	Unstable	—	Stabilization → cEBRT
	Radioresistant	Stable	—	SSRS
	Radioresistant	Unstable	—	Stabilization → SRS
High-grade ESCC ± myelopathy	Radiosensitive	Stable	—	cEBRT
	Radiosensitive	Unstable	—	Stabilization → cEBRT
	Radiosensitive	Stable	Can tolerate surgery	Decompression/ stabilization → SRS
	Radioresistant	Stable	Can not tolerate surgery	cEBRT
	Radioresistant	Unstable	Can tolerate surgery	Decompression/ stabilization → SRS
	Radioresistant	Unstable	Can not tolerate surgery	Stabilization → cEBRT

cEBRT (conventional external beam radiation therapy), ESCC (epidural spinal cord compression), SRS (stereotactic radiosurgery), MAS (minimal access surgeries), SLITT (spinal laser interstitial thermotherapy).

Low-grade ESCC — 0 or 1 according to the SOSG classification; high-grade ESCC — 2 and 3 according to the SOSG classification.

The term “decompression” includes open decompression, MAS, and SLITT.

The term “stabilization” includes percutaneous vertebroplasty, minimally invasive transpedicular stabilization, and open stabilization.

In patients with severe systemic concomitant diseases that limit the use of open surgery, stabilization may be limited to percutaneous vertebroplasty and minimally invasive transpedicular stabilization with screw augmentation, if necessary [22].

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