The Clinical point scale for assessing vertebral status in deformities and instability of the thoracic and lumbar spine

Ravshan Muslimovich Yuldashev

Republican Specialized Scientific Practical Medical Center of Neurosurgery Ministry of Public Health of the Republic of Uzbekistan

Abstract

The aim of this study was to develop a clinical point scale for assessing the initial state, the dynamics of treatment and the final results of surgical treatment of patients with instability of the thoracic and lumbar spine.

The results of treatment for the neuroindex were significantly better than for the vertebral index: the neuroindex was 47% for the delta or 2.2 points for the assessment of the result; the vertebral index was 31% for the delta or 1.3 points for evaluating the result. This indicates that in the surgical tactics in patients of the control group, the main emphasis was placed on decompression of compressed nerve elements. The result of treatment according to the vertebral index was significantly higher than according to the neuroindex: the neuroindex was 53% in the delta or 3.1 points in the assessment of the result; the vertebral index was 68% for the delta or 4.3 points for the assessment of the result. The emphasis on improving the vertebral status in the main group also allowed the improvement of neurological status to be extended. This made it possible to double the results of treatment according to IISI - delta IISI was 61%, the assessment of the results showed 3.8 points.

Keywords: spinal instability, spinal cord injuries, neoplasms of the spine, echinococcosis of the spine, neurological status, vertebral status, clinical point scale.

Introduction. The development of clinical score scales that allow, on the basis of a complex of clinical, clinical-laboratory and clinical-instrumental research methods, to give an integral quantitative assessment of the state is widely used in modern medicine - as an example, the Apgar scale for assessing the condition of a newborn (1), a scale for assessing the severity of cranial-brain injury by Glasgow (2), the TRISS injury severity scale (3), etc. In this case, the diagnostic value of these scales is determined by two criteria - first, the possibility of clarifying and differentiating treatment tactics, and secondly, the possibility of evaluating the results in the dynamics of treatment. In addition, the use of such scales makes it possible to standardize the assessment of treatment results not only in different groups of patients, but also the results of treatment in different periods and in different centers, which is very important when conducting scientific single and multicenter studies.

In vertebrology, to determine the surgical tactics and treatment outcomes, it is necessary to provide a comprehensive assessment of all clinical and radiological data. To date, there is no such complex clinical point scale that would provide an assessment in these patients in a single quantitative format of their initial state, the dynamics of treatment and the result.

The aim of this study was to develop a clinical point scale for assessing the initial state, the dynamics of treatment and the results of surgical treatment of patients with instability of the thoracic and lumbar spine.

To achieve these goals, the following tasks were identified:
1. Development of requirements for the clinical point scale.
2. Clinical score for neurological status.
3. Clinical point assessment of vertebral status.
4. Clinical scoring of spinal instability, its validation and determination of diagnostic value.
5. Scale for evaluating treatment results.

Clinical point scale requirements

Based on our own experience and on the basis of studying the literature, we have identified a number of principles for the development of a clinical point scale for assessing the initial status and treatment results in the studied contingent of patients, which allows us to give estimates in quantitative form:

1) Each criterion of the clinical point scale should have from three to five ranges (gradations) of change; each gradation is evaluated in points. It is optimal to evaluate all the criteria on a 5-point system.

2) The quantitative assessment of each criterion in points should be directly proportional to the severity of the lesion, since this is a scale for assessing the severity of pathology, and not an assessment of the functional state of organs and systems.

3) Taking into account that the leading in the clinical picture and prognosis in this category of patients are the general neurological and general vertebral status, in the integral point estimate the share of each of them should be 50%. The general neurological status should include the assessment of pain and the neurological status itself, while their shares in the integral scale should be equal.

4) The results of the assessment in points should be normalized by dividing the obtained assessment values in points by the maximum value in points and multiplying by 100%. The normalized result gives an estimate of the severity of the pathology as a percentage of the maximum possible severity of the corresponding criterion.

Normalization, in addition to bringing various indicators to a single percentage, gives another great advantage - the possibility of comparative comparison of dissimilar indicators with each other, since they are all now expressed as a percentage of the maximum severity.

5) Treatment outcomes should be assessed by the difference (delta) between the normalized pretreatment and posttreatment point scale values. In turn, the entire delta range should be divided into 5 sub-ranges to obtain a 5-point system for assessing the result.

Clinical score for neurological status

Neurological status was assessed according to two basic parameters - pain and score on the ASIA / ISCSI American Association of Spinal Injury Scale of Neurological Deficiency (5). Pain is the leading and main symptom, most often forcing patients to turn to vertebrologists; this symptom is the most dynamic and convenient for assessing the initial state, the dynamics of treatment and the final result. Recovery of neurological disorders after reconstructive surgery on the spine often takes a long time and the values of this indicator after surgery may change slightly. Therefore, we consider the use of pain assessment, as the most sensitive and rapidly changing parameter, and the assessment of neurological deficit, as the basic parameter, to be the optimal balance in the complex clinical and neurological assessment.

Pain scores were assessed using a widely used visual analogue scale (VAS) (4), the minimum pain value was 1 point, and the maximum value was 10 points.

The ASIA / ISCSI (American Spain Injury Association / International Standards for Neurological and Functional Classification of Spinal Cord Injury) scale (5; 6) assesses the complex of neurological disorders according to 5 levels of severity:

Table 1.

Assessment of neurological status according to ASIA / ISCSI scale

Type	Description of neurological disorders	Scale
A	complete anatomical or functional interruption of the spinal cord;	5
B	type B - lack of motor and sensory functions distal to the injury, preservation of sensitivity in the sacral segments;	4

C	type C - partial preservation of the motor and sensory function of the spinal cord, but the strength of half of the key muscles is below the damage level of less than 3 points;	3
D	type D - partial preservation of the motor and sensory function of the spinal cord, the strength of most muscles is below the level of damage of more than 3 points;	2
E	type E - the conduction function of neural structures is preserved.	1

The neurological status as a whole was assessed according to the Neuroindex developed by us, which was calculated as a percentage according to the formula (1), in which the values of the indicators are set in points:

Formula 1.

$$Neuroindex = (VAS + ASIA) / 15 * 100\%$$

The maximum score for Neuroindex is 15 points, which according to this formula corresponds to 100%.

Clinical score for vertebral status

The assessment of the vertebral status was carried out on the basis of radiological data by determining the following most informative 4 parameters: the index of wedge-shaped deformity of the vertebra (IWDV) - according to the formula (2); vertebra compression index (VCI) - according to the formula (3); Cobb corner; the degree of stenosis of the spinal canal (SCSD) (Fig. 1).

Fig.1. Characteristics of changes in the vertebrae and spine with injuries and diseases:
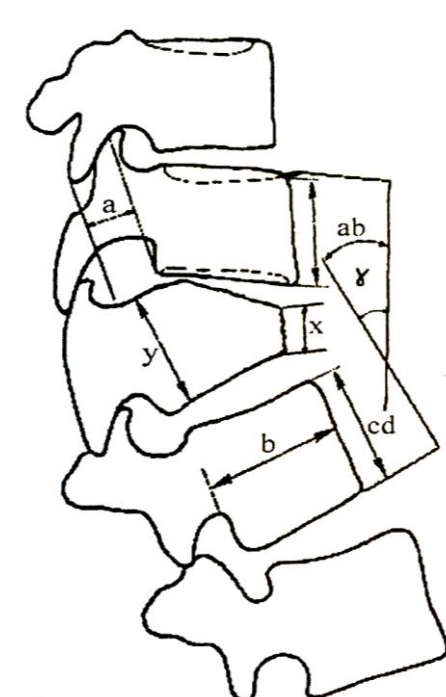
a – the magnitude of the anterior displacement above the dislocation,
b – the value of the longitudinal size of the vertebral body below the dislocation.
x –anterior dimension of the height of the body of the damaged vertebra;
ab – the front dimension of the body height of the superior intact vertebra;
cd - anterior dimension of the body height of the underlying intact vertebra;
y - posterior dimension of the height of the body of the damaged vertebra;
a – the value of the anterior displacement above the fracture;
b – the value of the sagittal body size below the offset;
γ – angle of local kyphosis (Cobb angle).

vertebra compression index - VCI:

Formula (2)

$$VCI = (1 - x / (ab + cd) : 2) * 100\%$$

index of wedge-shaped deformity of the vertebra - IWDV:

Formula (3)

$$IWDV = (1 - x/y) * 100\%$$

The degree of stenosis of the spinal canal - SCSD was determined by the formula (4) according to the data of MRI and CT:

Formula 4.

$$SCSD = (1 - (b * e) / ((d * a + f * c) / 2)) * 100\%$$

where a, b, c - transverse dimensions; d, e, f - longitudinal dimensions of the spinal canal (Fig. 2).

Fig. 2. Measuring the width of the spinal canal using CT or MRI scans

vertebra above affected one

affected vertebra

vertebra below affected one
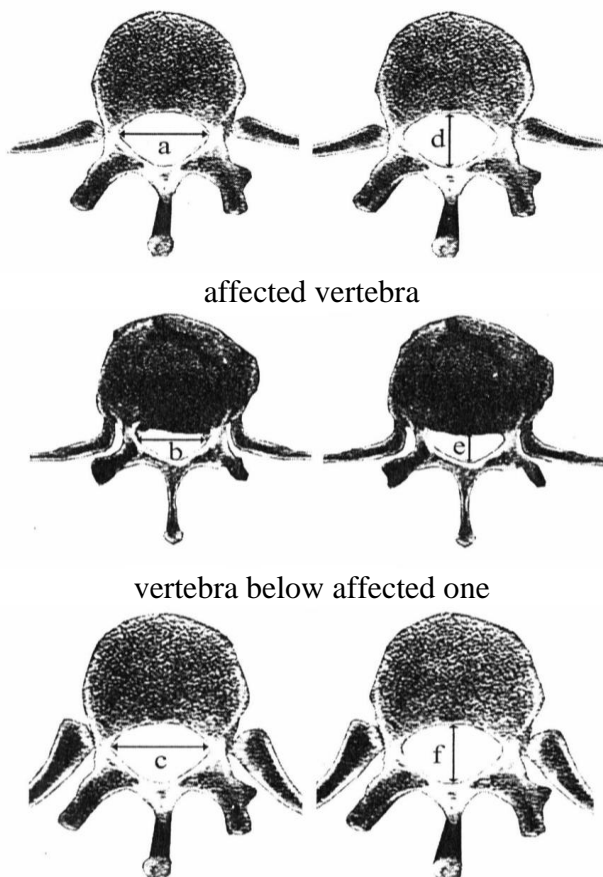
The study of these parameters was carried out in all patients in terms of maximum and minimum values, and then the real range of these parameters was divided into 5 subranges in order to set a point assessment of their severity (Table 2). For the IWDV and VCI indicators, the entire range between maximum and minimum values was divided into sub-ranges on a proportional basis. The Cobb angle indicator more often gave values in the range of up to 25º, and the indicator of the degree of stenosis - up to 50%, therefore these indicators were divided into subranges within the indicated limits.

Table 2.

Vertebral index indicators and their assessment

Indicators	Minimum value	Max. value	Scores and value ranges				
			1	2	3	4	5
IWDV	12%	45%	0-10%	11-20%	21-30%	31-40%	>40%
VCI	14%	45%	0-10%	11-20%	21-30%	31-40%	>40%

The Cobb angle	11°	42°	0-6°	7-12°	13-18°	19-24°	>24°
SCSD	13%	88%	0-10%	11-20%	21-30%	31-40%	>40%

The vertebral status as a whole was assessed according to the index developed by us, called the *Vertebral index*, which was calculated in% according to the formula (5), in which the values of the indicators are set in points:

Formula 5.

Vertebral index =
*(IWDV + VCI + The Cobb angle + SCSD) / 20 * 100%*

In this formula, for normalization, division by 20 is carried out, because the maximum value of the vertebral index points is 20 points.

Clinical scoring of spinal instability and determination of its diagnostic value.
For the clinical scoring of spinal instability, we used the Integral Index of Spinal Instability (IISI), which was calculated in% according to the formula (6):

Formula 6.

IISI = (neuroindex + vertebral index) /2

In this formula, the proportion of neuroindex is 50%, vertebral index - 50%, which, in our opinion, most accurately reflects the real clinical picture.

The diagnostic value of individual methods and parameters for detecting a disease and making a diagnosis is determined using indicators that assess positive, negative, false positive and false negative results. However, this approach is unsuitable for assessing the dynamics of the pathological process. In this case, the diagnostic value of individual criteria is determined by the correlation of the initial data with the final results, but the analysis of the correlation of the initial data with changes in individual parameters gives even more accurate information.

To determine changes in individual parameters as a result of treatment, we used the indicator of relative changes "delta", which was determined by the formula (7):

Formula 7.

$\delta = (B - A) / A * 100\%$

where:
A - the initial value of the investigated parameter;
B - the final value of the investigated parameter
δ - delta (indicator of relative changes).

The advantage of the "delta" indicator over the usual indicator of the difference between the final and initial values of the studied parameter is its relativity - it can be used to compare changes in any parameters, regardless of their nature, scale of changes, type, etc.

To determine the diagnostic value of the developed criteria and the integral clinical point scale, an analysis of the data of 260 patients with deformities and instability of the thoracic and lumbar spine, operated at the Republican Scientific Center of Neurosurgery (RSCN) (Republic of Uzbekistan, Tashkent) from 2003 to 2015 was carried out.

We analyzed the data of all patients according to the paired correlation coefficient (Pearson's test) of a number of parameters with four basic parameters: delta vertebral index, delta neuroindex, delta IISI, IISI before treatment (Table 3).

The set of the first three basic parameters was selected based on the fact that the result of treatment is assessed by delta - the difference in indicators before and after treatment. The parameter IISI before treatment was selected in order to compare its diagnostic capabilities with other diagnostic criteria.

Table 3.
Values of the paired Pearson correlation coefficient of the vertebral index delta index and the neuroindex with other indicators

First paired exponent → Second paired indicator ↓	Delta vertebral index		Delta neuroindex		Delta IISI		IISI before	
Etiology	-0,782	*	-0,305	*	-0,693	*	-0,469	*
Age, years	0,014	-	-0,043	-	-0,023	-	-0,181	*
Gender	-0,007	-	-0,018	-	-0,016	-	-0,090	*
Pain index - before	0,088	*	0,562	*	0,392	*	0,804	*
Neuroindex - before	0,037	-	0,294	*	0,181	*	0,915	*
IWDV, % - before	0,588	*	0,232	*	0,516	*	0,586	*
VCI, % - before	0,742	*	0,255	*	0,633	*	0,394	*
Cobb angle, degrees - to	-0,515	*	-0,005	-	-0,328	*	0,302	*
Step. stenosis,% - up to	-0,365	*	-0,175	*	-0,359	*	0,267	*
Vertebral index - up to	0,290	*	0,153	*	0,280	*	0,754	*
IISI - before	0,157	*	0,282	*	0,256	*		

Note:
" * " – the correlation coefficient is statistically significant (P<0,05)
" – " – the correlation coefficient is statistically unreliable (P>0,05).

The set of parameters that were included in the correlation analysis included the following: Etiology; Age, years; Gender; Pain index - before; Neuroindex - before; IWDV,% - before; VCI,% - before; Cobb angle, degrees - to; Stenosis degree,% - up to; Vertebral index - up to; IISI - before; Pain index - after; Neuroindex - after; Vertebral index - after; IISI - after; Neuroindex - delta; Vertebral index - delta; Pain index - delta; IISI - delta.

When calculating the Pearson criterion, the value of the Student's criterion and the reliability of the obtained value of the Pearson criterion were also calculated. The absolute values of the Pearson test were analyzed, showing the degree of interrelation of individual parameters.

When analyzing the results, the parameters "gender" and "age" did not give significant correlations, except for the pair with IISI. The absolute values of Pearson's criterion for the "etiology" criterion turned out to be very high: its values were -0.782 for a pair with "delta vertebral index", -0.305 with "delta neuroindex", -0.693 with "delta IISI", -0.469 from "IISI before".

The analysis of the results "before treatment" showed that the reliable and highest absolute values of the correlation coefficient paired with the "delta vertebral index" were for the parameters "VCI before" (0.742) and "IWDV before" (0.588). Together with the "delta neuroindex", most of the values of the correlation coefficient were relatively low, with the "pain index before" (0.562) leading. Together with the "delta IISI", the leaders were the indicators "VCI before" (0.633), "IWDV before" (0.516), "pain index" (0.392). Together with IISI before, the leading indicators were neuroindex (0.915), pain index before (0.804), vertebral index (0.754), IWDV before (0.586), and VCI before (0.394).

Thus, the results of the correlation analysis indicate a high diagnostic value of the vertebral index, IISI, and neuroindex for assessing the dynamics of the pathological process during treatment, while there is a slightly higher diagnostic significance of the vertebral index and IISI compared to the neuroindex.

Treatment outcome assessment scale
As you know, the clinical outcome is most accurately assessed not by the end result, but by the relative difference (delta) of the initial and final states. In turn, normalizing the scores, that is, bringing them to a percentage of the maximum possible level, allows you to take another important step - to break the delta ranges into 5 gradations and reduce the final score to the generally accepted 5-point system. Analysis of deltas in the studied patients showed that the most optimal for the final

assessment are not evenly divided delta ranges of 20% (80-100%, 60-79%, 40-59%, 20-39%, 0-19%), and the following ranges, taking into account the most common values: 70% and above - 5 points; 60-69% - 4 points; 50-59% - 3 points; 35-49% - 2 points; 20-34% - 1 point; 0-19% - 0 points. These ranges were taken as the basis for evaluating the end-point of treatment.

To assess the results of treatment, the analysis was carried out separately in patients with injuries, tumors and echinococcosis of the thoracic and lumbar spine, as well as in all studied patients in general. The results are shown in Table 4.

The most "age" was the group of patients with tumors - the average age was 42.6 ± 2.0 years, it statistically significantly exceeded the average age in the group of injuries - 33.8 ± 1.1 years, and echinococcosis - 34.1 ± 2, 5 years. The proportion of men statistically significantly prevailed in the groups of injuries - $72.9\% \pm 3.6\%$, and echinococcosis - $70.6\% \pm 7.9\%$, whereas in the group of tumors the proportion of men was $46.5\% \pm 6.0\%$, was approximately equal to the proportion of women.

According to the vertebral index and spinal instability index of the IISI before treatment, the group of injuries was the most severe; then there was a group of echinococcosis, then a group of tumors; There were no statistically significant differences between the groups in terms of neuroindex: in the group of injuries, the neuroindex was $66.3\% \pm 1.15\%$, vertebral index - $77.6\% \pm 0.47\%$, the integral index of spinal instability IISI - 71.9% ± 0 , 64%; in the echinococcosis group, the neuroindex value was $55.3\% \pm 2.50\%$, vertebral index - $68.7\% \pm 0.62\%$, integral IISI - $62.0\% \pm 1.40\%$; in the group of tumors, the value of the neuroindex was $53.3\% \pm 1.46\%$, the vertebral index - $61.3\% \pm 0.75\%$, the integral IISI - $57.3\% \pm 0.94\%$.

There were no statistically significant differences between the groups in the absolute values of the diagnostic indices of IWDV, VCI, Cobb angle and degree of stenosis after treatment.

After treatment, almost all the parameters studied statistically significantly differed from the parameters before treatment, which indicates both a certain treatment efficacy and a sufficient diagnostic sensitivity of the diagnostic parameters used.

The average estimates of treatment results in points were the highest in the group of injuries - 3.06 ± 0.10 according to the neuroindex, 3.72 ± 0.13 according to the vertebral index, 3.45 ± 0.10 according to the IISI. Slightly lower estimates of the results were in patients with echinococcus - 3.09 ± 0.29 for neuroindex, 3.59 ± 0.26 for vertebral index, 3.32 ± 0.26 for IISI. The lowest estimates of treatment results were found in the group of patients with tumors - 2.24 ± 0.19 according to the neuroindex, 3.13 ± 0.14 according to the vertebral index, 2.79 ± 0.14 according to the IISI.

Table 4.

Results of surgical treatment of patients with injuries, tumors and echinococcosis of the spine

	Trauma n=155		Tumors n=71		Echinococcosis n=34		All patients n=260	
	M±m		M±m		M±m			
Age, years	33,8±1,1		42,6±2,0		34,1±2,5		36,2±1,0	
Gender (man -1, woman -2)	1,27±0,04		1,54±0,06		1,29±0,08		1,35±0,03	
IWDV,% - up to	30,2±0,53		19,1±0,25		26,3±0,35		26,7±0,44	
VCI,% - up to	33,6±0,68		25,2±0,50		29,0±0,31		30,7±0,48	
Cobb angle, degrees - to	21,8±0,52		16,1±0,65		23,0±0,28		20,4±0,39	
Stenosis deg.,% - up to	39,9±0,78		33,8±0,86		27,2±1,06		36,6±0,60	
Vertebral deformities deg., points - up to	2,59±0,05		2,44±0,08		2,24±0,11		2,50±0,04	
Neuroindex - before	66,3%±1,15%		53,3%±1,46%		55,3%±2,50%		61,3%±0,93%	
Vertebral index - before	77,6%±0,47%		61,3%±0,75%		68,7%±0,62%		72,0%±0,57%	
IISI - before	71,9%±0,64%		57,3%±0,94%		62,0%±1,40%		66,6%±0,64%	
IWDV, % - after	11,8±0,46	*	10,1±0,72	*	11,8±1,37	*	11,4±0,38	*
VCI, % - after	12,2±0,42	*	12,7±0,70	*	13,6±1,35	*	12,5±0,36	*
Cobb angle, degrees - after	14,3±0,61	*	14,4±0,82	-	14,9±0,99	*	14,4±0,45	*
Stenosis degree,% - after	0,71±0,36	*	0,0±0,0	*	0,0±0,0	*	0,42±0,21	*
Neuroindex - after	30,6%±0,86%	*	30,1%±1,54%	*	25,2%±1,96%	*	29,8%±0,71%	*
Vertebral index - after	29,5%±0,98%	*	28,5%±1,34%	*	30,3%±2,26%	*	29,3%±0,74%	*
IISI - after	30,1%±0,71%	*	29,3%±1,22%	*	27,7%±1,78%	*	29,6%±0,58%	*
Neuro-index - delta	53,2%±1,32%	*	41,5%±3,34%	*	52,0%±3,99%	*	49,8%±1,34%	*
Vertebral index - delta	61,1%±1,44%	*	54,3%±1,65%	*	56,0%±3,18%	*	58,6%±1,07%	*
IISI - delta	57,8%±1,07%	*	49,2%±1,80%	*	54,8%±2,84%	*	55,0%±0,91%	*
Neuro-index score, points	3,06±0,10		2,24±0,19		3,09±0,29		2,84±0,09	
Vertebral index score, points	3,72±0,13		3,13±0,14		3,59±0,26		3,54±0,87	
IISI score, points	3,45±0,10		2,79±0,14		3,32±0,26		3,25±0,08	

Note:

P – reliability of differences between indicators before and after surgery

*" * " - differences in indicators are statistically significant (P<0,05)*

The obtained results are quite natural, since among the three studied categories of patients, patients with tumors have the worst prognosis and are subject to subsequent oncological treatment, while for patients after injuries and with echinococcosis, this treatment is the main and radical method of treatment.

A more detailed analysis of the results of treatment in different groups shows that there are statistically significant differences between the groups for some indicators, including indicators of scores for treatment results. Consequently, the developed diagnostic criteria based on clinical score scales have high diagnostic sensitivity and value.

Conclusions

1. Indicators based on the characteristics of neurological status according to the ASIA scale in patients with spinal instability have a lower diagnostic and prognostic value than indicators based on the characteristics of vertebral status. The neuroindex developed on the basis of the ASIA index of neurological deficit is of a certain diagnostic value, primarily for monitoring the treatment process. Both indicators of neurological status are not informative enough for the prognosis and choice of treatment tactics.

2. Analysis of the diagnostic value of various parameters based on the Pearson pair correlation criterion showed that the highest absolute values of correlation are observed in the indicators of VCI, IWDV, pain index (according to the visual analogue scale), as well as in the developed indices − vertebral index and IISI, and the indices on the basis of the developed point scales give a higher correlation with treatment outcomes than the indicators of VCI and IWDV. This proves the advisability of their use in clinical practice.

3. The developed indicators of the vertebral status in case of spinal instability in the thoracic and lumbar spine are the most informative both for assessing the initial state, the dynamics of the treatment process and its results, and for the choice of surgical tactics. The use of clinical point scales based on the developed principles and the normalization of clinical and clinical and radiological data in this contingent of patients makes it possible to increase the diagnostic and prognostic capabilities of the available methods, does not require the use of special additional equipment and complex calculations.

4. The developed system of scoring the results of treatment of patients with instability of the spine in the thoracic and lumbar spine using the developed diagnostic indices - the vertebral index and the integral index of spinal instability based on normalization, is valid and convenient, it can be used both in prospective and retrospective studies, as well as in the comparative analysis of treatment results in different spinal centers.

5. In patients with instability of the spine in the thoracic and lumbar regions, the etiological factor has a certain value for the prognosis. The group of patients with spinal injuries is the most severe in terms of the initial vertebral status, followed by a group of patients with tumors. The overall prognosis of treatment outcomes for trauma depends on the extent and extent of vertebral lesions. With tumors, surgical treatment allows stabilizing the patient's condition and his motor status, the general prognosis depends on the oncological diagnosis.

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