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USE OF THE MODIFIED FRANKEL SCALE IN ASSESSING VERTEBROMEDULLARY DISORDERS IN EMERGENCY SERVICE OF A MULTI-SPECIALITY HOSPITAL

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ПРИМЕНЕНИЕ МОДИФИЦИРОВАННОЙ ШКАЛЫ FRANKEL ПРИ ОЦЕНКЕ ВЕРТЕБРОМЕДУЛЛЯРНЫХ РАССТРОЙСТВ В УСЛОВИЯХ УРГЕНТНОЙ СЛУЖБЫ МНОГОПРОФИЛЬНОГО СТАЦИОНАРА

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Spinal canal deformities of various etiologies are one of the most severe types of spine pathology, which often cause disability and social alienation of patients, which requires long-term, expensive, multi-stage treatment. This indicates the high medical and social significance of the problem and requires developing a unified approach to the treatment of this pathology, in particular: choosing optimal tactics of surgical procedures to reduce the frequency of both immediate and long-term complications and return the patient to the previous level of activity. Usage of our modified Frankel scale based on the analysis of 236 cases of spinal canal deformities allows a to assess neurological disorders in patients not only with spinal injuries but also with other vertebromedullary pathologies, such as degenerative-dystrophic, inflammatory and tumoral diseases of the spine and spinal cord.

Keywords: spinal canal deformities, modified Frankel scale, vertebromedullary pathology

Деформации позвоночного канала различного генеза являются одним из самых тяжелых видов патологии позвоночника, которые часто приводят к инвалидизации и социальной дезадаптации пациентов, что требует длительного, дорогостоящего, многоэтапного лечения. Все это свидетельствует о высокой медико-социальной значимости проблемы и требует разработки единого подхода к лечению данной патологии, а именно: выбору оптимальной тактики оперативных вмешательств с целью снижения частоты развития как ближайших, так и отдаленных осложнений и возвращения пациенту прежнего уровня активности. На основании опыта применения у 236 пациентов с деформациями

позвоночного канала модифицированной шкалы Frankel определена эффективность ее использования для оценки неврологических расстройств у больных с позвоночно-спинномозговой травмой и с другой вертебромедуллярной патологией (дегенеративно-дистрофические, воспалительные и опухолевые заболевания позвоночника и спинного мозга).

Ключевые слова: деформации позвоночного канала, модифицированная шкала Frankel, вертебромедуллярная патология

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CT – computed tomography
DDDS – degenerative-dystrophic disease of the spine
LS – lumbar spine
MRI – magnetic resonance imaging
SC – spinal cord
SCD – spinal canal deformity
SI – spinal injury
SMS – spinal motion segment
TS – thoracic spine
VAS – visual analog scale

Spinal injuries constitute, on average, 17.7 % of the locomotor system injuries [1]. Unstable damage of the lower thoracic spine and lumbar spine are the most common – up to 54.9 %, and the outcome of treatment is affected by a variety of factors [2, 3, 4, 5, 6]. Aiming to perform decompression of neurovascular formations of the spinal canal and stabilize the affected segment of the spine with minimum invasion for the patient within the shortest possible time [7, 8, 9, 10, 11, 12].

In the emergency service of a large multi-specialty hospital, there can be implemented a particular algorithm of examination of patients coming in with signs of complicated SCD wherein neurological deficiency was assessed based on the modified Frankel scale. This scale, proposed by N. Frankel in 1969, has come into widespread acceptance among clinicians [13, 14, 15, 16]. In pediatric practice A.Y. Mushkin additionally distinguished the ER type – the absence of motor deficiency in the presence of radicular (pain) syndrome [17, 18, 19]. The scale distinguishes five types of the severity of motor and sensory spinal disorders, which is not enough for an objective analysis of structural damage, isolated sensory disorders, radiculopathy, disorders of pelvic organs with spinal canal deformity. The purpose of work was to assess the effectiveness of our modified Frankel scale for assessing vertebromedullary disorders with spinal canal deformity of various etiologies in emergency service of a multi-specialty hospital.

Material and Methods. When the patient was admitted to the hospital, his examination included history taking, general investigation, pain measurement, determination of the amplitude of active and passive movements of the limbs and muscle strength, assessment of sensory and pelvic disorders, as well as palpation of all parts of the spine. Thus, in neurological examination, first of all, the state of motor function of the limbs was assessed: active movements, deep and surface reflexes, range of motion in the joints of the limbs, and muscle strength. Assessment of conductor and segmental disorders allowed to determine the level and nature of the damage of the spinal cord and its roots.

Visual analog scale (VAS) was used to assess the intensity of pain syndrome [1, 8]. The VAS used was a horizontal line 10 cm long, the ends of which correspond to the extreme degrees of pain intensity (from «no pain» to «unbearable pain»). The patient was offered to assess the pain and make a mark corresponding to the severity of the pain syndrome at the moment. The distance between the marks from «no pain» to «unbearable pain» was measured in centimeters and rounded if necessary.

Long-term results of treatment were assessed by calling the patient in for a control examination in a hospital. The study included: complaints inquiry, history taking, physical examination, assessment of pain syndrome according to the VAS, neurological examination according to the modified Frankel scale.

Since an essential criterion for assessing the outcome of the treatment is the «satisfaction» of the patient, in our work, we used the MacNab scale [5], namely its modification [7], to conduct a subjective assessment of the effectiveness of the procedures. Proposed in 1971 by Canadian orthopedist Professor Ian MacNab, the scale is the most frequently mentioned and easy to use in assessing patient's satisfaction with the conducted treatment. The modified version of the MacNab scale differs in that each of the levels of patient satisfaction corresponds to the criteria according to which the researcher determines the outcome of the procedure for the patient.

Mandatory methods of patient examination at all stages of medical care, except for clinical and laboratory ones, were various methods of radiation diagnostics (spinal radiography with functional tests, computed tomography (CT), magnetic resonance imaging (MRI)).

Commonly used and mandatory for the initial examination was observational radiography of spine in two projections centered on the affected spinal motion segment, which allowed to assess the presence of axial deformation of the vertebral column and determine to some extent the localization of the damage level.

Stability and type of spinal injury were determined based on the Denis classification (1983), distinguishing stable and unstable spinal injuries (types B and C with damage of two or three supporting spinal columns, respectively).

The size of the kyphotic deformity of the affected spinal motion segment was determined according to the Cobb method using plain radiography measuring the angle formed by two straight lines passing through the intact endplates of the vertebral bodies closest to the affected spinal motion segment.

In all cases, the procedure was X-ray controlled using a mobile X-ray machine (C-arm). The latter was conducted both to determine the level of damage and to assess the location of the implants.

X-ray examination was performed on the machine make «SIEMENS» SIRESKOP BD CX.

The data obtained during the research were statistically processed using the Microsoft Windows Excel

application package and the Basic Statistic program, the significance of the differences was estimated using the Pearson's chi-squared test, the relationship between factors and types of outcomes was calculated using the Spearman's rank correlation coefficient. After the conducted correlation analysis, we selected only those features that had a significantly ($p<0.05$) strong ($R\geq0.7$) or moderate ($0.3\leq R\leq0.7$) correlation.

Results and Discussion. In order to clarify the tactics of surgical treatment and to assess the effectiveness of various decompressive-stabilizing procedures for patients with spinal canal deformities of the thoracic and lumbar spine, we analyzed the results of surgical treatment of 236 patients with spinal canal deformities of various etiologies (spinal injuries, degenerative-dystrophic disease of the spine, tumor lesion of the spine and spinal cord, spondylitis) of thoracic and lumbar spine. All the patients were operated on in St. Petersburg state budgetary institution of health care city hospital No. 26 in the period from 1998 to 2018. The scope and sequence of the surgical procedures were determined according to the nature of the vertebromedullary pathology, the degree of the spinal canal deformity and severity of neurological disorders, and the form and degree of the spinal canal deformity determined different approaches to the spine. The average age was 46.1±1.1, including 137 men, 44.2±1.3 years of average age, 99 women, and 48.8±1.8 years of average age. Preliminary planning of surgical procedure was based on the assessment of vertebromedullary pathology in patients, the degree of the spinal canal deformity, damage to osseous and ligamentous structures, the possibility of using methods of eliminating compression of neurovascular formations of the spinal canal and fixating the affected spinal motion segment. The main principles of surgical treatment of patients were the aiming for early implementation of surgery and simultaneous decompression of neurovascular formations of the spinal canal with the restoration of the support capacity of the affected spinal motion segment. The distribution of patients according to the type of neurological disorders depending on vertebromedullary pathology is shown in Table 1.

Table 1

Distribution of patients according to neurological disorders depending on vertebromedular pathology before surgery

Type of neurological disorders according to the modified Frankel scale		Type of pathology			
		DDDS	SI	Spondylitis	Tumor lesion
A	Number of cases	0	7	0	0
	% of all cases	0.0 %	3.0 %	0.0 %	0.0 %
B	Number of cases	0	4	0	0
	% of all cases	0.0 %	1.7 %	0.0 %	0.0 %
C	Number of cases	1	37	0	2
	% of all cases	0.4 %	15.7 %	0.0 %	0.8 %
D	Number of cases	0	22	0	2
	% of all cases	0.0 %	9.3 %	0.0 %	0.8 %
R	Number of cases	31	69	7	6
	% of all cases	13.1 %	29.2 %	3.0 %	2.5 %
RD	Number of cases	21	23	0	2
	% of all cases	8.9 %	9.7 %	0.0 %	0.8 %
S	Number of cases	0	1	0	0
	% of all cases	0.0 %	0.4 %	0.0 %	0.0 %
E	Number of cases	0	1	0	0
	% of all cases	0.0 %	0.4 %	0.0 %	0.0 %
Total		53	164	7	12
Total %		22.5 %	69.5 %	3.0 %	5.1 %

Upon comparing the results of examination of patients with traumatic and non-traumatic etiology of the formation of complicated forms of the spinal canal deformity, it was noted that the regression of neurological disorders in the presence of spinal injury depends not on the degree of the spinal canal deformity and kyphotic deformation, but on the initial traumatic changes in neural structures obtained at the time of the spinal injury.

The distribution of patients according to neurological disorders depending on the pathology after surgery is shown in Table 2.

Table 2

Distribution of patients according to neurological disorders depending on pathology after surgery

Type of neurological disorders according to the modified Frankel scale		Type of pathology			
		DDDS	SI	Spondylitis	Tumor lesion
A	Number of cases	0	5	0	0
	% of all cases	0.0 %	2.1 %	0.0 %	0.0 %
B	Number of cases	0	3	0	0
	% of all cases	0.0 %	1.3 %	0.0 %	0.0 %
C	Number of cases	0	10	0	1
	% of all cases	0.0 %	4.2 %	0.0 %	0.4 %
D	Number of cases	11	36	0	1
	% of all cases	4.7 %	15.3 %	0.0 %	0.4 %
R	Number of cases	0	3	0	0
	% of all cases	0.0 %	1.3 %	0.0 %	0.0 %
RD	Number of cases	0	0	0	0
	% of all cases	0.0 %	0.0 %	0.0 %	0.0 %
S	Number of cases	16	27	1	4
	% of all cases	6.8 %	11.4 %	0.4 %	1.7 %
E	Number of cases	26	80	6	6
	% of all cases	11.0 %	33.9 %	2.5 %	2.5 %
Total		53	164	7	12
Total %		22.5 %	69.5 %	3.0 %	5.1 %

As a result of ventral repositioning-stabilizing procedures in all cases, we achieved the reconstruction of the spinal canal deformity and decompression of neurovascular formations of the spinal canal to varying degrees.

We assessed the degree of spinal canal deformity in comparison with neurological disorders in the postoperative period. And to identify the correlation of neurological disorders to the degree of the spinal canal deformity, we made a comparative analysis of neurological disorders and the size of the spinal lumen deficit before and after surgery (Table 3).

The use of the modified scale made it possible to visually assess the dynamics of neurological disorders in general (Table 4).

To adapt this scale to the assessment of neurological disorders in the presence of spinal canal deformities of different etiologies, we have proposed and implemented into practice two more types of disorders – R – radiculopathy and S – isolated sensory disorders.

Thus, the scale has the following outlook: A – absence of motor and sensory function; B – complete absence of movements, but with the presence of sensitivity; C – significant impairment of motor function with the presence of sensitivity; D – slight impairment of movements with normal sensitivity; R – radiculopathy; RD – slight impairment of movements with radiculopathy; S – no motor disorders, only sensory disorders; E – no neurological complications.

Table 3

The correlation between the severity of neurological disorders and the spinal lumen deficit before and after surgery

Type of neurological disorders according to the modified Frankel scale	Spinal lumen deficit before the surgery				
	0–25 %	26–50 %	51–75 %	76–100 %	Total
A	1	4	1	1	7
% of total number	0.4 %	1.7 %	0.4 %	0.4 %	3.0 %
B	3	1	0	0	4
% of total number	1.3 %	0.4 %	0.0 %	0.0 %	1.7 %
C	8	25	7	0	40
% of total number	3.4 %	10.6 %	3.0 %	0.0 %	16.9 %
D	9	13	2	0	24
% of total number	3.8 %	5.5 %	0.8 %	0.0 %	10.2 %
RD	17	23	6	0	46
% of total number	7.2 %	9.7 %	2.5 %	0.0 %	19.5 %
R	56	50	7	0	113
% of total number	23.7 %	21.2 %	3.0 %	0.0 %	47.9 %
S	0	1	0	0	1
% of total number	0.0 %	0.4 %	0.0 %	0.0 %	0.4 %
E	1	0	0	0	1
% of total number	0.4 %	0.0 %	0.0 %	0.0 %	0.4 %
Total	95	117	23	1	236
Total %	40.3 %	49.6 %	9.7 %	0.4 %	100.0 %

Table 4

Neurological disorders according to the modified Frankel scale before and after surgery

Type of disorder	Before surgery		After surgery
	Number	%	Number
A	7	3.0	5
B	4	1.7	3
C	40	16.9	11
D	24	10.2	48
R	113	47.9	3
RD	46	19.5	0
S	1	0.4	48
E	1	0.4	118
Total	236	100.0	236

Muscle strength, tactile, and pain sensitivity were evaluated according to this scale.

The study of muscle strength was performed according to a five-point scale [1] as follows:

0 – atonic paralysis, no signs of active muscle contraction;

1 – weak active contractions of some muscles, but without movement in the corresponding limb joint;

2 – distinct (visual) active muscle contraction with movement in the joint while excluding the weight of the limb;

3 – movements in joints, coping with only the weight of the limb of various amplitudes;

4 – full scope of movement in the joint with overcoming resistance, which can be measured by a dynamometer;

5 – a full range of movement with overcoming the weight of the limb with overcoming the resistance equivalent to the healthy symmetrical muscle.

After a two-sided estimate of muscle strength, the scores obtained in each segment were summarized, and the results were put down into the patient's medical record. The maximum number of points for ten segments of each side was 50. In cases wherein muscle strength for some reason was not checked, the NT (not tested) mark was put down.

The following scale was used to study the sensitivity:

0 – no sensitivity;

1 – impaired sensitivity;

2 – normal sensitivity.

Neurological status was assessed before and after surgery, as well as in the following postoperative days. The control terms of assessment of the patient's condition were the date of admission of the patient to the hospital, the 10th day after the surgery, and the day of discharge from the hospital.

After the conducted treatment, the following variations of the dynamics of motor disorders were distinguished: full recovery, significant improvement, stabilization with minor improvement, and aggravation. Full recovery corresponded to the limb strength of 5 points. Significant enhancements included 2–3 points increase in strength in two or more myotomes, which corresponded to the rise in the amplitude of movements of the patient.

A slight improvement in motor function included the increase in strength in 1–2 myotomes by 1 point with the appearance of movements in them or a slight increase in the scope of movements in the presence of deep pareses.

In assessing the sensorium, the following variations of disorders were distinguished:

Full recovery: Characterized by normalization of all types of sensitivity from the damage level;

Significant improvement: Decrease of the hypoaesthesia level by 3–4 and more segments, as well as the transition of anesthesia to hypoaesthesia for three or more segments and restoration of deep sensitivity in the limbs;

Insignificant recovery of sensory impairment: Decrease of the hypoaesthesia level by 1–2 segment from the initial state;

Aggravation: Increase of the sensitivity disorders level from the initial state by two or more segments.

In the study of pelvic organ function, the duration of urine continence, sensation of bladder filling, and urine passing through the urethra were evaluated. The complete recovery included normalization of the bladder function. The significant improvement included an increase in the duration of urine continence for 2 hours or more, restoration of control over urination, and the sensation of bladder filling. Insignificant recovery included an increase in the urine continence time up to 2 hours. Aggravation included development of neurogenic bladder with urinary incontinence.

Thus, patients, according to the modified Frankel scale, were redistributed into groups, which subsequently allowed to evaluate neurological dynamics in general.

A general estimate of patients' initial state included a mandatory examination by a neurosurgeon and, if necessary, by other specialists, which allowed to plan the scope of the study, taking into account concomitant somatic conditions typical of patients with vertebromedullary pathology. In detecting somatic pathology, purposeful additional examination and treatment of patients were carried out, the degree of readiness of each patient for the upcoming surgery was assessed.

The conducted study showed the possibility of using our modified Frankel scale in the conditions of the 24-hour urgent service of a multi-specialty hospital for treating patients with spinal canal deformities of various etiologies.

Thus, one of the crucial aspects of the use of this scale is its simplicity and convenience, especially in the conditions of urgent service, where the use of detailed, complex, and cumbersome scales complicates the processes of urgent diagnostic and therapeutic measures.

The proposed scale of evaluation of neurological disorders makes it possible to see a follow-up pattern of the condition at admission during treatment and observation of patients with complicated spinal canal deformities of various etiologies. The scale is convenient for practical use by doctors of urgent specialized medical services.

Conclusions. The proposed modified scale of evaluation of neurological disorders in patients with vertebromedullary pathology, despite its simplicity, has shown its effectiveness, allowing to quickly obtain data necessary for making decisions on scheduling emergency medical procedures.

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