DISTURBANCE OF MOBILITY IN VERTEBRAL COLUMN WITH SPINAL NEUROTRAUMA

S.S. Wakista*, S.V. Shilko**

* Gomel State Medical Institute, 5 Lange Street, 246000, Gomel, Belarus
** V.A. Belyi Metal-Polymer Research Institute of National Academy of Sciences of Belarus, 32a Kirov Street, 246050, Gomel, Belarus, e-mail: Shilko_mpri@mail.ru

Abstract: Vertebral injuries with spinal cord damage are common but insufficiently studied pathology of the locomotor apparatus. In this paper the experimental results of mobility studies in different regions of the vertebral column in norm and pathology are given. It is established that patients with spinal neurotrauma have statistically reliable mobility reducing in all the regions of the vertebral column. The mechanism of pain feeling is proposed to be modelled by formulation of moving boundaries problem for the nerve and fibrous ring contact under segment loading. The results of biomechanical study can be used for objectivisation of pain syndrome and resolution of expert questions.

Key words: vertebral column, degree of mobility, motion parameters, spinal neurotrauma

Introduction

Vertebral injuries with spinal cord damage are common but insufficiently studied pathology among the injuries of the locomotor apparatus [1-4]. These injures compose about 4 % of the total number of traumas and require prolonged hospitalisation and course in significant incidence of disablement. The mortality rate reaches to higher values in spinal cord injuries (in the cervical region up to 60 %). With increase of number of vehicles and their speeds, wide use of modern weapons and explosives, the working inability is enhanced among people year after year; it gives to this problem a great scientific, social and economic value.

The state of the art in the development of resuscitative service, surgery, neurosurgery, pharmacology provides reducing the number of deaths and prolonging the lifetime of victims. Earlier most of those patients died during the acute stage. However, this causes an increase in the number of patients with heavy consequences of the injuries: disturbances in movements, inability to work. The defect leads to social deadaptation of patients and their family members.

Method and results of investigation

In our experiments all the patients are examined under 78 parameters. Diagnosis was verified by spondylography, tomography and was confirmed by clinical data. The patients were at 20 to 60 years with different periods after the trauma. In much of the patients the traumas were from 1 to 5 years (29.1 %) and from 5 to 10 years (15 %). The great number of injuries was caused by fall from height (35.6 %), road traffic accidents (26.7 %), work injuries (15.6 %) and during diving into water (11.0 %). The remaining 11.1 % was due to sport injuries, stab wounds and gun stab injuries, etc.

According to the universal classifications of fractures AO/ASIF, spinal injuries are separated into the following types: type A – damage of vertebral body with compression (28 patients); type B – damage of the anterior and posterior complexes with tension (14 patients); type C – damage of the anterior and posterior complexes with rotation.

In the cervical region most of the observed cases are differentiated as type A fractures. The severest injuries (type C) were diagnosed in 6.7 % cases.

To measure mobility in the cervical region (in degrees) the goniometer was used.

According to Table 1, in all the cases of cervical injuries there present statistically reliable limitations of the active movements.

The results of the measured movements are listed in Table 2.

According to the results presented in Table 2, significant movement changes caused by vertebral column injuries present in the thoracic and lumber regions. In the mild cases (limitations of spinal cord movements), reliable differences with the healthy persons are not established, but in the moderate and severe cases the values are reliably differed from the control magnitudes. Therefore, the results of the study of vertebral column movements are an important prognostic sign and can be used for objectivisation of pain syndrome and resolution of expert questions.

Table 1. Degree of limitations of active movements in the cervical region.

Movements	Statistical values, $S \pm M$, degrees			
	Norm, n=15	Mild limitation, n=7	Moderate limitation, n=9	Severe limitation, n=15
Flexion-extension	32.1 ± 2.4	21.4 ± 2.7	12.1 ± 1.3	3.9 ± 0.7
Lateral bending	39.4 ± 5.2	23.9 ± 4.3	14.2 ± 2.9	4.6 ± 0.5
Rotation	58.4 ± 8.9	39.6 ± 5.7	25.6 ± 3.8	14.0 ± 1.4

Table 2. Degree of limitations of active movements in different regions.

Region	The distance difference between two points in the position of flexion and extension, $X \pm S_x$, cm			
	Norm, n=15	Mild limitation, n=11	Moderate limitation, n=9	Sever limitation, n=4
Thoracic region	7.3 ± 1.4	5.7 ± 1.2	3.2 ± 0.3	1.1 ± 0.2
Lumber region	3.8 ± 0.8	3.1 ± 0.4	1.7 ± 0.1	0.9 ± 0.03
Thoracic and lumber regions	11.2 ± 1.7	7.1 ± 1.4	4.3 ± 0.9	2.2 ± 0.3

The ultimate values of displacements and rotations of the vertebral column are connected with pain feeling due to mechanical action of the spinal cord on nerve endings. The mechanism of spinal injuries may be modelled in accordance to [5] by solving moving boundaries problem for nerve and fibrous ring interaction in the vertebral column structural unit under bending and rotating moments (M_b, M_r), normal and shear forces (N, T) as shown in Fig. 1. This structural unit consists of rigid vertebras and elastic fibrous ring containing viscous core. There is no contact of the fibrous ring and nerve before loading. The deformation of the ring may be estimated by calculation, for example, by the finite element method. Thus, biomechanical study provides us to obtain the relation between parameters of
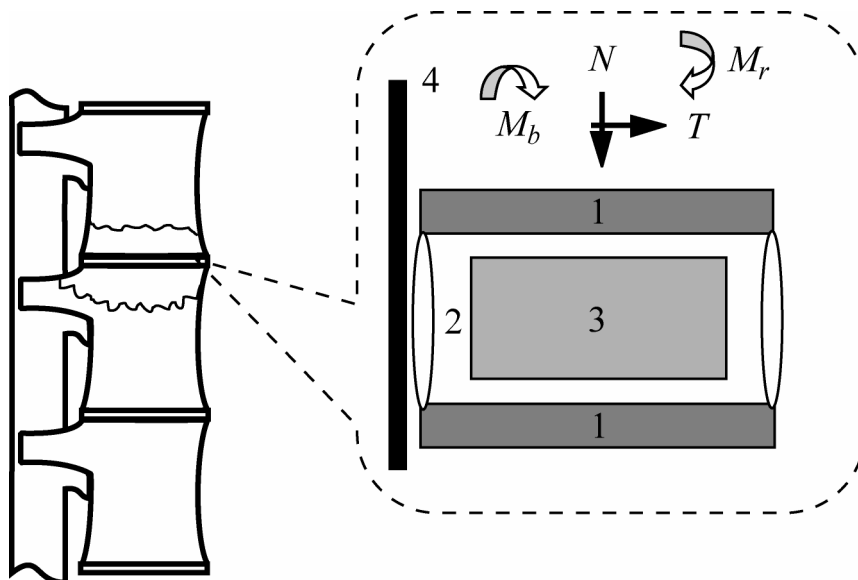
Fig. 1. Mechanical model of vertebral-spinal injuries under traumatic loading.
1 – vertebras, 2 – fibrous ring, 3 – core, 4 – nerve.

motion (tension, bending, rotation, etc.) of the vertebral column which determined by the procedure described above and the moment of contact of the deformed fibrous ring with nerve endings (Fig. 1).

So, by experimental determination of the mobility reducing of vertebral column, one may estimate the changing the geometry and deformation properties of the segment's biotissues due to spinal trauma, which is a subject of further investigations.

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НАРУШЕНИЕ ПОДВИЖНОСТИ ПОЗВОНОЧНИКА
ПРИ СПИНАЛЬНОЙ НЕЙРОТРАВМЕ

В.В. Вакиста, С.В. Шилько (Гомель, Беларусь)

Травма позвоночника с повреждением спинного мозга является распространенной, но недостаточно изученной патологией опорно-двигательного аппарата. Приведены результаты исследования подвижности различных отделов позвоночного столба в норме и при наличии травм различной тяжести. В частности,

проведены измерения параметров движения (углов поворота и амплитуды перемещения) позвонков в шейном и грудном отделах. Установлено, что у больных со спинальной нейротравмой имеет место статистически достоверное ограничение движения во всех отделах позвоночника. Моделируется механизм болевой чувствительности на основе формулировки задачи о подвижной границе контакта нерва и фиброзного кольца, деформируемого при нагружении сегмента позвоночника. Тем самым, биомеханическое исследование может быть использовано при диагностике травмы позвоночника. Библ. 5.