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SPINAL ISCHEMIA: THE REHABILITATION POTENTIAL. A CLINICAL CASE

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ABSTRACT

BACKGROUND: *Spinal myeloischemia is a rare but severe neurological disease, associated with high incapacitation level and high social-economical costs due to complications developing during the acute phase. The reasons for its development can include vascular malfomations, spinal stroke, extra- and intramedullary tumors, compression of the spinal cord in cases of vertebral fractures, intervertebral disc herniations, stenosis of the spinal canal at the cervical segment, medical manipulations and impaired segmental circulation during the anesthesia, lumbar puncture and surgical interventions.* ***CLINICAL CASE DESCRIPTION:*** *The presented clinical observation provides a description of the iatrogenic complication that has developed in a patient aged 52 years after discectomy and installation of the disc prosthesis due to the development of disco-radicular and spinal conflict, resulting due to the C5/C6 dorsomedial intervertebral hernia, the clinical manifestations of which, besides pain, included weakness in the left upper limb, causally related to the focus of intramedullary ischemia at the unilateral side. At the early post-surgery period, asymmetrical tetraparesis was revealed with the predominance in the distal segments of the left upper limb and with impaired functions of the pelvic organs, caused by the expansion of the ischemia zone in the gray and white matters in the anterior areas of the lower cervical segments of the spinal cord.* ***CONCLUSION:*** *The timely initiation of combined medication therapy and the staged rehabilitation, conducted by the multi-disciplinary team, have provided the restoration of the impaired functions and the quality of life for the patient. The proposed methods can be useful in the treatment of patients with compression-related and non-compression-related vascular myelopathies.*

Keywords: *discectomy; spinal stroke; myeloishemia; rehabilitation.*

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BACKGROUND

Spinal stroke, spinal ischemia and vascular myelopathy are the forms of acute or subacute impairment of circulation in the spinal cord, caused by the thrombosis of spinal arteries or veins, by their compression during the vertebral column injury, during the stenosis of the spinal canal, after surgical interventions in the vertebral column, aorta, brachiocephalic arteries and after their concomitant hemodynamic complications with further segmental focal softening in the ischemia zone, with developing neurological syndromes characteristic for each level of decreased perfusion [1].

The diagnosis of spinal stroke is more often set clinically, while the visualization methods are employed for the purpose of ruling out the presence of myelopathies of other etiology [2, 3]. The outcomes of impaired spinal circulation represent a medical-social economical problem. Though their occurrence is not high (from 1% to 2% [4]), the reasons and forms may vary [2, 5]. The difficulties occurring during setting the diagnosis include the defects of collecting the anamnestic data, the assessment of neurological symptoms, as well as low confidence levels of the results obtained during the electrophysiological tests and neurovisualization.

With all the variety of methods and means of rehabilitation therapy, there is no consensus on managing such patients and no widely acknowledged criteria for the clinical evidences of their use both during the post-surgery period and at the later stages of rehabilitation.

СПИНАЛЬНАЯ ИШЕМИЯ : РЕАБИЛИТАЦИОННЫЙ ПОТЕНЦИАЛ. КЛИНИЧЕСКИЙ СЛУЧАЙ

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АННОТАЦИЯ

Обоснование. *Спинальная миелоишемия — редкое тяжёлое неврологическое заболевание, сопровождающееся высоким уровнем инвалидизации и большими социально-экономическими издержками из-за возникших в остром периоде осложнений. Причиной её развития могут быть сосудистые мальформации, спинальный инсульт, экстра- и интрамедуллярные опухоли, компрессия спинного мозга при переломе позвонка, межпозвонковой грыже, стенозе позвоночного канала в шейном отделе, врачебных манипуляциях, нарушении сегментарного кровообращения при анестезии, люмбальной пункции, оперативных вмешательствах.* ***Описание клинического случая.*** *В представленном клиническом наблюдении даётся описание ятрогенного осложнения, случившегося у пациента в возрасте 52 лет после дискэктомии и установки протеза диска в связи с развитием у него диск-радикулярного и спинального конфликта, обусловленного дорсомедиальной межпозвонковой грыжей C5/C6, клиническими проявлениями которого, помимо боли, была возникшая слабость в левой руке, причинно связанная с очагом интрамедуллярной ишемии на одноименной стороне. В раннем постоперационном периоде выявлен асимметричный тетрапарез с преобладанием в дистальных отделах левой руки и нарушением функции тазовых органов, возникший из-за расширения зоны ишемии серого и белого вещества в передних отделах нижних шейных сегментов спинного мозга.* ***Заключение.*** *Своевременно начатая комплексная лекарственная терапия и этапная реабилитация, проводимая мультидисциплинарной командой, обеспечили восстановление нарушенных функций и качества жизни пациента. Предложенные методики могут быть полезными при лечении больных с компрессионными и некомпрессионными сосудистыми миелопатиями.*

Ключевые слова: *дискэктомия; спинальный инсульт; миелоишемия; реабилитация.*

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CLINICAL CASE

Patient info

Male patient aged 52, hospitalized to the Neurosurgery Department in Astrakhan city with the complaints of moderate pain in the cervical segment of the vertebral column (5 points of the visual analogue scale), weakness in the left upper limb, numbness in the shoulder, forearm and fingers I–II.

Case history. The anamnestic data show that the patient has been suffering from the neck pain for 5–6 years, repeatedly receiving courses of conservative therapy prescribed by the neurologist with temporary positive effect. A year before admission, based on the results of magnetic resonance imaging (MRI) of the lower area of the cervical spine, degenerative-dystrophic changes and the dorsal-medial subligamentous left-sided hernia was found in the C5/C6 intervertebral disc, measuring 0.7 cm and showing signs of caudal migration at an area with a length of up to 0.5 cm, spreading into the intervertebral foramen, with signs of discal-radicular conflict. The spinal cord and the radices show no signs of any changes. There were no clinical manifestations of compression. The dimensions of the spinal canal corresponded to the age-corrected reference ranges (1.4 cm).

laboratory and instrumental diagnosis

Paresis, hypotension in the muscles of the left upper limb (2 points), anisoreflexia D>S, radicular-type hypesthesia in segments C5 and C6. No pathological

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reflexes or symptoms of longitudinal-transverse damage of the spinal cord were found. The tests of scalenus syndrome or Adson syndrome on the left side were positive.

Due to the presence of distal paresthesia, ultrasound examination of the radices and nerves of the upper limbs was carried out: no solid evidence of their local compression were obtained.

MRI findings obtained using the modes T2-WI, T2-STIR (1.5 Tesla, slices thickness — 3 mm): disco-radicular conflict at the level of C5/C6; in the lower cervical segments of the spinal cord, the findings included a local intramedullary "pin" type focus — the marker of vascular myelopathy.

Taking into consideration the obtained data, surgery was performed at the extent of discectomy of C5/C6, resection of the disc hernia and prosthetic replacement (M6 disc prosthesis).

On the next day after surgical intervention, the aggravation of already existing neurological symptoms was noted: decreased muscle strength in the limbs (tetraparesis), more in the left (palm and foot); impaired functions of the pelvic organs expressed as insufficient control of urination. Upon the examination, the following was noted: the tendon reflexes are intensified, more on the right side; impaired superficial sensitivity matching the segmental radicular type on the left side (C5/C6); decreased muscle tone and strength S>D (down to 2 points). The proprioceptive sensitivity was intact. After assessing the data from the MRI scans of the cervical spine at the sagittal and axial planes, MRI-signs of postoperative changes were revealed along the surgical access area. Comparing to previous images, negative changes were reported — enlarged area of the myelopathy focus at the level of the lower segments with damaging the gray and white matters, predominantly in the left half of the spinal cord, which indicates that the patient is developing an iatrogenic complication — focal spinal ischemia (the anterior cord syndrome, the impairment of the afferent branches of the left lower cervical radiculomedullary artery), manifesting with asymmetrical tetraparesis and with the dysfunction of pelvic organs. No local hyperintensity was found in the slices obtained using the diffusion weighted images (DWI), but additional data obtained at the ventral-lateral area of the C5 vertebral body, showing the presence of a hyperintensive ovoid shape focus of bone tissue remodeling for modes T1, T2-WI, T2-STIR with unclear and uneven contours — the extramedullary sign of local ischemia, which was not found in the previous images.

Treatment

The physician has prescribed analgesics (Ketoprofen — 100 mg twice daily), hormonal medications (Dexamethasone — 8 mg, intravenous); the gastroprotective drug Omeprazol (40 mg); Pentoxifylline (100 mg + 200 ml 0.9% NaCl solution, intravenous); antioxidants, neurometabolic drugs (Cytoflavin — 10 ml intravenous, thioctic acid — 600 mg, intravenous); for the prevention of thromboembolic and infectious complications — Fraxiparine at a dosage of 0.4 ml subcutaneously and Ceftriaxon (1.0 g, intramuscular), respectively. Insignificant positive changes were noted in terms of the neurological status (level D of the ASIA scale).

The patient had received the recommendations to continue medication treatment at the 2nd stage, with further courses of individual differentiated medical rehabilitation taking into consideration the potential present, the parameters of the functional independence status and the clinical recommendations [6, 7].

Diagnosis

On admission to the Medical Rehabilitation Unit, the patient was examined by the physicians of the multidisciplinary rehabilitation team, consisting of the neurologist, the Head of Medical Rehabilitation Unit, the rehabilitation therapist, the medical psychologist, the physical therapist and the nurse. According to the examination results, the patient had his rehabilitation diagnosis set according to the categories of the International functional classification (table 1) and underwent an assessment of the motor and psychosomatic status in accordance with the scales (table 2).

Medical rehabilitation

The short-term objective of the second stage medical rehabilitation was restoring the ability of self-care (dressing/undressing, personal care) and the ability to walk with additional support to Day 21. The objective of the motor and household rehabilitation were the following: to restore the motor function of the left limbs, to have the capability of fully move in the bed, to be able to sit down without assistance, to sit and to use the technical means of rehabilitation (walking aid, walking cane), to stand up, to go to bathroom and to dress/undress.

Taking into consideration the age of the patient, the severity degree of the neurological deficit, his rehabilitation potential was assessed as medium, with the thing to be taken into account being the

Table 1

Rehabilitation diagnosis in the categories of the International functional classification

Diagnosis[1]	Key words[2]	Specialist[3]	Intervention[4]	Qualifier[5]
b28010.1 Pain in the head and neck	Pain with a background of degenerative changes in the vertebral column	Neurologist	Medication therapy, physiotherapy	b28010.0
b620.2 The urination functions	Control of urination	Neurologist	Medication therapy, physiotherapy	b620.2
b7603.3 Supporting functions of the hand or the leg	Leaning on the damaged leg	Physical therapist	Training of leaning on the leg	b7603.2
b7352.2 Muscle tone on one side	Hypotension on the left side	Physical therapist, neurologist	Active and passive gymnastics, robot-assisted mechanotherapy	b7352.1
b 7302.3 Muscle strength on one side of the body	Hemiparesis 3 points	Physical therapist, neurologist	Active and passive gymnastics, robot-assisted mechanotherapy	b 7302.2
S120.2 The spinal cord and related structures	Focus at the level of the lower segments of the spinal cord C5/C6 with damaging the substance of the spinal cord, according to data from MRI	Neurologist	-	S120.2
d4500.44 Walking short distances	Getting up, going to the toilet and to the wash basin with support	Physical therapist	Learning the correct algorithm of supported walking	d4500.23
d465.44 Moving using technical aids	Walking with the walking aids	Physical therapist	Training on the correct walking with the walking aids to a distance of not less than 50 m	d465.02
d4153.23 Staying at the sitting position	Sitting down and holding the sitting positions	Physical therapist	Training of long-term staying at the sitting position	d4153.00
d445.34 Using the palm and hand	Using the palm and hand in the household situations	Physical therapist	Training of leaning on the hand, of using the hands in everyday situations, such as taking meals, washing, dressing, other hygienic activities, the use of walking aids	d445.12
d540.03 Dressing	Dressing and undressing the upper and lower half of the body, putting on the shoes	Nurse	Training the patient on the methods of dressing and putting on the shoes	d540.01
d550.02 Taking meals	Eating and drinking	Nurse	Training on eating and drinking	d550.00
e1101.0 Medicinal substances	Symptomatic, pathogenetic therapy	neurologist	Symptomatic, pathogenetic therapy	e1101.+4
e310.0 Family and near relatives	Discussions with the relatives and the patient	Nurse, psychologist	Discussions with the relatives and the patient	e 310.+4
e340.0 Personnel, providing care and aid	Assisting with the care for the patient	Nurse	Assisting with the care for the patient	e340.+4

Note. [1] The rehabilitation diagnosis according to the categories of the International functional classification; [2] Key words for understanding what exactly the multidisciplinary rehabilitation team is discussing; [3] Specialist of the multidisciplinary rehabilitation team, responsible for the issue; [4] Rehabilitation intervention, allowing for solving the problem in the patient; [5] Repeated assessment.

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Table 2

Assessment using the scales

Scale	Assessment	
	On admission	On discharge
Rehabilitation routing scale (RRS)	5	4
Modified Rankin Scale (mRS)	5	4
Hauser Ambulation Index (HAI)	8	5
Rivermead Mobility Index (RMI)	3	7
Visual Analogue Scale (VAS) for pain in the cervical segment of the vertebral column	3	1
Functional Independence Measure (FIM)	63	88
American Spinal Injury Association (Asia)	D	D
Hospital Anxiety and Depression Scale (HADS): anxiety	5	4
Hospital Anxiety and Depression Scale (HADS): depression	7	6

high motivation of the patient in terms of undergoing rehabilitation and achieving the positive treatment result. Taking this into consideration, an individual rehabilitation program of activities was compiled:

- individual sessions of physiotherapy exercises with the physical therapist at the initial lying position with further verticalization of the patient (twice daily);
- verticalization using the "Imitron" active-passive mechanotherapy device;
- mechanotherapy (Thera-vital active-passive rehabilitation device, treadmill with the Rea-terra suspension system);
- physiotherapy (laser therapy — cervical spine, electrostimulation of the urinary bladder muscles);
- manual massage of limbs, electrostatic massage of the left limbs using the на "Hivamat" apparatus;
- medical psychologist sessions;
- medication treatment: neuroprotection (Cerebrolysin at a dosage of 10 ml, intravenous; Neuromidin, 15 mg/1.0 ml, intravenous); hormonal therapy (Dexamethasone at a dosage of 8 mg, intravenous), vascular medicines (2.4% Euphylline + 200 ml 0.9% NaCl, intravenous) and metabolic drugs (Thioctic acid — 600 mg, intravenous); multivitamin therapy.

Follow-up and outcomes

After the conducted treatment course, positive dynamic changes were noted — the gradual increase of the strength in the left upper limb up to 3 points, in the left lower limb — up to 4.0 points. The patient was verticalized using the walking aids, besides, he started moving with support within the hospital ward.

The everyday activities of the patient were restored to the level of self-care with minimal assistance (Fig. 1):

Fig. 1. The degree of compensation of the impaired functions before (*a*) and after (*b*) the first stage of the rehabilitation therapy.

the patient is capable of using the toilet by himself, to perform the daily hygiene and to walk not less than 100 m using the walking aids, also having full control of his urination.

Thus, the intermediate objectives of rehabilitation were achieved, a good level was reported for restoring the motor and pelvic functions.

Prognosis

The prognosis for life and functioning in this patient with a background of conducted therapy is favorable.

DISCUSSION

The surgical treatment of vertebral column diseases is always associated with a risk of developing iatrogenic (early and delayed) intra- and postoperative complications, such as spinal ischemia, vascular myelopathies, spinal ischemic or hemorrhagic stroke and venous congestive (hypertensive) myelopathies [8–13]. The local anterior and posterior compression of arteries and veins by the intervertebral disc herniations; the damage or compression of the vessels in the spinal cord during injuries; the congenital and acquired deformations of the vertebral column; the stenosis of the spinal canal; the presence of vascular malformations, tumors, episodes of arterial hypotension, blood loss, thrombosis, fibrotic-cartilage embolism during surgery and after it — all of these are significant causes of impaired spinal circulation [14–17]. The clinical manifestations and the mechanisms of developing the hypo-perfusion, the vasogenic myelopathy and the spinal stroke cord, to a significant extent, depend on the anatomic features of spinal circulation supply — the level of vessel origination, the diameter, the number of anterior and posterior afferent arteries [1, 18, 19]. The main ones, located along the spinal cord, are the azygos anterior cerebral artery, formed as a result of the confluence between the ascending and the descending branches of the radiculomedullary arteries and supplying the anterior 2/3 of the spinal cord, and the paired posterior spinal artery, supplying its posterior third. The level and the type of blood supply, the individual variants of origination and dimensions of the vessels lumen, the involvement of borderline zones (watershed/border zone infarct), the duration of occlusion, the dimensions of the infarction focus, the length of the transverse-longitudinal injury of the structures, the absence of anastomoses, the venous stasis and the variations of blood pressure are the factors defining the degree of severity, the duration, the reversibility of neurological deficit and the restoration of impaired functions [20–22]. Spontaneous and iatrogenic damage of spinal circulation most frequently develops during the aortic stenosis, coarctation, aneurism, arteriitis, parietal thrombosis, dissection of aorta, embolism in the bifurcation area, massive blood loss, clamping of aorta, as well as upon reconstructive or emergency surgical interventions related to it [23–27], much less frequently — during the dissection, stenosis and thrombosis of the vertebral artery, in cases of discal-osteo-arterial conflict or scheduled surgeries in the cervical and thoracic segment of the vertebral column [28–31].

The diagnosis of the forms of spinal arterial or venous ischemia is usually set clinically, but the neurovisualization of the spinal cord structure for its verification is the obligatory option. The magnetic resonance imaging (MRI) using T1- and T2-weighted images (T1-WI, T2-WI) with using the fat suppression program (Short Tau Inversion Recovery, STIR), with the administration of the paramagnetic contrasting agent and with the evaluation of the DWI signal is also, besides CT and MRI-angiography, the gold standard of examining the patients at the acute phase of developing complication. Additional information, allowing to define the cause and the rehabilitation potential of the segmental injury, can be obtained upon digital subtraction angiography and functional MRI [1, 32–36].

The acute focus of ischemia, the spinal stroke in the sagittal T2-WI and T2-STIR is most commonly represented by the rod-shaped (looking like a “pencil”, “white cord”, or the “pin”) hyperintensive signal within several damaged spinal segments (white cord syndrome) [37–39]. Due to the high susceptibility of the gray matter to ischemia, using the T2-WI at the axial plane, during the first 24 hours, one can also detect the other characteristic pattern — the bilateral hyperintensive signal in the area of the anterior horns (snake-eye appearance or owl’s eyes), in case of venous congestive myeloischemia (venous hypertensive myelopathy, Foix-Alajouanine syndrome) — hyperintensive signal along the posterior surface of the brain, the “flow voids sign” in the sagittal slice, the axial one is showing the “black round dots” (perimedullary dilated veins) [12, 13, 40–45]. The assessment of these markers at all stages of treatment and rehabilitation is important, for it additionally characterizes the local sanogenesis and the reparation mechanisms in the damaged zones. The ischemia focus not related to the injury is rarely visualized within the first hours after developing the neurological symptoms [1, 45].

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The analysis of clinical manifestations and of the obtained images allows for detecting not only the type, but also the circulation segment involved in the development of ischemia. The reasons for circulation "switch-off" in the blood supply zones of the anterior and posterior spinal artery along with its branches and anastomoses (hypo-perfusion) include the significant decrease of blood pressure, the local stenosis, the occlusion of the lumen by the thrombus, the embolism, the vasogenic swelling of the spinal cord, the impaired collateral circulation, the venous outflow during the mass effect, the narrowness of the spinal canal, the prolapse of the intervertebral disc, as well as the compression by hematoma, by bone tissue (during the fracture), by hypertrophic/ossified posterior longitudinal ligament (in case of type I and II ischemia), developing after the restoration of the lumens of the magistral arteries and after the surgical decompression; re-perfusion of ischemic zones [46–49]. The clinical manifestations, the dimensions and the degree of transverse-longitudinal injury for all the types are defined by the anatomical features of the blood supply at this level. The blood supply of the lower-cervical segments of the spinal cord is provided by the azygos anterior cerebral artery, by the paired radiculomedullary and sulcal arteries, as well as by the spinal vasocorona [50, 51].

Depending on the reason, the ischemia zone can be limited to the anterior horns of the spinal cord (the poliomyeloischemia syndrome), to the half of the cross-section (incomplete ischemic Brown-Séquard syndrome); it may involve the anterior segments (ischemia syndrome of the ventral and central zones), the lateral or the posterior funiculi ("lateral" or "posterior" damage syndromes, Posterior Funiculus syndrome (Williamson's)), the whole cross-section (the syndrome of complete transverse damage in cases of totally impaired circulation) [1, 35, 45, 52–56]. Besides, there are also descriptions of other verified phenotypes, reflecting the damage of the spinal structures in the cross-section involving the same segments: isolated post-surgical upper monoparesis, paraparesis [57–60]; the man-in-the-barrel syndrome [61, 62]; the sulcal artery syndrome [63–65]; the symmetrical lower paraparesis [66]; the ipsilateral hemiparesis [67, 68]; the symmetrical and asymmetrical tetraparesis [69, 70], as well as the extremely rare combined variants, and, like in our case, with the ischemia/infarction of the vertebral body [45, 71, 72].

Currently, there are no commonly acknowledged recommendations on the treatment of vascular myeloischemia. The absence of clear recommendations on managing the patients at the acute and subacute periods of the arterial infarction or venous thrombosis significantly complicates and oftentimes negatively affects the process of treatment and restoring the impaired functions in cases of iatrogenic complications. The rehabilitation potential in cases of spinal stroke depends on the correct assessment of the initial neurological deficit: more significant neurological deficit determines the less favorable outcome [6, 25, 26]. Using the individual approach when prescribing the medicinal products, when selecting the methods and the means of medical-social rehabilitation, allows for sufficiently restoring the damage of the spinal cord within a short period of time and adapting the patient to various aspects of life-sustaining activity [73–80].

CONCLUSION

Spinal ischemia, myelopathy and spinal stroke are serious complications, caused by vascular, compression-related or other reasons, less frequently — by surgical interventions. The damage pattern depends not only on the hemodynamical characteristics and the capabilities of the collateral circulation in the spinal cord, but also on the location, on the extent and the length of the ischemic focus. The commonly used protocols and clear recommendations on the treatment of vascular myelopathies are lacking; the degree of evidence of the applied programs of rehabilitation therapy corresponds to classes II–IV. The important direction in the rehabilitation of patients with acutely developing neurological deficit is the obligatory participation of the dedicated specialists within the cross-disciplinary teams at all the stages of rehabilitation.

ADDITIONAL INFORMATION

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Authors' contribution. *S.I. Tolstaya* — literature analysis, writing the text; *V.V. Belopasov* — the idea and concept of the review, literature analysis, text proofreading; *E.V. Chechukhin* — literature analysis, writing the text. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work.

Consent for publication. A written voluntary informed consent was obtained from the patient to publish

a description of the clinical case in the journal "Journal of Clinical Practice", including the use of his medical data (results of examination, treatment and observation) for scientific purposes (date of signing 11.03.2022).

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