

## Medication therapy in patients after total hip replacement

D.A. Markov, K.P. Zvereva, N.N. Pavlenko, V.N. Belonogov

Scientific Research Institute of Traumatology, Orthopaedics and Neurosurgery of Federal State Budgetary Educational Institution of Higher Professional Education *Saratov Razumovsky State Medical University* of the RF Ministry of Health, Saratov, Russia

**Introduction** Total hip replacement is a gold standard for dysplastic coxarthrosis treatment. Deformations in the bony structures that form the hip joint and develop directly due to the pathology and after surgical interventions, as well as shortened or lengthened soft tissues, scars, the necessity of bringing the femoral head down result in a significant number of postoperative complications. This study aimed to develop an algorithm of medication therapy for such patients in the postoperative period, based on pathogenic mechanisms that would enable to reduce complications. **Objective** To study long-term results of treatment in patients with coxarthrosis in stages 3–4 and dysplastic hip type 1, 2, 3 (Crowe) according to clinical, EMG and X-ray studies, as well as dual energy X-ray absorptiometry (DEXA) and modified Harris scale scores after total hip replacement and administration of medication therapy. **Materials and methods** The study was performed in 258 patients with dysplastic coxarthrosis in stage 3–4 and DHD types 1, 2, 3 (Crowe) after total hip replacement surgery who were divided into two groups according to the medication therapy administered. Patients of the main group received vitamins, anticholinesterase drugs, NSAIDs, antibiotics, anticoagulants, inhibitors of osteoclasts, and calcium supplements. The comparison group patients were administered NSAIDs, antibiotics, anticoagulants, and calcium supplements. The study was conducted 2 years after their operative treatment with clinical and radiological, EMG and densitometric methods. **Results** It was found that the use of anticholinesterase drugs and vitamins improves axonal conduction and neuromuscular transmission of the sciatic nerve in patients with dysplastic coxarthrosis. Inhibitors of osteoclasts, calcium and vitamin D3 improve the indices of bone mineral density. **Conclusions** Administration of the drug complex developed improves functional results in patients with dysplastic coxarthrosis after total hip replacement.

**Keywords:** dysplastic coxarthrosis, drug therapy, arthroplasty

### INTRODUCTION

Total hip replacement (THR) is a gold standard for dysplastic coxarthrosis treatment [1]. Deformations in bony structures that form the hip joint and develop directly due to the pathology and after surgical procedures, as well as shortened or lengthened soft tissues, scars, the necessity of bringing the femoral head down may result in a significant number of postoperative complications [2]. Prevention of complications is possible by administration of medication therapy in the pre- and postoperative period. The action of drugs is aimed at eliminating postoperative inflammation, combating pain syndrome, preventing infectious complications, thrombosis of the lower limbs veins and pulmonary embolism, early aseptic instability of implant components, as well as at improving the peripheral nervous system and reducing the number of sciatic nerve neuropathies, especially of its peroneal portion.

The first four indications for medication therapy application are standard after any surgical intervention, the latter are characteristic for THR. A significant elongation of the limb in THR increases the risk of traction injury to the sciatic nerve, especially to its peroneal portion. The incidence rate of peroneal nerve neuropathies

after THR, according to a number of authors, is 0.3–0.9 % [3]. This leads to an increase in the patient's rehabilitation period and worsening of the functional result in the postoperative period. Another complication is early aseptic instability of the components of the hip implant, which, according to various authors, is up to 40 % from the total of complications [4]. The disorders of bone tissue remodeling with a predominance of osteoclastic activity and development of aseptic periprosthetic inflammation as a result of "stress response" to implantation have been acknowledged as its causes [5]. This study is aimed at developing an algorithm of drug therapy for THR patients in the postoperative period, based on pathogenic mechanisms which might reduce the incidence of arising complications.

Our **objective** was to study the long-term treatment results after total hip arthroplasty in patients with coxarthrosis of grades 3–4 associated with dysplastic hip (Crowe types 1, 2, 3) basing on clinical laboratory, electroneuromyographic and radiographic methods, as well as dual-energy X-ray absorptiometry (DEXA) and modified Harris scale (HS) after application of the medication therapy complex developed.

## MATERIAL AND METHODS

During the period from 2013 to 2014, 258 patients with dysplastic coxarthrosis of grades 3-4 were under observation. Women prevailed. The ratio of females to males was 199 (77 %) to 59 (23 %), respectively. The average age of the patients was  $46 \pm 3.1$  years. The mean limb shortening was  $4 \pm 1.3$  cm. Patients were selected on the basis of preoperative X-ray examination. Inclusion criteria were: 1) coxarthrosis grades 3 and 4 according to the X-ray study; 2) Crowe DHD types 1, 2, 3 according to X-ray study; 3) maximum limb shortening of 8 cm. Patients with coxarthrosis grade 3 made 93 % (240 patients), and 7 % (18 patients) had grade 4. The distribution of patients according to the degree of dysplastic coxarthrosis according to Crowe: 76 % (196 patients) of type 1, 18 % (46 patients) with type 2, and 6 % (16 patients) had type 3. All patients were divided into 2 groups. The main group included 125 patients (117 patients with stage 3 and 8 patients with stage 4 of coxarthrosis; Crowe DHD distribution was 93 patients with type 1, 24 with type 2, and eight with type 3. The comparison group included 133 patients (123 had coxarthrosis stage 3, ten had stage 4; distribution by Crowe classification were 103 patients with type 1, 22 with type 2, and eight with type 3).

THR was performed according to a standard procedure. Approach to the hip joint was carried out depending on the morphological features of the patient. Moore's posterolateral approach was mainly used. The Mueller version of the anterolateral approach was less frequent. The ratio of approaches was 175 (68 %) to 83 (32 %), respectively. Surgery was performed in 95 % (245 patients) of cases under spinal anesthesia. Total intravenous anesthesia with muscle relaxants under the conditions of mechanical ventilation with air-oxygen mixture was used in 5 % (13 patients). In 91 % (235 joints), implant fixation was cementless, and only 23 joints (9 %) were cemented.

In the preoperative period, the patients of the *main group* were assigned a complex of group B vitamins (*Compligamm B*) in a dose of 2 ml intramuscularly once a day for 10 days in order to improve the conductivity of the nerve impulses and neuromuscular transmission, including in terms of prevention of sciatic nerve neuropathy, and especially of its peroneal portion. In the postoperative period, *Neuromultivit*, participating in the metabolic processes of the nervous tissue and synthesis of the myelin sheath, was prescribed as one tablet once a day for 1 month for improving the nerve trunks trophics. To improve the axonal conductivity and neuromuscular transmission, *Neuromidine* was administered as 20 mg once a day for one month. The medication therapy with drugs was prescribed to repeat three times a year. To prevent infectious complications, a "prolonged" antibiotic prophylaxis was prescribed (intravenous infusions, mainly cephalosporins of 2<sup>nd</sup> or 3<sup>rd</sup>

generation, continued in the early postoperative period in the dosage of 1.0 g twice a day for 5 days). In order to prevent thrombosis and thromboembolism of the pulmonary artery, all patients were assigned elastic bandage of limbs and low-molecular heparin (*Clexane*) at a dosage of 40 mg subcutaneously once a day for the whole period of stay in the hospital. Then, oral anticoagulants (*Xarelto*, 20 mg once a day during meals) were prescribed for the entire period of walking with additional support means. With the analgesic and anti-inflammatory purposes as well as for prevention of early aseptic instability of the components, *Nimesil* was administered 100 mg twice a day for 5-7 days. Patients, who according to DEXA and intraoperatively were diagnosed with osteoporosis, were prescribed zoledronic acid in the postoperative period once from week 2 up to 2 months after the operation, injected at a dosage of 5 mg intravenously. The main condition for regulating bone remodeling is a sufficient supply of calcium to the body and vitamin D3 for its assimilation. For this purpose, all patients in the postoperative period were prescribed a preparation of *Ca-D3-Nycomed* in a dosage of 2 tablets once a day. The duration of the course was 2 months with a frequency of 2 times a year.

The *comparison group* received standard medication therapy such as 2<sup>nd</sup> generation cephalosporins of 1.0 g intramuscular injection twice a day for 5 days, NSAIDs (*Ketorol* 30 mg i/m depending on the severity of the pain syndrome, but no more than 4 times a day), anticoagulant therapy (*Clexane* 0.4 mg once a day till discharge, followed by *Xarelto* pills administered at a dose of 20 mg per day), calcium preparations (two tablets of *Ca-D3-Nikomede* once a day for 2 months).

Clinical results before THR and 2 years after it were evaluated using a modified Harris scale. Radiographic follow-ups were performed at 3, 6, 12 and 24 months after surgical treatment. The position of the acetabular and femoral components, the state of the periprosthetic bone tissue and cement mantle, the presence of resorption zones around the implant components were estimated on the X-rays. In pre- and postoperative periods, all patients underwent an ENMG study using a stimulation technique using the "Keypoint" electromyography (Alpine Biomed ApS, Denmark) and its accessories. The evaluation of the peroneal and tibial nerves with the determination of the motor response of the muscle (M-response), latency period of the M-response with stimulation at the proximal and distal points, and velocity of excitation along the motor fibers (VEMF) was conducted. In order to assess bone mineral density, all patients received pre- and postoperative standard dual-energy X-ray absorptiometry on a Prodigy X-ray densitometer (GE LUNAR Corporation, UK) using a cadmium-zinc-telluride detector array in the proximal femur and lumbar spine, and the determination of the T-test.

The findings were processed using the STATISTICA program (version 8.0). Statistical hypotheses were tested using the Student's t-test. The null hypothesis was rejected with  $p < 0.05$  in all cases. The study was carried out after signing the informed consent by the patients and the permission of the ethical committee in accordance with

ethical standards developed by the WMA Helsinki Declaration "Ethical Principles for Medical Research Involving Human Subjects", as amended in 2000, and "The Rules of Clinical Practice in the Russian Federation", approved by the Order of the Ministry of Health of the Russian Federation of June 19, 2003, No. 266.

## RESULTS

The results of total hip arthroplasty in patients with dysplastic coxarthrosis were evaluated 24 months after surgery. In the preoperative period, all patients of the main group and the comparison group had poor HS. The treatment significantly improved the results and the daily life of patients. The mean values of the modified Harris scale after surgery were statistically significantly different from the preoperative score in both the main and the comparison group ( $p < 0.001$ ). Mean values of the modified HS after surgery in the main group were statistically different from those in the comparison group ( $p < 0.05$ ). The data are presented in **Table 1**.

Bone mineral density values were within the normal range in the preoperative period in more than half of patients with dysplastic coxarthrosis. The diagnosis of "osteoporosis" was established only in 8 % of the examined subjects of the main group and in 7 % in the comparison group. Mean T-test values of dual-energy X-ray absorptiometry in the preoperative period was similar in both groups, while in the postoperative period there was a statistically significant dif-

ference in this index between the main group and the comparison group ( $p < 0.05$ ). The data are presented in **Table 2**.

It should be noted that T-test score up from -1 SD were assessed as normal BMD, the indices between -1SD and -2.5 SD were estimated as osteopenia, and values lower than -2.5 SD were judged as osteoporosis.

According to the stimulation ENMG data, the mean amplitude of the M-response (in terms of the height of the negative peak) of the peroneal and tibial nerves was decreased in the preoperative period relative to the age norm in both observation groups without statistically significant differences. The latent period (LP) of the nerves investigated was within the limits of the age norm. A marked decrease in the speed of impulses along the motor fibers of the nerves under investigation was indicative of their axonal-demyelinating damage. After the treatment, there was a change in the indices with an improvement in conduction along the nerve trunks. The data are presented in **Table 3**.

In the postoperative period, the following complications were observed and are shown in **Table 4** and in **Figure 1**.

**Table 1**

Evaluation of the THR results according to the modified Harris scale (95 %, CI)

Group	Mean preoperative score	Mean postoperative score
Main group (n = 125)	42.56 (41.23–43.75) *	89.42 (88.27–90.74) * #
Comparison group (n = 133)	42.78 (41.47–43.92) *	85.33 (84.08–86.49) * #

Note: \* – statistically significant differences between the main group and the comparison group at  $p < 0.001$ ; # – statistically significant differences between the main group and the comparison group at  $p < 0.05$

**Table 2**

BMD in patients in the pre- and postoperative periods

Group	Main group (n = 125)	Comparison group (n = 133)
T < -1 SD before intervention, abs. (%)	77 (62.1 %)	83 (62.6 %)
-1 SD < T < -2.5 SD before intervention, abs. (%)	40 (31.7 %)	42 (31.6 %)
T > -2.5 SD before intervention, abs. (%)	8 (6.2 %)	8 (5.8 %)
T < -1 SD after intervention, abs. (%)	91 (73.1 %) *	88 (65.9 %) *
-1 SD < T < -2.5 SD after intervention, abs. (%)	32 (25.4 %) *	40 (30.0 %) *
T > -2.5 SD after intervention, abs. (%)	2 (1.5 %) *	5 (4.1 %) *
Mean value of T-score before intervention, SD	-1.11 (-1.08–(-1.15)) *	-1.10 (-1.06–(-1.13))
Mean value of T-score after intervention, SD	-0.96 (-0.92–(-1.03)) *	-1.07 (-1.04–(-1.10)) *

Note: \* – statistically significant differences between the main group and the comparison group at  $p < 0.05$

**Table 3**

ENMG values in patients in the pre- and postoperative periods (95 %, CI)

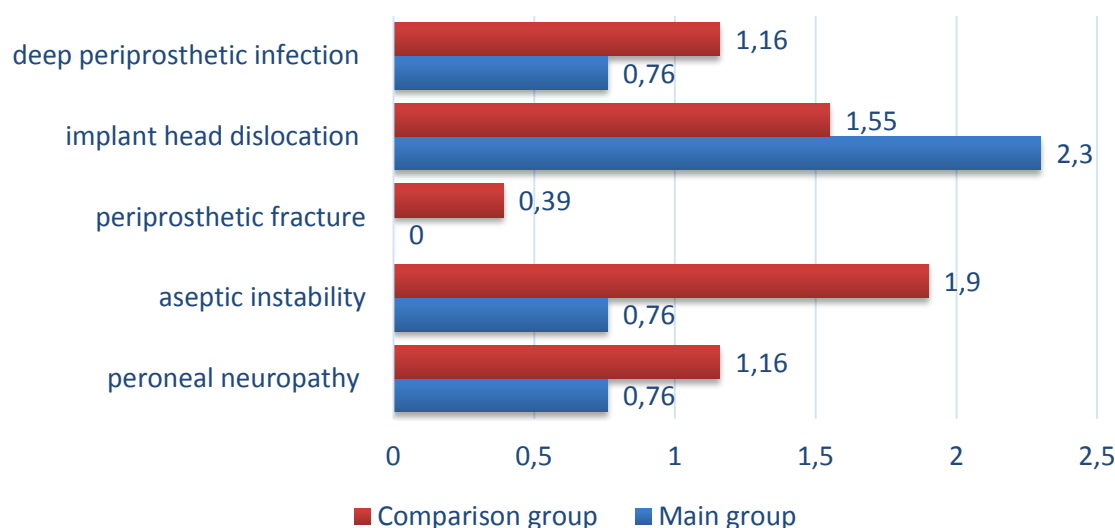
ENMG parameter	Main group		Comparison group	
	Tibial nerve	Peroneal nerve	Tibial nerve	Peroneal nerve
M-response amplitude before surgery	2.7 ± 0.2*	2.4 ± 0.3*	2.8 ± 0.3	2.5 ± 0.2*
M-response amplitude after surgery	3.0 ± 0.2*	2.7 ± 0.2*	3.0 ± 0.2	2.7 ± 0.3*
LP before surgery	4.6 ± 0.2	4.7 ± 0.2	4.6 ± 0.3	4.8 ± 0.2
LP after surgery	4.7 ± 0.2	4.8 ± 0.3	4.7 ± 0.2	4.8 ± 0.2
VEMF before surgery	44.1 ± 0.4*	46.0 ± 0.4*	44.2 ± 0.5	45.9 ± 0.3
VEMF after surgery	47.3 ± 0.3*	48.5 ± 0.3*	45.6 ± 0.3*	46.7 ± 0.4*

Note: \* – statistically significant differences between the indicators before and after treatment  $p < 0.05$

**Table 4**

Overall incidence of postoperative complications

Type of complication	Incidence	
	Number	%
Implant head dislocation	10	3.9
Periprosthetic fracture of the femur	1	0.4
Deep periprosthetic infection	5	1.9
Aseptic instability of implant components	7	2.7
Peroneal nerve neuropathy	5	1.9

**Fig. 1** Incidence of postoperative complications in the main and comparison groups, %

There were no statistically significant differences in the incidence of periprosthetic fractures, neuropathy of the peroneal nerve, periprosthetic infection and dislocation of the femoral component head between the main group and the comparison group in the postoperative period.

High rates of implant dislocation were associated with a violation of the postoperative regimen and falls on the operated limb in the early postoperative period.

A peri-prosthetic fracture of the femur was recorded in one patient during the period of observation. This patient fell on the operated limb at home 8 months after the operation. This patient underwent a revision surgery with the installation of an extended Wagner stem and application of cerclage wires.

Early aseptic instability, developed in 7 patients during the 5-year period after surgery, was revealed on the basis of clinical (pain syndrome, impaired function), laboratory (negative C-reactive protein, no shift of the leukocyte formula to the left), and X-ray data (Zagorodniy N.V., 2011), and was also confirmed with histological examination of soft tissues taken intraoperatively. All patients underwent revision operations with the change of the components. The statistically significant differences between the main group and the comparison group in the postoperative period were most likely associated with improvement of BMD in patients of the main group. The deep periprosthetic infection, detected in 5 patients, also required revisions, placement of a cement spacer and its change for new implant components later.

## DISCUSSION

Positive statistically significant dynamics in BMD and ENMG indices that was observed in the main group during the observation period was accompanied by a decrease in the incidence of early aseptic instability of the implant components and improvement in the results of postoperative treatment. At the same time, there were no statistically significant differences between the groups in the incidence of neuropathy of the peroneal nerve, despite a statically significant increase in the conductivity of the nerves and neuromuscular transmis-

sion. In our opinion, this is due to an insufficient sample and a different mechanism of this complication onset.

According to ENMG findings, in addition to the disturbance of the conductivity of the sciatic nerve branches, myeloradiculopathy was noted in patients with dysplastic coxarthrosis due to complex compensatory-adaptive mechanisms with the involvement of the lumbar spine [6, 7] for prolonged pain syndrome, restriction of weight-bearing and shortened limb length, which is also consistent with the results we obtained.

As reported in the literature, the complex use of group B vitamins enables to achieve neurotrophic, regenerative, antioxidant and neuromodulatory effects and to ensure the regression of clinical manifestations of radiculopathy and neuropathy. Moreover, a double-blinded randomized study showed that the combined use of group B vitamins with non-steroid anti-inflammatory drugs enhances the effect of the latter and plays an important role in pain relief [8, 9]. The effects of these drugs were reflected in a statistically significant improvement in the ENMG indices and clinical results in the main group of our study after the treatment.

Foreign and Russian literature reports that recent research has revealed the causes of aseptic instability which are of priority importance. One of its etiological factors is bone tissue remodeling deficiency with a predominance of osteoclastic activity and the development of periprosthetic osteolysis. The proven effect of zoledronic acid preparations belonging to the group of osteoclast inhibitors was revealed and presented for the prevention of aseptic instability [4, 5]. The level of evidence in the studies was acknowledged as A. The use of the drug resulted in BMD improvement around the prosthesis and in a decrease of component migration that clinically was reflected in an increase in the mean HS which is comparable to the results obtained in this study. The second etiological factor that plays a priority role is aseptic inflammation in the periprosthetic tissues that arises in the early postoperative period as a "stress response" of the body to the metal implant with "press-fit" fixation and thermal necrosis of the osteocytes during the polymerization of bone cement. The most significant role in the development of inflammation is given

to TNF-alpha, interleukin-1, interleukin-6 [5]. Inhibition of TNF-alpha and interleukin-6 production was noted by *Nimesulide* administration [5].

Our study revealed a statistically significant decrease in the development of aseptic instability of the implant components in the main group. Summarizing the data of the literature, it can be assumed that the combination of the preparations prescribed that improve bone tissue condition along with the preparation that influences the production of pro-inflammatory cytokines in combination with group B vitamins that enhance the effect of NSAIDs, provided the result obtained. All of the above can be a promising combination for prevention of aseptic instability and requires further studies.

According to the literature, dislocations of the implant head are one of the most common THR complications in the early postoperative period. They take the third place after aseptic instability and periprosthetic infection. Their main reasons are incorrect implantation of the components and the violation of the restrictive regimen in the early postoperative period [10]. This fact has been also confirmed by our data. There was no statistically significant difference in the incidence of dislocations between the main group and the comparison group. In this regard, we have to admit that there is no medication prophylaxis for this complication, and the main measures to reduce the incidence are accurate planning of the operation, experience of the surgical team, and a good contact between the surgeon and the patient that foresees preventive talks about the compliance with the restrictive regime in the early postoperative period.

## CONCLUSIONS

1. Administration of anticholinesterase drugs and group B vitamin complexes makes it possible to effectively fight the axonal-demyelinating processes characteristic for this pathology.

2. Normal BMD and drugs inhibiting the production of TNF-alpha, IL-1, and IL-6 can reduce the incidence of early aseptic instability of implant components.

3. The algorithm of medication therapy proposed

might improve the functional results of total hip arthroplasty in patients with dysplastic coxarthrosis.

4. The complex of medication therapy does not cause dislocation of the femoral component. In our opinion, correct orientation of the implant components and patient compliance with the cautious regime in the postoperative period are basic requirements to prevent this complication.

Conflict of interest: not declared.

## REFERENCES

1. De Fatima de Pina M., Ribeiro A.I., Santos C. Epidemiology and Variability of Orthopaedic Procedures Worldwide. In: Bentley G., ed. European Instructional Lectures. Berlin, Heidelberg, Springer, 2011, vol. 11. DOI: 10.1007/978-3-642-18321-8\_2.
2. Denisov A.O., comp. Displasticheskii koksartroz na fone vrozhdenного vyvikha bedra i drugie displasticheskie koksartrozy (M16.2, M16.3; M16.6; M16.7): klin. rekomendatsii [Dysplastic coxarthrosis through congenital hip dislocation and other dysplastic coxarthroses (M16.2, M16.3; M16.6; M16.7): clinical recommendations]. FGBU «RNIITO im. R.R. Vredena. SPb., 2013, 26 p. (In Russ.)
3. Meshcheriagina I.A., Mukhtiaev S.V., Rossik O.S., Grigorovich K.A., Khomchenkov M.V., Mitina Iu.L. Neiropatiia sedalishchnogo nerva u patsientki posle endoprotezirovaniia po povodu vrozhdenного vyvikha golovki bedra (klinicheskii sluchai iz praktiki) [Sciatic nerve neuropathy in a female patient after arthroplasty for congenital femoral head dislocation (A case report)]. *Genij Ortopedii*, 2014, no. 3, pp. 82-88. (In Russ.)

4. Rodionov S.S., Torgashin A.N., comp. Profilaktika rannei asepticheskoi nestabil'nosti endoprotezov krupnykh sustavov (M 16; M 17; M 80; M 81; M 85.9): klin. protokol [Prevention of early aseptic instability of large-joint implants (M 16; M 17; M 80; M 81; M 85.9): clinical protocol]. FGBU «RNIITO im. R.R. Vredena. SPb., 2013, 19 p. (In Russ.)
5. Sagalovski S., Shenert M. Kletочно-молекулярные механизмы развития асептической нестабильности эндопротеза тазобедренного сустава [The cellular-molecular mechanisms of developing aseptic instability of the hip implant]. *Травма*, 2012, vol. 13, no. 1, pp. 153-160. (In Russ.)
6. Reshetnikov A.N., Zaitsev V.A., Korshunova G.A., Anisimova E.A., Gladilin G.P., Reshetnikov N.P., Chekhonatskii A.A., Adamovich G.A., Romakina N.A. Analiz sostoianiia neiromyshechnoi i lokomotornoii funktsii nizhnikh konechnostei u patsientov s displasticheskim koksartrozom do i posle total'noi artroplastiki [Analysis of the condition of the lower limb neuromuscular and locomotor function in patients with dysplastic coxarthrosis before and after total arthroplasty]. *Sovremennye Problemy Nauki i Obrazovaniia*, 2016, no. 3. (In Russ.) Available at: <https://science-education.ru/ru/article/view?id=24477>
7. Iusupov K.S., Anisimova E.A., Anisimov D.I. Pokazатели mineral'noi plotnosti kostnoi tkani i elektroneiromiograficheskoi aktivnosti u patsientov s displasticheskim koksartrozom razlichnoi stepeni vyrazhennosti [The values of bone tissue mineral density and electrical neuromyographic activity in patients with dysplastic coxarthrosis of different severity]. *Biul. Med. Konf.*, 2014, vol. 4, no. 6, pp. 928-932. (In Russ.)
8. Kosarev V.V., Babanov S.A. Khronicheskaiia poiasnichno-kresttsovaia radikulopatiia: sovremennoe ponimanie i osobennosti farmakoterapii [Chronic lumbosacral radiculopathy: current understanding and pharmacotherapy characteristics]. *Rus. Med. Zhurn. Ser.: Nevrologiia. Psikhatriia*, 2013, vol. 21, no. 16, pp. 844-851. (In Russ.)
9. Shavlovskaiia O.A. Vitaminy gruppy B v nevrologicheskoi praktike [B-group vitamins in neurological practice]. *Rus. Med. Zhurn. Ser.: Nevrologiia. Psikhatriia*, 2013, vol. 21, no. 30, pp. 1582-1585. (In Russ.)
10. Kanziuba A.I. Vyvikh bedra posle total'nogo endoprotezirovaniia tazobedrennogo sustava [Hip dislocations after the hip total arthroplasty]. *Травма*, 2016, no. 1, pp. 106-110. (In Russ.)
11. Scott D.F., Woltz J.N., Smith R.R. Effect of zoledronic acid on reducing femoral bone mineral density loss following total hip arthroplasty: preliminary results of a prospective randomized trial. *J. Arthroplasty*, 2013, vol. 28, no. 4, pp. 671-675. DOI: 10.1016/j.arth.2012.08.007.

Received: 02.05.2017

#### Information about the authors:

1. Dmitrii A. Markov, M.D., Ph.D., Scientific Research Institute of Traumatology, Orthopaedics and Neurosurgery of Federal State Budgetary Educational Institution of Higher Professional Education *Saratov Razumovsky State Medical University* of the RF Ministry of Health, Saratov, Russia, Department of Traumatology and Orthopaedics, assistant professor
2. Kseniia P. Zvereva, M.D., Scientific Research Institute of Traumatology, Orthopaedics and Neurosurgery of FSBEI HPE *Saratov Razumovsky State Medical University* of the RF Ministry of Health, Saratov, Russia, Department of Traumatology and Orthopaedics, assistant; e-mail: [ksenya.zvereva.91@mail.ru](mailto:ksenya.zvereva.91@mail.ru)
3. Nikolai N. Pavlenko, M.D., Ph.D., Scientific Research Institute of Traumatology, Orthopaedics and Neurosurgery of FSBEI HPE *Saratov Razumovsky State Medical University* of the RF Ministry of Health, Saratov, Russia, Department of Traumatology and Orthopaedics Innovation Technologies, leading researcher
4. Valerii N. Belonogov, M.D., Ph.D., Scientific Research Institute of Traumatology, Orthopaedics and Neurosurgery of FSBEI HPE *Saratov Razumovsky State Medical University* of the RF Ministry of Health, Saratov, Russia, Department of Traumatology and Orthopaedics, assistant