



# SCIENTIFIC RESEARCH OF THE SCO COUNTRIES: SYNERGY AND INTEGRATION

上合组织国家的科学研究：协同和一体化

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这些会议文结合了会议的材料 – 研究论文和科学工作者的论文报告。它考察了职业化人格的技术和社会学问题。一些文章涉及人格职业化研究问题的理论和方法论方法和原则。

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# CONTENTS

## MEDICAL SCIENCES

- 应激交感神经应对学龄前儿童重度颅脑外伤心肌需氧量的影响  
Influence of stress sympathotonic response on myocardial oxygen demand in severe concomitant traumatic brain injury in preschool children  
*Muhitdinova Hura Nuritdinovna, Shamurodov Akmal Yangibayevich*.....8
- 根据俄罗斯新西伯利亚第一区域血管中心数据显示 SARS-COV-2 感染背景下的心肌梗死病程特征  
Features of the course of myocardial infarction against the background of SARS-COV-2 infection according to the data of the Regional Vascular Center No. 1 Novosibirsk, Russia  
*Lozhkina Natalya Gennadievna, Gushchina Olesya Igorevna*.....17
- 心肌梗死后的急性和亚急性心力衰竭  
Acute and subacute heart failure after myocardial infarction  
*Lozhkina Natalya Gennadevna, Mukaramov Isatillo*.....22
- 寻找一种预测冠心病患者快速进展的动脉粥样硬化的方法  
Finding a method for predicting rapidly progressing atherosclerosis in patients with coronary heart disease  
*Lozhkina Natalya Gennadevna, Parkhomenko Olga Mikhailovna*.....26
- 使用根标签时的主要错误（2013–2022年法庭案例分析）  
The main errors when using root tabs (analysis of court cases 2013-2022)  
*Andreeva Svetlana Nikolaevna, Ertuvkhanov Marat Zainulabidovich, Andreev Mikhail Mikhailovich*.....33
- 现代俄罗斯人口形势不利的原因及解决方法  
The causes of the unfavorable demographic situation in modern Russia and ways to solve them  
*Karimova Daniia Yusufovna, Zargarova Ayten Eldarovna*.....38
- 根据上诉数据分析莫斯科和莫斯科地区人口的牙齿发病率  
Analysis of dental morbidity of the population of Moscow and the Moscow region according to the data of appeal  
*Demuriya Lubov Edwardovna, Lubimova Ekaterina Edwardovna, Zacharenkova Nataliya Michailovna, Magomedov Magomed Magomedovich*...46
- 使用辅助生殖技术评估妊娠期妊娠并发症发展的预测实验室小组  
Predictive laboratory panel for assessing the development of gestational complications during pregnancy with the use of assisted reproductive technologies  
*Shabalina Alla Anatolievna, Soboleva Viktoria Vladimirovna, Roitman Evgeny Vitalievich, Antonova Ksenia Valentinovna* .....59

库尔斯克地区法医精神科医生的情绪倦怠  
Emotional burnout in forensic psychiatrists in the Kursk region  
*Levchenko Elena Vadimovna, Kolchin Andrey Viktorovich*.....68

透明质酸联合富血小板血浆治疗膝关节骨性关节炎的积极作用  
Positive effect in the knee joint osteoarthritis treatment with hyaluronic acid in combination with platelet-rich plasma  
*Belov Alexander Nikolaevich, Belova Olga Anatoliyevna, Belova Elizaveta Alexandrovna, Kozlov Nikita Iurievich*.....72

牙医对治疗诊断为“根尖周组织疾病”患者的临床建议的认识问卷调查结果  
The results of the questionnaire of awareness of dentists about Clinical recommendations in the treatment of patients diagnosed with "Diseases of periapical tissues"  
*Shukhorova Yulia Andreevna, Chigarina Svetlana Egorovna, Postnikov Mikhail Aleksandrovich*.....77

真皮移植后第23天缺血性皮肤创面活检肉芽组织细胞的超微结构特征  
Ultrastructural characteristics of granulation tissue cells of biopsies of ischemic skin wound on the 23rd day after dermal transplantation equivalent  
*Shapovalova Elena Yuryevna, Baranovsky Yuri Gennadievich, Barsukov Nikolai Petrovich*.....81

## PHARMACEUTICAL SCIENCES

药工劳动激励基础制度，形成药学组织竞争优势的增强  
The system of motivational bases of pharmaceutical workers' labor, forming an increase in the competitive advantages of pharmacy organizations  
*Petrov Andrey Georgievich, Khoroshilova Olga Vladimirovna, Sashko Yulia Alexandrovna*.....91

人群职业病医疗和药学护理的现代问题  
Modern problems of medical and pharmaceutical care in occupational diseases of the population  
*Petrov Andrey Georgievich, Khoroshilova Olga Vladimirovna, Semenikhin Viktor Andreevich*.....98

## BIOLOGICAL SCIENCES

从波罗的海筛选微藻以进一步用于工业  
Screening of microalgae from the Baltic Sea for further use in industry  
*Dolganyuk Vyacheslav Fedorovich, Ulrikh Elena Viktorovna, Kashirskikh Egor Vladimirovich*.....105

以西伯利亚云杉为例研究针叶类木本植物水碱性提取物的促生长活性  
Study of the growth-stimulating activity of water-alkaline extracts of coniferous woody greenery using the example of Siberian spruce  
*Soboleva Svetlana Vitalievna, Voronin Valery Mikhailovich*.....113

## TECHNICAL SCIENCES

信息安全事件检测支持系统

Information security incidents detection support system

*Tokarev Vjacheslav Leonidovich*.....120

引入“工业4.0”理念，构建工业企业业务流程智能控制系统金字塔

Building a Pyramid of Intelligent Control System of Business Processes of Industrial Enterprises by Introducing the Concept of “Industry 4.0”

*Yusupbekov Nadirbek Rustambekovich, Avazov Yusuf Shodiyevich*.....128

为智能测量仪器创建软件算法的识别方法

Identification approach for creating software algorithms for intelligent measuring instruments

*Yusupbekov Nodirbek Rustambekovich, Ruziev Umidjon Abdimajitovich*.....135

高速磁悬浮运输系统中车载系统的电磁兼容性

The electromagnetic compatibility of onboard systems in a high-speed magnetic levitated transport systems

*Dedova Olga Andreevna, Nikitin Victor Valerievich*.....141

水力压裂技术改造应用

Appliance of hydraulic fracturing by adapted technologies

*Mustafin Islam Rasulievich*.....147

考虑液体润滑剂可压缩性的推力轴承计算模型

Calculation model of a thrust bearing considering the compressibility of a liquid lubricant

*Kumanin Stanislav Vitalievich*.....155

无人船与远程控制中心虚拟标记传输信息交换系统架构及协议开发

Architecture and protocol development of the information exchange system between an unmanned vessel and a remote control center for the transmission of virtual marking

*Tsybulya Alena Denisovna*.....161

应激交感神经反应对学龄前儿童重度颅脑外伤心肌需氧量的影响  
**INFLUENCE OF STRESS SYMPATHOTONIC RESPONSE ON  
MYOCARDIAL OXYGEN DEMAND IN SEVERE CONCOMITANT  
TRAUMATIC BRAIN INJURY IN PRESCHOOL CHILDREN**

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抽象的。在 SCTBI 后的第一天,第 1 组的交感神经活动增加了 40%,TNMO 增加了 13%,第 2 组 - OBT 增加了 60%,TNMO 增加了 23%,第 3 组的交感神经活动增加了 50% TNMO 减 27%。交感神经活动的平均水平在最重的儿童中最高,在第 2 组中略低,在第 1 组的儿童中相对于正常水平适度增加,在第 3 组中 OBT 的约一周生物节律变形最明显。损伤严重时,脑损伤程度越大,交感肾上腺系统的应激反应越增强,同时伴随着白天和夜间心肌需氧量的相应增加。在第 1 组和第 3 组中,交感神经的动态与心肌需氧量的变化、所有三组中的 CO 和所有受试者的 SV 之间存在强烈的直接相关性,并且在所有患者中 OBT 和 GPVR 之间存在强烈的负相关。

关键词: 昼夜节律, 自主神经张力, 心肌需氧量, 严重合并颅脑损伤, 儿童。

**Abstract.** *On the first day after SCTBI, there was an increase in sympathotonic activity in group 1 by 40%, TNMO by 13%, in group 2 - OBT by 60% TNMO by 23%, in group 3 there was an increase in sympathotonic activity by 50% TNMO by 27%. The average level of sympathotonic activity was the highest in the heaviest children, somewhat less in group 2 and moderately increased relative to the norm in children of group 1 with the most pronounced deformation of the circa-week biorhythm of OBT in group 3. The more severe the injury, the greater the degree of brain damage, the more increased the stress response of the sympathoadrenal system, which was accompanied by a corresponding increase in the increase in myocardial oxygen demand both during the day and at night. A strong direct correlation was found between the dynamics of sympathicotonia and changes in*

*myocardial oxygen demand in groups 1 and 3, with CO in all three groups, and with SV in all subjects, and a strong inverse correlation between OBT and GPVR in all patients.*

**Keywords:** *Circadian rhythm, autonomic tone, myocardial oxygen demand, severe concomitant traumatic brain injury, children.*

**Relevance.** According to the WHO, the incidence of traumatic brain injury does not tend to decrease. At the same time, skull and brain injuries account for 40-60% of all peacetime injuries, and in children - 23.5-42.3%. At the same time, in 8-15%, and in road accidents - in 60% of cases, the victims have severe injuries of the skull and brain with a mortality rate of up to 40-60%, and in patients with impaired vital body functions - up to 75-85%. Brain damage is accompanied by cerebral circulatory hypoxia of the cells of the central nervous system, against which the pathophysiological effect of the injury is realized. As a result, favorable conditions are created for the occurrence of hydrodynamic, metabolic disorders, the result of which is reactive edema and swelling of the brain. All this is reflected in the regulatory role of the central nervous system, the central mechanisms of regulation of the vital functions of the body are disrupted, which poses a threat to life. This is more pronounced in children with concomitant severe traumatic brain injury, which occurs in 8.6-30.3% of cases and is accompanied by acute blood loss and shock, causing the development of pathology by the type of mutual aggravation and interdependence [1-7].

**Purpose of the work.** To study the effect of stress sympathotonic response on myocardial oxygen demand in severe concomitant traumatic brain injury in preschool children.

**Material and research methods.** The results of monitoring clinical and functional parameters, hemodynamics, heart rate, the need of myocardium in oxygen (TNMO), estimation of vegetative tone (EVT) in 34 children aged 3.1-7 years with SCTBI were studied. Of these, 12 children were assigned to a less severe group with a duration of intensive care in the ICU up to 10 days, patients with a duration of therapy of 11-20 days were included in group 2, and 10 patients with a duration of intensive care for more than 21 days were included in group 3. Male patients predominated in each group, amounting to 9 in group 1, 2-8 in group 3, and 8 boys in group 3 (table 1) aged 5.4-5.1 years on average. The cause of the injury was RTA in 9,7,10 children in groups, respectively, and a fall from a height in group 1 - 3 children, in 2-5 children. All patients admitted to RSCEMA were operated on in the first hours after the injury, in extremely severe cases, with simultaneous, urgent resuscitation and correction of serious disorders of vital organs and systems (tab. 1).

**Table 1**

*Characteristics of SCTBI patients admitted at the age of 3.1-7 years*

Groups	Num. of patients	Gender m/f	Age, years	RTA	Catat-rauma	traum. shock 2,3 deg.	Oper. on admission	Num. of days in ICU	Num. of days in hosp.
1	12	9/3	5,4±1	9	3	12	12	5,4±1,4	16,2±5,2
2	12	8/4	5,25±1,2	7	5	12	12	15±2,8	24±5,9
3	10	8/2	5,1±0,9	10	0	10	10	39,9±15,8	46±18,6

**Table 2**

*Duration of respiratory support*

Groups	CMV	IPPV	SIMV	CPAP	spont. breath
1(12 pat.)	2,2±1,4 (5)	-	3±1 days (2)	1 (1)	3,5±1,4 (12)
2 (12 pat.)	6±3 (6)	2 (1)	7,6±2,8 (9)	3,2±1,5 hours (8)	5,4±2,7 (12)
3 (10 pat.)	10,5±8,5 (6)	10,3±4,4(2)	14,7±8,6 (9)	6,6±2,8 (7)	15,8±8,9 (10)

As shown in tab. 2, almost all patients admitted to the clinic needed prosthetic external respiration after a severe injury. Differences in the duration of ALV/AALV according to the severity of the condition were not identified. The determining factors in the severity of the condition of injured children in group 3 were severe CTBI (50%), severe OSTBI (50%), skull fracture with transition to the base (50%), SBC (100%), traumatic shock grades 2-3 (100%).

**Results and its discussion.**

**Table 3.**

*Dynamics of EVT and TNMO mesors by SCTBI severity*

Days	EVT, units			TNMO,%		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
1	1,4±0,1	1,6±0,1	1,5±0,1	113±9	123±9	127±5
2	1,6±0,1	1,7±0,1	1,8±0,1*	134±3*	124±4	143±5* <sup>0</sup>
3	1,5±0,0	1,7±0,1	1,7±0,1	129±3*	125±6	133±7
4	1,3±0,1	1,5±0,1	1,6±0,1	122±4	121±5	130±4
5	1,3±0,02	1,5±0,1	1,6±0,1	113±2	118±6	133±4 <sup>00</sup> □
6	1,4±0,1	1,5±0,1	1,5±0,1	124±4	118±3	128±5 □
7	1,4±0,1	1,4±0,1	1,6±0,1	120±4	121±4	130±5 <sup>00</sup>
8	1,1±0,1*	1,4±0,1	1,6±0,1	111±8	124±5 <sup>00</sup>	130±6 <sup>00</sup>
9	1,2±0,1	1,5±0,1	1,7±0,1	114±5	121±4	142±5 <sup>000</sup> □
10		1,5±0,1	1,5±0,1		116±5	134±7 □
11		1,4±0,03	1,6±0,1		116±4	136±7 □
12		1,5±0,1	1,6±0,1		116±3	133±4 □
13		1,3±0,1*	1,5±0,1 □		104±4*	126±3 □
14		1,4±0,1	1,5±0,1		111±5	127±4 □

15		1,4±0,1	1,5±0,1□		107±6	127±6 □
16		1,4±0,1	1,5±0,1□		111±4	131±4 □
17		1,4±0,1	1,5±0,1□		113±5	129±7 □
18		1,4±0,1	1,4±0,1□		110±8	125±5 □
19		1,6±0,1	1,4±0,1□		110±5	123±3 □
20			1,4±0,1□			126±11
21			1,5±0,1□			127±4
22			1,4±0,1□			121±6
23			1,4±0,1□			118±5
24			1,6±0,1			127±6
25			1,5±0,1□			125±3
26			1,3±0,1□			120±7
27			1,4±0,1□			124±4
28			1,3±0,1□			124±5
29			1,4±0,1□			123±4
30			1,3±0,1□			119±5

\*- reliable relative to the indicator in 1 day

□ - the difference is significant relative to the indicator on the 2nd day

''' - significant relative to the indicator in group 1

□ - significant relative to the indicator in group 2

On the first day, an increase in sympathotonic activity was revealed in group 1 by 40%, in group 2 by 60%, in group 3 by 50%. During the acute period, a significantly significant decrease in the hypersympathotonic reaction was observed in group 1 on day 8 by 30%, in group 2, only on day 13, a decrease in the sympathotonic effect of nm 30% was noted ( $P < 0.058$ , respectively). However, in children of the 3rd group on the 2nd day there was an increase in the sympathotonic reaction by 30% ( $p < 0.05$ ) with a gradual trend towards a decrease in the indicator relative to the level on the day of the injury, starting from the 13th day after the injury. Revealed characterizes the effectiveness of stress-protective therapy (tab. 2).

Throughout the observation period, the TNMO indicator in injured children of group 3 remained higher than that in group 2 on days 2, 5, 6, 9-19 by 15%, 12%, 8%, 17%, 15-12% ( $p < 0.05$ , respectively), remaining increased by an average of 20% relative to the norm until the end of the observation (tab. 3).

Thus, the more severe the injury, the more pronounced the sympathotonic reaction and the greater the myocardial oxygen demand, respectively, the greater the risk of developing acute heart failure due to the energy-deficient state of the myocardium against the background of the negative effect on myocardial trophism of increased heart work, systemic inflammatory response, volemic factors, changes in electrolyte balance, more significant brain damage and others.

The average level of sympathotonic activity was the highest in the heaviest children, slightly lower in group 2 and moderately increased relative to the norm in children of group 1 with the most pronounced deformation of the EVT around-week biorhythm in group 3. The amplitude of the EVT circadian rhythm also changed in waves, fitting into periods of fluctuations lasting 7 days in group 1, from 3 to 5 days in group 2, and 4, 5, 5 days in group 3. Diurnal changes in EVT occurred almost synchronously with changes in the amplitude of the EVT circadian rhythm. A dependence on the severity of SCTBI was found, a trend towards an increase in the average values of the mesor, amplitude, and daily range of fluctuations in sympathetic activity in the acute period of SCTBI. The ongoing stress-protective therapy made it possible to reduce the degree of deformation of circadian and near-weekly EVT biorhythms, including limiting the degree of displacement of the peak of the EVT circadian rhythm acrophase by a light period. That is, in the 1st group for 44%, in the 2nd group 52%, in the 3rd group 56% of the duration of intensive care in the ICU, a moderate shift of the acrophase peak was detected within the daytime.

Changes in the amplitude of the circadian rhythm TNMO occurred in waves with maximum values in group 1 on days 5 and 8.9, in group 2 on days 1.5, in group 3 on days 1, 11.20. Fluctuations of the indicator occurred in a circa-weekly rhythm, amounting to 5, 4 daily periods in group 1. In group 2, 5, 5, 7 day waves were noted. Children of the 3rd group showed the greatest degree of deformation of the oscillations of the circa-weekly biorhythm TNMO. The average values for the TNMO circadian rhythm groups revealed the most pronounced myocardial oxygen demand in the daytime, increased to 135% with a slight tendency to decrease to 125% at night. TNMO in group 1 (at the level of 120%) and in group 2 (at the level of 115%) turned out to be relatively steeply elevated both in the daytime and at night. Thus, the more severe the injury, the greater the increase in TNMO regardless of the time of day.

**Table 4. Correlation relations of EVT.**

	<b>Group 1</b>	<b>Group 2</b>	<b>Group 3</b>
EVT/TNMO	0,9	0,7	0,9
EVT/GPVR	-0,9	-0,8	-0,8
EVT/CO	1,0	0,9	0,9
EVT/SV	0,8	0,9	0,8
EVT/MBP	-0,1	-0,1	0,0
EVT/PBP	0,9	0,4	0,4
EVT/SBP	0,3	0,4	0,4
EVT/T	-0,2	0,6	0,6
EVT/DBP	-0,5	-0,4	-0,5

A strong direct correlation was found between the dynamics of sympathicotonia and changes in TNMO parameters in groups 1 and 3 (Table 4), EVT and CO

in all three groups, EVT and SV in all subjects, EVT and PBP in group 1, and a strong inverse correlation of EVT and GPVR in all patients.

**Table 5.**  
*Correlation relations of TNMO.*

Parameters	Group 1	Group 2	Group 3
TNMO/GPVR	-0,74	-0,23	-0,58
TNMO/CO	0,73	0,55	0,68
TNMO/SV	0,46	0,30	0,47
TNMO/MBP	0,23	0,48	0,37
TNMO/PBP	0,63	0,48	0,72
TNMO/SBP	0,51	0,72	0,62
TNMO/T	0,27	0,74	0,72
TNMO/DBP	-0,08	0,30	-0,06

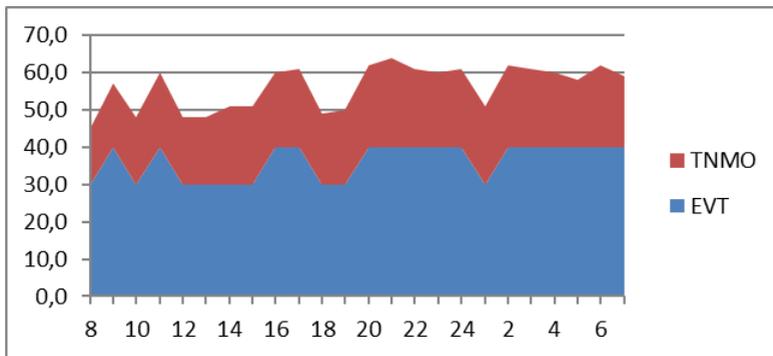
The disappearance of a significant direct correlation between TNMO and CO (0.73) and inverse TNMO and GPVR (-0.74) found in group 1, and inverse TNMO and GPVR (-0.74), which meant an increase in the oxygen demand of the myocardium with an increase in CO and a decrease in GPVR, is noteworthy in the injured groups 2 and 3, that is, with the progression of the hyperdynamic reaction of hemodynamics in children of the 1st group. This dependence significantly weakened in the 2nd group and showed an increase in the trend identified in the 1st group in children of the 3rd group (tab. 5). The noted correlations were detected at a significantly increased level of GPVR up to  $1790 \text{ dyn} \cdot \text{s} \cdot \text{cm}^{-5}$  in group 1 and up to  $1955 \text{ dyn} \cdot \text{s} \cdot \text{cm}^{-5}$  in group 3 (tab. 5). Apparently, the level of MBP  $76.7 \pm 1.4$  mmHg in group 1 should be considered optimal.

The increased value of the mesor of the circadian rhythm MBP  $81.4 \pm 2.0$  mmHg and  $85.7 \pm 1.8$  mmHg may have a predominantly compensatory value for maintaining cerebral blood flow perfusion with more severe TBI in groups 2 and 3.

Thus, intensive therapy with respiratory support of respiration and hemodynamics made it possible to maintain the hyperdynamic direction of compensatory changes in the cardiovascular system in response to secondary disorders, according to the severity of the traumatic disease caused by SCTBI, which is more physiological, increasing the possibility of optimizing the fight against ischemia, edema-swelling of the brain, especially in children of the 3rd group.

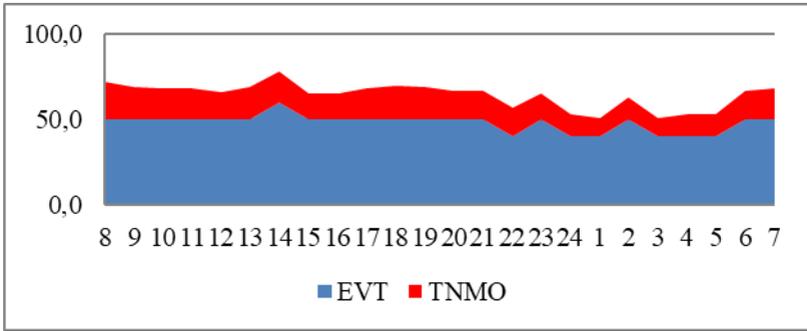
**Table 6.**  
*Effect of SCTBI severity on mean hemodynamic parameters  
in the acute period*

Parameters.	Group 1	Group 2	Group 3
EVT, units	1,35±0,12	1,49±0,09	1,51±0,10
TNMO, %	120,0±6,5	116,2±5,2	128,1±4,6
GPVR,dyne*s*cm <sup>-5</sup>	1790,0±136,1	1937,2±143,4	1955,5±126,7
CO,l/min	3,2±0,3	2,9±0,2	3,1±0,2
SV, ml	27,6±1,8	26,5±1,5	25,7±1,1
MBP, mmHg	76,7±1,4	81,4±2,0	85,7±1,8
PBP, mmHg	41,6±2,2	42,8±2,3	43,4±1,9
SBP, mmHg	103,7±2,2	104,4±2,4	108,2±1,8
T ° C	37,1±0,1	37,1±0,2	37,4±0,2
DBP, mmHg	62,0±1,9	61,6±2,2	64,7±2,0



**Figure 1.** *The increase in the average values of EVT and TNMO  
in the circadian rhythm in group 1.*

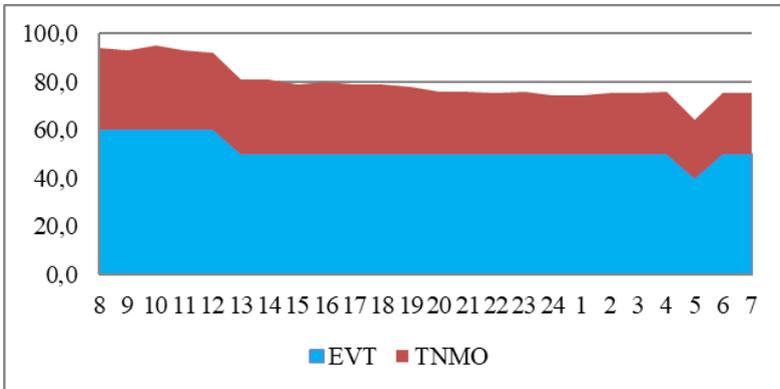
As shown in fig. 1, during the day, TNMO changes occurred in parallel with the dynamics of EVT both in the daytime and at night, amounting to an increase in sympathetic influences up to 40%, at the same hours an increase in TNMO by 60%. The greatest increase in TNMO was noted at 20-22 hours.



**Figure 2.** Increase in EVT and TNMO values in the circadian rhythm in children of the 2nd group in %.

A relatively large degree of increase in the activity of sympathetic influences by 50-60% was accompanied by an increase in TNMO by 55-75% in the daytime and at night in injured children of the 2nd group. The greatest expressiveness of the growth of both indicators was revealed at 14:00 (fig. 2).

Percentage increase in EVT and TNMO in circadian rhythm



**Figure 3.** Increase in EVT and TNMO in circadian rhythm in group 3 in %.

As shown in Fig. 3, the most pronounced increase in sympathetic activity was observed from 8 to 12 noon, amounting to 60% EVT, TNMO - more than 90% with a slight tendency to decrease by 5 am (fig. 3). Thus, the more severe the injury, the more pronounced brain damage, the more increased the stress response of the sympathoadrenal system, which was accompanied by a corresponding increase in myocardial oxygen demand both during the day and at night. On the day

of injury, the TNMO circadian rhythm mesor showed a trend towards an increase in oxygen demand, most pronounced in the most severe CTBI in group 3. The more severe the injury, the greater the myocardial oxygen demand, the greater the risk of developing acute heart failure due to the energy-deficient state of the myocardium against the background of a negative effect on myocardial trophism of increased heart work, systemic inflammatory response, volemic factors, changes in electrolyte balance, more significant brain damage. With SCTBI, the MBP level of  $76.7 \pm 1.4$  mm Hg, detected in group 1, should be considered optimal for the age of 3.1-7 years.

**Conclusion.** On the first day after SCTBI, an increase in sympathotonic activity was detected in group 1 by 40%, TNMO by 13%, in group 2 - EVT by 60% TNMO by 23%, in group 3 there was an increase in sympathotonic activity by 50% TNMO by 27%. The average level of sympathotonic activity was the highest in the heaviest children, somewhat less in group 2 and moderately increased relative to the norm in children of group 1 with the most pronounced deformation of the EVT around-week biorhythm in group 3. The more severe the injury, the greater the degree of brain damage, the more increased the stress response of the sympathoadrenal system, which was accompanied by a corresponding increase in the increase in myocardial oxygen demand both during the day and at night. A strong direct correlation was found between the dynamics of sympathicotonia and changes in myocardial oxygen demand in groups 1 and 3, with CO in all three groups, and with SV in all subjects, and a strong inverse correlation between EVT and GPVR in all patients.

## References

1. <https://cyberleninka.ru/article/n/ustoychivost-miokarda-k-defitsitukisloroda-i-glyukozy-pri-tyazheloy-cherepno-mozgovoy-travme-eksperimentalnoe-issledovanie>
2. <http://www.dslib.net/fiziologia-patologii/morfofunkcionalnye-izmeneniya-serdca-i-ih-korrekcija-jetilmetilgidroksipiridina.html>
3. [https://meduniver.com/Medical/Xirurgia/vedenie\\_pacientov\\_c\\_chmt.html](https://meduniver.com/Medical/Xirurgia/vedenie_pacientov_c_chmt.html)
4. <https://medical-diss.com/medicina/vegetativnaya-regulyatsiya-v-razlichnyeperiody-cherepno-mozgovoy-travmy-u-detey>
5. [https://zakon.today/anesteziologiya-reanimatologiya\\_1078/intensivnaya-terapiya-sochetannoy-cherepno-140268.html](https://zakon.today/anesteziologiya-reanimatologiya_1078/intensivnaya-terapiya-sochetannoy-cherepno-140268.html)
6. <https://medbe.ru/materials/cherepno-mozgovye-narusheniya/cherepno-mozgovaya-travma-u-detey-osobennosti/>
7. [https://online.zakon.kz/Document/?doc\\_id=31321833](https://online.zakon.kz/Document/?doc_id=31321833)

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根据俄罗斯新西伯利亚第一区域血管中心数据显示 SARS-COV-2 感染背景下的心肌梗死病程特征

**FEATURES OF THE COURSE OF MYOCARDIAL INFARCTION  
AGAINST THE BACKGROUND OF SARS-COV-2 INFECTION  
ACCORDING TO THE DATA OF THE REGIONAL VASCULAR  
CENTER NO. 1 NOVOSIBIRSK, RUSSIA**

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抽象的。 COVID-19 大流行已连续第三年成为整个医学界的一个重大问题。既往心血管疾病 (CVD) 患者的死亡风险增加, 需要对这类患者给予更多关注。鉴于高死亡率, 大流行中的后勤问题, 作为感染过程的一部分的急性心肌梗塞 (MI) 的病程是令人感兴趣的。介绍了俄罗斯联邦新西伯利亚市第一临床医院收治的心肌梗死患者的一些中期检查结果, 并伴有新的冠状病毒感染。

关键词: 急性冠状动脉综合征, 心肌梗死; SARS-CoV-2 感染; 加速动脉粥样硬化, 冠状动脉疾病

利益冲突: 作者声明没有利益冲突

**Abstract.** *The COVID-19 pandemic has been a significant problem for the entire medical community for the third year now. The increased risk of mortality in patients with previous cardiovascular diseases (CVD) requires increased attention to this category of patients. Given the high mortality rate, logistics issues in a pandemic, the course of acute myocardial infarction (MI), as part of an infectious process, is of interest. Some interim results of examination of patients with MI*

*admitted to the City Clinical Hospital №1, Novosibirsk, Russian Federation with concomitant new coronavirus infection are presented.*

**Keywords:** *Acute coronary syndrome, myocardial infarction; SARS-CoV-2 infection; accelerated atherosclerosis, coronary artery disease*

*Conflict of interest: The authors declare no conflict of interest*

### **Relevance**

Worldwide, as of July 29, 2022, 572,239,451 confirmed cases of COVID-19 (CoronaVirus Disease 2019) have been registered with WHO, including 6,390,401 deaths [1]. Despite the widespread attention given to the SARS-CoV-2 (severe acute respiratory syndrome-related coronavirus 2) virus that causes this disease, the mechanisms of the link between cardiovascular disease (CVD) and COVID-19 are not fully understood. The impact of the new coronavirus infection COVID-19 on the cardiovascular system is enormous. Cardiovascular disease is significantly associated with higher mortality [2] and an increased risk of complications in patients affected by the SARS-CoV-2 virus [3]. Although acute respiratory manifestations are the most common sign of severe COVID-19, many non-respiratory effects have been reported in the acute phase of the disease, and increasing evidence points to long-term complications (post-COVID syndrome or long-term COVID) [4, 5]. This complex clinical picture suggests that SARS-CoV-2 causes widespread immune-inflammatory and metabolic disorders. Understanding the pathophysiology of COVID-19, including host response to SARS-CoV-2, will be key to developing individualized patient management strategies. The spectrum of cardiovascular disease associated with COVID-19 is extensive and includes myocarditis, acute coronary artery disease, arrhythmias, heart failure, and cardiogenic shock.

Given the high mortality rate, logistics issues in a pandemic, the course of acute myocardial infarction, as part of an infectious process, is of interest. At the moment, an active study of the mechanisms of individual susceptibility is being carried out, which can certainly affect the course and development of certain conditions [6,7]. The current coronavirus infection reminds us of the need to be prepared for a new environment in which the importance of international cooperation only grows.

Some intermediate results of a survey of patients with myocardial infarction admitted to the Novosibirsk City Clinical Hospital No. 1 with concomitant new coronavirus infection are presented.

Purpose of the study: To assess the relationship between the severity of the course, clinical and laboratory parameters, comorbidity in patients with myocardial infarction and SARS-CoV-2 infection.

### **Materials and Methods**

Examination and treatment of 150 patients with myocardial infarction (with and without ST segment elevation), confirmed by a typical clinic, electrocardio-

gram, highly sensitive troponin and concomitant new coronavirus infection, admitted to the clinic of GBUZ NSO GKB No. 1, was carried out. The patients included 86 men and 64 women. In all patients, the diagnosis of COVID-19 was confirmed by polymerase chain reaction (no more than 28 days before or within 14 days after the onset of myocardial infarction). The average age was  $66.3 \pm 10.31$  years. All subjects were evaluated for general laboratory parameters, serum markers of systemic inflammation (C-reactive protein (CRP), ferritin, procalcitonin), markers of myocardial damage (Troponin-I, CK, CK-MB), lipid spectrum (total cholesterol, low density lipoproteins, high-density lipoproteins, triglycerides), hemostasiogram (with the definition of D-dimer), echocardiography, coronary angiography.

The exclusion criteria were the absence of a signed voluntary informed consent. The study did not include patients with malignant neoplasms, severe autoimmune diseases, or pre-existing mental disorders.

### Results

Primary myocardial infarction was noted in 62% of cases. Repeated in 38% of cases. Of these, in 3 patients, myocardial infarction was associated with the development of stent thrombosis. All patients underwent primary percutaneous coronary intervention on admission. In 90% of cases, surgically significant atherosclerosis of the coronary arteries was detected, and drug-eluting stents were implanted. In 3 cases, surgically significant coronary atherosclerosis was not detected, probably the development of type 2 myocardial infarction. In 58.2% of patients, the Charlson comorbidity index exceeded 6 points, which corresponds to a severe degree. This emphasizes the cumulative effect of comorbid pathology both on the course of myocardial infarction and on the course of a new coronavirus infection. The most common comorbidities were Type 2 diabetes mellitus (40%), chronic non-communicable lung diseases among which chronic obstructive pulmonary disease prevailed (21%). Hypertension was noted in all patients included in the study. At the time of admission to the hospital, 98% did not achieve satisfactory control of blood pressure. This was due to both the lack of awareness of patients about their disease and low adherence to previously prescribed therapy. In 98% of patients, signs of viral interstitial pneumonia were detected (in 78.9% using computed tomography of the lungs, in 21.1% using standard radiography of the lungs).

A significant increase in the levels of pro-inflammatory markers was noted. The average level of CRP was  $49.25 \pm 68.05$ ; in 23%, there was an increase in CRP levels over 100 mg/l, which was naturally associated with an extremely severe course and an unfavorable outcome. Severe SARS cov 2 infection was observed in 35%, troponin I levels were higher in patients with severe course, by an average of 25.6%. The average ferritin level was  $270 \pm 72.1$ . The ferritin level correlated with the severe course.

The average duration of hospitalization was  $19 \pm 13.2$  days. Mortality was 13.3%. This may be due to a number of reasons and requires further study.

It is not clear whether the risk of cardiovascular complications and cardiac arrhythmias persists in the long term. During repeated surveys of patients after three months after discharge from the hospital, symptoms persisted in 40% of the respondents. The main symptoms were general weakness (53.1%), poor exercise tolerance (46.9%). None of the patients had fever or any other signs of acute illness.

At the moment, the formation of a registry and the accumulation of data, including a bank of genetic material for further research, are ongoing. The dynamics of symptoms and clinical indicators after discharge is assessed.

### Conclusions

The medical community is just entering the era of dealing with the consequences of the pandemic. The manifestations of COVID-19 infection and post-COVID syndrome are very variable, which makes it difficult to develop a universal approach to the treatment and rehabilitation of such patients. The stage of data accumulation continues, which would allow to optimize their maintenance. Patients with a new coronavirus infection and myocardial infarction demonstrate a high duration of hospitalization, complication rates, and mortality, which requires study and finding approaches for optimal treatment of this category of patients. The issue of stratifying the risk of cardiovascular events against the background of a new coronavirus infection remains open, which requires the accumulation of fundamental data and additional clinical studies.

### References

1. World Health Organization. *Coronavirus disease 2019 (COVID-19) situation report – 47*. <https://web.archive.org/web/20200308150245/https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200307-sitrep-47-covid-19.pdf>
2. Wang D., Hu B., Hu C. et al. *Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China*. *JAMA*, 2020. doi: 10.1001/jama.2020.1585
3. Wu Z., McGoogan J.M. *Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention*. *JAMA*, 2020; 323 (13): 1239–1242. doi: 10.1001/jama.2020.2648

4. Carfi A., Bernabei R., Landi F.; Gemelli Against COVID-19 Post-Acute Care Study Group. *Persistent symptoms in patients after acute COVID-19. JAMA*, 2020; 324 (6): 603–605. doi: 10.1001/jama.2020.12603
5. Helms J., Kremer S., Merdji H. et al. *Neurologic features in severe SARS-CoV-2 infection. N. Engl. J. Med.*, 2020; 382 (23): 2268–2270. doi: 10.1056/NEJMc2008597
6. Mesas AE, Cavero-Redondo I, Álvarez-Bueno C, Sarriá Cabrera MA, Maffei de Andrade S, Sequí-Dominguez I, Martínez-Vizcaino V. *Predictors of in-hospital COVID-19 mortality: A comprehensive systematic review and meta-analysis exploring differences by age, sex and health conditions. PLoS One*. 2020 Nov 3;15(11): e0241742. doi: 10.1371/journal.pone.0241742. PMID: 33141836; PMCID: PMC7608886.
7. Das S, Pearson M, Taylor K. et al *Combinatorial Analysis of Phenotypic and Clinical Risk Factors Associated With Hospitalized COVID-19 Patients. Front Digit Health*. 2021 Jul 8; 3:660809. doi: 10.3389/fdgth.2021.660809. PMID: 34713134; PMCID: PMC8521999.

心肌梗死后的急性和亚急性心力衰竭  
**ACUTE AND SUBACUTE HEART FAILURE AFTER  
MYOCARDIAL INFARCTION**

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抽象的。 该研究检查了心肌梗死 (MI) 后急性和亚急性心力衰竭 (HF) 发展中的临床功能和生化因素。 Killip 2 级以上患者的 GRACE 评分、心率 (HR) 和 MB 肌酸激酶 (MB KK) 水平较高; 相比之下, 收缩压 (BP) 水平低于 Killip 1 级患者。 亚急性心力衰竭的发展受到既往冠心病史、左心室射血分数 (LV EF) 降低和任何形式的影响。 心房颤动 (AF)。

关键词: 急性和亚急性心力衰竭, 心肌梗死

**Abstract.** *The study examined clinical-functional and biochemical factors in the development of acute and subacute heart failure (HF) after myocardial infarction (MI). Patients with Killip over grade 2 had higher GRACE scores, heart rate (HR), and MB fraction creatine kinase (MB KK) levels; in contrast, systolic blood pressure (BP) levels were lower than in patients with Killip grade 1. The development of subacute heart failure was influenced by a previous history of coronary heart disease, reduced left ventricular ejection fraction (LV EF), and any form of atrial fibrillation (AF).*

**Keywords:** *acute and subacute heart failure, myocardial infarction*

### **Introduction**

Despite significant progresses in the diagnosis of myocardial infarction and the development of reperfusion treatment methods, heart failure still often complicates its course. There are three types of postinfarction heart failure: occurring in the acute period, during hospital treatment and after discharge. Factors contributing to heart failure during hospitalization for MI and after discharge include comorbidity of the patient, worsening of pre-existing CHF and comorbidities. In the last decades we can observe higher level of myocardial percutaneous coronary

intervention (PCI), improvement of pre-hospital care, which decreased mortality and HF; however, the proportion of HF patients with preserved ejection fraction increased. All these factors determine the urgency of the studied problem.

### **Purpose of the study**

To identify the most significant factors contributing to the development of acute and subacute heart failure after myocardial infarction

### **Materials and methods**

Prospective non-randomized parallel-group analysis of 186 suffered MI (mean age 63.5 y) during one year was performed in this work, and in the main group of patients (86 patients) at 30 days after MI, chronic heart failure over 2F by NYHA was confirmed, and in comparison group (100 patients) CHF was either absent or did not exceed 2F by NYHA. The diagnosis of MI and CHF was made according to national and European guidelines [1-4]. Both groups received standard therapy for CHF: ACE inhibitors/angiotensin 2/angiotensin receptor antagonists and neprolysin inhibitor (ARNI),  $\beta$ -blockers, mineralocorticoid receptor antagonists (AMCR), SGLT2-receptor inhibitors; anticoagulants, antiplatelet agents, statins, diuretics if necessary were also used.

### **Results and discussion**

The analysis of subgroups revealed that the patients in the main subgroup (MI + CHF over 2 liters NYHA) had a complication in the form of acute heart failure according to Killip II and III classes. In contrast, in the comparison subgroup, only 5 patients (5%) had Killip II acute heart failure. These data suggest that not all acute heart failure after a previous MI turns into chronic heart failure, but that CHF in turn did not develop without OSN in MI patients. A study involving 187,803 MI patients hospitalized between 2007 and 2011 showed that 12% of patients had signs of heart failure on admission, and another 4% developed CHF during hospitalization [5].

Patients with Killip stage II or higher had higher GRACE scores of  $200.2 \pm 10.4$ , HR of  $85.5 \pm 6.4$  beats per minute, CF fraction of creatine phosphokinase of  $142.5 \pm 81.6$  U/L, and lower BP of  $110.8 \pm 7.7$  mm Hg compared to those in stage I AHF (mean  $\pm 4.7$  mm Hg).

At the same time, we observed the low blood pressure of patients with STEMI of stage I according to Killip: GRACE score -  $156.4 \pm 3.5$ , HR  $80.5 \pm 2.4$  beats per minute, CF fraction of creatine phosphokinase -  $45.19 \pm 5.9$  U/L, BP -  $135.6 \pm 7.7$  mm Hg.

In the European Heart Failure Registry it was shown that patients with decreased EF were more often associated with COPD, renal and hepatic insufficiency. CHF as a cause of CHF had the same prevalence among patients with reduced and preserved LV EF phenotype. Patients with preserved LV EF had higher prevalence of type 2 DM, anemia, CHD, atrial fibrillation compared to patients with

reduced LV EF. The long-term prognosis of patients was significantly influenced by the presence of CVD and T2 DM [6].

In the thesis, significant correlations were obtained for the following factors: the presence of a history of guideline-confirmed CHD before MI: OR 10.208, CI (5.114-20.379), LV EF less than 40% OR 6.831, CI (1.905-24.491), presence of atrial fibrillation (AF) OR 6.831, CI (1.905-24.491). Other parameters, such as smoking, BMI, type 2 diabetes mellitus, dyslipidemia, tachycardia, hypotension, and many others did not significantly affect the development of CHF, this is consistent with other studies [7, 8].

### Conclusions

So, the present study broadened the understanding of the factors correlating with acute heart failure over Killip 2. The formation of subacute CHF was influenced by factors characterizing patient comorbidity and previous myocardial damage.

### References

1. *ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: Task Force for the Management of Acute Coronary Syndromes in Patients Presenting without Persistent ST-Segment Elevation of the European Society of Cardiology (ESC)*. *Eur. Heart J.* 2016; 37: 267–315.

2. Mareev V.Y., Fomin I.V., Ageev F.T., Begrambekova Y.L., Vasyuk Y.A., Garganeeva A.A., Gendlin G.E., Glezer M.G., Gautier S.V., Dovzhenko T.V., Kobalava Z.D., Koziolova N.A., Koroteev A.V., Mareev Y.V., Ovchinnikov A.G., Perepech N.B., Tarlovskaya E.I., Chesnikova A.I., Shevchenko A.O., Arutyunov G.P., Belenkov Y.N., Galyavich A.S., Gilyarevsky S.R., Drapkina O.M., Duplyakov D.V., Lopatin Y.M., Sitnikova M.Y., Skibitsky V.V., Shlyakhto E.V. *Russian Heart Failure Society, Russian Society of Cardiology. Russian Scientific Medical Society of Internal Medicine Guidelines for Heart failure: chronic (CHF) and acute decompensated (ADHF). Diagnosis, prevention and treatment // Kardiologiya. 2018;58(6S):8-158. (In Russ.)* <https://doi.org/10.18087/cardio.2475>. Park HS, Kim IJ, Kim EG, Ryu CS, Lee JY, Ko EJ, Park HW, Sung JH, Kim NK. *A study of associations between CUBN, HNF1A, and LIPC gene polymorphisms and coronary artery disease. Sci Rep. 2020 Oct 1;10(1):16294. doi: 10.1038/s41598-020-73048-6. PMID: 33004870; PMCID: PMC7530657.*

3. *2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines / P. A. Heidenreich, B. Bozkurt,*

D. Aguilar [et al.] // *Circulation*. – 2022. – Vol. 145. – e895–e1032. <https://doi.org/10.1161/CIR.0000000000001063>. Epub 2022 Apr 1. Narula S., Yusuf S., Chong M. Plasma ACE2 and risk of death or cardiometabolic diseases: a case-cohort analysis. *Lancet*. 2020; 396(10256): 968-976. doi: 10.1016/S0140-6736(20)31964-4.

4. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) With the special contribution of the Heart Failure Association (HFA) of the ESC / Theresa A McDonagh, Marco Metra, Marianna Adamo, Roy S Gardner, Andreas Baumgartner, Michael Böhm, Haran Burri, Javed Butler, Jelena Čelutkienė, Ovidiu Chioncel, John G F Cleland, Andrew J S Coats, Maria G Crespo-Leiro, Dimitrios Farmakis, Martine Gilard, Stephane Heymans, Arno W Hoes, Tiny Jaarsma, Ewa A Jankowska, Mitja Lainscak, Carolyn S P Lam, Alexander R Lyon, John J V McMurray, Alexandre Mebazaa, Richard Mindham, Claudio Muneretto, Massimo Francesco Piepoli, Susanna Price, Giuseppe M C Rosano, Frank Ruschitzka, Anne Kathrine Skibelund, ESC Scientific Document Group, , *European Heart Journal*, Volume 42, Issue 36, 21 September 2021, Pages 3599–3726, <https://doi.org/10.1093/eurheartj/ehab368> Shishkova K.Yu., Nikulina S.Yu., Shulman V.A. et al. The role of single nucleotide polymorphism rs10824026 of the SYNPO2L gene in the development of atrial fibrillation in a study in the East Siberian population. *CardioSomatics*. 2019; 10(4):34–38. DOI: 10.26442/22217185.2019.4.190722.

5. Risk of heart failure complication during hospitalization for acute myocardial infarction in a contemporary population: insights from the National Cardiovascular Data ACTION Registry / R. V. Shah, D. Holmes, M. Anderson et al. // *Circ. Heart Fail.* – 2012. – Vol. 5. – P. 693

6. Heart failure with mid-range ejection fraction: pro and cons of the new classification of Heart Failure by European Society of Cardiology guidelines / Luca Branzi, Marco Senni, Marco Metra et al. // *ESC Heart Failure*. – 2020. Published online in Wiley Online Library ([wileyonlinelibrary.com](http://wileyonlinelibrary.com))

7. Kalyuzhin V.V., Teplyakov A.T., Solovtsov M.A., Kalyuzhina E.V., Bepalova I.D., Terentyeva N.N. REMODELING OF THE LEFT VENTRICLE: ONE OR SEVERAL SCENARIOS? *Bulletin of Siberian Medicine*. 2016;15(4):120-139. (In Russ.) <https://doi.org/10.20538/1682-0363-2016-4-120-139>

8. Galli A., Lombardi F., Postinfarct Left Ventricular Remodelling: A Prevailing Cause of Heart Failure. *Cardiology Research and Practice*. 2016; 2016; 12. Article ID 2579832. [doi.org/10.1155/2016/2579832](https://doi.org/10.1155/2016/2579832).

寻找一种预测冠心病患者快速进展的动脉粥样硬化的方法  
**FINDING A METHOD FOR PREDICTING RAPIDLY  
PROGRESSING ATHEROSCLEROSIS IN PATIENTS WITH  
CORONARY HEART DISEASE**

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抽象的。为了创建一种预测进行性动脉粥样硬化的方法，对冠心病患者和进行性动脉粥样硬化（主要组）患者的记忆、临床、实验室、仪器和分子遗传学数据进行了综合评估：复发性心肌梗死、不稳定型心绞痛的存在，在纳入研究前两年内，急诊动脉支架置入术、中风、外周动脉血栓形成、严重缺血和下肢截肢；对照组没有列出表明动脉粥样硬化快速进展的事件。使用因子回归分析的方法，我们开发了一种评估 CHD 患者进行性动脉粥样硬化风险的方法，包括患者的年龄、至少在 50% 或更多的血管腔内确定是否存在颈动脉狭窄一方面，通过体重指数有无肥胖，有无不稳定型心绞痛病史，确定患者血清中高敏C反应蛋白和高密度脂蛋白胆固醇的浓度。该模型在 Excel 电子表格处理器中编程，使每位医生能够轻松快速地计算办公室或患者床边每位患者动脉粥样硬化快速进展的个体风险。

关键词：冠状动脉疾病；快速进展的动脉粥样硬化；个体心血管风险

**Abstract.** *To create a method for predicting progressive atherosclerosis, a comprehensive assessment of anamnestic, clinical, laboratory, instrumental, and molecular genetic data in patients with coronary heart disease and signs of progressive atherosclerosis (main group) was performed: presence of recurrent MI, unstable angina, emergency artery stenting, stroke, peripheral artery thrombosis, critical ischemia, and lower extremity amputation within two years before inclusion in the study; the comparison group had no listed events suggestive of rapid progression of atherosclerosis. Using the methods of factor regression analysis, we developed a method to assess the risk of progressive atherosclerosis in CHD patients, including the patient's age, determination of the presence or absence of carotid artery stenosis by 50% or more of the vessel lumen on at least*

*one side, the presence or absence of obesity by body mass index, the presence or absence of a history of stable angina pectoris, determining the patient's serum concentrations of high-sensitivity C-reactive protein and high-density lipoprotein cholesterol. This model is programmed in an Excel spreadsheet processor, which allows each physician to easily and quickly calculate the individual risk of rapid progression of atherosclerosis for each patient at the office or at the patient's bedside.*

**Keywords:** *coronary artery disease; rapidly progressive atherosclerosis; individual cardiovascular risk*

### **Introduction**

Mortality from coronary heart disease, which is based on atherosclerosis, leads in the structure of total mortality in Russia and in many other countries. The syndrome of progressive atherosclerosis was first described in patients who underwent various operations on the heart and coronary arteries. It is a type 2 lesion involving exposure of the endothelium followed by thrombus formation and proliferation of smooth muscle cells. However, the role of persistent inflammation and angiogenesis, as well as other factors, including well-known ones, in accelerated plaque development and the occurrence of cardiovascular events has been further shown. Identification of predictors of rapid progression of atherosclerosis in coronary heart disease will make it possible to identify this special group of patients for the purpose of personalized management of individual cardiovascular risk.

### **Purpose of the study**

To identify the most significant risk factors of rapidly progressing atherosclerosis in patients with confirmed coronary heart disease.

### **Materials and methods**

A retrospective cohort study included 202 patients with coronary artery disease: 147 men and 55 women. The mean age of the patients was  $53.3 \pm 7.16$  years. The diagnosis of coronary artery disease was established according to a set of criteria developed by Russian Society of Cardiology, the European Society of Cardiology and the American College of Cardiology (2019, 2021), including: a) stenosis of the lumen of at least two coronary arteries by 50% or more according to selective coronary angiography; b) ECG changes in 2 or more consecutive leads (pathological Q, or the presence of QR, c) the presence of zones of local hypokinesis according to echocardiography [1, 2, 3]. The main group (100 people) included those who had had a type 1 myocardial infarction (MI) within two years prior to the study (54 people) or had been diagnosed with CHD by selective coronary angiography: the presence of lumen stenosis of at least two coronary arteries of 50% or more (46 people) and two (or more) additional cardiovascular events of the following: MI or unstable angina, emergency artery stenting, stroke, peripheral

artery thrombosis, critical ischemia and lower limb amputation. The combination of two or more of the above cardiovascular events occurring within two years was indicative of rapid progression of atherosclerosis in these patients. This condition was formed based on the literature data indicating that the criteria for rapidly progressing, or accelerated, atherosclerosis are either the presence of two or more ischemic events within two years or more (ischemic events are listed above), or progression of any artery stenosis (coronary or noncoronary) by 20-30% or more within 3-6 months according to angiography. The comparison group included 102 patients with similarly confirmed CHD (56 had only one type 1 MI in the past and 46 had CHD confirmed by selective coronary angiography) who had none of the cardiovascular events described above in the two years before study inclusion, indicating the absence of rapid progression of atherosclerosis (spontaneous course of atherosclerosis). All patients underwent clinical and instrumental examination according to the following program: clinical examination, electrocardiography, echocardiography, Holter monitoring, inflammatory cytokines and molecular genetic studies. Using the methods of factorial and correlation analysis, the influence of each of the studied indicators on the probability of an unfavorable annual forecast was determined in the work.

### **Results and discussion**

Retrospective analysis was performed to identify the main factors playing a role in rapidly progressing atherosclerosis. A nonlinear regression model was constructed to assess the influence of clinical, instrumental, and laboratory factors in a comprehensive and objective manner. The following 15 factors, which had significant correlation with the dependent variable (outcome-cardiovascular event) and weak correlation of these independent variables with each other, were selected out of 100 studied factors. Such variables were: patient age-X1, patient sex-X2, carotid artery stenosis of 50% or more on at least one side-X3, arterial hypertension-X4, smoking-X5, obesity more than 1 degree-X6, history of stable angina - X7, blood leukocyte level UD/L - X8, blood creatinine level - X9, C-reactive protein level in mg/L - X10, total blood cholesterol level in mM/l - X11, high-density lipoprotein cholesterol (HDL) level in mM/l - X12, low-density lipoprotein cholesterol (LDL) level in mM/l - X13, left ventricular ejection fraction in % - X14, coronary multivessel disease - X15.

The final regression equation included the patient's age, presence or absence of carotid artery stenosis by 50% or more of the vessel lumen on at least one side, presence or absence of obesity according to BMI, history or absence of stable angina, high-sensitivity C-reactive protein serum levels and high-density lipoprotein cholesterol. The above factors have a significant correlation with the outcome - rapidly progressing atherosclerosis - and a weak correlation with each other. The regression model has a good prognostic accuracy.

For the convenience of using the model in clinical practice, the regression equation was programmed in an Excel spreadsheet processor under the name “Calculator for assessing the increased risk of progressive atherosclerosis”.

According to the literature, rapid progression of atherosclerosis can also be determined by angiography: diameter reduction of at least one previous arterial stenosis by 20-50% or more within 3-6, 9 or 12 months, or lesion progression to complete occlusion or diameter reduction by 50% or more in a previously successfully stented segment [4]. Since angiography cannot be performed without clinical, and most often urgent indications according to the existing federal diagnostic and treatment standards, dynamic routine angiography in real clinical practice is impossible.

It should also be considered that the diagnostic part of the CA procedure is not absolutely harmless, and trauma associated with ballooning and stent implantation destroys the plaque and can even damage the coronary artery; microembolization and myonecrosis can also cause endogenous SRB production in the vessel wall or in coronary atherosclerotic plaques. Rapid progression of noncritical lesions may result from negative remodeling and organization of plaque hemorrhages or repeated subclinical ruptures, hemorrhages and organization [5].

In the following study of patients with chronic stable angina pectoris it was shown that CRP is an independent predictor of rapid progression [6, 7].

A number of studies have shown the association of various biomarkers with the rapid progression of atherosclerosis, namely, neopterin, a substance produced by activated macrophages, which, in turn, leads to the destruction of the fibrous membrane of atheromatous lesions [8]. Similar data refer to osteopontin, a substance that activates the release of matrix metalloproteinase, as well as neoangiogenesis, bleeding, degradation of the fibrous plaque covering [9].

The role of persistent inflammation in plaque progression, the therapeutic effect on inflammation is well demonstrated [10] in the recently completed CANTOS study, where in 10,000 patients who underwent myocardial infarction, taking 150 mg canakinumab every 3 months led to a statistically significant reduction in the main combined endpoint: nonfatal myocardial infarction, nonfatal stroke, or cardiovascular death (hazard ratio 0.85 compared with placebo,  $P = 0.021$ ). This effect was associated with a decrease in CRP levels but no significant change in plasma LDL or HDL [10].

The lipid theory of atherosclerosis, of which Nikolai Nikolayevich Anichkov is the founder, is undoubtedly the leading one. Most of the evidence-based research in this field concerns “remnant cholesterol,” i.e., cholesterol included in large, triglyceride-rich lipoprotein particles, that is, very low density lipoproteins (VLDL), intermediate density lipoproteins (IDL), and chylomicrons. While chylomicrons, due to their size, cannot penetrate into the subendothelial space with a mini-

mal amount of cholesterol, LONP and LPP particles, on the contrary. A significant number of both prospective and genetic studies demonstrate an independent association of cholesterol in their composition with ischemic complications, which is not inferior but even superior to that of atherogenic low-density lipoproteins (LDL). The role of the latter is undeniable, and they are the marker that doctors around the world focus on when selecting hypolipidemic therapy.

The role of high-density lipoprotein cholesterol has been studied, but as a treatment target is highly debatable. Although high-density lipoprotein cholesterol (HDL-C) levels are inversely related to cardiovascular risk in many studies, recent pharmacological intervention studies with strategies to increase HDL-C have shown no benefit in terms of vascular events. HDL-C particles are heterogeneous and have antiatherogenic functions and nonvascular effects. Many factors affect the components of HDL and can either cause compositional changes, post-translational modifications of proteins, or alter lipids and other cargo molecules; these factors usually cause more than one of these changes, resulting in functional differences [11]. Therefore, the role of lipoproteins varies under different physical and disease conditions. Basically, the proteome, apolipoprotein A1 (Apo-A1), myeloperoxidase (MPO), and paroxonase (PON) are affected by inflammation or factors related to glycation; and especially lipid esterification or non-esterification, changes in phospholipids or unsaturated lipids alter HDL function.

In the present study, it was HDL that showed a strong correlation with the rapid progression of atherosclerosis, especially as part of the prognostic model of the present disease. Therefore, it is necessary to develop therapeutic approaches to improve HDL function. Apo-A1 mimetics, reduced HDL, nanoparticles, and microRNA therapy may be promising as antiatherosclerotic therapy, especially in individuals with advanced atherosclerosis.

The proposed author's risk assessment calculator for rapidly progressing atherosclerosis has undoubted advantages: simplicity and accessibility of use, since it uses parameters determined within the framework of federal standards of management of patients with coronary heart disease. This method also defines a new treatment target influencing the progression of atherosclerosis - HDL cholesterol level, in contrast to the existing one - LDL cholesterol level, which broadens the prospects of treatment of such patients.

### **Conclusions**

The authors developed a high-precision prognostic model of progressive atherosclerosis, including patient's age, presence of carotid artery stenosis by 50% or more of vessel lumen on at least one side, presence or absence of obesity according to body mass index, presence or absence of stable angina in the history, high-sensitivity C-reactive protein and high-density lipoprotein cholesterol levels in patient's blood serum. For convenient use of the model in clinical practice, the regression equation was programmed in an Excel spreadsheet processor under the

name “Calculator for assessing the increased risk of progressive atherosclerosis”. The calculator is easy to use and promotes personalized management of this complex category of patients.

## References

1. 2020 *Clinical practice guidelines for Stable coronary artery disease. Russian Journal of Cardiology*. 2020;25(11):4076. (In Russ.) doi:10.15829/1560-4071-2020-4076
2. Juhani Knuuti, William Wijns, Antti Saraste, Davide Capodanno, Emanuele Barbato, Christian Funck-Brentano, Eva Prescott, Robert F Storey, Christi Deaton, Thomas Cuisset, Stefan Agewall, Kenneth Dickstein, Thor Edvardsen, Javier Escaned, Bernard J Gersh, Pavel Svitil, Martine Gilard, David Hasdai, Robert Hatala, Felix Mahfoud, Josep Masip, Claudio Muneretto, Marco Valgimigli, Stephan Achenbach, Jeroen J Bax, ESC Scientific Document Group, 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes: The Task Force for the diagnosis and management of chronic coronary syndromes of the European Society of Cardiology (ESC), *European Heart Journal*, Volume 41, Issue 3, 14 January 2020, Pages 407–477, <https://doi.org/10.1093/eurheartj/ehz425>
3. Lawton J, Tamis-Holland J, et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization. *J Am Coll Cardiol*. 2022 Jan, 79 (2) e21–e129. <https://doi.org/10.1016/j.jacc.2021.09.006>
4. Rapid progression of coronary atherosclerosis: a review / P. Shah, S. Bajaj, H. Virk, M. Bikkina // *Thrombosis*. – 2015. – Vol. 2. – P. 1–6. DOI: 10.1155/2015/634983.
5. 2018 ESC/EACTS Guidelines on myocardial revascularization / Fr.-J. Neumann [et al.] // *European Heart J*. – 2018. – Vol. 40, Iss. 2. – P. 87–165. doi. org/10.1093/eurheartj/ehy394.
6. Resolvin E1 (RvE1) attenuates atherosclerotic plaque formation in diet and inflammation-induced atherogenesis / H. Hasturk [et al.] // *Arterioscler Thromb Vasc Biol*. – 2015. – Vol. 35 (5). – P. 1123–1133.
7. Taleb, S. Inflammation in atherosclerosis / S. Taleb // *Arch Cardiovasc Dis*. – 2016. – Vol. 109. – P. 708–715. doi: 10.1016/j.acvd.2016.04.002.
8. Targeting inflammation to reduce cardiovascular disease risk: a realistic clinical prospect? / P. Welsh, G. Grassia, S. Botha [et al.] // *Br J Pharmacol*. – 2017. – Vol. 174 (22). – P. 3898–3913. doi: 10.1111/bph.13818.
9. Taleb, S. Inflammation in atherosclerosis / S. Taleb // *Arch Cardiovasc Dis*. – 2016. – Vol. 109. – P. 708–715. doi: 10.1016/j.acvd.2016.04.002.

10. *Inflammatory cytokines and risk of coronary heart disease: new prospective study and updated meta-analysis / S. Kaptoge, S. R. Seshasai, P. Gao [et al.] // Eur Heart J. – 2014. – Vol. 35 (9). – P. 578–589. doi: 10.1093/eurheartj/ehi367. Epub 2013 Sep 10.*

11. März W, Kleber ME, Scharnagl H, Speer T, Zewinger S, Ritsch A, Parhofer KG, von Eckardstein A, Landmesser U, Laufs U. HDL cholesterol: reappraisal of its clinical relevance. *Clin Res Cardiol.* 2017 Sep;106(9):663-675. doi: 10.1007/s00392-017-1106-1. Epub 2017 Mar 24. PMID: 28342064; PMCID: PMC5565659.

DOI 10.34660/INF.2022.32.93.118

使用根标签时的主要错误 (2013-2022年法庭案例分析)  
**THE MAIN ERRORS WHEN USING ROOT TABS (ANALYSIS OF  
COURT CASES 2013-2022)**

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抽象的。根据 2013 年至 2022 年期间的法医检查材料评估了带有铸根标签的修复体的结果, 这些检查与劣质牙科护理有关。在所有牙科法庭案件中, 有 40% 的假牙质量得到了评估。77% 的矫形牙科病例是由于对固定假牙质量的索赔引起的。在 8.8% 的牙科整形案件中记录了铸根片使用错误, 主要违规与没有保留区 (30% 的病例)、通道的牙髓准备质量差 (26% 的病例) 有关) 和错误的选项卡建模 (23% 的案例)。

关键词: 牙根修复错误, 骨科治疗质量评价

**Abstract.** *The results of prosthetics with cast root tabs were evaluated based on the materials of forensic medical examinations for the period 2013-2022, conducted in connection with poor-quality dental care. The quality of dentures was assessed in 40% of all dental court cases. 77% of cases in orthopedic dentistry were caused by claims to the quality of fixed dentures. Errors in the use of cast root tabs were registered in 8.8% of court cases in orthopedic dentistry, the main violations are associated with the absence of retention zones (30% of cases), poor-quality endodontic preparation of channels (26% of cases) and incorrect modeling of tabs (23% of cases).*

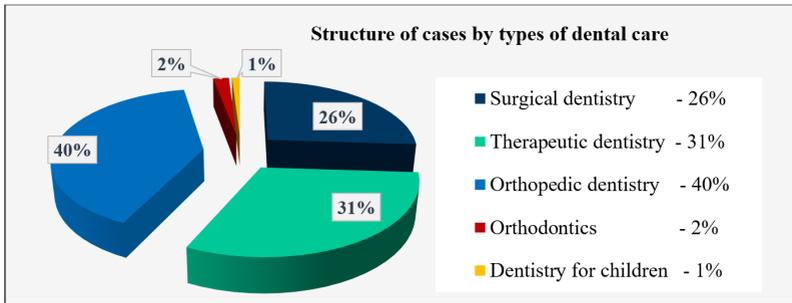
**Keywords:** *errors in prosthetics with root tabs, evaluation of the quality of orthopedic treatment*

Achieving key, socially significant indicators of the dental health of the population of the Russian Federation requires constant attention from dentists to preventive measures. High rates of caries in some regions of the country (up to 82% at the age of 15 and 99% in the age group from 35 to 44 years [1]) necessitate the improvement of methods for replacing defects in hard dental tissues. Despite the widespread introduction of dental implants into dental practice, at this stage it is impossible to abandon the traditional methods of restoring damaged teeth with root tabs, since this method allows not only to restore the functional, aesthetic properties of the tooth, but also to preserve its natural root, periodontal, physiological load on the bone [2].

The results of prosthetics with cast root tabs largely depend on compliance with the indications for using the method, the quality of preparation of root tabs and the exact implementation of the technique for making the tab. Complications resulting from inadequate distribution of the load on the root walls and a reduction in the service life of orthopedic structures due to poor-quality manufacturing of root tabs are the reasons for patients to apply for replacement structures or repair defects using dental implants and lawsuits [3,4].

In order to study the main complications arising from the restoration of decayed teeth with cast root tabs, the materials of court cases and forensic medical examinations for the period 2013-2022 were studied. The analysis of unfavorable treatment outcomes, which led to the emergence of conflict situations resolved within the framework of civil litigation, made it possible not only to identify complications, but also to systematize the main reasons for the unsatisfactory results of orthopedic treatment of patients using this type of prosthesis. In total, more than 2.5 thousand cases of poor-quality dental treatment were studied, but the study used data from 1731 court cases to conduct statistical calculations.

In the general set of court cases in dentistry over a 10-year period, the proportion of cases where there were complaints about the volume and quality of orthopedic treatment was 40% of all cases in dentistry (Figure 1). At the same time, most often, in 75% of all cases related to claims for poor-quality orthopedic treatment, orthopedic dental care was assessed in combination with therapeutic, surgical, orthodontic medical care, and only orthopedic dental care was evaluated only in 25% of cases.



*Figure 1. Proportion of cases with claims to the quality of orthopedic treatment (2013-2022)*

The main reason for applying to the courts was complaints about the quality of manufacturing fixed orthopedic structures - crowns, bridges, veneers. The share of such cases amounted to 77% of all court cases where there were complaints about the quality of prosthetics, in 23% of cases, citizens' claims related to complaints about the quality and timing of manufacturing removable dentures (laminar, clasp, conditionally removable dentures).

In the study, we analyzed the frequency of complaints about cast root tabs and prostheses based on them, and also structured the reasons for the unsatisfactory result of their use and the reduction in the service life of the discussed orthopedic structures. Claims to cast root tabs occurred in 8.8% of cases (Table 1).

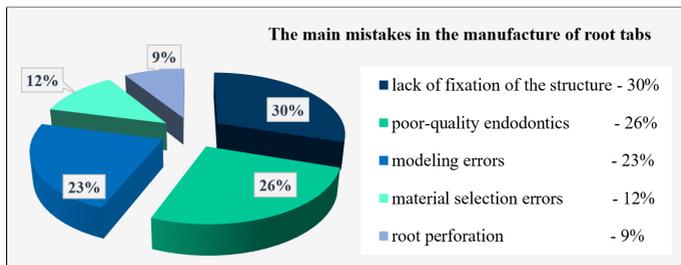
It is important that, for example, claims for metal-plastic crowns or crowns made of precious metals have decreased by 2-2.5 times over the past 5 years (when comparing data for the periods 2013-2017 and 2018-2022). The number of complaints about veneers/lumineers and crowns based on dental implants, on the contrary, has doubled in the last 5 years. The number of claims for poor-quality manufacturing of cast root tabs remained unchanged throughout the 10 years of the study and ranged from 8% to 9% of all cases of fixed prosthetic restorations, which indicates the frequency of their use in dental practice and the presence of problems with regard to workmanship.

**Table 1**

*The frequency of occurrence of forensic medical examinations in which the quality of manufacturing of fixed orthopedic structures was assessed in 2013-2022*

Fixed dentures	Number of cases 2013-2022	
	quantity	P±m, B %
veneers lumineers	21	2,2±0,47 %
dental mouthguards	3	0,3±0,17 %
cast root tabs	83	8,8±0,28 %
metal-ceramic crowns	485	51,6±1,63 %
crowns on implants	140	14,9±1,16%
stamped crowns, metal-plastic crowns, plastic crowns	71	17,1±1,23 %
metal-free crowns	48	5,1±0,72 %
<b>Total number of fixed dentures</b>	<b>940</b>	<b>100%</b>

The greatest number of unsatisfactory results of prosthetics with cast root tabs was associated with the lack of creation of retention zones and frequent decementation of structures (30% of all shortcomings when using prostheses). In 26% of cases, violations were determined associated with poor-quality endodontic preparation of the canals of the teeth before prosthetics and improper obturation of the canals at the time of root tabs fixation. It was determined that complications such as root perforation at the stages of treatment caused litigation only in 9% of cases, much more often, in 23% of cases, incorrect modeling of root tabs was recorded, consisting in the absence of creating the correct ratio of the intra-root and extra-root parts of the structure or the location of the pin part not along the canals of the teeth. It should be noted that 12% of complaints about the quality of cast root tabs were related to their qualitative composition, in particular, allergic reactions to metal, the lack of a combination of inlay material and an artificial tooth crown (Figure 2).



**Figure 2.** *The structure of defects when using cast root tabs according to forensic medical examinations (2013-2022)*

Thus, the analysis of adverse outcomes when using cast root tabs shows that over the course of 10 years, during forensic medical examinations, shortcomings in the manufacture of this type of orthopedic structures have been noted in 8.8% of cases of all claims to fixed prostheses. Most often, these claims are associated with the lack of retention, incorrect design design and poor quality of tooth canal preparation. It should be recognized as relevant further development of the principles of modeling cast root tabs, including the use of mathematical models.

### References

1. *Kuzmina E.M. Dental morbidity of the Russian population. The condition of the hard tissues of the teeth. Prevalence of dental anomalies. The need for prosthetics. – M.: MGMSU, 2009. – 104 P.*
2. *Gariev, I.Yu. Comparative characteristics of cast stump pin inlays and pins in orthopedic treatment /I.Yu. Gariev, M.Yu. Grigorieva //In the collection: Scientific research of young scientists. Collection of articles of the VIII International Scientific and Practical Conference. In 2 parts. – 2020. – P. 158-162.*
3. *Andreeva, S.N. Analysis of judicial practice in civil cases related to defects in the provision of dental care to the population of the Russian Federation for the period from 1993 to 2017./ S.N. Andreeva, A.A. Gusarov, V.A. Fetisov // Forensic medical examination. – 2018. – No.3(61). – P. 44-48.*
4. *Andreeva, S.N. Retrospective evaluation of the quality of dental orthopedic treatment on the basis of studying cases. Health and education in the twenty-first century. – 2018. – V.9 (20). – P.52-56.*

现代俄罗斯人口形势不利的原因及解决方法

**THE CAUSES OF THE UNFAVORABLE DEMOGRAPHIC  
SITUATION IN MODERN RUSSIA AND WAYS TO SOLVE THEM**

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抽象的。关联。人口统计学与现代青年对家庭和婚姻制度的看法的变化有着千丝万缕的联系。家庭和家庭价值观是人类生活和幸福的基础。正是她在发展现在和未来青年的精神和道德品质方面发挥着主要作用。目前，家庭和孩子已经不再是现代年轻人的首要任务。独立和专业成长脱颖而出。在建立了成功的事业之后，家庭的建立被长期推迟。

研究目的: 分析该国不利的人口状况的主要原因并说明解决方法的合理性。

材料和方法。该研究是回顾性的。WHO 官方数据和 Rosstat 数据 (<https://rosstat.gov.ru> 和 [rosinfostat.ru](https://rosinfostat.ru))。采用专论法进行分析。共分析了36个统计数据。

结果。在过去的十年中，由于社会经济问题、国内领域的混乱和其他困扰俄罗斯社会十多年的困难，该国的出生率一直处于超低水平。然而，研究家庭关系的人口学家和社会学家已经证明，生育问题是不同的。现代人口减少的主要原因是生殖态度的改变。现代都市家庭不需要大量的孩子。在经济上，一个孩子多的城市家庭总是会输给一个孩子少的家庭。大多数人口的低生育率在当代城市社会的生活方式和价值体系中根深蒂固。

结论。因此，现代俄罗斯的主要医疗和人口问题是人口持续自然下降、劳动年龄人口的高死亡率和低预期寿命。出路在于提高俄罗斯人的生活水平并将国家转向人口问题。当前，健康家庭工作应成为首要任务，主要任务是在人群中形成健康生活方式的文化。

关键词: 人口状况, 主要原因, 生育率下降, 解决方案。

**Abstract. Relevance.** *Demography is inextricably linked with a change in the views of modern youth on the institution of family and marriage. Family and family values are the basis of human life and well-being. It is she who plays the main role in the development of the spiritual and moral qualities of present and future youth.*

*At present, family and children have ceased to be priorities for modern young people. Independence and professional growth come to the fore. The creation of a family is postponed for the long term, after building a successful career.*

**Purpose of the study:** *analyze the main causes of the unfavorable demographic situation in the country and justify ways to solve it.*

**Materials and methods.** *The study is retrospective. The data of official WHO sources and Rosstat data (<https://rosstat.gov.ru> and [rosinfostat.ru](https://rosinfostat.ru)) were analyzed by the monographic method. A total of 36 statistical data were analyzed.*

**Results.** *In the last decade, the country has been marked by an ultra-low birth rate, which is due to socio-economic problems, the disorder of the domestic sphere and other difficulties that have been shaking Russian society for more than a decade. However, demographers and sociologists who study family relations have proved that the problem of fertility is different. The main cause of modern depopulation is a change in reproductive attitudes. A modern urban family does not need a large number of children. Economically, an urban family with many children will always lose to a family with few children. Low fertility for the majority of the population is deeply ingrained in the lifestyle and value system of contemporary urban societies.*

**Conclusions.** *Thus, the main medical and demographic problems of modern Russia are the continuing natural population decline, high mortality of people of working age, and low life expectancy. The way out is seen in raising the standard of living of Russians and turning the state to the demographic problem. At present, work with a healthy family should become a priority, and the main task is to form a culture of a healthy lifestyle among the population.*

**Keywords:** *demographic situation, main causes, fertility decline, solutions.*

## Introduction

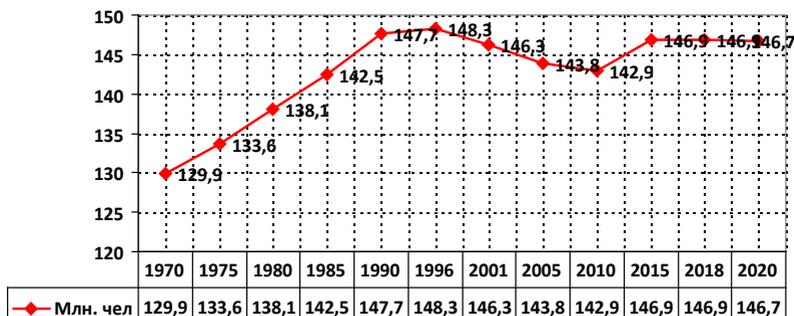
Medical demography is a science that studies the relationship between population reproduction and medical and social factors and develops, on this basis, medical, social, and organizational measures aimed at ensuring the most favorable development of demographic processes and improving the health of the population [1].

Global problems (from the Latin “globusterrae” - the globe) are a set of problems of mankind that confronted it in the second half of the XX century and on the solution of which the further existence of civilization depends. Demographic problems in the world are part of the so-called global problems, which continue to worsen in the XXI century. Their feature is a stable relationship with each other. The demographic problem itself is divided into two parts: 1) the problem of a sharp increase in the population in the countries of Asia, Africa and Latin America; 2) the problem of population decline and aging in Western Europe, Japan and Russia [2].

Youth and adolescents are identified by the development programs of our state as a priority group in solving reproductive health issues. Many demographic problems (declining birth rates, high levels of maternal mortality and complications of pregnancy and childbirth, the prevalence of infertility) are determined by attitudes towards childbearing, contraceptive and reproductive behavior of young people. Demography is inextricably linked with a change in the views of modern youth on the institution of family and marriage. Family and family values are the basis of human life and well-being. It is she who plays the main role in the development of the spiritual and moral qualities of present and future youth. At present, family and children have ceased to be priorities for modern young people. Independence and professional growth come to the fore. The creation of a family is postponed for the long term, after building a successful career [3].

**Results.** The demographic situation is one of the most acute problems of today's Russia. The First World War and the Civil War, the famine and repressions of the 1930s, and the Second World War are three periods when the population decline was caused by the most acute social upheavals. In 1964, the coefficient of natural growth of the population of Russia for the first time fell below 10 per thousand inhabitants, in 1967 - below 7. Since that time, it has never risen to the indicated level, fluctuating mainly in the range from 5.5 to 6.5 per thousand. The current fourth decline in the population was quite expected, because it is associated with long-term evolutionary processes. Russia embarked on the path of depopulation (extinction of the nation) and negative natural increase in 1992, and then every year there was a decrease in the population [4].

According to figure 1, one can trace the changes in the population of Russia over the period 1970 – 2020 [5]



*Figure 1. Dynamics of the population of the Russian Federation according to the Federal State Statistics Service of 06.05.2020*

In recent years, there has been a slight increase in population in the country, due to the birth rate and immigration from the CIS countries. Government policy aimed in recent years at providing financial support to families who decide to have a second and third child has yielded results. The improvement of medical care also played a certain role. The birth rate in the country has increased significantly, while the death rate has slightly decreased.

The reasons for the unfavorable demographic situation can be determined as follows.

#### I - Consequences of the economic and social decline of the 1990s

Since the beginning of perestroika (1985-1991), the social well-being of the population began to deteriorate rapidly.

The All-Russian micro-census of the population of 1994 showed that, on average, married women would like to have 2.03 children under the most favorable conditions. According to the results of the study “Russia-2000”, conducted in 2000-2001 by the Faculty of Sociology of Moscow State University named after M.V. Lomonosov under the guidance of A.I. Antonov, the average desired number of children was 2.48.

According to the study “Family. Demography. Social Health of the Population” conducted by the Sociological Ratings Service of the RSSU in January 2006 [6], the desired number of children on average in the sample was 2.31 children per respondent. Among the men surveyed, this figure was 2.32, and among women - 2.26 children.

Low birth rates are typical not only for Russia, but also for most developed countries. But it is worth noting that the causes of low birth rates in Russia and in developed countries are very different. The fact is that for a significant part of the population of prosperous states, the reason for the decline in fertility is egocentrism: the heirs should be fully provided for, parents should take care of themselves more, which means that there should be as few children as possible. In Russia, it's different: the loss of social confidence and, as a result, a frightening rate of decline in the birth rate.

#### II - Narrowing of the reproductive period

According to WHO data, the reproductive age interval from 15 to 55 years is used for statistics (in Russia, the interval from 15 to 49 years is often considered a statistical reproductive period). However, the best reproductive years for women are considered to be the age of 20-30 years. Fertility gradually begins to decline by the age of 30.

In the modern world, the reproductive period is significantly narrowed. Increasingly, the appearance of the first child occurs when a woman reaches the age of 28, when the body already begins to accumulate negative factors that directly affect the health of the offspring: unfavorable ecology, stress, past illnesses, etc.

And increasingly, the reproductive period is limited to only two years: after 30 years, women stop giving birth [7].

At first glance, the ultra-low birth rate is due to socio-economic problems, the disorder of the domestic sphere and other difficulties that have been shaking Russian society for more than a decade. However, demographers and sociologists who study family relations have proved that the problem of fertility is different. The main cause of modern depopulation is a change in reproductive attitudes. A modern urban family does not need a large number of children. Economically, an urban family with many children will always lose to a family with few children. Low fertility for the majority of the population is deeply ingrained in the lifestyle and value system of contemporary urban societies.

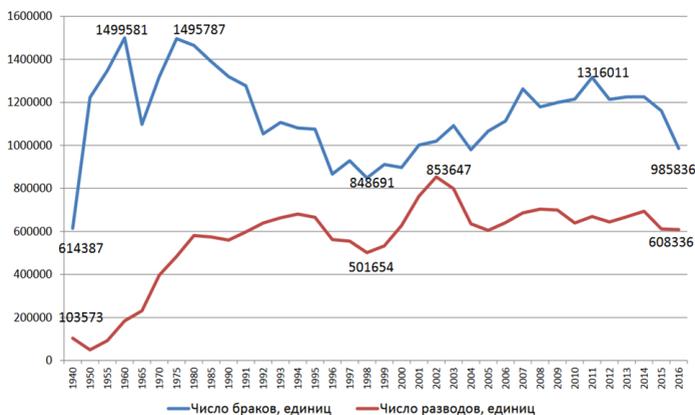
Simple reproduction of the population is ensured if the statistical indicator of 2.15 births per woman is maintained. In the last years of the existence of the USSR, this figure was 1.9, in today's Russia - 1.3. Only 7% of Russian families bring up three children or more, 28% - two, 65% - one.

### III - The institutional crisis of the family

Let's consider another problem of birth rate growth - the institutional crisis of the family.

Polls of young people demonstrate "the fading of the need of the individual and the family for children". Among single-child families only 33% want to have a second child, among two-child families only 7% think about the birth of a third, however, this declared need is not fully realized.

Until recently, Russia was dominated by a multi-generational patriarchal family with traditional moral principles. There was a sharp destruction of natural traditional ties between people: communal, tribal [6].



**Figure 2.** Statistics on the number of marriages and divorces in the Russian Federation in 1940-2016 according to Rosstat

Considering the statistics on the number of marriages and divorces in Russia from 1940 to 2016 as a percentage [8] (figure 2), it is worth highlighting the following features:

1) In the 40s, there was an average of 1 dissolution for every 6 families. Thus, the number of divorces in Russia at that time was approximately 17%.

2) In the 1950s, the situation improved markedly. During this period, the number of divorces per 1,000 marriages was approximately 120. Official statistics in Russia give an indicator for this period, indicating that about 12% of couples separate during this historical period of the country. This is one of the best indicators for the entire remaining period in Russia to this day. At this stage of the country's development, the fewest couples break up.

Further, the situation with the percentage of divorces in Russia only worsened:

3) From about 2000 to 2005, there were too few marriages - up to 1 million, and against this background, the number of dissolutions was too high. The figure ranged from 600.000 to 800.000. Thus, the termination of relations in Russia occurred in 6 or 8 cases out of 10.

4) Then the situation improved somewhat. The number of marriages peaked in 2011-2012 and amounted to more than 1.300.000. But the number of divorces during this period decreased slightly and fluctuated around the 700.000 mark.

5) Further, the statistics of termination in Russia over the years, up to 2018, remains unchanged from that moment - on average, it is about 610.000.

6) Marriage statistics since 2012 indicate that this number is steadily falling.

### **Discussion**

Thus, based on the results of the analysis of WHO official statistics and Rosstat data, ways of solving the demographic problem were outlined.

The solution of global problems is possible only with the joint efforts of the entire world community. The creation in 1969 within the framework of the United Nations of a special UN Fund for Population Activities (UNFPA) and the holding of three World Population Conferences under its auspices contributed greatly. The Fund, already at the beginning of its activity, developed the UN program in the field of population, which covered more than 100 countries and included about 1.400 projects.

A special role belongs to the Foundation for the organization and holding of World Population Conferences, held in 1974 in Bucharest, in 1984 in Mexico City and in 1994 in Cairo, at which acute population problems were considered, the most important policy documents in this area were adopted.

In some developed countries (France, Germany, Denmark, Belgium, Hungary), a policy is being pursued to increase fertility: families with two or more children are provided with good benefits and various benefits [14].

In Russia, no official statements have been made regarding the goals of demographic policy. The Government of the Russian Federation has only outlined measures to study the prospects for demographic development and to solve urgent problems of the population. A policy of social protection of families with children is being pursued, and a system of family allowances is in place.

In 2007, the “Concept of the demographic policy of the Russian Federation for the period up to 2025” was adopted [15]. There is a set of measures aimed at solving the demographic problem, such as:

1. Strengthening the institution of the family.
2. Support for large families.
3. Financial support for the family.

In Russia, small state payments are made at the birth of a child, as well as assistance for the maintenance of a child to low-income families.

In 2006, Russian President V.V. Putin adopted the Federal Law “On additional measures of state support for families with children” (N 256-FZ of 29.12.2006), which formulates a number of measures to stimulate the birth rate, including large payments for the birth of a second child [16].

4. Health measures.

One way to increase fertility could be to improve medical care for infertile women. However, due to the high cost of the in vitro procedure, it is available only to a few. Without the broad participation of the state in the financing of these procedures, their application is not capable of solving the problems of demographic decline.

Measures aimed at creating the value of a family with several children, increasing the prestige of motherhood and fatherhood, and strengthening the family are unlikely to quickly give tangible results. However, without them, it is absolutely impossible to increase the birth rate in the future (after 2025) to a level that ensures the reproduction of the population. The main directions of the demographic policy in the field of increasing the birth rate and strengthening the family are: socio-economic support for families with children, stimulation of the birth of 2 and 3 children; improving reproductive health; formation of the value of a family with several children, increasing the prestige of motherhood, fatherhood, strengthening the family.

### **Conclusion**

The main medical and demographic problems of modern Russia are the continuing natural population decline, high mortality of people of working age, and low life expectancy. The potential danger of the current demographic situation lies in the increase in the world’s population due to the increase in the birth rate in the countries of the Third World, the increase in the starving, unemployed and disadvantaged people living below the “poverty line”. Such a situation would be

fraught with deep economic, social and political upheavals both within individual countries and in the international arena.

In Russia, the demographic situation is the reverse of the world one. There is a population decline. The statistics speak of the extinction of Russians. The way out is seen in raising the standard of living of Russians and turning the state to the demographic problem. At present, work with a healthy family should become a priority, and the main task is to form a culture of a healthy lifestyle among the population. This is what will make it possible to preserve the spiritual value of the individual and, despite life's difficulties, to strengthen physical and mental health, which is so necessary for creating a healthy environment and a full-fledged family.

### References

1. *Public health and health care: textbook / V. A. Medic, V. K. Yuryev. - 3rd ed., rev. and add. - 2012. - 288 P.: ill.*
2. *Ladygina G.O. Problems of demography in the world / Articles // Demography of infertility in the world// [Electronic resource]. - URL: <https://demografiabesplodie-v-mire.ru/problemyi-demografii-v-mire.html> (Appeal date 31. 05. 2022)*
3. *Pestrikova T.Yu. and etc. Trends in the reproductive behavior of young people in the realities of the current demographic situation / Pestrikova T.Yu., Yurasova E.A., Yurasov I.V., Shmatkova A.S. // Reproductive health of children and adolescents. -2019. - Volume 15. - № 3. - P. 89 - 99.*
4. *Zakharov S.V., Ivanova E.V. What is happening with the birth rate in Russia / Russian Demographic Journal. - 2003. - №1. - P. 5-11.*
5. *Population of the Russian Federation / Demography // Statistical data of the Federal State Statistics Service [Electronic resource]. - URL:<https://rosstat.gov.ru/> (Appeal date 31. 05. 2022)*

根据出勤数据分析莫斯科和莫斯科州人口的牙齿发病率  
**ANALYSIS OF DENTAL MORBIDITY IN THE POPULATION OF  
MOSCOW AND THE MOSCOW OBLAST ACCORDING TO THE  
DATA OF ATTENDANCE**

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抽象的。关联。根据医疗机构就诊数据得出的人口牙科发病率资料对于当前和未来的牙科保健规划非常重要。尽管转诊材料通常无法全面反映人口的所谓“真实发病率”，但它们对于确定各种形式的牙科和口腔病理学门诊就诊频率绝对必不可少。

研究目的: 以大城市(莫斯科)和莫斯科州的居民为例, 评估在医疗机构寻求牙科护理的患者队伍。

材料和方法。该研究于 2018 年至 2022 年进行。评估牙科病理学患病率所需的信息是从作者专门开发的研究地图上的主要医疗文件 - 门诊卡(表格 № 043/y)中复制的, 这使得有可能分析牙科患者的各种特征, 并确定向他们提供的护理数量和质量的指标。总共研究了 9,000 多种初级会计表格, 其中包括 2,925 份深度文件, 并将数据复制到观察地图上。

结果。在研究的五年中, 在莫斯科和莫斯科州申请牙科诊所的人中, 大约四分之一是男性(23.4%), 略高于 3/4 是女性(分别为 76.6%)。这种情况再次证实了女性通常比男性更关注牙齿健康的事实。

在被调查居民登记的口腔黏膜病理结构中，两个年龄组的主要疾病是急性疱疹性口炎和慢性复发性口疮性口炎 (CRAS) 等疾病。此外，在35-44岁年龄段，白斑占很大比例。

对35-44岁居民的口腔检查结果显示，该年龄段人群的龋齿患病率为100%。根据 KPU 指数，莫斯科 35-44 岁人群的平均龋齿强度达到  $16.20 \pm 0.64$  (平均龋齿数为  $4.16 \pm 0.43$ ，填充 -  $6.55 \pm 0.51$ ，去除 -  $5.60 \pm 0.50$ )。

结论。因此，根据世卫组织专家的现有建议，就诊人群的资料，以及针对人群指标群体的特殊流行病学调查数据，为分析和评估各种指标提供了相当可靠的基础。牙科发病率，并确定人口对某种形式的牙科护理的需求。

关键词：可协商性，牙科发病率，牙科保健组织。

**Abstract. Relevance.** *Materials of dental morbidity of the population according to the data of appeals to medical institutions are very important for the purposes of current and future planning of dental care. Despite the fact that referral materials most often cannot give a complete picture of the so-called "true morbidity" of the population, they are, nevertheless, absolutely indispensable for determining the frequency of outpatient visits for various forms of dental and oral pathology.*

**Purpose of the study:** *to evaluate the contingents of patients seeking dental care in medical organizations, using the example of residents of a large city (Moscow) and Moscow Oblast.*

**Materials and methods.** *The study was conducted from 2018 to 2022. The information necessary to assess the prevalence of dental pathology was copied from primary medical documents - outpatient cards (form № 043/y) on a study map specially developed by the author, which made it possible to analyze various characteristics of dental patients and determine indicators of the volume and quality of care provided to them. In total, more than 9,000 primary accounting forms were studied, including 2,925 documents in depth with copying data onto observation maps.*

**Results.** *Among the persons who applied to dental clinics in Moscow and Moscow Oblast over the five years studied, about a quarter were men (23.4%) and a little more than 3/4 were women (76.6%, respectively). This circumstance once again confirms the fact that women are generally more attentive to their dental health than men.*

*In the structure of the pathology of the oral mucosa registered in the surveyed residents, the leading diseases in both age groups are such diseases as acute herpetic stomatitis and chronic recurrent aphthous stomatitis (CRAS). In addition, at the age of 35 - 44 years, leukoplakia occupies a significant proportion.*

*The results of dental examinations of residents aged 35-44 showed that the prevalence of dental caries in the population at this age is 100%. The average intensity of the carious process in 35 - 44-year-olds in Moscow in terms of the KPU index reached  $16.20 \pm 0.64$  (the average number of carious teeth was  $4.16 \pm 0.43$ , filled -  $6.55 \pm 0.51$ , removed -  $5.60 \pm 0.50$ ).*

**Conclusion.** *Thus, the materials of the population seeking dental care, together with the data of a special epidemiological survey of index groups of the population, conducted in accordance with the existing recommendations of WHO experts, represent a fairly reliable basis both for analyzing and evaluating various indicators of dental morbidity, and for determining the population's need for some form of dental care.*

**Keywords:** *negotiability, dental morbidity, organization of dental care.*

**Introduction**

Dental care is currently one of the most popular types of medical care, which is associated with high rates of dental morbidity in the population, both in our country and around the world [1,2,3,4].

The indicators of negotiability and attendance, both in general and in individual specialties (therapeutic, surgical receptions), characterize the work of dentists and, with the correct organization of the treatment process, are one of the most important conditions that allow establishing the relationship between the incidence of the population and negotiability for medical purposes, substantiating the multiplicity of outpatient visits for various nosological forms of dental diseases [5.6.7].

To study the activities of individual dental institutions and the dental service as a whole, data characterizing the contingents of the population seeking dental care are of undoubted interest.

**Results**

Among those who applied to dental clinics in Moscow and Moscow Oblast for the three years studied, about a quarter were men (23.4%) and a little more than 3/4 were women (76.6%, respectively). This circumstance once again confirms the fact that women are generally more attentive to their dental health than men.

An analysis of the age structure of the population who applied for dental care showed that the largest proportion of requests, namely 60.7%, falls on people under the age of 45 years. Moreover, it should be noted that the main proportion of applicants belongs to the age group of 30-39 years (Table 1).

**Table 1**  
*Distribution of residents of Moscow and Moscow Oblast who applied for dental care by gender and age (in % of the total)*

Floor	Age group							Total
	15-19 years	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years	70 and older	
Men	2,2	3,1	5,8	5,5	2,2	3,4	1,2	23,4

Women	4,0	13,2	21,2	16,0	8,1	9,8	4,3	76,6
Both genders	6,2	16,3	27,0	21,5	10,3	13,2	5,5	100,0

With the socio-hygienic characteristics of the appeal for dental care, data on the social structure of the contingents of the population who applied are of particular interest. Of the total number of those who applied for dental care, more than 2/3 were employed and students, and almost 1/3 were unemployed and pensioners.

It is characteristic that the main share is made up of persons engaged mainly in intellectual work, i.e. employees (38.7%). They are followed by pensioners (21.4%), workers (20.7%), unemployed able-bodied persons (10.0%) and students (8.4%). It is noteworthy that among the men who applied for dental care, workers prevail (Table 2).

Of great interest is the distribution of applicants according to the immediate purpose of their request for outpatient dental care (Table 3). So, for example, 3.7% of the total number of all requests are made for a preventive examination without presenting any specific complaints on their own initiative or by referral. Such a significant proportion of those who applied for prophylactic purposes is due to the fact that this group includes not only persons undergoing a preventive examination on their own initiative, but also patients referred for a dental examination by doctors of other specialties, including, if necessary, a conclusion on the sanitation of the cavity mouth.

**Table 2**  
*The social structure of the population who applied for dental care in basic medical institutions (in % of the total)*

Social group	Men	Women	Both genders
students	2,5	5,9	8,4
workers	7,4	13,3	20,7
employees	6,6	32,1	38,7
unemployed able-bodied persons	1,9	8,9	10,8
pensioners	5,0	16,4	21,4
Total	23,4	76,6	100,0

It should be noted that the majority of calls (90%) are associated with dental caries (36.8%) and its immediate complications - pulpitis (22.1%) and periodontitis (31.1%). As can be seen, the largest share in the overall structure of all reasons for the adult population to seek dental care falls on periodontitis after dental caries.

**Table 3**

*Structure of appeals of the adult population for dental care to basic medical institutions (in % of the total)*

<b>Reason for appeal</b>	<b>ICD section code - X</b>	<b>Share of individual causes (in %)</b>
Preventive purpose	V70, V72	3,7
Anomalies of teething	520	0,2
Dental caries	521	36,8
Pulpitis	522	22,1
Periodontitis	523	31,1
Gingivitis	523	0,1
Periodontitis	523	3,2
Periodontal diseases	523	0,2
Alveolitis	526	0,7
Periostitis	526, 730	0,6
Osteomyelitis	730	0,05
Stomatitis	054, 528	0,9
Phlegmon and abscesses	528, 682	0,2
Injuries of the maxillofacial region	802, 910 920, 941	0,05
Other diseases	473, 521, 523 527, 529, 683	0,1
Total		100,0

Obviously, this is to some extent due to the lack of access to dental care.

Other inflammatory diseases of the maxillofacial region (alveolitis, periostitis, osteomyelitis, abscesses and phlegmon) in the aggregate amount to only no more than 1.6%. At the same time, more than half (54.8%) of all requests of the population for dental care are caused by complications of the carious process, including pulpitis, periodontitis and various inflammatory processes of odontogenic etiology. This circumstance, taking into account a small proportion of preventive appeals, indicates that the population mainly seeks help with advanced forms of dental pathology.

Obviously, this is to some extent due to the lack of access to dental care.

It is noteworthy that, despite the high prevalence of periodontal diseases among the population, their share in the overall structure of the reasons for the population seeking dental care is small and amounts to only 3.5%. At the same time, 0.1% falls on gingivitis, 3.2% - on periodontitis and 0.2% - on periodontal disease.

Of particular interest are information about the proportion of certain reasons for seeking dental care among residents of Moscow Oblast and Moscow, depending on their gender (Table 4). So, if in women, as well as in the whole population, the first place is occupied by dental caries (38.9%), and the second - by periodontitis (28.3%), then in men, on the contrary, the main reason for visits is periodontitis (39.2%), followed by dental caries (31.5%).

**Table 4**  
*The structure of the reasons for seeking dental care in people of different genders (in % of the total)*

<b>Reason for appeal</b>	<b>Men</b>	<b>Women</b>	<b>Both genders</b>
Preventive purpose	3,8	3,4	3,7
Anomalies of teething	0,2	0,2	0,2
Dental caries	31,5	38,9	36,8
Pulpitis	18,8	23,2	22,1
Periodontitis	39,2	28,3	31,1
Gingivitis	0,2	0,1	od
Periodontitis	1,6	3,7	3,2
Periodontal diseases	0,2	0,1	0,2
Olveolitis	1,3	0,5	0,7
Periostitis	1,3	0,4	0,6
Osteomyelitis	-	0,1	0,05
Stomatitis	1,5	0,7	0,9
Phlegmon and abscesses	0,2	0,3	0,2
Maxillary injury	0,2	-	0,05
Other	-	0,1	O-
Total	100,0	100,0	100,0

As for pulpitis, both in women and in men, it firmly occupies the third place. From the numerical data given in the table, it can be seen that in men, in comparison with the representatives of the opposite gender, in general, more severe forms of dental pathology predominate.

To study the organizational aspects of outpatient care for the population, the analysis of attendance data is extremely important. This provision also applies to the dental care system. Thus, the average level of attendance at dental institutions for the study period was 0.85 per year per inhabitant of Moscow Oblast and Moscow. At the same time, the largest share of the accumulated level of visits for dental care was recorded in the age groups of 30-39 and 40-49 years (30.3% and 21.0%, respectively), who made a total of more than half (51.3%) of all visits in dental institutions.

The lowest indicators of the accumulated level of visits are noted in the two extreme age groups (15-19 years old and 70 years and older), whose representatives together account for only every 10th visit (Table 5).

**Table 5**

*Indicators of the share of individual age and gender groups of the population who applied for dental care in basic medical institutions in the overall structure of attendance at dental institutions (in % of the total)*

Gender	Age group							Total
	15-19 years	20-29 years	30 - 39 years	40-49 years	50-59 years	60-69 years	70 and older	
Men	2,7	2,6	7,7	5,0	2,6	4,7	1,3	26,6
Women	3,5	11,7	22,6	16,0	8,2	8,1	3,3	73,4
Both genders	6,2	14,3	30,3	21,0	10,8	12,8	4,6	100,0

When studying the intensity of visits for dental care, the highest frequency of attendance per one applied resident of Moscow Oblast and Moscow is noted for both men and women aged 30-39 years (respectively 2.65 and 2.14). In turn, the lowest frequency of visits was found in men aged 20-29 (1.70) and in women 70 years and older (1.55). It should be noted that, in general, the intensity of visits for men is noticeably higher than for women (Table 6).

**Table 6**

*Indicators of the average frequency of visits per year for dental care per one applicant, taking into account gender and age*

Gender	Age group							Total
	15-19 years	20-29 years	30-39 years	40-49 years	50 - 59 years	60-69 years	70 and years	
Men	2,52	1,70	2,65	1,80	2,43	2,79	2,08	2,28
Women	1,74	1,78	2,14	2,01	2,05	1,66	1,55	192
Both genders	2,02	1,76	2,25	1,96	2,13	1,95	1,67	2,01

Of undoubted interest is the determination of the number of outpatient visits per year based on one resident of Moscow Oblast and Moscow who applied for help regarding the treatment of the main forms of dental pathology. At the same time, we took into account the number of cases of treatment of a particular disease and the average frequency of visits for each case of treatment (Table 7).

According to the data obtained, the maximum value of the attendance rate per one person who applied for dental care was noted for dental caries (0.83). At the same time, the frequency of visits per case of carious tooth treatment is the lowest relative to other types of treatment (0.70). This is obviously due to the fact that in the work of dental institutions, the treatment of uncomplicated dental caries is the main part among other groups of cases of dental care.

**Table 7**

*Indicators of the average frequency of visits per year for the treatment of major dental diseases (per 1 applicant)*

Type of dental care	Number of cases treated per visitor	Number of visits per case	Number of visits per other applicant
Treatment of dental caries	1,19	0,70	0,83
Pulpitis treatment	0,22	1,92	0,42
Treatment of periodontitis	0,10	1,73	0,17
Treatment of periodontal diseases	0,03	2,64	0,08
Treatment of diseases of the mucous membrane	0,01	2,45	0,02

Treatment of inflammatory diseases of the maxillofacial area	0,02	2,71	0,05
Treatment of injuries of the maxillofacial area	0,001	2,00	0,002
Extraction of teeth	0,38	0,92	0,35

As for other types of dental care, the highest rates of frequency of visits were established per case of treatment of inflammatory diseases of the maxillofacial region (2.71) and periodontal diseases (2.64).

For the most complete study of the dental morbidity of the population, according to the data on the appealability, to a certain extent, data on the indicators of certain types of dental care provided can serve. Based on the study materials, it was found that, on average, 4.20 teeth were filled and 1.14 teeth were removed from one applied resident of Moscow Oblast and Moscow over the three years studied. Also, the following average values of cases of dental treatment fall on one applicant: dental caries - 3.57, pulpitis - 0.66, periodontitis - 0.29, periodontal disease - 0.09, diseases of the oral mucosa - 0.04, inflammatory diseases maxillofacial area - 0.07, injuries of the maxillofacial area - 0.0005. At the same time, these indicators of dental care vary in men and women (Table 8).

**Table 8**

*Dental care rates (average per visitor over five years)*

Type of dental care	Men	Women	Both genders
Treatment of dental caries	3,01±0,37	3,75±0,23	3,57±0,20
Pulpitis treatment	0,59±0,11	0,86±0,06	0,66±0,05
Treatment of periodontitis	0,36±0,07	0,27±0,03	0,29±0,03
Treatment of periodontal diseases	0,04±0,02	0,11±0,04	0,09±0,03
Treatment of diseases of the mucous membrane	0,03±0,01	0,04±0,02	0,04±0,02
Treatment of inflammatory diseases of the maxillofacial area	0,16±0,05	0,04±0,01	0,07±0,02
Treatment of injuries of the maxillofacial area	0,002	-	0,0005
Extraction of teeth	1,59±0,22	1,00±0,09	1,14±0,09

As a result of the study of the attendance data, it was found that some patients, after the initial visit to the dentist due to an exacerbation of toge or another disease, receive emergency care and subsequently come to the next appointment with the doctor. Within three years, such cases were recorded in 11.5% of residents of Moscow Oblast and Moscow who applied for dental care.

Statistical development of materials of negotiability made it possible to determine the indicators of the intensity of damage to the population by dental caries. At the same time, not only were the values of the KPU indices in the context of various groups of the adult population of Moscow Oblast and Moscow, but also an analysis of individual elements of these indicators was carried out. So, in an average resident who applied for dental care, more than half of the teeth (57.8%) were affected. At the same time, the average caries intensity factor was  $15.5 \pm 0.34$  teeth with the following structure of the KPU index:  $K = 3.4 \pm 0.14$ ,  $P = 8.7 \pm 0.23$ ,  $Y = 6.4 \pm 0.35$ . It is noteworthy that the teeth of women are more intensively affected by caries than in men (KPU  $18.8 \pm 0.37$  versus  $17.7 \pm 0.75$ ). At the same time, compared to men, women have, on average, somewhat less carious teeth ( $K = 3.2 \pm 0.16$  versus  $3.9 \pm 0.30$ ), extracted teeth ( $U = 6.4 \pm 0.41$  versus  $6.6 \pm 0.72$ ) and the number of filled teeth predominates ( $P = 9.2 \pm 0.27$  versus  $7.0 \pm 0.42$ ).

Analyzing the constituent elements of the KPU index among residents of Moscow Oblast and Moscow who applied for dental care, depending on their belonging to one or another age and gender group of the population, it should be noted that in young and middle age, the leading teeth in the structure of the affected teeth are filled teeth, and in older age groups (for men - after 50 years, for women - after 60 years), extracted teeth already begin to prevail (Table 9).

**Table 9**  
*The intensity of dental caries in different age and gender groups of the population who applied to basic medical institutions (average per 1 applicant)*

Age	Gender	KPU index	Element «K»	Element «P»	Element «U»	Proportion of affected teeth (%)
15-19 years	m	9,8±1,1	3,0±0,6	6,5±1,0	0,3±0,2	25,8
	f	11,0±1,6	4,6±1,1	5,8±1,1	0,6±0,4	34,4
20-29 years	m	11,9±1,0	3,9±0,9	6,4±1,0	1,6±0,5	37,2
	f	14,3±0,7	3,7±0,4	8,8±0,7	1,8±0,4	44,7
30-39 years	m	14,8±1,2	3,4±0,3	7,6±0,8	3,8±0,9	46,3

	f	17,8±0,7	3,3±0,3	10,2±0,7	4,3±0,5	55,6
40-49 years	m	17,4±1,2	4,6±0,8	6,9±1,1	5,9±0,9	54,4
	f	19,4±0,8	3,1±0,4	10,4±0,7	5,9±0,7	60,6
50-59 years	m	23,9±1,8	2,9±0,6	8,1±1,5	12,9±1,5	74,7
	f	21,4±0,8	3,4±0,4	10,0±0,8	8,0±0,9	66,9
60-69 years	m	24,5±1,3	4,3±0,7	6,1±1,4	14,1±1,5	76,6
	f	24,4±1,2	2,9±0,5	7,7±0,7	13,8±1,3	76,3
70 years and older	m	27,6±2,3	5,0±1,4	6,8±2,0	15,8±2,5	86,3
	f	27,0±1,6	2,4±0,4	6,8±1,1	17,8±1,8	84,4
Total	m	17,5±0,8	3,9±0,3	7,0±0,4	6,6±0,7	4,7
	f	18,8±0,4	3,2±0,2	9,2±0,3	6,4±0,4	58,8

### Discussion

Taking into account the deterioration in the health status of the adult population of Moscow and the Moscow Oblast, both in general for the main somatic diseases and for dental diseases, the article carried out an in-depth study of the appeals of the population of Moscow for dental care and obtaining information that allows us to evaluate in terms of age, gender and social aspects:

- indicators of the population seeking dental care for three calendar years;
- the number of visits made about certain diseases for therapeutic and prophylactic purposes;
- the value of indicators of the intensity of the carious process (according to the KPU index) and the level of dental care (according to the USP index);
- the frequency of various complications during the first year after the treatment of dental diseases.

With the socio-hygienic characteristics of the appeal for dental care, data on the social structure of the contingents of the population who applied are of particular interest. Of the total number of those who applied for dental care, more than 2/3 were employed and students, and almost 1/3 were unemployed and pensioners.

Of undoubted interest is the determination of the level of dental care among the population of Moscow Oblast and Moscow according to the data on the appealability. With the help of average KPU coefficients and information about the number of carious teeth (element "K") and teeth removed, but not replaced by a prosthesis, age-gender indices of the level of dental care (USP) were calculated

according to the method described in the second chapter of this dissertation. Attention is drawn to the fact that in no age-gender group of the population the value of the USP index will allow it to be assessed as “good”. In general, as in the vast majority of age and gender groups, this indicator is assessed as satisfactory. At the same time, it should be noted that the lowest level of dental care was recorded in men in the age range of 60-69 years, and the USP indicator in this case is assessed only as “insufficient”.

### Conclusion

Thus, the optimization of patient flows, the redistribution of resources in the health care industry as a whole and in the provision of dental care at its various levels from the high-cost inpatient stage to the primary health care sector, the reduction in cases of temporary and permanent disability as a result of optimizing the activities of the system of medical rehabilitation of patients will contribute to improving the quality of dental care provided to the population and will lead to the optimization of public spending both on the actual operation of the health care system and on the provision of specialized dental care.

### References

1. Ganshin I. B., *quality control System of specialized medical care. Natural and technical Sciences.* 2013; (1): 126-128.
2. Gabrielyan A. R. *Health care in a market economy. Demand, supply and market structures in health care. Social aspects of public health [electronic scientific journal]* 2013; 34 (6). URL: <http://vestnik.mednet.ru/content/view/522/30/lang EN/> (accessed 26.04.2014)
3. Hanshin I. B., Gelenberg L. V. *the Study of domination in the relationship doctor – patient. Medical Sciences.* 2013; (6): 19-20.
4. Zhigareva N. P ... Filatkina N. In. *Physical culture and health environment in the system of rehabilitation of disabled people. Medical and social expertise and rehabilitation of children with disabilities.* 2010: (1); 12-15.
5. Zhigareva N. P ... Filatkina N. In. *Social and cultural environment as a component of rehabilitation space in a psychoneurological boarding school. Medical and social expertise and rehabilitation of children with disabilities.* 2010: (3); 13-16.
6. Zhigareva N. P., Filatkina N. In. *Social indicators of the group of disabled persons for their rehabilitation. Medical and social expertise and rehabilitation of children with disabilities.* 2010: (3); 57-59.
7. Stasevich N. Yu. Lassky I. A. *the Role of medical-organizational and economic technologies in assessing the quality of medical care and improving health. Social*

*aspects of public health [electronic scientific journal] 2015; (5). URL: <http://vestnik.mednet.ru/content/view/708/30/lang,ru/> (accessed 20.10.2015).*

8. Storozhenko, D. V., Filatkina.B. *Characteristics of the professional qualities of nurses working in inpatient social protection rehabilitation profile. Medical and social problems of disability. 2014: (2); 70-73.*

9. Terekhov A. N. *The history of social work: Textbook / ed. by Matveeva L. P. Novikov, A. D. Ed. 2-e ISPR. and DOP. – M.: Thought. 2006; 304.*

10. Filatkina N. *In. Modern approaches to the organization of the nurse in a neuropsychiatric boarding school as part of a polyprofessional team. Mental health. 2014: (3); 9-11.*

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使用辅助生殖技术评估妊娠期间妊娠并发症发展的预测实验室小组  
**PREDICTIVE LABORATORY PANEL FOR ASSESSING THE  
DEVELOPMENT OF GESTATIONAL COMPLICATIONS DURING  
PREGNANCY WITH THE USE OF ASSISTED REPRODUCTIVE  
TECHNOLOGIES**

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抽象的。 这篇文章调查和分析了广泛的血液流变学和止血参数，以开发一个实验室参数的预测小组，以评估使用辅助生殖技术（ART）进行妊娠的患者发生妊娠并发症的风险。

**Abstract.** *The article investigates and analyzes a wide range of parameters of hemorheology and hemostasis in order to develop a predictive panel of laboratory parameters to assess the risk of developing gestational complications in patients whose pregnancy occurred using assisted reproductive technologies (ART).*

### **Introduction**

In the structure of gestational and obstetric complications of pregnancy that occurred with the use of ART, a significant role belongs to a complex of fac-

tors, including hemorheology disorders, dysregulation of the parameters of the hemostasis system, endothelial dysfunction with a decrease in its antithrombotic properties [Davison J.M., Homuth V., Jeyabalan A. New aspects in the pathophysiology of preeclampsia. *J. Am. Soc. Nephrol.* 2014; 15: 2440–2448; Yakovleva O. V., Glukhova T. N., Rogozhina I. E. Basic principles of pregnancy management after assisted reproductive technologies. *Medical Bulletin of the North Caucasus.* 2020;15(1):140-145. DOI – <https://doi.org/10.14300/mnnc.2020.1503>]. The pathology associated with increased blood clotting and metabolic disorders during pregnancy, which occurred with the help of ART, is heterogeneous and represents an interconnected set of problems, the most important of which are complications of gestation associated with thrombophilia [Vermeij B. G., Buchanan A., Chambers G. M., Kolibianakis E. M., Bosdou J. [et al.]. Are singleton pregnancies after assisted reproduction technology (ART) associated with a higher risk of placental anomalies compared with non-ART singleton pregnancies? A systematic review and metaanalysis. *BJOG.* 2018;12;

American College of Obstetricians and Gynecologists. Perinatal risks associated with assisted reproductive technology. Committee Opinion No. 671. *Obstet. Gynecol.* 2016;128:61-68.]

Normal pregnancy is accompanied by several mechanisms of adaptation: an increase in blood volume, cardiac output, a decrease in peripheral vascular resistance and blood viscosity and is determined by the state of angiogenesis, the production of angiogenic factors that control the growth, development and regression of blood vessels, as well as stimulate the proliferation of cells and tissues [Sergeeva O.N., Chesnokova N.P., Ponukalina E.V., Rogozhina I.E., Glukhova T.N. Pathogenetic relationship between endothelial dysfunction and disorders of blood coagulation potential during pregnancy complicated by the development of preeclampsia. *Herald of RAMS.* 2015; 70 (5): 599–603. Doi: 10.15690/vramn.v70.i5.1448]. Neuroendocrine changes during stimulation of superovulation in the IVF cycle create additional conditions for the formation of blood flow disorders with changes in the rheological and hemostasiological properties of blood, morphofunctional characteristics of formed elements and hemodynamic parameters, which can be the main factor determining the inadequacy of implantation of a fertilized egg, transformation of spiral arteries and placentation and create pathogenetic basis for the high risk of developing major gestational complications and reproductive losses. [Heimrath J, Paprocka M, Czekanski A, et al. Pregnancy-induced hypertension is accompanied by decreased number of circulating endothelial cells and circulating endothelial progenitor cells. *Arch Immunol Ther Exp (Warsz).* 2014; 62 (4): 353–356]. Simultaneously with the violation of the coagulation system, a change in the rheological properties of the blood occurs, as a result, a single chain of positive feedback is created according to the type of a

vicious circle. Violations of microcirculation and rheological properties of blood, coagulation, anticoagulant and fibrinolytic systems represent the unity of mutually activating each other nonspecific processes that increase with hyperestrogenism.

Of particular importance is the violation of hemorheology in pregnant women after in vitro fertilization (IVF) due to the fact that hormonal stimulation of superovulation is an additional powerful activating factor in triggering thrombus formation against the background of hypercoagulation shifts. [Grigorieva K.N., Bitsadze V.O., Khizroeva D.Kh., Tretyakova M.V., Ponomarev D.A., Tsvetnova K.Yu., Doronicheva D.A., Mamaeva A.R., Mekhedova K.V., Rizzo D., Gris J.-K., Elalami I., Makatsaria A.D. Clinical significance of the determination of ADAMTS-13, its inhibitor and von Willebrand factor in obstetric and gynecological practice. *Obstetrics, Gynecology and Reproduction*. 2021;15(1):93–106. <https://doi.org/10.17749/2313-7347/ob.gyn.rep.2021.203>.] A serious problem is gestational complications against the background of the pathology of the immune system, metabolic disorders, genetically determined and acquired thrombophilic conditions, pathology of the reproductive system due to inflammatory genesis, leading to chronic hypoxia and fetal retardation processes. [Kirakosyan E.V., Lundup A.V., Alexandrov L.S., Demchenko A.G., Ishchenko A.I., Nikonov A.P., Bokarev M.I., Berishvili M.V., Budnikova K.A., Proklova G.F., Zholobova M.N. Prospects for the use of cellular technologies in the treatment of female infertility. *Issues of gynecology, obstetrics and perinatology*. 2020. V. 19. № 4. P. 146-158.]

Despite the accumulated knowledge, there is a need to develop a personalized laboratory examination algorithm with the identification of the most significant indicators and the determination of their threshold levels to assess the risk of developing gestational complications in patients whose pregnancy occurred using assisted reproductive technologies (ART). This will allow the formation of risk groups for patients with the possibility of developing gestational complications that require enhanced monitoring and additional therapeutic measures.

**Purpose of the study:** To identify changes in hemorheology and hemostasis parameters, the characteristic ranges of their deviations in the first trimester of pregnancy that occurred with the use of ART, and to assess their significance in predicting the risk of gestational complications.

#### **Materials and methods**

The study included 97 patients with a singleton pregnancy that occurred using ART, including 32 women whose pregnancy occurred using donor oocytes; 30 women whose pregnancy occurred with the use of donor eggs under the program “Surrogate motherhood”; 35 women who got pregnant using their own eggs. To identify the most significant laboratory parameters for assessing the development of gestational complications, all patients were divided into groups II according to their presence (n=61; 62%) and absence (n=36; 38%).

Taking into account the waves of trophoblast invasion, the attendance of patients for screening examinations, 3 points of clinical examination were selected: I trimester (7-8 weeks; II trimester (19-21 weeks); III trimester (30-34 weeks). In order to assess the significance of laboratory indicators and to study the relationship of their levels with the development of gestational complications at the selected terms, all patients underwent a comprehensive clinical, instrumental and detailed laboratory examination - in the first trimester of pregnancy [order of the Ministry of Health of the Russian Federation dated November 1, 2012 No572n “On approval of the Procedure for the provision of medical care in the field of obstetrics and gynecology”; Clinical guidelines “Preeclampsia. Eclampsia. Edema, proteinuria and hypertensive disorders during pregnancy, childbirth and the postpartum period” LLC “Russian Society of Obstetricians and Gynecologists” (RSOG) 2020; Miscarriage in early pregnancy: diagnosis and management. Clinical guidelines (approved by the Russian Ministry of Health). Laws, codes and regulations of the Russian Federation; 2016]. Drug antithrombotic preparation for IVF programs was carried out taking into account the parameters of the hemostasis system, differentiated depending on the presence, form of thrombophilia and its severity. Low molecular weight heparin (LMWH) preparations were used, which were prescribed starting from the fertile cycle and used in the process of ovulation stimulation. Doses were selected individually, taking into account the levels of hemostasis parameters, platelet aggregation activity and the woman’s weight. Depending on the platelet aggregation activity, acetylsalicylic acid (ASA) preparations were prescribed in parallel at a dose of 50–75 mg once a day. All women were prescribed vitamins, polyunsaturated fatty acids and antioxidants. Following international recommendations for the use of LMWH in ovulation stimulation programs, in order to minimize hemorrhagic complications during egg collection, no LMWH injection was performed on the days of the ovarian puncture and embryo transfer procedure; antithrombotic prophylaxis LMWH resumed 12 hours after the procedure [Pfeifer S, Butts S, Dumesic D, Fossum G, Gracia C, La Barbera A, et al. Prevention and treatment of moderate and severe ovarian hyperstimulation syndrome: a guideline. *Fertil Steril.* 2016 Dec;106(7):1634–47; Ovarian Hyperstimulation Syndrome: A Narrative Review of Its Pathophysiology, Risk Factors, Prevention, Classification, and Management. *Iran J Med Sci.* 2018 May;43(3):248–60]. If pregnancy was confirmed, prophylactic anticoagulant therapy was continued. The diagnosis of gestational diabetes mellitus was established in accordance with clinical guidelines. [Funnell MM, Brown TL, Childs BP, Haas LB, Hoseney GM, Jensen B, et al. National standards for diabetes self-management education. *Diabetes care.* 2009;32(Supplement 1):S87–S94. - PMC – PubMed; Russian Association of Endocrinologists. Russian Society of Obstetricians and Gynecologists. Clinical guidelines. Gestational diabetes. — 2016 ]

**Laboratory examination:**

The concentration of hemoglobin (Hb, g/l), hematocrit (Ht, %), the number of erythrocytes ( $10^{12}/l$ ), leukocytes ( $10^9/l$ ), platelets ( $10^9/l$ ) was studied on an automatic hematological analyzer Nihon Konden MEK-7222 (Nihon Konden, Japan). The erythrocyte sedimentation rate (ESR, mm/h) was measured by the Panchenkov method. The rheological characteristics of erythrocytes were studied on a LOR-RCA laser optical erythrocyte aggregometer (Mechatronics, the Netherlands). We measured the amplitude of aggregation (Amp) c.u., the time of formation of coin columns (Tf) sec. and three-dimensional aggregates (Ts) sec., aggregation index (AI) c.u., rate of complete disaggregation (Y-dis) c.u. – a parameter reflecting the force required for the destruction of erythrocyte aggregates and the deformability of erythrocytes (DI<sub>max</sub>) c.u. The aggregation ability of platelets in citrated blood plasma was studied on a Biol aggregometer (Russia) according to the standard scheme by the turbidimetric method (according to G. Born). Adrenaline at a final concentration of 2 mmol/l (Adr-AT, Technology-Standard, Russia), ADP at a final concentration of 1  $\mu$ mol/l (ADP-AT, RENAM, Russia), collagen at a final concentration of 0.18 mg were used as inducers. /ml (KOL-AT, RENAM, Russia). Fibrinogen concentration g/l (FG) according to the Claus method, D-dimer (ng / ml), plasminogen activity (PLG%), proteins C (PC%), S (PS%), alpha2-antiplasmin, coagulation factors VIII, XII (%), von Willebrand factor (VWF %) was determined on an automatic coagulometer ACL Elite Pro (Instrumentation Laboratory, USA) using reagents from the same manufacturer. ADAMTS-13 ( $\mu$ g/l), tissue plasminogen activator (t-PA ng/ml) and tissue plasminogen activator inhibitor (PAI-1 ng/ml) were studied in blood plasma by ELISA method (sandwich-type variant) on a plate ELISA reader Real-best (Russia) using Technoclone reagent kits (Austria).

Statistical data processing was performed using the KNIME software using the GraphPad Prism v.8.4 and JASP v.0.13 programs. Parameters without missing values were selected for analysis. The median (Md) and the values of 25% of the lower and 75% of the upper quartiles (Q 25%-75%) were used. Groups were compared using the Kruskal-Wallis test followed by pairwise comparisons according to Mann-Whitney. Pearson's correlation analysis was used to assess the relationship between indicators. Risk analysis was carried out according to the chi-square test ( $\chi^2$ ) using contingency tables and odds ratio calculation.

**Results and discussion**

The presence and types of gestational complications in patients with IVF are presented in table 1

**Table 1.**  
*Gestational complications in patients of the study group*

	<b>n (%)</b>
<b>Gestational complications</b>	<b>n=61 (62%)</b>
The threat of abortion in the I trimester	44(72,1)
The threat of abortion in the II trimester	24(39,3)
Threatened preterm labor in the III trimester	45(73,7)
Isthmic-cervical insufficiency	23 (37,7)
Preeclampsia	15 (24,6)
Severe preeclampsia	6 (9,8)
Gestational arterial hypertension (GAH)	31 (50,8)
Gestational diabetes mellitus	6 (9,8)
Fetal growth retardation syndrome (FGR)	17(27,8)
Cholestasis	7 (11,5)
Oligohydramnios	7 (11,5)
Polyhydramnios	5 (8,1)
Premature placental abruption	8 (31)

To identify the most informative potential biomarkers associated with the development of gestational complications, we compared the studied parameters between groups of patients (table 2.)

**Table 2**  
*The level of statistically significantly different laboratory parameters in patients with and without gestational complications*

<b>Groups Parameters</b>	<b>I Group with gestational complications (n=61)</b>	<b>II Group without gestational complications (n=36)</b>	<b>Group comparison, p</b>
	(Md; Q)	(Md; Q)	
clotting factor VIII, %	188,0 [179,3;192,1]	121,0 [106,3; 134,5]	0,000
Erythrocyte deformability (Dlmax)	0,39 [0,31;0,42]	0,47[0,38;0,54]	<b>0,000</b>

<i>Fibrinogen g/l</i>	4,1[3,3;5,2]	3,6[3,2;4,1]	0,009
D-dimer, ng/ml	468,0 [350,7;515,7]	224,0 [199,2;284,6]	<b>0,000</b>
<i>t-PA, ng/ml</i>	3,2[2,1;4,5]	9,4[6,9;,7]	<b>0,000</b>
<i>PC (%)</i>	68,0 [55,6; 76,2]	84,3 [65,6; 93,9]	<b>0,008</b>
<i>PLG (%)</i>	80,2 [76,1;82,3]	129,4 [101,5;142,8]	<b>0,000</b>
<i>VWF % antigen</i>	162,6 [144,7;179,1]	136,6 [122,2;155,1]	<b>0,006</b>
<i>ADAMTS-13 µg/l</i>	1,49 [1,26;1,73]	1,95 [1,7;2,2]	<b>0,000</b>
ADP-AT %	45,3[38,1;61,3]	35,4 [24,6;43,3]	<b>0,001</b>
Qty-AT%	66,5[58,3;71,1]	47,6[39,8;56,4]	0,001

Pearson's correlation analysis made it possible to identify the most significant laboratory parameters determined in the first trimester of pregnancy in predicting the development of gestational complications in patients whose pregnancy occurred using ART (Table 3). It follows from the table that the following indicators studied in the first trimester make the greatest contribution to the prognosis of the development of gestational complications: fibrinogen, coagulation factor VIII, erythrocyte deformability, t-PA, VWF antigen, ADP-AT, Collagen-AT, D-dimer, plasminogen, protein C, ADAMTS-13.

**Table 4**

*Pearson's correlation analysis of laboratory parameters in the first trimester of pregnancy with the development of gestational complications in patients whose pregnancy occurred using ART*

<b>Indicator</b>	<b>Pearson correlation coefficient, r</b>
Fibrinogen, g/l	<b>0,560**</b>
clotting factor VIII, %	<b>0,530**</b>
Erythrocyte deformability (Dlmax)	<b>-0,510**</b>
t-PA ng/ml	<b>-0,500**</b>
VWF % antigen	<b>0,460**</b>
ADP-AT %	<b>0,391**</b>
Qty-AT %	<b>0,354**</b>
D-dimer, ng/ml	<b>0,376*</b>

PLG (%)	-0,292*
PC (%)	-0,310**
ADAMTS-13	-0,320**

**Note:** \* – statistical significance level  $p < 0,05$ ; \*\* – statistical significance level  $p < 0,01$ .

The predictive value of using laboratory parameters to assess gestational complications was assessed using ROC analysis, which established thresholds for the above parameters at optimal sensitivity and specificity (table 5)

**Table 5**

*Threshold values of laboratory indicators for assessing hemostasis in the first trimester of pregnancy with the development of gestational complications in patients whose pregnancy occurred using ART*

Indicator	Threshold	Sensitivity	Specificity
Fibrinogen concentration, g/l	4,9	82%	74%
Coagulation factor VIII, %	171	85%	85%
t-PA ng/ml	1,9	84%	86%
VWF % antigen	177	75%	66%
ADP-AT %	51	79%	75%
Qty-AT %	55	75%	73%
D-dimer, ng/ml	510	77%	82%
PLG (%)	70,5	73%	65%
PC (%)	75	76%	63%
ADAMTS-13	1,1	70%	61%
Erythrocyte deformability, DImax, c. u.	0,41	76%	71%

The results of the ROC analysis were used to build a predictive model for assessing the development of gestational complications (Table 6).

**Table 6**

*Characteristics of the predictive model for assessing the development of gestational complications*

Predictors	B	r	OS	Lower limit 95% DI	Upper limit 95% DI
Fibrinogen concentration, g/l	1,344	0,004	8,326	4,583	12,384
Coagulation factor VIII, %	1,145	0,011	7,821	3,937	10,691

t-PA ng/ml	0,645	0,016	6,351	3,455	10,646
VWF % antigen	1,244	0,022	5,850	3,046	7,538
ADP-AT %	0,987	0,017	5,203	2,978	7,126
Qty-AT %	1,145	0,003	4,029	2,764	7,875
D-dimer, ng/ml	0,256	0,012	4,005	2,598	7,139
PLG (%)	0,678	0,011	2,950	1,588	5,896
PC (%)	1,244	0,022	2,852	0,967	5,533

**Note:** V – the factor by which the predictor value is multiplied to calculate the linear function of the exponent in calculating the probability of an event occurring.

The significance and adequacy of the pooled laboratory score predictive model for diagnosing the development of gestational complications was assessed by ROC analysis and determined to have a sensitivity of 87% and a specificity of 85% at the above threshold levels of indicators.

The widespread introduction of ART, a fairly high level of qualification of reproductologists and embryologists, makes it possible to increase the number of IVF cycles every year [Analysis of the results of early prenatal screening in the Russian Federation AUDIT – 2019. Information and reference materials. MZRF letter № 15-4/2963-07 dated 11.10.2019]. The increase in the number of cycles and the accumulation of medical experience has led to the accumulation of information about the problems of ART. According to various authors, pregnancy resulting from the use of ART belongs to the high-risk category and is characterized by an increased incidence of spontaneous abortion and obstetric complications [Korsak VS, Smirnova AA, Shurygina OV. Reproduction problems 2019, V. 25, No6, P. 9-21; Dodd J. M., Grivell R. M., O'Brien C. M., Dowswell T., Deussen A. R. Prenatal administration of progestogens for preventing spontaneous preterm birth in women with a multiple pregnancy. *Cochr. Datab. Syst. Rev.* 2017;10:CD012024.]. The social significance of early prediction of the risk of gestational complications is undeniable. The issue of identifying laboratory factors for the prognosis of these complications requires further comprehensive study using accumulated knowledge in various fields of medicine and modern technologies. Cooperation between specialists in the field of gynecology and laboratory diagnostics can significantly increase the possibility of adequate diagnosis and pathogenetic prevention of various complications in pregnant women after IVF.

Thus, when managing pregnant women after IVF programs, an individual approach to each patient, a thorough analysis of anamnestic data, and a comprehensive thorough laboratory examination are required to determine the degree of risk of developing gestational complications and the need for additional examination and treatment.

库尔斯克州法医精神科医生的情绪倦怠  
**EMOTIONAL BURNOUT AMONG FORENSIC PSYCHIATRISTS  
IN THE KURSK OBLAST**

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Kursk State Medical University of the Federal agency of  
public health and social development*

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抽象的。 文章介绍了库尔斯克州法医精神病学资料中医务人员的健康数据。介绍了情绪倦怠综合征 (EBS) 的触发因素、个人因素、角色因素和组织病因。介绍了在库尔斯克州的法医精神病学家中发现 EBS 表现的研究结果。

关键词: 倦怠综合征, 法医精神科医生, 触发因素

**Abstract.** *The article presents data on the health of medical workers of the forensic psychiatric profile of the Kursk Oblast. Trigger, personal, role and organizational etiological factors of emotional burnout syndrome (EBS) are presented. The results of studies in which manifestations of EBS were revealed in forensic psychiatrists of the Kursk Oblast were presented.*

**Keywords:** *burnout syndrome, forensic psychiatrists, trigger factors*

### **Introduction**

The development of society, despite progress, inevitably leads to the emergence of negative consequences (urbanization, acceleration of the pace of life, information overload), which in general can be considered as a stressful situation, which leads to an increase in neuropsychic stress and the emergence of borderline forms of neuropsychic pathology [1,2].

The main risk group for the development of burnout syndrome are representatives of socioeconomic professions, in particular those who are directly faced with the suffering of other people and, due to their professional duty, are obliged to provide assistance.

Burnout Syndrome (EBS) has been the subject of many studies, but this issue continues to be more relevant than ever. According to the World Health Organization (WHO), an average of 42% of physicians report symptoms of EBS [1,2].

The first mention of burnout syndrome dates back to 1974, when the American psychologist Herbert Freidenberger introduced it to describe the processes of demoralization, frustration and extreme fatigue observed by him in psychiatric workers [1,2,5,6,7]. The World Health Organization (WHO) defines “burnout syndrome” as physical, emotional or motivational exhaustion, characterized by impaired work productivity and fatigue, insomnia, increased susceptibility to somatic diseases [5,6,7].

Burnout is to a greater extent not a scientific construct, but a functional stereotype that combines both the consequences of prolonged work stress, the causes and consequences of a professional crisis, and ways to achieve rational and economical use of energy resources [1,2].

If its dysfunctional consequences occur, “burnout” negatively affects the performance of professional activities.

The ambiguity and multi-competence of EBS for quite a long time made it very difficult to study this phenomenon due to the lack of adequate measuring tools [5.6.7].

V.V. Boyko is one of the founders of the development of this topic in Russian psychology [3]. Emotional burnout according to V.V. Boyko is defined as a psychological defense mechanism developed by a person in the form of a complete or partial exclusion of emotions in response to psycho-traumatic influences [3,4]. In the case of violations in the functioning of this form of a protective reaction to stress factors, professional deformation of the personality may occur.

There are 3 groups of factors influencing the development of the burnout syndrome in professions of the “man-to-man” type: personal, role-playing and organizational [8,9]. EBS trigger factors in forensic psychiatric specialists are: a tendency to emotional rigidity, perfectionism, increased responsibility for the functions and operations performed; work in the mode of tight external and internal control, high moral and legal responsibility, psychologically difficult contingent, the need to carefully perceive, intensively memorize and quickly interpret information, quickly weigh alternatives and make decisions [9].

**The purpose of this study** is to investigate the prevalence of EBS among forensic psychiatrists of the Kursk Oblast.

#### **Materials and methods**

Our study involved 14 forensic psychiatrists-experts of both sexes from the Kursk Psychiatric Hospital. Both outpatient and inpatient doctors were examined.

Inclusion criteria:

- informed consent to participate in the survey;
- average age of study participants  $38.33 \pm 8.08$  years;
- duration of professional work experience  $22.3 \pm 0.6$  years.

Exclusion criteria:

- refusal to participate in the study.

For the study, a questionnaire was used by the domestic scientist V.V. Boyko, who developed his own methodology for diagnosing emotional burnout, consisting of 84 questions that allow diagnosing the phases of development of this emotional burnout syndrome (tension, resistance, exhaustion) [3,4]. Each phase is diagnosed on the basis of its four characteristic symptoms. Symptoms with indicators of 20 or more points are dominant in the phase or in the entire syndrome of "emotional burnout". The technique allows you to see the leading symptoms of "burnout". The results obtained were subjected to mathematical analysis. The arithmetic mean was calculated, the significance of differences was calculated using the Mann-Whitney test.

### **Research results**

A survey of forensic psychiatrists of the Kursk Oblast of doctors revealed signs of professional maladaptation in 37.3% of doctors, among them the proportion of doctors with a high qualification category was 44.3%. Signs of EBS of varying severity were found in 69.7% of respondents. Psychosomatic and psychovegetative disorders were diagnosed in 21% of forensic psychiatrists.

Different resistance to this syndrome was determined depending on age and length of service. Among forensic psychiatrists aged 37-43 years with a long work experience of 15-23 years, moderate levels of reactive and high levels of personal anxiety were diagnosed. At the same time, higher rates of burnout were found among psychiatrists working in hospitals, and not in outpatient settings.

### **Conclusions**

Thus, all of the above confirms the need:

- conducting a study on the implementation in practice of the provisions of the Concept of personnel policy in the health care of the Russian Federation, which, in particular, refers to the need to maintain optimal relationships between employers and employees based on compliance with the law, ensuring a fair wage system, social protection of workers, and creating favorable industrial relations and a healthy climate, ensuring labor protection and other conditions that have a positive impact on the quality of work and the quality of life of employees;
- creation of effective work in medical institutions of the human resource management service, the list of duties of which should include, among other things, the prevention of the development of professional burnout syndrome among employees of medical institutions.

## References

1. *Bashenkova, L.A. Diagnostics of the syndrome of emotional burnout and measures aimed at its prevention / L.A. Bashenkova, E.V. Kukharskaya // Secondary vocational education. – 2015. – №11. – P. 43 – 48.*
2. *Berdyayeva, I.A. Burnout syndrome in doctors of various specialties / I.A. Berdyayeva, L.N. Voight // Far Eastern Medical Journal. – 2012. – №2. – P. 117-120.*
3. *Boyko, V.V. Methods for diagnosing the level of emotional burnout / V.V. Boyko // “Practical Psychodiagnostics”, ed. Raigorodsky D.Ya., Samara, 1999, P.161-169.*
4. *Boyko, V.V. Burnout syndrome in professional communication. St. Petersburg: SPbSU, 2009. – 278 P.*
5. *Bulgakova, O.S. Medicine: social, psychological, psychophysiological and physical health of physicians in conditions of chronic occupational stress (XXI century) / O.S. Bulgakov, D.S. Parkhomchuk, D.V. Saveliev, T.A. Ulyanov // SPb. Publishing house Publ.: NPC PSN. – 2019, 288 P.*
6. *Bulgakova, O. S., Parkhomchuk D. S., Ulyanov, T. A. Burnout syndrome among physicians as a sign of profession (review article) // Bulletin of psychophysiology. – 2020. – № 1. – P. 9-20.*
7. *Bulygina, S. I. Emotional burnout among doctors / S. I. Bulygina, E. A. Bulygina, I. A. Dubova // Multidisciplinary hospital. – 2019. – V. 6. – № 1. – P. 12-13.*
8. *Bulygina, V. G. Risk factors for burnout syndrome among employees of forensic psychiatric services: Guidelines. /V.G. Bulygina, T.G. Anisimova // M: FSBI “The Serbsky State Scientific Center for Social and Forensic Psychiatry” Serbian Ministry of Health of the Russian Federation, 2012.*
9. *Bulygina V.G., Petelina A.S. Emotional burnout among specialists in general and forensic psychiatric practice (analytical review) / V.G. Bulygina, A.S. Petelina // Russian Psychiatric Journal. – 2013. – № 6. – P. 24-30.*

透明质酸联合富血小板血浆治疗膝关节骨性关节炎的积极作用  
**POSITIVE EFFECT IN THE KNEE JOINT OSTEOARTHRITIS  
TREATMENT WITH HYALURONIC ACID IN COMBINATION  
WITH PLATELET-RICH PLASMA**

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抽象的。在过去的十年中，医学界对使用富含血小板的血浆（以下简称 PRP）治疗大关节骨性关节炎的兴趣显著增加。这是由于其绝对安全的有效性、相当低的成本以及不依赖制药公司的供应。这种生物技术方法已在牙科、眼科、美容、心脏病学、燃烧学中使用了大约 30 年。在过去的十年中，创伤科医生和骨科医生开始积极使用 PRP 治疗肌肉、肌腱、韧带损伤和骨性关节炎。我们建议将 PRP 与透明质酸结合用于膝关节骨性关节炎的关节内注射，考虑到糖胺聚糖的特殊流变特性，允许形成具有显著粘弹性和显著成纤维细胞迁移的基质，作为主要的胶原蛋白来源。

关键词：富含血小板的血浆，透明质酸，再生，创伤学，骨科，骨关节炎，膝关节。

**Abstract.** *There has been a significant increase in interest in the treatment of large joints osteoarthritis using platelet-rich plasma (hereinafter referred to as PRP) in the last decade in medicine. This is due to its effectiveness with absolute*

*safety, a fairly low cost, and lack of dependence on the pharmaceutical companies supply. This biotechnological method has been used in dentistry, ophthalmology, cosmetology, cardiology, combustiology for about 30 years. In the last decade traumatologists and orthopedists have begun to actively use PRP for the treatment of muscles, tendons, ligaments injuries, and osteoarthritis. We proposed to combine PRP with hyaluronic acid for intra-articular injections in the knee osteoarthritis, taking into account glycosaminoglycan special rheological properties, allowing the formation of a matrix with pronounced viscoelastic properties and pronounced fibroblasts migration which serve as the main collagen source.*

**Keywords:** *platelet-rich plasma, hyaluronic acid, regeneration, traumatology, orthopedics, osteoarthritis, knee joint.*

### **Introduction**

One of the most common joint diseases in the orthopedist practice is osteoarthritis, a degenerative-dystrophic disease characterized by primary degeneration of hyaline cartilage, followed by a change in the articular surfaces and the osteophytes development which leads to joint deformation. It is the most common joint disease today, affecting at least 20% of the world's population. The manifestation of the disease occurs at the age of 40–50 years, coinciding with the menopause onset in women. About 10-14% of patients with osteoarthritis are registered among the population of all age groups. Their number is 27.1% over 50 years, and 97% in the age group over 60 years [4].

Currently, four main methods of intra-articular injections are used in the treatment of the knee osteoarthritis: glucocorticosteroids, hyaluronic acid, PRP, autologous mesenchymal stem cells. Surgical interventions can be used in patients who do not benefit from conservative therapy: arthroscopic method, corrective osteotomy or joint arthroplasty [9]. Of course, the patient tries to avoid or delay the surgical method of treatment, and the doctor's task is to help him in this.

PRP is the patient's blood plasma, with an increased number of platelets up to 1,600,000 /  $\mu\text{l}$ , while normally plasma contains 200-350 thousand platelets in 1  $\mu\text{l}$  [2]. Platelets are a natural source of growth factors and cytokines, which attract other cells to the damage site, thereby accelerating the regenerative processes in damaged tissues. Growth factors are human body natural proteins which can stimulate the growth, proliferation and differentiation of cells. They include:

**TGF $\beta$ 1** Transforming Growth Factors Beta

**PDGF** Platelet Growth Factors

**IGF1** Insulin-like Growth Factors

**FGF1** Fibroblast Growth Factors

**EGF** Epidermal Growth Factor

**VEGF** Vasculoendothelial Growth Factor [8].

All these factors affect the damaged cartilage. An important PRP functional property is its ability to activate fibroblasts, which, in turn, stimulate the synthesis of type II collagen and prostaglandin, increasing the chondrocyte proliferation intensity and matrix production. As a result of stimulation of synovocytes, the secretion of hyaluronic acid increases, which stimulates high-quality angiogenesis and reduces the interleukin-I level, decreasing inflammation and tissue repair time [11]. PRP also contains angiogenesis inhibitors (endostatin, fibronectin, PF4,  $\alpha$ 2-macroglobulin, etc.) which limit excessive angiogenesis, according to the negative feedback mechanism [5]. Pain reduction is provided by the suppression of inflammation, which is the leading indicator of the growth factors action in the application of PRP [3]. In fact, blood plasma has anti-inflammatory and analgesic effects comparable to those of corticosteroid drugs [6].

Hyaluronic acid (hereinafter referred to as HA) is a unique glycosaminoglycan, which plays an important role in tissue hydrodynamics, cell migration and proliferation, due to its high content in extracellular matrices. The participation of HA in the processes of tissue repair and regeneration, cell differentiation, morphogenesis, angiogenesis, and inflammation has been confirmed at the present time. With intra-articular administration HA improves joint congruence, reducing friction by maintaining the synovial fluid viscosity, HA is an important component of hyaline cartilage, in which it is present as a shell of each cell (chondrocyte), it also starts regeneration processes, inhibits the granulocytes, macrophages, and peripheral blood lymphocytes migration, without reducing the fibroblasts and epithelial cells activity [10]. When HA binds to aggrecan monomers in the binding protein presence, large negatively charged aggregates are formed in the cartilage that absorb water, which ensures the cartilage elasticity and its resistance to compression.

According to the literature, PRP and HA do not have a negative effect on each other [12], on the contrary, the addition of HA to PRP has a stronger anti-inflammatory effect and significantly accelerates regeneration processes, compared to the separate use of both HA and PRP, which increases the procedure efficiency by several times and increases the clinical results duration [1].

**Purpose:**

Development of a technique for obtaining and administering platelet-enriched plasma stabilized by gluconate mixed with hyaluronic acid in the knee joint osteoarthritis, evaluating the effectiveness and safety of this method.

**Materials and methods:**

As part of a scientific study, for 2 years we have treated 42 patients (27 men and 15 women) aged 32 to 64 years with knee osteoarthritis grades 2-3 according to Kellgren & Lawrence. To obtain PRP, venous blood is taken into a syringe, with a pre-filled 1.5 ml of anticoagulant, using a butterfly needle in an amount of 15 ml. The patient's blood in the syringe is first mixed with 8-shaped movements,

after which, using a needle, it is transferred to the YCELLBIO-KIT test tube and cooled for 40 minutes at a temperature of +4°C. Then it is subjected to double centrifugation in a rotary centrifuge, the speed of 3400 rpm. As a result, the leukocyte-platelet layer (hereinafter referred to as LTL) moves into the test tube narrow isthmus, from which the LTL is taken using a needle, which is a platelet-rich plasma with the stabilized calcium gluconate help (contains about 1,000,000 - 1,600,000 platelets per 1 µl). Mixing with a low molecular weight fraction of HA was carried out by means of a convector before intra-articular injection. The resulting substance was injected into the knee joint. The patient after the procedure excluded additional physical activity for 3 days. The procedure was repeated after 7-10 days two or three times, depending on the osteoarthritis manifestation severity. At the end of the therapy course, the patient returned to full physical activity after 10-14 days and continued to play sports.

As a result, we received a decrease in pain on the next day after the procedure, a decrease in the pain severity on the 5th day, and joint function restoration within 4 weeks.

We used the WOMAC scale to assess the objectivity of specific symptoms and limit the knee joint function. The average score on the WOMAC scale was 72 points prior to the treatment start. According to the observation results, it was noted that in 34 out of 42 patients the improvement in the joint functional state according to the WOMAC scale averaged from 18 to 26 points after the first intra-articular injection and during the 1st week, and in 6 out of 42 patients - 35 and 41 points, respectively. After 3 months, the WOMAC score averaged 23 points, even in those patients who had only a slight decrease in pain in the first week after the course. After 6 months from the end of the treatment course, this indicator reached 32 points. Only pain in the joints remained when walking up the stairs, after a long walk (more than 2 hours), and also after intensive work in the garden in most patients.

### **Conclusions:**

Our data showed that the effectiveness of the PRP and HA combination intra-articular administration with proper preparation was determined in patients from 32 to 64 years old. The study showed that intra-articular administration of this combination is a safe and at the same time effective method for the treatment of the knee joint osteoarthritis of 2-3 degrees according to Kellgren & Lawrence, it contributes to the rapid pain relief, stiffness reduction, joint function improvement, and a significant functional tests improvement. All this has a positive effect on the patient's life quality and delays the arthroplasty term. The use of this treatment method is becoming a promising direction in the orthopedist's work.

## References

1. Bennell K, Hunter D, Paterson K. Platelet-rich plasma for the management of hip and knee osteoarthritis. *Curr Rheumatol Rep.* 2017;19-24. <https://doi.org/10.1007/s11926-017-0652-x>.
2. Foster T, Puskas B, Mandelbaum B, Gerhardt M, Rodeo S. Platelet-rich plasma. *Am J Sports Med.* 2009; 37:2259-2272. <https://doi.org/10.1177/0363546509349921>
3. Moussa M, Lajeunesse D, Hilal G, el Atat O, Haykal G, Serhal R. Platelet rich plasma (PRP) induces chondroprotection via increasing autophagy, anti-inflammatory markers, and decreasing apoptosis in human osteoarthritic cartilage. *Exp Cell Res.* 2017;352:146-156.
4. Martini A. Single Platelet-Rich Plasma Injection for Early Stage of Osteoarthritis of the Knee. *Joints.* 2017;5:2-6.
5. Achkasov EE, Bezuglov EN, Ulyanov AA, Kurshev VV, Repetyuk AD, Egorova ON. The use of autoplasm enriched with platelets in clinical practice. *BIOMEDICINE.* 2013;1(4):46-59. (In Russ.)
6. Zagorodny GM, Mukha PG, Yasyukevich AS, Gulevich NP. Domestic and foreign experience in the use of PRP-therapy in medicine and sports practice. *Applied sports science.* 2017;4:83-91. (In Russ.)
7. Klimovitsky VG, Soloviev IA. The use of platelet-rich plasma in the treatment of soft tissue injuries. *Injury.* 2015;16(6):77-80. (In Russ.)
8. Kontorshchikova KN, Shakhova KA, Yanchenko OS, Tikhomirova YR, Bulat VV, Bulat AV. Determination of platelet growth factors in non-platelet-rich plasma. *Medical almanac.* 2018;2(53):41-44. (In Russ.)
9. Lisitsyn MP, Zaremuk AM, Lisitsyna EM, and Atlukhanov RY. The use of platelet-rich autoplasm in the treatment of gonarthrosis. *Endoscopic surgery.* 2020;26(6):49-62. (In Russ.)
10. Ryabinin SV, Samoday VG. The use of autologous platelet-rich plasma in the treatment of gonarthrosis. *Prakticheskaya Meditsina.* 2018;16(6):190-194. (In Russ.)
11. Chesnikov SG, Rosenberg DV, Timoshenko ME, Dedyayev SI. Experience of PRP-therapy in the treatment of patients with gonarthrosis. Publishing house: Federal scientific and clinical center for specialized types of medical care and medical technologies of the Federal medical and biological Agency. M. 2018. (In Russ.)
12. Halimov EV, Savelev SN, Halimov AE, Nuriev RF, Ochkurenko AA. «Possibilities of using platelet-rich autoplasm in the treatment of osteoarthritis of the knee joint». *Vestnik travmatologii i ortopedii im. N.N. Priorova.* 2016;23-27. (In Russ.)

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牙医对诊断为“根尖周组织疾病”患者治疗中临床建议的认识问卷调查结果  
**THE RESULTS OF THE QUESTIONNAIRE OF AWARENESS OF  
DENTISTS ABOUT CLINICAL RECOMMENDATIONS IN THE  
TREATMENT OF PATIENTS DIAGNOSED WITH “DISEASES OF  
PERIAPICAL TISSUES”**

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抽象的。对在萨马拉地区城市和农村地区工作的专科医生进行了一项调查，分析了牙医在治疗被诊断为“根尖周组织疾病”的患者时对临床建议（CR）的认识结果。

关键词：牙医问卷，临床建议，根尖周组织疾病。

**Abstract.** *A survey of specialist doctors working in cities and rural areas of the Samara region was conducted, and the results of awareness among dentists about Clinical recommendations (CR) in the treatment of patients diagnosed with “Diseases of periapical tissues” were analyzed.*

**Keywords:** *questionnaire of dentists, Clinical recommendations, diseases of periapical tissues.*

**Relevance.** To implement the Federal Law “On Amendments to Article 40 of the Federal Law “On Compulsory Medical Insurance in the Russian Federation” and the Federal Law “On the Basics of Protecting the Health of Citizens in the Russian Federation” on Clinical Guidelines” dated December 25, 2018 N 489-FZ, which from January 1, 2019 regulates the provision of medical care on the basis of Clinical Recommendations, it is necessary to determine the level of theoretical training of specialist doctors according to protocols treatment and, therefore, willingness to comply with this law.

**The purpose of the study** is to conduct a survey on the awareness of dentists about Clinical recommendations in the treatment of patients diagnosed with “Diseases of periapical tissues”.

**Material and research method.** The study was conducted on the basis of state medical organizations of the dental profile of the Samara region. In order to analyze the level of awareness of dentists about Clinical recommendations in the treatment of patients diagnosed with “Diseases of periapical tissues” (Fig. 1), a questionnaire was compiled, on the basis of which a survey-questionnaire of 80 specialist doctors was conducted. The selection of respondents for the questionnaire was carried out using a targeted sample.

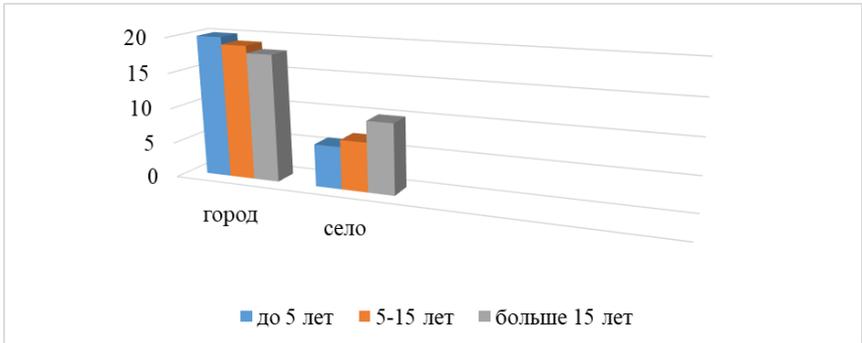


*Figure 1. Clinical recommendations (treatment protocols) for the diagnosis of Periapical tissue disease (Approved by Resolution No. 18 of the Council of the Association of Public Associations “Dental Association of Russia” dated September 30, 2014, updated on August 2, 2018)*

The questionnaire contained 17 questions and consisted of 2 blocks: the 1st block contained questions about the work experience of a dentist and the place of work. The 2nd block of questions is compiled in accordance with Clinical recommendations (treatment protocols) for the diagnosis of “Diseases of periapical tissues”.

#### **Results of the study.**

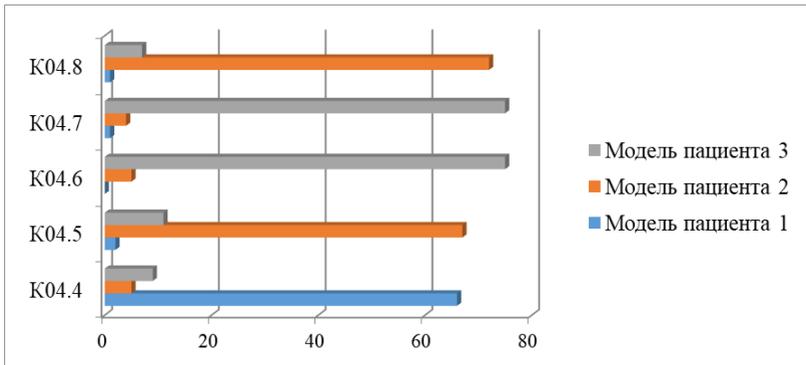
Analysis of questionnaires, questions of the 1st block showed that out of the total number of surveyed specialist doctors, 71.25% work in urban clinics, and 28.75% in rural areas. Dentists have different work experience in dentistry: among the surveyed doctors in the cities, 35.09% have been working for less than 5 years, 33.33% from 5 to 15 years, the remaining 31.58% have been working for more than 15 years (Fig. 2). Respondents were distributed on a gender basis: in the clinics of the cities, women - 66.67%, men - 33.33% and, accordingly, women - 65.22%, men - 34.78% in the rural areas.



**Figure 2.** Work experience as a dentist-therapist / general dentist

It should be noted that to the question “Do you know on which resource the current version of the “Clinical Guidelines” was published, 50.88% of the 57 dentists working in cities answered “yes” and in the village out of 23 respondents - 26.09%.

The analysis of 80 questionnaires testified to certain patterns, awareness of dentists in the treatment of patients according to clinical recommendations. The questions “Criteria and signs that determine the model of a patient diagnosed with K04.4, K04.5, K04.6, K04.7, K04.8” were answered correctly by respondents of cities and villages - within 91.4% and 81.4% of cases, respectively (Fig. 3).



**Figure 3.** Criteria and signs that determine the model of a patient diagnosed with K04.4, K04.5, K04.6, K04.7, K04.8

On the issue “The multiplicity of the implementation of medical and diagnostic measures without fail and more than once in clinical recommendations”,

doctors specialists of the city and village adhere to treatment protocols in 70.18% and 56.52% of cases, respectively. To the question “The following set of actions applies to mandatory diagnostic manipulations before endodontic treatment with the diagnosis of “Periapical tissue diseases include the following set of actions”, dentists of the city and village adhere to clinical recommendations: 89.47% and 60.87% of cases, respectively. It should be noted that the X-ray examination of the causative tooth is performed by almost all dentists “according to the algorithm”. To the question “Quality criteria for the obturation of root canals in the diagnosis of “Diseases of periapical tissues”, urban respondents in 42.19% of cases fulfill the requirements of the CR, and dentists working in the village in 57.12% of cases do not adhere to the CR. Drug therapy with antibacterial and anti-inflammatory effects in the diagnosis of K04.8, according to the protocol, is prescribed by 78.95% of dentists in cities, and in the village drug therapy is prescribed in more than 50% of cases as needed.

Analyzing the answers to the 15th question: “Restoration of the anatomical shape of the crown part of the tooth after endodontic treatment with the diagnosis of “Diseases of periapical tissues” with the destruction of the occlusive surface of the tooth (IROPZ) according to V.Y. Milikevich more than 0.8”, we can conclude that the majority of dentists in cities and rural areas strictly adhere to the treatment protocol for the CR - 64.91% and 52.17% of cases, respectively. Restoration of the anatomical shape of the crown part of the tooth after endodontic treatment with the diagnosis of “Diseases of periapical tissues” with the destruction of the occlusive surface of the tooth (IROPZ) according to V.Y. Milikevich less than 0.4” meet the requirements of the CR respondents of cities - 68.42% of cases and villages - 52.17% of cases.

After the endodontic treatment with the diagnosis of “Diseases of periapical tissues” in terms of dynamic monitoring of the cured tooth, 20 respondents do not adhere to the Clinical Recommendations, of which: city - 9 people out of 57, village - 11 people out of 23.

Thus, based on the results of the survey-questionnaire of dentists, it can be concluded that the majority of doctors in their work adhere to the requirements of the CR (treatment protocols). The awareness of specialist doctors on the protocols for the treatment of patients diagnosed with “Diseases of periapical tissues” in accordance with the CR leads to positive dynamics both in the immediate and long-term observation periods after the treatment.

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真皮移植后第23天缺血性皮肤创面活检肉芽组织细胞的超微结构特征  
**ULTRASTRUCTURAL CHARACTERISTICS OF GRANULATION  
TISSUE CELLS OF BIOPSIES OF ISCHEMIC SKIN WOUND  
ON THE 23RD DAY AFTER DERMAL TRANSPLANTATION  
EQUIVALENT**

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概括。缺血性长期不愈合皮肤缺损的治疗仍然是一个重要的医学问题。目的是在将具有异种成纤维细胞的真皮等效物移植到缺血性皮肤伤口后第 21 天研究再生组织成分的超微结构特征。材料与方法。该研究是在 24 只 C57/B1 系的成熟小鼠上进行的，这些小鼠在标准条件下保存在饲养箱中。将动物分为对照组和实验组，每组12只。在两组小鼠中，通过手术在肩胛间区域形成了缺血性伤口。在对照组中，伤口未经治疗而愈合。在实验组中，将皮肤相当于 1 型胶原蛋白和异种成纤维细胞移植到伤口中。在伤口愈合的第 23 天，进行了活检。在 UMPP-7 超薄切片机（乌克兰）上制备超薄切片，并在 Selmi 电子显微镜下以 125 kV 的电压加速度进行研究。在带有照相机的 OLYMPUS C5050Z 光学显微镜下进行组织切片的显微镜检查。结果。在移植具有异种成纤维细胞的真皮等效物后，在小鼠中发现了具有高功能活性迹象的特化双核成纤维细胞，以及通常的特化单核成纤维细胞。结论。细胞可塑性被认为是生物学的一项基本特性，这使得在循环功能不全的背景下实现广泛组织缺陷的愈合成为可能。

关键词：缺血性皮肤伤口，异种成纤维细胞，真皮等效物，再生。

**SUMMARY.** *The treatment of ischemic long-term non-healing skin defects is still an important medical problem. The aim was to study the ultrastructural characteristics of the regenerative histion components on the 21th day after transplantation of a dermal equivalent with xenofibroblasts into an ischemic skin wound. Material and methods.* The study was performed on 24 mature mice of the C57/B1 line, which were kept in a vivarium under standard conditions. Animals were divided into control and experimental groups of 12 animals each. In mice of both groups, an ischemic wound was formed by surgery in the interscapular region. In the control group, the wound healed without treatment. In the experimental group, a dermal equivalent of type 1 collagen and xenogenic fibroblasts was transplanted into the wound. On the 23rd day of wound healing, a biopsy was obtained. Ultra-thin sections were prepared on a UMPP-7 ultratome (Ukraine) and studied under a Selmi electron microscope at a voltage acceleration of 125 kV. Microscopic examination of histological sections was performed under an OLYMPUS C5050Z light microscope with a camera. **Results.** The presence of specialized binuclear fibroblasts with signs of high functional activity was found, along with the usual specialized mononuclear fibroblasts in mice after transplantation of a dermal equivalent with xenogenic fibroblasts. **Conclusion.** Cellular plasticity is presented as a fundamental property of biology, which makes it possible to achieve healing of extensive tissue defects against the background of circulatory insufficiency.

**Keywords:** *ischemic skin wound, xenofibroblasts, dermal equivalent, regeneration.*

**Introduction.** Healing of ischemic long-term non-healing skin defects is still an important medical problem [1]. For this purpose, many different medical, physiotherapeutic and surgical methods have been proposed and applied with varying degrees of success, both in isolation and in various combinations [1]. At the present stage of the development of medicine, attempts are being made to stimulate the regenerative potential in chronic wounds of the skin with the help of tissue technologies by both introducing functionally active fibroblasts into the wound and tissue-engineered structures with these cells [2]. In a chronic wound, the first phase of the wound process – the phase of inflammation is usually delayed and then signs of all three phases of the wound process may be present at the same time [3]. The search for ways to reduce the duration of inflammation revealed that dermal fibroblasts are a source of adiponectin, which acts as an active anti-inflammatory cytokine and induces the production of anti-inflammatory factors such as IL-10 and IL-1RA [4]. The papillary layer of the dermis is formed by loose unformed connective tissue, where type 1 collagen is the main component of the intercellular substance, and fibroblasts are the main cell pool, mainly responsible

for its biosynthesis and remodeling. The creation of an artificial construct based on these main components, the dermal equivalent, was an important step in the treatment of long-term non-healing ischemic wounds, which makes it possible to perform a skin defect and create optimal conditions for the proliferation and functioning of the main cellular elements of the regenerative skin histion [5]. However, information about the ultrastructural features of the cellular elements of this histion against the background of transplantation of the dermal equivalent is rare and rare, which determines the relevance of the study.

The aim of the study was to study the ultrastructural characteristics of the regenerative histione components on the 23rd day after transplantation of the dermal equivalent into an ischemic skin wound.

### **Material and methods**

The study involved 24 individuals of four – to six-month-old mice of the C57/B1 line, which were kept in the vivarium of the FSAOU VO “V. I. Vernadsky KFU”. The animals were divided into a control and experimental group of 12 individuals each. The experiments were carried out in compliance with all the principles of humanity contained in the Directive of the European Community (86/609/EC), and in accordance with the “Rules for performing work involving experimental animals”. Mice in both groups were surgically formed a cutaneous ischemic wound in the scapular region [6]. For the experimental group, dermal fibroblasts were obtained enzymatically and cultured in DMEM F12 (Lonza) medium. Cells of the third passage with the CD44+CD90+CD105+CD73+CD45+CD31-CD34-CD45 phenotype were used to form a dermal equivalent. The dermal equivalent was prepared on the basis of collagen of the first type from rat tails. A sterile 0.34M NaOH solution was combined with concentrated (x10) nutrient medium 199 in a ratio of 1:1. The resulting mixture was combined with a cooled type I collagen solution, after which a suspension of fibroblasts in the amount of 1.33 million cells was added in a DMEM F12 nutrient medium containing 10% embryonic serum (HyClone). The resulting mixture was incubated at 37°C in an incubator until the gel was completely polymerized [7]. The finished tissue-engineered construct was transplanted into the skin ischemic wound of mice of the experimental group [7].

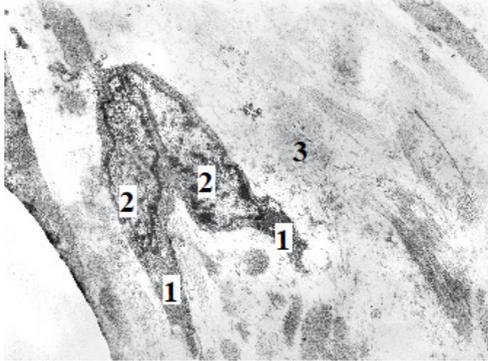
On the 23rd day after surgery, the resulting scar was intraoperatively excised in mice of all groups and fixed with glutaraldehyde on a phosphate buffer. Preparation of the material for ultramicroscopic examination was carried out according to the standard methodology. Ultrathin sections were made on the UMTP-7 ultratome (Ukraine), painted with toluidine blue, contrasted with lead citrate and uranyl acetate. Ultrathin sections were studied in an electron microscope “Selmi” (Ukraine) at an accelerating voltage of 125 kV.

Morphological examination of semifine sections was carried out using the OLIMPUS CX-31 light-optical microscope with the OLIMPUS Z5050Z digital cam-

era. The area of sections, the area of cells and their number in the dermis of biopsies were measured using the ImageJ program with an increase of 40 lens and 10 eyepiece for 50 measurements in each group. The obtained digital data (expressed in pixels) were converted to microns by dividing pixels by coefficients specially derived for this purpose: lenses x10 – 6379251, x40 – 98911797. Statistical processing of digital data was carried out using licensed MS Office Excel 2007 software, an analytical package of the STATISTICA Enterprise application (StatSoft Inc., USA), using the capabilities of the STATGRAPH 5.1 program (Microsoft, USA). The arithmetic mean and standard error of the mean were calculated. To compare the two samples, the Mann-Whitney criterion with a significance level of  $p=0.05$  was used.

### **Results and discussion**

On the 23rd day of healing of the model ischemic wound, the process of morphological differentiation of the epidermis and its slight thickening continues without treatment. The thickness of the epithelium averages  $62.32 \pm 0.12$  microns (Table 1). It has four layers peculiar to thin skin, but the stratum corneum is still very poorly developed. The ingrowth of epithelial strands into the granulation tissue to be treated, which could be regarded as the laying of skin derivatives, is not visible. The border between the epidermis and the future dermis is smooth, without papillae. The basement membrane of the epidermis is well developed. Granulation tissue at this age completes the process of fibrosation and consists mainly of thick bundles of collagen fibers without a clear orientation with respect to the basement membrane. For the entire depth of the biopsy that performed the defect of the skin, the granular tissue has the same morphology. The bundles of fibers are relatively tightly packed. Cells and blood vessels are rarely found between the fibers. The average area occupied by collagen fibers, as well as blood vessels, is shown in Table 1. The vessel wall has one layer of endothelial cells on the underlying basement membrane. The cellular composition of the biopsy is represented by fibroblastic differon cells and cells of hematogenic origin. During transmission electron microscopic examination, fibroblasts with two elongated oval nuclei are present in the central sections of the biopsy in loose fibrous connective tissue (Figure 1). Their cytoplasm forms three processes: two proximal, directed backward, and one distal, directed forward. The structure of the nuclei is dominated by euchromatin, while marginal heterochromatin forms extended areas along the periphery of the nuclei, and karyotypic heterochromatin looks like lumps discretely scattered in expanded areas. Nuclear pores are isolated and poorly visible on this magnification. Numerous nuclear courtyards in the form of smooth invaginations are visible on the surface of the nuclei. This structure of the nuclei is typical for active

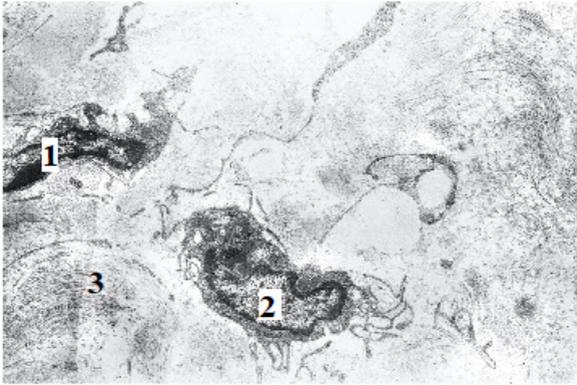


**Figure 1.** Control group. Biopsy on the 23rd day after surgery. Active binuclear fibroblast with processes in the central areas of the biopsy on the 23rd day of repair. Electronic micrography. 1 – fibroblast; 2 – nucleus; 3 – collagen fibrils. Magnification:  $\times 4000$ .

functionally mature fibroblasts at the stage of intensive biosynthesis. The latter is confirmed by a well-developed membrane system of the granular endoplasmic network, which is located in an unpaired process and alternates with groups of vacuoles, the most numerous in two paired processes. A feature of these vacuoles is the homogeneous structure of the contents of a non-osmophilic nature, which makes it possible to define these zones as sites of intracellular stages of fibrillogenesis, in contrast to hollow vacuoles with small seals in the unpaired proximal process, which, apparently, reflect the process of resorption of intercellular matter. Clusters of free ribosomes are visible in the cytoplasm of the processes. In the upper part of the slice, the artifact is a hole in the epoxy resin, however, a large accumulation of collagen protofibrils is clearly visible on its border, as well as between the processes and at the top of the slice. It should be noted that the stages of extracellular fibrillogenesis are noticeable around the proximal processes. Some bundles of collagen fibers are arranged longitudinally, others transversely, indicating a different modality of collagen biosynthesis around fibroblasts. The amorphous component is also noticeable, the predominance of which is observed from the distal side of the binuclear cell.

The same research method detects intercellular interactions of the macrophage of loose fibrous connective tissue with fibroblasts (areas with a nucleus and processes of which are visible on the slice) (Figure 2). This is the active form of the macrophage, as indicated by the developed lysosomes, lamellopodia, phagolysosomes, euchromatin, heterochromatin in the nucleus and the presence of nuclear pores and nuclear courtyards. Near the macrophage, a zone of destruction is noticeable – resorption of collagen and matrix fibers, which is noticeable as

empty non-electron-dense areas. Matrix components are visualized in macrophage phagolysosomes. There are no large clusters of collagen fibers in the area of action of the macrophage, collagen fibers are located above and below this zone, undulating along the orientation vectors of fibroblast bodies and processes, one of which is visible from below the macrophage and has pronounced heterochromatin, active processes, free ribosomes and mitochondria in the cytoplasm. Another process of another fibroblast actively contacts the lamellopodia of the macrophage and contains a structured cytoplasm and vacuoles, but the nucleus of this cell did not get into the slice. Another couple of processes are observed on the periphery.



**Figure 2.** Control group. Biopsy on the 23rd day after surgery. Active fibroblast and macrophage with multiple processes in the central areas of the biopsy on the 23rd day of repair. Electronic micrography. 1 – fibroblast; 2 – macrophage; 3 – collagen fibrils; 4 – fibroblast processes. Magnification: x2000.

Intercellular interactions in the area of cell interaction are less dense, which is explained by the action of enzymes and indicates the processes of remodeling of loose connective tissue.

On the 23rd day after transplantation of the dermal equivalent with xenogenic b fibroblasts into a model wound in mice of the experimental group, the thickness of the emerging epidermis covering the healing ischemic wound is on average  $121.22 \pm 1.15$  microns (see Table. 1), which is  $48.73 \pm 0.02\%$  more than in the control group. All four layers characteristic of thin skin are present: basal, spiny, granular and horny. The stratum corneum is thin. On the periphery of the wound there are bookmarks of skin derivatives – wool. The basis of the biopsy is the granulation tissue of the third stage of the wound process. Thick bundles of collagen fibers are most densely packed in the subepidermal region. In the deep layers of the biopsy, the architectonics of collagen fibers are looser. The area of collagen

fibers in relation to the area of the dermis is  $28.28 \pm 0.01\%$  larger compared to the control, vascularization is poorer by  $35 \pm 0.01\%$ .

Figure 3 shows a cell that resembles an active mature fibroblast in structure, as indicated by deep pointed invaginations in the nucleus, especially intense from the side of a large process. Heterochromatin clusters with well-defined nuclear pores are also present. In this case, the nucleolus is not visually determined. Euchromatin predominates in the nucleus. Two globular clusters of more than corresponding to karyotypic heterochromatin. All of the above points to a high level of protein synthesis and metabolism, especially on the part of the cell process. In the cytoplasm of the cell and

**Table 1**

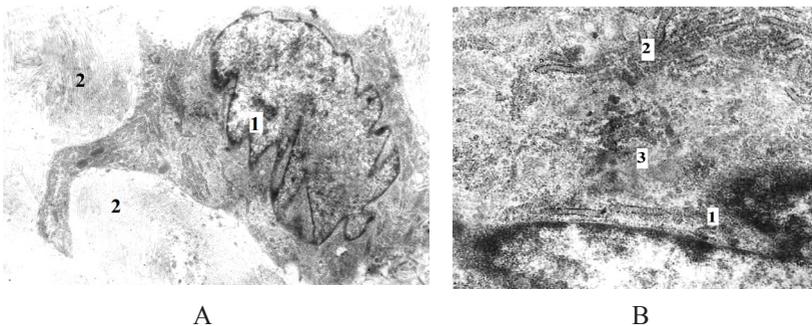
*Thickness of the epidermis, area of vessels and collagen fibers in biopsies of an ischemic skin wound without treatment and after transplantation of the dermal equivalent with xenofibroblasts on the 23rd day of its healing*

The day after the operation	The thickness of the epidermis in microns	The area of vessels in the dermis in %,	The area of collagen fibers in the dermis in %
Control group			
23-and	$62.32 \pm 0.12$	$1.06 \pm 0.04$	$55.39 \pm 0.19$
Experimental group			
23-and	$121.22 \pm 1.15$	$0,689 \pm 0.03$	$77.23 \pm 0.23$

the process, numerous membranes of the granular endoplasmic network, free ribosomes and the Golgi complex, which is located closer to the invaginations of the nucleus, are determined (Figure 5A). Groups of free ribosomes and membranes of the granular endoplasmic network are visible nearby in the cytoplasm. Distally, mitochondria and clusters of peroxisomes and lysosomes can be seen, which are located close to the plasmalemma. In the expanded part of the fibroblast process (see Fig. 4 and Figure 5B), mitochondria and a powerful membrane system of the granular endoplasmic network are noticeable, and the distal part, along with the endoplasmic network, also contains structures similar to lysosomes and peroxisomes. The described cell actively synthesizes proteins and participates in the processes of catalytic reactions, releasing proteolytic enzymes, which corresponds to an active fibroblast in the zone of remodulation or reconstruction of connective tissue. The latter is confirmed by active intracellular fibrillogenesis noticeable in the proximal lower part of the cell and numerous groups of collagen protofibrils around the cell, some of which are cut longitudinally and some transversely. In addition, it is possible to notice the zone of remodulation, where the action of

enzymes is directed, by the characteristic fibrinolysis and reorganization of the matrix. This site is located opposite the zones of pointed invaginations of the nucleus in the cell.

In our previous studies, we found the presence of binuclear active fibroblasts on the 12th day of healing of an ischemic model skin wound on the back of mice after transplantation of xenogenic dermal fibroblasts [8]. This paper describes the presence of binuclear fibroblasts on the 23rd day of healing of a skin defect in a similar experiment. A number of researchers agree that when organs and tissues are damaged, there is such a phenomenon as plasticity, which consists in the fusion of mesenchymal stem cells with target organ cells [9]. Recent studies have revealed the heterogeneity



**Figure 3.** Fibroblast in the central part of the biopsy on the 23rd day after transplantation of the dermal equivalent with xenogenic fibroblasts. Electronic micrography. A – Pointed invaginations in the nucleus (1) surrounded by collagen fibers (2) Magnification:  $\times 4000$ . B – A fragment of a fibroblast with a pointed invagination of the nucleus surrounded by collagen fibers in the central part of the biopsy. 1 – invagination of the nucleus; 2 – granular endoplasmic network; 3 – Golgi complex. Magnification:  $\times 6000$ .

and plasticity of dermal fibroblasts inside the skin, which has implications for skin diseases and tissue engineering [10]. Summing up our research, we can say that there is currently no general view on the plasticity of stem cells in the scientific community, however, it is hardly possible to deny the existence of mechanisms that allow stem cells to overcome epigenetic barriers and change their fate either by differentiating into different pools of cells, or as a result of direct exposure to the cellular environment or other signals. According to this kind of ideas, at least two conditions are required for the manifestation of plasticity *in vivo*: first, certain factors secreted by the damaged organ are necessary, which mobilize stem cells (i.e. cause the release of stem cells from their natural niches in the body and enter

the bloodstream) and promote their migration towards the damaged organ and its subsequent colonization. One of these factors is probably the SDF-1 factor [11].

In any case, the presence of specialized binuclear fibroblasts with signs of high functional activity, along with the usual specialized single-core fibroblasts in mice after transplantation of the dermal equivalent with xenogenic fibroblasts, is a very interesting fact not described earlier. Cellular plasticity is presented as a fundamental property of biology [10], which makes it possible to achieve the healing of extensive tissue defects against the background of circulatory insufficiency.

### Conclusion

On the 23rd day of healing of the model ischemic skin wound in mice after transplantation of the dermal equivalent with dermal xenofibroblasts, the thickness of the regenerate epidermis was  $48.73 \pm 0.02\%$  greater than in the control group. In the epidermis, all layers of multilayer flat non-corneal epithelium are present, but in the control group, the granular and horny layers are very thin. Skin derivatives are present on the periphery of the wound only in the experimental group. The basis of the dermis of the scar is granulation tissue at the remodeling stage. In the granulation tissue of the experimental group, along with mature fibroblasts, there are binucleated specialized functionally active fibroblasts. The area of collagen fibers is  $28.28 \pm 0.01\%$  larger compared to the control, and the vascularization of scarring ischemic skin defect is  $35 \pm 0.01\%$  less.

### References

1. Glukhov A.A., Aralova M.V. *Pathophysiology of long-term non-healing wounds and modern methods of stimulation of the wound process.* – *News of surgery*, 23(6):673-679, 2015.
2. Meleshina A.V., Bystrova A.S., Rogovaya O.S., Voroteliak E.A., Vasiliev A.V., Zagaynova E.V. *Tissue-engineered skin constructs and the use of stem cells to create skin equivalents (review).* *Modern technologies in medicine*, 9(1):198-218, 2017.
3. Glukhov A.A., Aralova M.V. *Glukhov A.A., Aralova M.V. Patofiziologiya dlitel'no nezazhivayushchikh ran i sovremennyye metody stimulyatsii ranevogo protessa.* *Novosti khirurgii*, 23(6):673-679, 2015.
4. Esfahani M, Movahedian A., Baranchi M. *Adiponectin: An adipokine with protective features against metabolic syndrome.* *Iran J Basic Med Sci.*, 18:430-442, 2015.
5. Meleshina A.V., Bystrova A.S., Rogovaya O.S., Vorotelyak Ye.A., Vasil'yev A.V., Zagaynova Ye.V. *Tkaneinzhenernyye konstrukty kozhi i ispol'zovaniye stvolovykh kletok dlya sozdaniya kozhnykh ekvivalentov (obzor).* *Sovremennyye tekhnologii v meditsine*, 9(1):198-218, 2017.

6. Baranovskiy Yu.G., Il'chenko F.N., Shapovalova Ye.Yu. *Sposob modelirovaniya troficheskoy yazvy u laboratornykh myshey v opytnoy modeli. Vestnik neotlozhnoy i vosstanovitel'noy khirurgii.* 1(2):259-261, 2016.

7. Yuditseva N.M., Samusenko I.A., Blinova M.I., Pinayev G.P. *Dermal'nyy ekvivalent na osnove fibrina i vosstanovleniye soyedinitel'noy tkani v rezul'tate yego transplantatsii na rany eksperimental'nykh zhyvotnykh. Autologichnyye stvolovyye kletki: eksperimental'nyye issledovaniya i perspektivy klinicheskogo primeneniya / Pod redaktsiyey V.A. Tkachuka. – M.: Litterra, 2009:209-221.*

8. Shapovalova Y.Yu., Morozova M.N., Boyko T., Dem'yanenko S.A., Baranovsky Y.G., Barsukov N.P., Baranovsky A.G. *Allogenic fibroblasts in collagen-based dermal equivalent change ultramicroscopic characteristic of the cells of granulation tissue by the 12<sup>th</sup> day of the healing of cutaneous wound against the background of hemodynamic insufficiency. Adv. Biores., 11(1): 51-6, 2020.*

9. Paksa A., Rajagopal J. *The epigenetic basis of cellular plasticity. Wiley Interdiscip Rev Dev Biol., 7(2), 2018.*

10. Roh J.L., Lee J., Kim E.H., Shin D. *Plasticity of oral mucosal cell sheets for accelerated and scarless skin wound healing. Oral Oncol., 75: 81-8, 2017.*

11. Ying J. W., Wen T. Y., Pei S. S., Su L. H., Ruan D. K. *Stromal cell-derived factor-1 $\alpha$  promotes recruitment and differentiation of nucleus pulposus-derived stem cells. World J Stem Cells., 11(3): 196–211, 2019.*

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药工劳动激励基础体系，形成药学组织竞争优势增强  
**THE SYSTEM OF MOTIVATIONAL BASES OF  
PHARMACEUTICAL WORKERS' LABOR, FORMING AN  
INCREASE IN THE COMPETITIVE ADVANTAGES OF  
PHARMACY ORGANIZATIONS**

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抽象的。近年来，俄罗斯医药市场发生了重大变化，因此需要在竞争环境中获取生存领域的新知识。市场经济的进一步发展导致越来越多的制药组织对通过增加药学工作者工作的激励基础来正确有效地形成竞争优势感兴趣，从而为药学组织的战略可持续性做出贡献。实现组织目标的必要条件是有效利用药房组织员工的创造潜力。对于小型企业来说尤其如此。药房组织的成功取决于许多因素，包括增加工作的积极性。正是这些因素往往在市场环境中起决定性作用，为药房组织及其财务成功提供公开评级。因此，激发药学从业人员的积极性是药学组织现代化管理的迫切任务之一。

关键词：动机，药学工作者，竞争优势，药学组织。

**Abstract.** *Significant changes that have taken place in recent years in the Russian pharmaceutical market have led to the need to acquire new knowledge in the field of survival in a competitive environment. The further development of the market economy has led to an increase in pharmaceutical organizations interested in the correct and effective formation of competitive advantages by increasing the motivational bases of the work of pharmaceutical workers, contributing to the strategic sustainability of the pharmacy organization. A necessary condition for achieving the goals of the organization is the effective use of the creative potential of the employees of the pharmacy organization. This is especially true for small businesses. The success of a pharmacy organization depends on many*

*factors, including by increasing the motivation to work. It is these factors that often become decisive in the market environment, providing a public rating of a pharmacy organization and its financial success. Therefore, the motivation of a pharmaceutical worker is one of the urgent tasks of modern management of a pharmacy organization.*

**Keywords:** *motivation, pharmaceutical worker, competitive advantages, pharmacy organization.*

**Purpose of the study:** study of the motivational bases of the work of pharmaceutical workers, which form an increase in the competitive advantages of pharmacy organizations.

**Materials and methods:** when studying the motivational foundations of the work of pharmaceutical workers, which form an increase in the competitive advantages of pharmacy organizations, the following methods were used: marketing, graphic, sociological, content analysis.

**Results and discussion.** The successful functioning and competitiveness of a pharmacy organization depend, first of all, on the interest of its employees in active, efficient activities [1,2,3].

In this regard, the heads of pharmaceutical organizations should know and be able to put into practice all the approaches to labor motivation available in management. To do this, you need to know the factors that affect the motivation of work and be able to analyze them.

When planning and organizing work, the manager determines what goals and objectives the pharmacy organization should achieve, in what timeframe, how and who, in his opinion, will do it. But it does not always work out in practice the way the manager plans. In order to achieve the intended goals, the leader must coordinate the activities of people, force them to fulfill their duties. For this purpose, motivation is used in management.

Motivation is the process of stimulating oneself and others to activities in order to achieve personal or production goals. Motive is one of the fundamental concepts used in sociology to describe and analyze the scope of an individual's motivation for activity [4,5].

The assessment of the complex of factors that determine the motivation of the professional activity of pharmaceutical workers is based on the results of a sociological survey. It was conducted according to a specially designed questionnaire. An analysis was made of the perception of pharmaceutical activity by specialists through the factors of attractiveness and unattractiveness. It was found that the strongest aspects of the attractiveness of the pharmaceutical activity, according to the respondents, are the opportunity to communicate (60.9%) and the opportunity to express themselves (56.1%); workplace stability and respect in society (48.7%).

Wages were in fifth place (46.3%), which indicates that they do not meet the needs of pharmaceutical workers.

Among the factors that reduce the attractiveness of pharmaceutical activity, there were physical and neuropsychic stress (92.6%) and unfair pay (36.5%), poor working conditions (14.6%), lack of independence (14.6%) and conflicts in the team (12.2%).

As a rule, any person tries to use in his workplace the knowledge and skills gained in the process of training, advanced training, and accumulation of practical experience. The more he succeeds, the higher his degree of satisfaction. An employee is disappointed if the workplace or management does not provide him with such opportunities, i.e. his professional skills remain unclaimed [6,7].

The development of pharmacy is impossible without taking into account social and professional needs and a set of factors that form the motivational structure of the work of pharmacy workers. Managers need to be aware of ways to motivate themselves and their subordinates. The criterion for optimal motivation is that both parties are satisfied as a result. It is important that the interests of the pharmacy organization and employees coincide, cooperation and understanding of the logic of production relationships, encouraging the independence of employees and responsibility for their own actions [8,9].

Table 1 shows job satisfaction data for pharmaceutical workers.

**Table 1.**  
*Satisfaction with the work of pharmaceutical workers*

<b>Aspect of work activity</b>	<b>Share of employees satisfied with this aspect, %</b>
Relationship with immediate supervisor	88,7
Relationship with colleagues	87,8
Payment of salaries on time and in full	85,2
Convenient work schedule	78,2
Bonus reward system	66,1
Ability to show initiative	64,3
Providing social guarantees	61,7
Promotion and professional development	41,7
Awareness about the affairs of the pharmacy	40,0
Additional types of benefits	39,1
The volume of wages	14,7

The highest satisfaction with work was noted in the following aspects: relations with the immediate supervisor (88.7%), relationships with colleagues (87.8%), payment of wages on time and in full (85.2%) and a convenient work schedule (78.2%). Specialists are the least satisfied with the amount of wages (14.7%).

The obvious influence on the success of the pharmacy organization is exerted by the strength of motivation and its structure. The motive can be characterized not only quantitatively (according to the principle “strong - weak”), but also qualitatively. Allocate motives external and internal in relation to the content of the activity. If activity in itself is significant for a person, then they speak of intrinsic motivation. If other needs are significant (social prestige, salary, etc.), then they speak of external motives. External motives themselves can be positive (motives for success, achievement) and negative (motives for avoidance, protection). External positive motives are more effective than external negative ones, even if they are equal in strength. The result of negative motivation may be unwillingness to work in this area.

Intrinsic motivation (IM) consists of the following motives: the possibility of self-realization, satisfaction from a job well done, awareness of the social significance of one’s work, and a creative approach to work.

External positive motivation (EPM) consists of: the desire for greater material rewards, the possibility of promotion, the success of the enterprise, respect from the boss, a good team, recognition, the ability to stand out, quiet work, the desire for independence, awareness, clear task setting.

External negative motivation (ENM) consists of: the desire to avoid criticism from the leader or colleagues; the desire to avoid possible punishments or troubles and the desire to avoid responsibility, independent decision-making.

The motivational complex of a personality is a type of correlation between three types of motivation: intrinsic motivation (IM), extrinsic negative motivation (ENM), extrinsic positive motivation (EPM). The best, optimal motivational complexes include the following combinations:

$IM > EPM > ENM$  and  $BM = EPM > ENM$

The worst motivational complex is the type:

$ENM > EPM > IM$

Satisfaction with professions is the higher, the more optimal the motivational complex, besides, the activity of a specialist is motivated by the very content of labor. And vice versa, the more the specialist’s activity is conditioned by the motives of avoidance, censure, the desire “not to get into trouble” (which begin to prevail over the motives associated with the value of the pharmaceutical activity itself, as well as over external positive motivation), the higher the level of emotional instability and the lower the labor efficiency.

The leading motives for labor activity are normal physical and neuropsychic stress, wages and good working conditions.

One of the important factors influencing the motivation of employees is the organizational culture of a pharmacy organization. To develop the improvement of the culture of a pharmacy organization, it is necessary to achieve compliance with the management style and features of managerial activity, the values of the manager with the level of development and values of the team.

Since failures, difficulties and simply wrong actions sometimes occur in the work of any person, how they are corrected is important to maintain motivation. The actions of the manager in such situations should be based on the impulse to help the employee, and not on the intention to relieve his irritation. It is also important that in time they follow immediately after the critical moment.

Comparison of the ideal model with the models of current managers allows us to determine the directions for the development of the qualities of pharmacy managers necessary in managerial activity.

Our study showed that 40.8% of respondents can change the decision of the boss with their opinion. That is, almost 60% of respondents are not able to influence the opinion of management, which has a negative impact on employee loyalty. At the same time, 65.8% of respondents said that the manager's work style contributes to their motivational process, which is a good sign. Relations with superiors are good in 88.7% of respondents.

Any systems, including the motivation system, are developed and implemented as part of the overall strategy of the pharmacy organization. However, it should be remembered that the strategy itself is implemented in specific workplaces. A reasonable balance is needed between the interests of the pharmacy organization as a whole and the interests of individual employees. The motivation system should be adjusted and communicated to each employee. Whether the proposed system will become a motivating or demotivating factor largely depends on the manager's approach.

One of the most important parameters to be assessed is the number of proposals for improving activities received from the employee.

It has been established that only the professionalism of employees is not enough to achieve the goals of a pharmacy organization. No matter how qualified an employee is, his labor activity depends on the desire to work or on the motives he has formed for work and the labor incentives that affect him.

Stimulation of labor is, first of all, an external motivation, an element of the labor situation that affects a person's behavior in the sphere of work. Stimulation of labor involves the creation of conditions under which active labor activity, which gives predetermined results; becomes a necessary and sufficient condition for satisfying the significant and socially determined needs of the worker, the formation

of labor motives in him. The purpose of incentives is not to encourage a person to work in general, but to encourage him to do better (more) what is due to labor relations. This process also carries an intangible burden that allows the employee to realize himself as a person and a specialist at the same time. Stimulation of labor should be based on its value orientations.

Pharmaceutical specialists are characterized by a type of motivation in which the significance of the material, spiritual, social and professional values of labor is balanced, and the need to satisfy them, developing in parallel and independently, governs the labor behavior of workers.

Our study showed that 85.2% of the surveyed specialists are not satisfied with the amount of wages they receive. The leading factors stimulating labor productivity are presented in table 2.

**Table 2.**  
*Factors that stimulate labor productivity*

<b>Incentives for pharmaceutical activity</b>	<b>Share (in %) of the number of respondents</b>	<b>Rating</b>
Wage increase	85,3	1
Improvement of working conditions	63,4	2
Provision of social benefits	56,1	3
Increasing social status	36,5	4
Changing the operating mode	24,3	5

The currently existing system of material incentives for labor activity in pharmacy organizations is largely ineffective. In pharmacy organizations, there are the following types of material payments: official salary, bonus payments, allowances for night shifts, compensation for deviations from normal working conditions, payment for overtime hours and work on weekends, payments under the piece-work wage system.

According to employees, the current system of remuneration also does not perform a stimulating function, since equalization in many respects flourishes in remuneration. The official salary of pharmacy workers depends little on the personal labor contribution of the employee to the final result of the team, on personal business qualities, professional knowledge and skills.

The basic principles of building a motivation system include:

- goals and objectives of the pharmacy organization, which will stimulate labor behavior aimed at the fulfillment of strategic objectives;
- resources of the pharmacy organization, its budget;
- taking into account individual requests of employees of a pharmacy organization.

When motivating to work, taking into account non-material incentives, in particular, benefits and incentives provided to an employee without paying cash, is of particular importance.

**Conclusion.** The formation of a system of motivational bases for the work of pharmaceutical workers, which form an increase in the competitive advantages of pharmaceutical organizations to stimulate labor, is the area of work for the head of any organization. The developed social policy of a pharmaceutical organization helps to increase the efficiency of a pharmacy organization. The complex use of material and non-material methods of the system of motivational foundations of the work of pharmaceutical workers contributes to the growth of labor productivity and increase the competitiveness of the pharmacy organization.

### References

1. Vasilenko, I.L. *The study of the competitiveness of the pharmacy* / I.L. Vasilenko // *Economic Bulletin of Pharmacy*. – 2004. - № 8. – P. 47 – 50.
2. Grishin, A.V. *Motivational procedure for remuneration of workers of pharmaceutical enterprises* /A.V. Grishin, M.V. Malakhovskaya // *Methodological guide*. – Tomsk. – 2000. – 22 P.
3. Gribkova E.I., Bazarkina O.V. *Communications as a factor of competitiveness*. / E.I. Gribkova, O.V. Bazarkin // *Russian pharmacies*, 2011. № 8, P. 18–23.
4. Dryomova, N.B. *We study marketing communication in a pharmacy* /N.B. Dryomova // *New Pharmacy: Effective Management*. -2007. -№ 9. – P. 24-32.
5. Dryomova, N.B. *Mastering competitive analysis* /N.B. Dryomova // *New Pharmacy: Effective Management*. – 2007. - № 8. – P. 37 - 45.
6. Ivanova, S.V. *50 tips for non-material motivation*. – M.: *Alpina Business Books*, 2012. – 125 P.
7. Kryukova A.A., Gizatulina M.F. *Innovative approaches to personnel motivation* // *Karelian scientific journal*. 2017. V. 6. № 2 (19). P. 67-68.
8. Panina, I.N. *Structure, formation and development of motivation to achieve success among employees of the organization* // *Azimuth of scientific research: pedagogy and psychology*. 2016. V. 5. № 4 (17). P. 477-480.
9. Cherezova, Ya. A. *Development of an effective motivation system for pharmacy employees* / Cherezova Ya. A., Khalimanenko S.N. // *Azimuth of scientific research: economics and management*. 2018. V. 7. № 2(23). P. 350-354.

人群职业病医疗和药学护理的现代问题

**MODERN PROBLEMS OF MEDICAL AND PHARMACEUTICAL  
CARE IN OCCUPATIONAL DISEASES OF THE POPULATION**

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抽象的。劳动人口健康是国内重要的国民医疗和社会问题。近年来,尽管采取了措施,但劳动人口的职业发病率有所增加。对国内职业医学系统的药学部分的分析表明,综合方法的重要性以及利用药学专家的专业潜力来解决这一问题的必要性。以库兹巴斯为例,对职业病问题的综合医学和药学研究,具有经济、医疗和社会发展的特点,但没有进行足够的研究,这些研究结果有助于解决职业病问题,维护健康 俄罗斯工业化地区的劳动人口。

关键词: 医疗和医药保健, 职业病, 人口。

**Abstract.** *The health of the working population is an important domestic national medical and social problem. In recent years, despite the measures taken, there has been an increase in the occupational morbidity of the working population. An analysis of the pharmaceutical component of the domestic system of occupational medicine indicates the importance of an integrated approach and the need to use the professional potential of pharmaceutical specialists in solving this problem. Comprehensive medical and pharmaceutical studies of the problem of occupational morbidity on the example of Kuzbass, having features of economic and medical and social development, were not carried out enough and the results of these studies contribute to solving the problem of occupational diseases, maintaining the health of the working population in the industrialized regions of Russia.*

**Keywords:** *medical and pharmaceutical care, occupational diseases, population.*

**Purpose of the study.** The study of the provision of medical and pharmaceutical care for occupational diseases of the population.

**Materials and research methods.** When studying the provision of medical and pharmaceutical care for occupational diseases of the population, methods were used: marketing, graphic, sociological, content analysis.

**Results of the study and their discussion.** In modern conditions, the protection of the professional health of workers is one of the key issues of the economic development of society and national security [1].

One of the reasons for the decline in the working-age population over the past decade is the high level of morbidity and mortality in the population of working age from 40 to 60 years, mainly due to unfavorable working conditions, as the main source of occupational health risk [3,4,5].

It has been established that under the conditions of the complex impact of environmental factors, nutrition and lifestyle, the likelihood of developing various occupational pathologies increases among the population. In the analysis of multiple models reflecting the dependence “factor - response probability”, it was shown that the maximum contribution to the formation of disorders is made by negative factors (up to 49.8%), lifestyle and chemical pollution of the environment [3,4].

It was revealed that in total in 2021, 530 (2020 - 558) cases of occupational diseases (OD) were registered in Kuzbass, of which 520 cases of chronic occupational diseases, 10 cases of acute occupational diseases. All cases of acute occupational diseases in 2021 are associated with the death of a healthcare worker as a result of infection with a new coronavirus infection (COVID-19) while on duty [2].

It has been established that the rate of occupational morbidity in Kuzbass per 10 thousand employed population in 2020 is 7.34, which is 9 times higher than the same indicator in the Russian Federation and is associated with a high prevalence of occupational diseases in coal industry enterprises (tab. 1).

**Table 1.**  
*Indicators of occupational morbidity for the period 2012–2020  
(cases per 10 thousand employees)*

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Kuzbass	11,73	14,14	13,0	13,32	13,23	10,93	9,96	8,64	7,34
Russian Federation	1,71	1,79	1,74	1,65	1,47	1,31	1,17	1,03	0,78

As follows from Table 1, in the levels of occupational morbidity, the highest rates were observed in 2013 and amounted to 14.14 cases per 10 thousand of the population. In 2020, occupational morbidity rates in Kuzbass were 7.34, and in the Russian Federation, 0.78 cases per 10,000 workers [2].

The trend of uneven changes in the relative indicators of chronic occupational morbidity of the population of Kuzbass for a long period of 2012-2020 is presented in table 2.

**Table 2.**  
*Indicators of chronic occupational morbidity in Kuzbass  
(per 10000 population)*

Years	Cases of OD per 10000 population	«X» Conditional time	XY	X <sup>2</sup>	Aligned data Y <sub>x</sub>
2012	11,73	-4	-46,92	16	7,19
2013	14,14	-3	-42,42	9	7,90
2014	13,0	-2	-26,0	4	8,61
2015	13,32	-1	-13,32	1	9,32
2016	13,23	0	0	0	10,03
2017	10,93	+1	+10,93	1	10,11
2018	9,96	+2	+19,92	4	11,44
2019	8,64	+3	+25,92	9	12,15
2020	7,34	+4	+29,36	16	12,86
	Σy=90,29	X=0	Σxy=+42,53	Σx <sup>2</sup> =60	

In order to establish a trend and to identify the dynamics of the studied number of indicators, such as it would be outside the influence of “random” factors, the least squares equalization method was used, which is recognized as an effective way of analytical trend equalization [2,5].

The task was to select such a logarithmic curve for a specific dynamic series that would most accurately reflect the features of the actual dynamics. Based on the method of least squares, a line was found that is as close as possible to the empirical data and characterizes the direction of the process under study, while the sum of the squared deviations of the actual data from the aligned ones will be the smallest.

Equation (1) was used to equalize the dynamic series:

$$y = a_0 + a_1 n X \tag{1}$$

where y - magnitude of a phenomenon that changes over time;

a<sub>0</sub> - first level;

a<sub>1</sub> - row start speed;

X - periods of time;

n - number of observations.

The least squares method is based on a simplified selection of the time reference method x so that Σx = 0.

$a_0$  and  $a_1$  were calculated using formulas (2 and 3):

$$a_0 = \Sigma y/n \tag{2}$$

$$a_1 = \Sigma xy/\Sigma x^2, \tag{3}$$

$$a_0 = 90,29/9 = 10,03$$

$$a_1 = 42,53/60 = 0,708$$

Calculation example:

$$y = 10,03 + 0,708 * (-4) = 7,19$$

$$y = 10,03 + 0,708 * (-3) = 7,906 \text{ etc.}$$

In order to objectify the information for greater clarity, a qualitative analysis of the essence of the phenomenon under study was carried out.

Table 3 presents actual and calculated data on general occupational morbidity in Kuzbass and in the Russian Federation for a number of years [2].

**Table 3.**  
*Comparative characteristics of the general occupational morbidity in Kuzbass and in the Russian Federation (per 10 thousand working population)*

Years	Kuzbass		Russian federation	
	Cases of OD per 10000 working population	Aligned data $Y_x$	Cases of OD per 10000 working population	Aligned data $Y_x$
2012	11,73	7,19	1,71	0,88
2013	14,14	7,90	1,79	1,01
2014	13,0	8,61	1,74	1,14
2015	13,32	9,32	1,65	1,27
2016	13,23	10,03	1,47	1,40
2017	10,93	10,11	1,31	1,53
2018	9,96	11,44	1,17	1,66
2019	8,64	12,15	1,03	1,79
2020	7,34	12,86	0,78	1,92

As follows from Table 3, there are periods of increase and decrease in the levels of occupational morbidity for the indicated years. A comparative analysis of the leveled levels of general occupational morbidity in Kuzbass in dynamics has revealed, in general, the current trend of its increase.

As a result of the analysis of programmatic, regulatory, methodological and scientific materials related to occupational medicine and occupational pathology, we found that the issues of drug provision and pharmaceutical care (PC) for this category of patients were not sufficiently considered, and in the structure of occupational medicine there are no units responsible for organizational - methodological support of drug assistance in the field of occupational morbidity.

In modern socio-economic conditions, it is necessary to develop and implement a new unified concept of assistance to the able-bodied population, which combines the medical and pharmaceutical components. An analysis of the literature on PC has shown that PC is considered to be a set of measures for drug, informational, organizational and methodological support of individualized pharmacotherapy of specific diseases and is implemented at various levels (local, regional) in the hospital or outpatient healthcare sectors, hospital and general pharmaceutical practice in the form of models, describing the processes of drug supply, pharmacotherapy of patients, consultation of doctors and patients, provision of additional pharmaceutical services, as well as measurement of performance.

It has also been established that to date, several areas have been formed in which the results of PC research are used: development of elements of a regional policy in the field of drug provision, research in the field of consumption of medical drugs (MD) and their cost, the introduction of a PC quality management system and, accordingly, the development and implementation of PC standards, etc.

An analysis of existing scientific approaches to MS has shown that a direction has been formed for clinical or specialized MS, the purpose of which is to ensure the proper quality of pharmacotherapy for a specific patient with a specific disease, and the tasks are to provide MD of the required quality, educate the patient on the correct use of MD, control the use of over-the-counter MD, maintain a database of the patient, MD issued to him, cooperate with the doctor, inform the doctor about MD, course and complications of pharmacotherapy.

The focus of PC on patients with a certain nosology is determined by the specifics of the disease, therefore, in the case of OD, it is necessary to take into account the etiological factor, the structure and nature of the medical care provided. These circumstances, in turn, will determine the drug supply, the range of MDs used, the range of pharmaceutical services provided, the need for specialists, programs and the PC standard.

Summarizing the results of the analysis of scientific publications on issues of pharmaceutical care and occupational pathology, we can conclude that at the present stage the following are not yet sufficiently developed: the concept of a specialized PC in OD of the working population; the main directions of PC - organizational, marketing, sociological, pharmacoeconomic, personnel and others. These issues at the regional level are resolved by the service of medicine and labor protection, in particular, the regional and city center of occupational pathology.

An analysis of the emerging system of occupational medicine indicates the need to address issues related to quality pharmaceutical care for patients with OD and the active adoption of the modern WHO concept of "Health for all in the XXI century", aimed at promoting health and preventing diseases by strengthening the role of the pharmacist in the treatment process.

A logical-framework approach was taken to analyze the state of drug supply and pharmaceutical care for patients with OD. As a result, it was found that the participants in the drug supply system are MD consumers - patients with a diagnosis of OD, as well as healthy production workers; healthcare professionals prescribing medications; wholesale and retail pharmaceutical organizations that sell MD; as well as structures that finance drug provision.

The most important aspect of this problem is that the state is interested, on the one hand, in improving the health of the working population and reducing the number of patients diagnosed with OD, on the other hand, in the rational use of financial resources for health care, including occupational medicine. These tasks can be realized only by researching and solving the problems of drug supply and pharmaceutical care in the field of occupational pathology.

An analysis of the actual state of the organization of medical care, the system of labor protection and medicine, its pharmaceutical component revealed the weaknesses of this system. As further studies show, at the stage of treatment, the means of pathogenetic therapy are not used enough.

From this it follows that the actual pharmaceutical assistance at the stages of prevention, treatment and rehabilitation is replaced by drug provision. Accordingly, there is no structure of pharmaceutical assistance in the framework of occupational health and safety and specialized pharmaceutical personnel.

The introduction of pharmaceutical specialists into the structure of the service and labor protection, the increase in the pharmaceutical component of occupational medical care makes it possible to optimize the standardization processes taking place in healthcare through the introduction of patient management protocols at the stages of treatment and rehabilitation. This, in turn, will lead to savings in the budgets of various levels.

In general, the organization of pharmaceutical care in the field of occupational safety and health will lead to a decrease in morbidity (due to timely prevention of OD) and the number of adverse outcomes.

The dominant problems are: lack of a pharmaceutical care system for patients with OD; lack of specialists with pharmaceutical education in the structure of the service and labor protection; not implemented function of the pharmacy organization (pharmacy) to serve patients with OD; inappropriate use of health care resources.

The lack of a pharmaceutical care system is manifested by the lack of participation of authorities in matters of pharmaceutical care in the framework of medicine and labor protection. At the regional level, this is manifested by the absence in the regional programs for occupational health and safety of aspects related to the organization of MS by patients with OD.

Another private problem associated with the lack of a PC system is the lack

of priority and lack of interest of business leaders in the development of pharmaceutical care at the preventive stage, which leads to low preventive work, which is part of medical and social programs in the workplace. At the regional level, pharmaceutical assistance to patients is implemented through the activities of a pharmacist-consultant of the regional center of occupational pathology, which is reflected in the “pharmaceutical aspects” of regional programs on occupational health and safety.

The next level of implementation of pharmaceutical care is a pharmacy organization serving the population and a pharmacy of a medical institution (rehabilitation center), where marketing programs are implemented (for example, programs for the prevention of OD, a healthy lifestyle, etc.).

The final consumers of pharmaceutical care are directly patients with OD, workers at risk groups, pensioners. An important link in the implementation of pharmaceutical care should be considered the employer of the enterprise, which is interested in healthy workers. It is at this level that powerful preventive programs should take place, which can be implemented through the pharmacies of enterprises.

In general, the proposed system of medical and pharmaceutical care for patients with OD reflects all levels of system implementation, covers all consumers at all stages (preventive, outpatient, rehabilitation) and has the features of an analog and optimization model, has a controllable structural and quantitative-qualitative apparatus. The use of the proposed structural-functional model as a base one allows creating various versions of analogue models of pharmaceutical care for certain diseases, including professional ones at the regional level.

**Conclusion.** A generalized form of reflection of all the mechanisms of interaction between pharmacy and medical organizations in the work to rationalize medical and pharmaceutical care for the population should be individual interaction with consumers; control over the use of medicines in accordance with the prescribed course therapy; identification and prevention of possible difficulties in drug care; timely informing the attending physician about the manifestation of the undesirable effect of drugs; teaching the principles of responsible self-treatment.

## References

*1. Actual problems of occupational medicine. Preserving the health of workers as the most important national task: materials of the scientific. conf. with international participation [Text] / ed. S. V. Grebenkova, I. V. Boyko. – SPb.: Publishing house Mechnikov NWSMU, 2014. – 240 P.*

2. *Report on the state of public health and health care activities in the Kemerovo region to improve the organization, improve the quality of medical care in 2020 and tasks for 2021–2025 [Text]. – Kemerovo: Code, 2021.–158 P.*

3. *Izmerov, N. F. Issues of occupational morbidity: retrospective and modernity [Text] / N. F. Izmerov, I. V. Bukhtiyarov, L. V. Prokopenko // Proceedings of the XI All-Russian Congress “Profession and Health” November 27-29, 2012 – M.: FSBI “RI MT” RAMS. – P. 29-40.*

4. *Kiku, P.F. The concept of risk factors for public health: a review / P.F. Kiku, D.S. Zhigaev, N.S. Shiter et al. // Bulletin of Physiology and Pathology of Respiration. – 2016. – № 62. – P. 101-109.*

5. *Petrov, A.G., Organizational and methodological foundations for improving specialized pharmaceutical assistance to coal industry workers: monograph / A.G. Petrov, O.I. Knysh, V.A. Semenikhin, O.V. Khoroshilova et al. - Kemerovo: Kuzbassvuzizdat, 2019.-255 P.*

从波罗的海筛选微藻以进一步用于工业  
**SCREENING OF MICROALGAE FROM THE BALTIC SEA FOR  
FURTHER USE IN INDUSTRY**

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抽象的。种植微藻不需要种植传统作物所需的土地和自然资源，并且产量高于陆基作物。这项科学研究的目的是筛选从波罗的海分离的微藻——多糖的生产者，用于随后的培养和在各个行业中的使用。显微镜、光谱学、离心和渗滤被用作研究方法。微藻 *Scenedesmus obtusiusculus* *Scenedesmus obtusiusculus* Chod, *Chlorella fusca*, *Chlorella* sp. 的形态特征 *Bejer, Nannochloris* sp. *Naumann, Ankistrodesmus acicularis* *Korsch*。事实证明，微藻在培养的第7天消耗了高达51%的含氮物质、高达95%的磷酸盐和17%的硝酸盐。在分析微藻产生的胞外多糖时，发现胞外多糖的主要碳水化合物单体是木糖、半乳糖、葡萄糖和葡萄糖醛酸。研究了提供最大多糖积累的微藻，从微藻和蓝藻的生物质中提取多糖；以及对多糖特性（包括生物活性）的分析，将用于研究其在各个行业的应用前景。

关键词：微藻，形态，筛选，钝角栅藻，*Chlorella fusca*, *Chlorella* sp. *Bejer, Nannochloris* sp. *Naumann, Ankistrodesmus acicularis* *Korsch*。

**Abstract.** *Growing microalgae does not require the land and natural resources needed to grow traditional crops and yields higher yields than land-based crops. The purpose of this scientific study is the screening of microscopic algae isolated from the Baltic Sea - producers of polysaccharides for subsequent cultivation and use in various industries. Microscopy, spectroscopy, centrifugation and diafiltration were used as research methods. Morphological features of microalgae Scenedesmus obtusiusculus Scenedesmus obtusiusculus Chod, Chlorella fusca, Chlorella sp. Bejer, Nannochloris sp. Naumann, Ankistrodesmus acicularis*

Korsch. It has been proven that microalgae consumed up to 51% of nitrogen-containing substances, up to 95% of phosphates and 17% of nitrates on the 7th day of cultivation. When analyzing exopolysaccharides produced by microalgae, it was found that the main carbohydrate monomers of exopolysaccharides were xylose, galactose, glucose and glucuronic acid. Investigated microalgae providing the maximum accumulation of polysaccharides, extraction of polysaccharides from the biomass of microalgae and cyanobacteria; as well as the analysis of the properties of polysaccharides (including biological activity) will be used to study the prospects for their application in various industries.

**Keywords:** microalgae, morphology, screening, *Scenedesmus obtusiusculus* Chod, *Chlorella fusca*, *Chlorella* sp. Bejer, *Nannochloris* sp. Naumann, *Ankistrodesmus acicularis* Korsch.

### Introduction

Important indicators of the growth efficiency of microalgae are the productivity of the accumulation of biologically active substances (BAS) and the level of biomass accumulation. The value of these indicators depends on such technological parameters as the qualitative and quantitative composition of the nutrient medium, active acidity, temperature, growth phase, illumination, and the method of harvesting cultures [1-3].

The optimal temperature regime for cultivation of microalgae *Botryococcus*, *Scenedesmus*, *Chlamydomonas*, *Chlorella*, *Haematococcus*, *Neochloris* is from 15 to 35°C. A more precise technological mode of cultivation depends on the name of the strain [4,5]. It was also found that microalgae can actively accumulate biomass more in severe temperature conditions. For example, the microalgae strain *Chlorella sorokiniana* and the microalgae strain *Asterarcys quadricellulare* actively develop at a temperature of 43°C; in addition, these strains are able to grow at elevated levels of carbon dioxide and nitric oxide [4]. It has been established that the use of thermotolerant microorganisms in industry can significantly reduce the development of pathogenic microorganisms and carry out the cultivation process in natural conditions [6-8].

The ideal culture medium for microalgae should contain inorganic elements such as nitrogen (N) and phosphorus (P), which can vary depending on the cultivated species. After carbon, which makes up approximately 50% of the share of elements in the biomass of microalgae, nitrogen takes the second place, with a concentration of 1 to 14% in the dry mass. It can be absorbed in the inorganic forms  $\text{NO}_3$ ,  $\text{NO}_2$ ,  $\text{NO}$ ,  $\text{NH}_4$  and, in some cases, as  $\text{N}_2$  or in organic form via urea or amino acids. A decrease in the nitrogen concentration during cultivation leads to a preferential synthesis of lipids and carbohydrates. The concentration of phosphorus in the dry biomass of microalgae can range from 0.05 to 3.3% [9]. In natural

environments, as well as in wastewater, phosphorus is present in various forms, such as orthophosphate, polyphosphate, pyrophosphate and metaphosphate. In addition, there are various types of agricultural fertilizers that can be used to saturate the microalgae culture medium with phosphorus, such as phosphates and superphosphates derived from phosphorites. For adequate growth of microalgae, the medium must also contain other nutrients - trace elements. The main trace elements are Mg, S, Ca, Na, Cl, Fe, Zn, Cu, Mo, Mn, B, and Co, with an emphasis on Mg, S, and Fe [10].

Nutrient restriction has a direct impact on the synthesis of biologically active substances, biomass growth, and photosynthesis processes in microalgae [11]. For example, nitrogen deficiency in culture media stimulates lipid synthesis. High light exposure and nutrient restriction (nitrogen or phosphorus) lead to an increase in the size of the lipid fraction and stimulate the accumulation of triacylglycerols. In low light, mainly polar lipids (phospholipids and glycolipids) accumulate, which are structurally and functionally associated with cell membranes. However, cell growth under such conditions is reduced. There are exceptions, for example, diatoms, in which the lipid content in long phases does not respond to nitrogen starvation [12].

The purpose of this scientific study is the screening of microscopic algae isolated from the Baltic Sea - producers of polysaccharides for subsequent cultivation and use in various industries.

### **Materials and methods of research**

The objects of study were microalgae isolated on the coast of the Baltic Sea, in the Kaliningrad Oblast: *Scenedesmus obtusiusculus* Chod, *Chlorella fusca*, *Chlorella* sp. Bejer, *Nannochloris* sp. Naumann and *Ankistrodesmus acicularis* Korsch.

Microalgae were sown on liquid nutrient media obtained from the IPPAS Collection of Microalgae and Cyanobacteria, IFR RAS, Russian Ministry of Education and Science. Microalgae were cultivated under laboratory conditions and the accumulated biomass was screened for subsequent isolation of target products (carbohydrate-mineral complexes). Algae cells were counted under a microscope using a Micros binocular microscope (Austria). This microscope is used to study stained and unstained preparations in the form of smears and tissue sections, as well as biological fluids in the Golyaev chamber [1,2]. Microalgae cells were photographed using an iPhone 13 mini-APPLE digital camera. This camera transmitted color images viewed under a microscope during laboratory tests to be displayed on a personal computer screen. Using a binocular microscope and a SolidSpec-3700/3700 DUV spectrophotometer (Shimadzu Corporation, Japan) measuring optical density, a calibration curve (the ratio of the number of microalgae cells in suspension to optical density) was constructed using a Goryaev camera. Spectrophotometers SolidSpec-3700/3700 DUV are designed to measure the

optical density of liquids and solids in the spectral region of 190-1100 nm. The experiments were carried out in triplicate.

Among the morphological features identified in the taxonomy of green algae, the following types of thallus tissue were used: the morphology of vegetative cells, the number and shape of chloroplasts, the ability to form colonies and their shape, the structure of cell membranes and the formation of mucus; Number of Cores; position, number and type of flagella; accumulation of reserve nutrients.

All work with pure cultures of algae was carried out under sterile conditions generally accepted in microbiological practice. Reseeding of cultures was carried out in a special microbiological safety box type II B2 BMB-II-Laminar-S (Russia) and sterilized with a BUV-40 bactericidal lamp for at least 20-30 minutes before work.

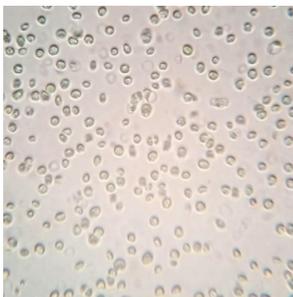
Algae were grown in sterile test tubes or flasks closed with cotton swabs or foil. After sowing, the cultures were placed in “racks” with LED lighting. In this study, densely grown young cultures of microalgae in a liquid medium were used. They were in good physiological condition and did not form altered forms.

At the end of the culture period, the biomass was collected by centrifugation and the supernatant was diafiltered to recover exopolysaccharides (EPS).

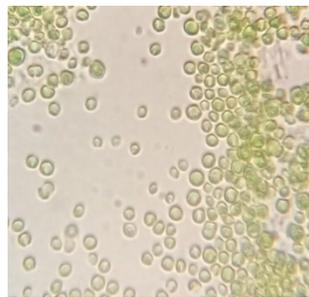
### Results and its discussion

In isolates of microalgae, the morphological organization of the thallus is monomorphic. Individual cells of a certain shape can actively move in the aquatic environment with the help of flagella. Microalgae separate and unite in colonies or coenobia (colonies with a certain number of cells). Different stages of development of microalgae (zoospores, gametes) also have a single structure. Hemimonal (palmeroid, capsal) type - cells are similar to monadic cells, some organelles are characterized by a monadic cell type, but live a motionless life. They usually form colonies consisting of mucous secretions and mucus-soaked cells. Cells of the hemimonas type are characterized by a polar structure and can lead an attached lifestyle, which is not found in standard collections.

The view of the studied microalgae under a microscope is shown in figure 1.



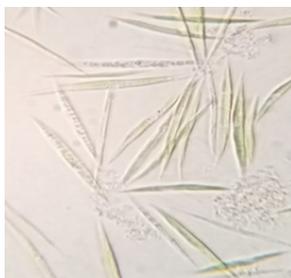
*Chlorella* sp. Bejer



*Nannochloris* sp. Naumann



*Scenedesmus obtusiusculus* Chod



*Ankistrodesmus acicularis* Korsch

**Figure 1.** Morphological screening of microalgae strains

Analysis of Figure 1 allows us to conclude that the microalgae *Chlorella sp. Bejer* have a single spherical shape, size 3-5  $\mu\text{m}$ , green. Chloroplasts contain chlorophyll a and chlorophyll b, large chromatophore, up to 90% of the cell volume.

Microalgae *Nannochloris sp.* Naumann have a single spherical or ellipsoidal shape, size 2-3  $\mu\text{m}$ , green. The chloroplast is solitary, occupies more than half of the cell volume and contains chlorophyll a and is completely devoid of chlorophyll b and chlorophyll c.

Microalgae *Scenedesmus obtusiusculus* Chod have an ellipsoid shape with curved ends, form colonies of 4/8/16 cells, size - 5-40  $\mu\text{m}$ , green.

Microalgae *Ankistrodesmus acicularis* Korsch have an elongated shape with pointed ends, dimensions: length 35-45  $\mu\text{m}$ , width 2-4  $\mu\text{m}$ , color - green.

Screening of morphological forms of microalgae revealed: coccoid type - cells are solitary or colonial (cenobial), dressed in dense shells, without flagella, immobile in the vegetative state. The sarcinoid type is characterized by a combination of coccoid habitus with the ability for vegetative cell division, which occurs in different planes, resulting in the formation of two and three-dimensional cell complexes.

Among the various types of green microalgae, the producers of sulfated polysaccharides are of great importance. The studied strains of microalgae are also producers of exopolysaccharides.

Exopolysaccharides are polymers of sugars released into the culture medium. In this study, representatives of green microalgae were evaluated as EPS producers. The evaluation was carried out on several aspects, such as morphological differences of strains followed by comparison of growth behavior, nitrogen and phosphate uptake during cultivation of strains, and a detailed analysis of EPS. Microalgae consumed up to 51% of nitrogen-containing substances, up to 95% of phosphates and 17% of nitrates on the 7th day of cultivation. The EPS produced were analyzed and the results showed that the main constitutional carbohydrate

monomers of EPS were xylose, galactose, glucose and glucuronic acid. In addition, EPS derivatives have been identified as sulfate and methyl groups.

The visual aspect of the cultures shows that the biomass of microalgae developed on a nutrient medium with high kinetic activity. This was confirmed by screening the concentration of nitrogen-containing substances, when comparing group values, the level of the desired indicator, i.e. nitrogen, did not change significantly.

### Conclusions

Thus, the studied characters cannot be diagnostically significant in the taxonomic determination of these genera. Morphological features are individual depending on the level of the taxonomic category and the biological characteristics of the studied group of green algae.

Microalgae and cyanobacteria are a promising type of raw material for the sustainable production of a carbohydrate-mineral complex. Currently, microalgae nutritional supplements constitute an important market in which carbohydrate-containing compounds such as starch, sucrose and ethylene are an alternative source of energy-intensive foods [2,3,13].

Further stages of scientific research will be the development of scientific bases for the cultivation of microscopic algae and cyanobacteria, which ensures the maximum accumulation of polysaccharides, the extraction of polysaccharides from the biomass of microalgae and cyanobacteria; as well as the analysis of the properties of polysaccharides (including biological activity) and the study of the prospects for their use in various industries.

**Acknowledgements:** This research was funded by the Ministry of Science and Higher Education of the Russian Federation (grant of the President of the Russian Federation), project No MK-484.2022.1.4 (agreement No. 075-15-2022-393).

### References

1. Dolganyuk V., Andreeva A., Budenkova E., Sukhikh S., Babich O., Ivanova S., Prosekov A., Ulrikh E. *Study of Morphological Features and Determination of the Fatty Acid Composition of the Microalgae Lipid Complex. Biomolecules.* 2020 Nov 19;10(11):1571. doi: 10.3390/biom10111571.
2. Su Y., Song K., Zhang P., et al. *Progress of microalgae biofuel's commercialization Renewable and Sustainable Energy Reviews.* 2017; 74:402–411.

3. Chandra T.S., Aditi S., Kumar M.M., Mukherji S., Modak J., Chauhan V.S., Sarada R., Mudliar S.N. Growth and biochemical characteristics of an indigenous freshwater microalga, *Scenedesmus obtusus*, cultivated in an airlift photobioreactor: Effect of reactor hydrodynamics, light intensity, and photoperiod. *Bioprocess. Biosyst. Eng.* 2017;40:1057–1068. doi: 10.1007/s00449-017-1768-0.
4. Phong W.N., Show P.L., Ling T.C., et al. Mild cell disruption methods for bio-functional proteins recovery from microalgae—Recent developments and future perspectives *Algal research.* 2018; 31:506–516.
5. Rizwan M., Muftaba G., Memon S.A., Kisay L., Naim R. Exploring the potential of microalgae for new biotechnology applications and beyond: A review. *Renew. Sustain. Energy Rev.* 2018;92:394–404. doi: 10.1016/j.rser.2018.04.034.
6. Amorim M.L., Soares J., Coimbra J.S.D.R., et al. Microalgae proteins: Production, separation, isolation, quantification, and application in food and feed *Critical Reviews in Food Science and Nutrition.* 2020:1–27.
7. Sakarika M., Kornaros M. Effect of pH on growth and lipid accumulation kinetics of the microalga *Chlorella vulgaris* grown heterotrophically under sulfur limitation *Bioresource technology.* 2016;219:694–701.
8. Borowitzka M.A. High-value products from microalgae—their development and commercialisation *Journal of applied phycology.* 2013;25(3):743–756.
9. Sambit S., Mriganka S.M., Tridib K.B., Kalyan G. Priority-based multiple products from microalgae: Review on techniques and strategies. *Crit. Rev. Biotechnol.* 2020;40:590–607.
10. Dolganyuk V., Belova D., Babich O., Prosekov A., Ivanova S., Katsarov D., Patyukov N., Sukhikh S. Microalgae: A Promising Source of Valuable Bioproducts. *Biomolecules.* 2020;10:1153. doi: 10.3390/biom10081153.
11. Dupré C., Burrows H.D., Campos M.G., Delattre C., Encarnaçãõ T., Fauchon M., Gaignard M., Hellio C., Ito J., Laroche C., et al. Microalgal Biomass of Industrial Interest: Methods of Characterization. In: Nzihou A., editor. *Handbook on Characterization of Biomass, Biowaste and Related By-Products.* Springer; Cham, Germany: 2020. pp. 537–639.
12. Sprague M., Betancor M.B., Tocher D.R. Microbial and genetically engineered oils as replacements for fish oil in aquaculture feeds. *Biotechnol. Lett.* 2017;39:1599–1609. doi: 10.1007/s10529-017-2402-6.
13. Scharff C., Domurath N., Wensch-Dorendorf M., Schröder F.G. Effect of different photoperiods on the biochemical profile of the green algae *C. vulgaris* and *S. obliquus*. *Acta Hortic.* 2017:1149–1156. doi: 10.17660/ActaHortic.2017.1170.148.

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UDC 502.74

以西伯利亚云杉为例研究针叶类木本植物水碱性提取物的促生长活性  
**STUDY OF THE GROWTH-STIMULATING ACTIVITY OF WATER-  
ALKALINE EXTRACTS OF CONIFEROUS WOODY GREENERY  
USING THE EXAMPLE OF SIBERIAN SPRUCE**

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抽象的。在这项工作中，研究了不同浓度针叶树的水碱性提取物对西伯利亚云杉种子萌发的促生能力。获得的数据可以用来增加针叶树种子的发芽率。

关键词：针叶树提取物，促生长活性，西伯利亚云杉。

**Abstract.** *In this work, the growth-stimulating ability of water-alkaline extracts of conifers of various concentrations for the germination of seeds of Siberian spruce was studied. The data obtained can serve to increase the germination of coniferous seeds.*

**Keywords:** *coniferous extracts, growth-stimulating activity, Siberian spruce.*

### **Introduction**

Currently, one of the urgent problems of forestry is the complex processing of plant waste left after harvesting marketable timber in the cutting area, these include tree greens, branches and bark. Coniferous tree greens are a source of biologically active substances. These wastes can be competently used in the national economy.

At the same time, there is a problem of increasing the germination of coniferous seeds during long-term storage. A number of authors have studied the problem of increasing the germination of coniferous seeds using various growth stimulants [1–2]. So, the employees of V.N. Usov and B.N. Popkov conducted experiments to study the effect of epin on the germination of seeds and the growth of seedlings of densely flowered pine and Banks [3]. Among the plant growth regulators there is a group of preparations, the active substance of which is triterpene acids obtained from Siberian fir needles. An overview of such stimulants is given in the

works of V.A. Raldugin [4]. One of such developments is the biological preparations Verva and Verva-el. Triterpene acids contained in the preparation contribute to the activation of biological and immune processes in plants, including stimulating the germination and growth-stimulating activity of seeds [5]. The active substance of the biological product Verva-el is flavonoids, which are contained in the woody greenery of Siberian spruce. Ground woody greens with a moisture content of 35% are treated with a 5% potassium hydroxide solution. Receive 120 g of an emulsion containing 3 g/l of potassium salt of acids and 0.4 g/l of neutral components. The resulting mixture of acidic and neutral components (at a ratio of acidic:neutral 1:0.1-0.2) was used as a growth stimulant in various concentrations. The drug is non-toxic, environmentally friendly (sanitary and epidemiological conclusion of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare № 77.99.28.929.A.000218.09.05 dated September 14, 2005 and № 77.99.28.929.A.000219.09.05 dated September 14, 2005), retains biological activity for 2 years and has a density of 1.04–1.06 g/cm<sup>3</sup> [6].

Coniferous tree greens usually contain 65–75% needles, 15–20% bark, 10–15% wood, but larch woody greens contain only about 50% needles. The thinner the shoots, the greater the proportion of needles, therefore, shoots up to 0.6 cm in diameter are the most valuable. Organic impurities (moss, lichen, herbaceous plants) and mineral (sand) may be present in woody greenery. According to GOST 21769–84, tree greens are divided into 3 varieties (tab. 1).

**Table 1**  
*Composition of tree greens [7]*

<b>Indicator</b>	<b>I variety</b>	<b>II variety</b>	<b>III variety</b>
Mass fraction of needles, leaves, buds and non-lignified shoots, %, not less than	80	70	60
Mass fraction of bark and wood, %, no more	15	25	35
Mass fraction of other organic impurities, %, no more	5	5	5
Mass fraction of inorganic impurities, %, max	0,2	0,2	0,2

Tree greens are transported by any type of transport that excludes its contamination with mineral impurities.

Storage conditions for woody greens should ensure the safety of biologically active substances. Since the content of vitamins, and especially carotene, decreases rapidly during storage of woody greens, the standard establishes strict maximum permissible periods of its storage from the moment of harvesting to the start-up in the plant for the production of vitamin flour: at plus air temperature - no more than 1 day, at minus air temperature - no more than 5 days. Depending on the chemical composition of tree greens and the scope of its use is determined.

The most promising direction for the use of logging waste and woody greenery is, among other things, the production of biologically active additives and water extracts. The chemical composition of coniferous tree greens (pine, spruce) includes: 3.5-3.9% of crude protein; 2.3-4.6% crude fat; 14.0-17.3% crude fiber; 22.0-26.4% without nitrogenous extractive substance and 1.6-2.3% crude ash. The digestibility of organic matter is 20.7-22.6%, and the energy value is 3302-3461 kJ/kg of dry matter. In winter, deciduous branches have a minimum amount of carotene and vitamin C, while coniferous branches have a maximum. Therefore, the harvesting of greenery is carried out in the autumn-winter period [8].

The integrated use of logging waste is constrained due to the heterogeneity of the fractional composition of the crushed mass. Therefore, an important problem is to obtain finished products from logging waste, including biologically active additives and growth-stimulating extracts based on it [9,10].

Objects and methods of research. In this work, we studied the growth-stimulating ability of aqueous solutions of woody greens (WG) of conifers on the germination of seeds of Siberian spruce. Requirements for coniferous seeds are laid down in GOST 14161-86 [7]. Spruce seeds of Siberian procurement in 2017, 2018 and 2019 were provided by the Krasnoyarsk forest seed station. Seeds of Siberian spruce of the second germination class according to GOST 14161-86. For germination analysis, 100 seeds of different storage periods were selected, the experiment was carried out in triplicate. Seeds were germinated in Petri dishes, filter paper was used as bedding. Preparation of seeds and methods of their germination, determination of germination was carried out according to GOST 13056.6-97 [8]. For the study, water extracts of coniferous tree greens (GOST 21769-84) were taken and treated with 2 and 5% aqueous sodium hydroxide solution [6]. Distilled water was used as a control. On the 7th day, the germination energy was determined, on the 14th day, the absolute and technical germination of seeds. The growth-stimulating activity of water-alkaline extracts of conifers was tested on seedlings of Siberian spruce with measurement of the length of the shoots on the 3rd and 7th days. The experiment was carried out in 2-fold repetition.

### **Research results and discussion**

The composition of the extractives of aqueous extracts of logging waste, g/l is given in tab. 2.

**Table 2**

*Composition of extractive substances in aqueous extracts of logging waste, g/l*

Name	Content g/l
carbohydrates	0,19
carotenoids	0,014
fatty acids and their derivatives	0,67
diterpenoids	0,38
phenolic compounds	2,61
lignin-like substances	10,89
unidentified	2,21
Total	16,96

According to the studies, the component composition of the water-alkaline extract, wt. %: neutral components 70-85; sodium salts of triterpenic acids 10-15; flavonoids -1-2. In the aqueous extract of coniferous logging waste, a rather high content of carotenoids (0.014 g/l) with provitamin activity and phenolic compounds (2.61 g/l) with growth-stimulating activity was found.

In this work, we investigated the possibility of obtaining a drug with growth-stimulating properties on a water basis from logging waste of coniferous species. For analysis, 3 extracts with different concentrations of sodium salts of triterpene acids were taken. Extract 1 - treatment of the initial solution of logging waste with 2% sodium hydroxide solution; Extract 2 - treatment of the initial solution of logging waste -5% sodium hydroxide solution; Extract 3 - treatment of the initial solution of logging waste with a 5% solution of potassium hydroxide. The amount of neutral substances in aqueous extracts of logging waste, g/l is given in tab. 3.

**Table 3**

*The amount of neutral substances in water-alkaline extracts of logging waste, g/l*

Name*	Extract № 1	Extract № 2	Extract № 3
Test 1	2,44±0,01	0,71±0,04	0,41±0,05
Test 2	2,50±0,02	0,73±0,05	0,55±0,03
Mean value	2,47±0,05	0,72±0,17	0,48±0,21

\*Extract 1 – treatment of WG with 2% sodium hydroxide solution; \*Extract 2 - treatment with WG -5% sodium hydroxide solution; \*Extract 3 – treatment of WG with 5% potassium hydroxide solution.

According to the studies, the component composition of the water-alkaline extract, wt. %: neutral components WG conifers 70-85; sodium salts of triterpenic acids 10-15; flavonoids -1-2. Seed germination was determined according to GOST 14161-86. These data are given in tab. 4.

**Table 4**  
*Germination of spruce seeds on coniferous WG water extracts of various concentrations, %*

Name*	Extract № 1	Extract № 2	Extract № 3	Control
Collection year 2017	$\frac{0}{10}$	$\frac{5}{30}$	$\frac{10}{50}$	$\frac{0}{10}$
Collection year 2018	$\frac{10}{20}$	$\frac{15}{40}$	$\frac{20}{45}$	$\frac{10}{20}$
Collection year 2019	$\frac{10}{20}$	$\frac{20}{40}$	$\frac{45}{80}$	$\frac{30}{55}$

\*The numerator contains data for 3 days; in the denominator on the 7th day.

According to the presented data, it can be seen that from 0 to 45% of spruce seeds hatched on the 3rd day and from 0 to 35% of the seeds on the 7th day. It should be noted that the data on seed germination are 30-35% higher for spruce seeds with a shorter shelf life (2019).

On the 14th day, the germination energy of all seeds was determined by the formula:

$$E = \frac{A \cdot 100}{100}, \%$$

where A - is the number of germinated seeds, pcs;

100 –is the number of seeds in the experiment.

The results are shown in tab. 5.

**Table 5**  
*Length of spruce seedlings on the 14th day, mm*

Name	Extract № 1	Extract № 2	Extract № 3
Collection year 2017	$\frac{15,0}{12,0}$	$\frac{16,0}{15,0}$	$\frac{15,0}{17,0}$
Collection year 2018	$\frac{15,0}{11,7}$	$\frac{15,0}{17,0}$	$\frac{15,0}{17,0}$
Collection year 2019	$\frac{15,0}{20,3}$	$\frac{15,5}{19,5}$	$\frac{15,5}{28,0}$

Note\* In the numerator on distilled water, in the denominator on the water-alkaline extract of WG conifers



a

b

**Figure 1.** a- The length of the seedlings of the seeds of the Siberian spruce 2017 harvested on the 14th day, mm: b- The length of the seedlings of the seeds of the Siberian spruce 2018 harvested on the 14th day, mm



**Figure 2.** The length of the seedlings of Siberian spruce seeds collected in 2019 on the 14th day, mm

## Conclusions

According to the data presented, it can be concluded that the concentration of extractive substances of logging waste, which remain in the logging site after timber harvesting, has an effect. According to the studies, it can be seen that the greatest length of sprouts is observed after seed treatment with extract № 3 (up to 28 mm) with a concentration of extractives of  $0.48 + 0.21$  g/l. The smallest (11.7 mm) is extract 1 with a concentration of extractives of  $2.47 + 0.05$  g/l.

It was determined that with an increase in the storage period, the germination of seeds decreases both in the control and in the experimental sample. It was determined that the highest germination of Siberian spruce seeds is observed when

using an extract with a concentration of extractive substances of 0.48 + 0.21 g/l and Siberian spruce seeds harvested in 2019.

As a result of the research, it was proposed to use 5% water-alkaline extracts of logging waste to increase the germination of Siberian spruce seeds. The study of the effect of soaking seeds in water-alkaline extracts of coniferous logging waste of various concentrations after appropriate tests will allow us to recommend them to increase the germination of seeds of coniferous plants and obtain high-quality planting material.

## References

1. *The influence of growth stimulators of natural origin on coniferous seedlings* / E.M. Andreeva, S.K. Stetsenko, A.V. Kuchin et al. // *Forestry Journal*. 2016. No.3. – 2016. P.10-18.
2. Pentelkina N.V., Pentelkina Yu.S. *The effect of growth stimulants on the sowing qualities of long-stored seeds* // *Forest management and reproduction of forest resources / Scientific tr.MGUL.-2001.-Issue 311.-P.150-153.*
3. Usov V. N. *Influence of the growth stimulator "Epin" on seed germination and growth of seedlings of gustotsvetkovaya pine and Banks* / V. N. Usov, B. V. Popkov // *K 50-the anniversary of the Department of Forestry of the Institute of Forestry and Forestry of the FGOU VPO "Primorskaya GSHA". Anniversary collection of scientific papers.* –Ussuriysk: PGSHA, 2010. –P. 180-185.
4. Ustinova T. S. *The effect of the drug Humate+7 on the growth processes of conifers* /Raldugin, V.A. *Fir triterpenoids and a highly effective plant growth regulator based on them* /V.A. Raldugin//*Russian Chemical Journal*. – 2004. – Vol.86. - No. 3.-P.84-88.
5. RF Patent No. 2298327. *Plant growth regulator with fungicidal action of Verva* / A.V. Kuchin, T.V. Khurshkainen, V.A. Kuchin, N.N. Skripova, patent owner: State Institution Institute of Chemistry of the Komi Scientific Center Uran. – 2006101648/04; publ.10.05.2007. 6.Recommendations for the use of the preparation Verva-spruce for agricultural crops. Syktyvkar, 2012. - 8 P.
7. GOST 21769-84 *Tree greens: put into effect by the resolution of the State Committee of the SSR on Standards of March 23, 1984 No. 923.* - <https://files.stroyinf.ru/Data2/1/4294831/4294831958.pdf?ysclid=l3wjn42foj>
8. Popov, V.K. *Harvesting and processing of forest seed raw materials* / V.K. Popov, T.S. Smogunova, L.T. Sviridov. – Voronezh: VGLTA, 1997. 60 P.
9. Konakov S.I. *Complex use of wood [Electronic resource]: method. instructions* / S.I. Konakov. – Syktyvkar: SLI, 2010. – Access mode: <http://lib.sfi.komi.com>
10. Safina A.V., Timerbaev N.F., Ziatdinova D.F. *Extraction of valuable components from logging waste.*

信息安全事件检测支持系统  
**INFORMATION SECURITY INCIDENTS DETECTION  
SUPPORT SYSTEM**

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抽象的。提出了一种智能支持系统，用于自动化系统信息安全事件的快速检测和响应。该系统的基础是一个知识库，其中包括二分图形式的事件模型，以及一个由这些事件使用存储的触发过程更新的信息安全事件数据库。

关键词：信息安全，智能系统，预防性保护。

**Abstract.** *The article proposes a system of intellectual support for the rapid detection of information security incidents of automated systems and response to them. The basis of the system is a knowledge base that includes incident models in the form of a bipartite graph, and a database of information security events updated by these events using stored trigger procedures.*

**Keywords:** *information security, intelligent system, preventive protection.*

The applied information security policies (IS) and the measures and means taken cannot fully guarantee the protection of information in automated systems (AS), services or computer networks, due to the presence of weaknesses (vulnerabilities) remaining in the AS, which make possible the occurrence of information security incidents. Information security incidents can have negative impacts (both direct and indirect) on the organization's activities. In addition, the emergence of new threats causes the emergence of new, previously unknown information security incidents, for which there are no ready-made recipes for detection and response.

Thus, for any organization seriously concerned about ensuring its information security, it is important to timely: 1) detect and identify (classify) emerging IS incidents; 2) notify all interested parties about their detection and respond to IS incidents, including the activation of appropriate protective measures to prevent (or reduce) negative consequences and restore the security of the AS after the results of negative consequences; 3) carry out preventive measures for the protection of information in the AS, I exclude the occurrence of similar incidents in the future.

One of the ways to ensure the timely detection of information security incidents, their classification and response to them is intellectual support [1] for the detection and classification of information security incidents, which will allow to launch the implementation process in a timely manner and, thereby, significantly reduce the impact of information security incidents on information security in automated systems for various purposes.

As an example, the paper considers the following, quite common, but far from complete, set of incidents  $Y = \{y_i, i=1, \dots, 8\}$  of information security:  $y_1$  - occurrence of the threat of “denial of service”;  $y_2$  - occurrence of the threat of unauthorized access to confidential information, to the resources or premises of the organization;  $y_3$  - occurrence of the threat of collecting information about the protected system;  $y_4$  - abuse of authority by an employee of the organization (unauthorized access to any resources and premises);  $y_5$  - compromise of accounts or passwords;  $y_6$  - virus attack or virus infection;  $y_7$  - violation or malfunction of the backup system;  $y_8$  - violation of the rules for the use of personal data.

At the same time, it is taken into account that the main sources of information are:  $s_1$  - facts identified by employees of the organization;  $s_2$  - the results of the work of information security monitoring tools, the results of inspections and audits (internal or external);  $s_3$  - logs and alerts of operating systems of servers and workstations, antivirus system, backup system and other systems;  $s_4$  - appeals of personal data subjects with an indication of an information security Incident;  $s_5$  - requests and instructions of the supervisory authorities for the observance of the rights of personal data subjects;  $s_6$  - other sources of information: firewalls, attack detection systems, antivirus systems, applications, physical access controls, finally, information from users and administrators themselves, information from external sources.

That is, the information of the set  $S$  of such sources is a set of facts on the basis of which decisions are made about the presence ( $y \in Y$ ) or absence ( $y \notin Y$ ) of an information security incident in the current time interval  $t$  of monitoring the state of information security.

Responding to IS-incidents is the sequence of some actions  $R(t) = \{r_1, r_2, \dots, r_n\}$ , both simple (suspending the automated system, notifying the administrator about the incident, registering it and saving certificates) and complex, requiring a set of specific actions (analysis, classification, localization, identification and elimination of the consequences of an IS incident).

Then the presented problem can be formulated as follows.

It is assumed that all information received from sources  $s_k \in S$  is stored in a special database "INCIDENTS", in which each source  $s_k$  corresponds to a specific record - a table row with which a stored procedure ( $x_k$  - trigger) is associated. A trigger executed automatically when some event  $f \in F$  is occurred.

It is required, according to the information received from the set of triggers  $X$ , to automatically (without the participation of the operator, administrator, etc.) promptly detect, classify the incident (attribution to one of the types  $y \in Y$ ) and start the process of responding  $R(t)$  to it.

As a way to solve this problem used the methods of artificial intelligence systems, and as a built-in means of intellectual support for detecting incidents of information security, we will use a decision support system (DSS) [2]. As the basis of the knowledge base of such a DSS, we will take a correspondence  $F \rightarrow Y$  in which  $F$  is an odd set of IS-events,  $Y$  – a set of IS-incidents. Having such a model, the problem of detecting and classifying information security incidents can be solved using the rule of concluding the calculus of statements [3]:

$$\hat{Y} = \rho[F(X), (F \rightarrow Y)], \quad (1)$$

where  $\rho[\cdot]$  is the rule of logical conclusion,  $F(X)$  is the vector of facts obtained as a result of using information from the set  $X$ .

The rule of conclusion in the classical version has the form:  $\rho: \frac{P, P \rightarrow Q}{Q}$  if the  $P$  (vector of facts) and implication are true, then conclusion  $B$  is true.

From it follows that: 1) it is necessary and sufficient to solve the problem. to construct a model  $(F \rightarrow Y)$ , since the values of  $F(x)$  can always be obtained from a set of specified sources  $X$ ; 2) since the premise  $F_i$  a vector of events, a separate group  $F_i$  of which corresponds to a single incident  $y_i$ , the composition of which can have a different number of events, i.e. the number of events in the group is a random number, then instead of the classical conclusion rules it is advisable to use a fuzzy conclusion rule:

$$\tilde{\rho}: \frac{F(X), F(X) \rightarrow M_Y(X) = \{\mu_i(X), i = 1, \dots, 8\}}{\max\{\mu_i(X), i = 1, \dots, 7\} \rightarrow y_i} \quad (2)$$

The model  $(F \rightarrow Y)$  can be represented as a bipartite graph that meets the following features: 1) the set of vertices is divided into two fractions  $F$  and  $Y$ , 2) any two adjacent vertices, if and only if they belong to different fractions.

In the model  $(F \rightarrow Y)$  the vertices of the fraction  $F$  are events  $f_j$  and the vertices of the second fraction are incidents  $y_i \in Y$ . Such a graph can be represented in the form of adjacency lists  $L = \{ly_1, ly_2, \dots, ly_8\}$ , where  $ly_i$  is a list of vertices (events) of the left side of the graph  $(F \rightarrow Y)$  associated with the vertex  $y_i$  and corresponding to a certain group  $F_i$ . The counter  $St_i$  is associated with each vertex  $y_i \in Y$  the value of which increases by one when the detected event of  $\phi(x)$  coincides with one of the vertices of the adjacency list  $ly_i$ .

With the help of the counter  $St_i$  the values of the membership function for each incident  $\{\mu_i(X), i = 1, \dots, 8\}$  are determined:

$$\mu_i(X) = \frac{\langle St_i \rangle}{n_i}, \quad i = 1, \dots, 8, \quad (3)$$

where  $n_i$  is the cardinality (number of vertices) of a subset  $F_i \subseteq F$  all vertices of which are connected to the vertex  $y_i \in Y$ .

This allows, in accordance with expression (3), to perform the resulting defuzzification of a fuzzy subset:  $\max\{\mu_i(X), i=1, \dots, 7\} \rightarrow y_i$ . Then the problem of identification of incidents is reduced to the problem of traversing the vertices of the left part of the vertices of the graph ( $F \rightarrow Y$ ) in order to count the number of coincidences of the detected event  $f_k(x)$  with the event  $f_{ij}$  in each adjacency list  $l_i$ .

To reduce the dimensionality of the task of traversing the vertices of the graph of the left part (1), the  $f \in F$  events are divided into classes: A – a set of events at the physical level of the AS information infrastructure; B – a set of events at the level of network equipment; C – a set of events at the level of network applications and services; D – a set of events related to the identification of potential the purpose of the attack and getting an idea of the services running on the attacked AS, that is, conducting reconnaissance in order to get an idea of the network topology surrounding the AS and who this AS is usually associated with by exchanging information; and about the potential vulnerabilities of the AS or the network environment directly surrounding it; H – a lot of events at the level of operating systems; G – a lot of events at the level of technological processes, applications, business processes.

Then the search for a match with a vertex consists of two steps: 1) definitions of the event class  $F_i(X)$ ; 2) search for a match  $f_{ij}(x) \approx f_{ij} \in F_i$  inside the class  $F_i$ .

For example, incident  $y_1$  – the occurrence of a denial of service threat, corresponds to an adjacency list  $(a_{14}, a_{15}, a_{16}, b_{01}, b_{02}, b_{03}, c_{05}, c_{06}, c_{07}) \rightarrow y_1$ . And incident  $y_3$  – the occurrence of the threat of "Collecting information", corresponds to the list of adjacency  $(a_{04}, b_{20}, c_{09}, d_{01}, d_{02}, d_{03}, d_{04}, h_{02}) \rightarrow y_3$ .

The response process is started immediately after the identification of a specific incident, where:  $r_1$  – suspend work – turn off the computer by "hard" power off;  $r_2$  – issue a message to the immediate supervisor and information security administrator;  $r_3$  – register the incident;  $r_4$  – if possible, take measures to preserve the evidence of the incident (screenshots of the screen, saving copies of documents).

After these actions, instructions are issued to perform the following actions.

*IS incident analysis* ( $r_5$ ). During the analysis process: 1) the date and time of the information security incident, the full name, position and division of the information security violator are established; 2) workstation data, including information about components such as the operating system and installed applications, network data: network log files, network protection systems, proxy servers, intrusion detection systems, etc. log files of remote access services and network monitor are investigated; 3) data carriers are analyzed to determine their involvement (or non-involvement) in the incident, while it is necessary to establish the fact of using data encryption based on registry keys, as well as file recovery tools.

The analysis ends with the collection of data indicating the causes or source of the incident. Based on the results, the causes of the incident and the persons responsible for its occurrence are established.

*Classification ( $r_7$ ). Information security incidents* are classified according to the following criteria: 1) according to the severity of the consequences for the organization's activities (in monetary terms, on a point scale); 2) according to the degree of probability of a recurrence of an information security incident; 3) according to the types of sources of information security threats causing information security incidents; 4) according to the premeditation of an information security incident (accidental, intentional, erroneous); 5) by types of information infrastructure objects involved (affected) in the implementation of an information security incident; 6) by the level of information infrastructure at which an information security incident occurs; 7) by the violated properties of information security (confidentiality, integrity, accessibility); 8) by the type of incident information security (an accomplished incident, an attempt to implement an incident, a suspicion of an incident); 9) by the complexity of detecting an information security incident; 10) by the complexity of closing an information security incident.

*Localization of an information security incident ( $r_7$ )* - actions aimed at identifying and limiting the functioning of information resources on which signs of a registered information security incident have been detected in order to prevent its further spread.

Examples of possible strategies that can be used to localize IS incidents include:

1. Application of locks (use of a firewall). For example, with the use of a firewall, it is possible to block information flows from IP addresses from which malware, spyware, unauthorized software is distributed, as well as IP addresses of mail repeaters, sources of "phishing" and "spam" or known IP addresses of hosts of violators. Mail locks include filtering attachments, subject lines, and sender addresses. URL and domain name locks may be applied to prevent access to unauthorized or malicious websites or hosts (nodes).

2. Disabling an infected information resource (resource group) from network, allows you to prevent: 1) infection of the rest of the network, 2) unauthorized access to information and, accordingly, violation of confidentiality, integrity and availability of information, 3) further infection or deterrence of malicious actions in the information infrastructure or in a separate segment of the network. This will help the information resource itself to function correctly and at the same time not to spread malicious activity to the rest of the infrastructure.

3. Monitor malicious activity (in some cases it may be appropriate) while limiting the attacker's ability to exploit other information resources.

4. Shutdown. If it is established that the further functioning of the information resource will lead to the destruction (loss) of data in the information infrastructure of the organization, as a deterrent measure, a decision may be made to terminate the functioning of the information resource. If it is determined that a certain information resource, for example, an e-mail server or a web server, should be turned off until the spread of malware is prevented, then the operation of this server should be suspended.

5. Routing changes are carried out in order to eliminate the route along which the attacker operates, preventing the attacker from gaining access to information resources that may be objects of attack, as well as blocking transmission (distribution) mechanisms malware between "infected" information resources.

6. Disabling processes means disabling processes that could be used in a computer attack.

7. Disabling user accounts implies disabling the accounts of those users who could be used in a computer attack.

*Identification of the consequences of an IS incident* ( $r_8$ ) from the implementation of an IS incident consists in forecasting: 1) direct financial damage; 2) reputational damage; 3) potential damage; 4) indirect losses related to unavailability of services, loss of information; 5) other types of damage or aspects of negative consequences for the AS or personal data subjects.

Defined by: 1) information resources affected by the IS-incident; 2) circumstances that contributed to the IS-incident.

Examples of signs of a negative impact on the elements of the information infrastructure that are identified during the analysis include: a) abnormal network activity of the target of a computer attack; b) created, modified, deleted files, directories, software settings, including software tools; c) deviations from the reference (acceptable) configuration parameters of the operational system (OS), and software, including the information protection software; d) deviations from the reference (permissible) composition installed in the OS, software; e) deviations from the reference (permissible) contents of system and protected files; f) potentially timely commands executed, including those located in the RAM of computer equipment; g) signs identifying the source of a computer attack; h) signs of failures, overloads, stops and other violations in the regular operation of the software, signs of violations of the functioning of network services, abnormal use of system resources; and) other information characteristic of certain types of computer incidents, computer attacks.

When assessing the negative impact on the elements of the information infrastructure as a result of an information security incident, the following should be evaluated: 1) labor costs associated with carrying out measures to respond to a computer incident; 2) the duration of the operation of information resources;

3) harm caused to the interests of the person responsible for the operation of the information infrastructure element exposed, the user (users) of the information infrastructure element exposed, including related to the violation of confidentiality, integrity and availability of information processed by this object; 4) harm caused to the organization, including reputational losses, economic damage and other harm; 5) financial costs for the restoration of the regular functioning of information resources.

The elimination of the consequences of the IS-incident ( $r_0$ ) includes the following activities:

At the network level: 1) making changes to the settings of the software operating in the information resources involved in the computer incident; 2) connecting backup resources (communication channels, server equipment, virtual machines, equipment from spare tools and accessories); 3) making changes to the architecture of information resources involved in the computer incident .a computer incident, including the relevant project documentation; 4) migration (relocation) of virtual machines to third-party virtual infrastructures.

At the application software level: 1) setting up a secure configuration of an information resource involved in an information security incident; 2) restoring files, databases, and configuration files that were modified during an information security incident from actual backups; 3) restoring deleted files, including using special tools; 4) deleting software involved- the information security incident and all its files, followed by the installation of the current version of this software and current security updates.

At the OS level: 1) removal of traces of malicious activity; 2) restoration of the OS as a whole of the affected object; 3) setting up a secure OS configuration; re-installing the OS and software with subsequent installation of current security updates.

Closure of a computer incident ( $r_{10}$ ) after receiving confirmation of the adoption of all measures provided for at the stages of localization of an information security incident and identification and elimination of its consequences, provided that the conducted testing showed the sufficiency of the measures taken.

A feature of the proposed method of intellectual support for solving the problem of operational detection of information security incidents is the possibility of its application in the construction of preventive information protection systems, which is today one of the main directions of the theory and practice of information security.

## References

1. Tariq, Rafi, *Intelligent Decision Support Systems- A Framework, India, 2011*
2. Sanchez i Marre, Gibert, *Evolution of Decision Support Systems, University of Catalunya, 2012*
3. Ltifi, Trabelsi, Ayed, Alimi, *Dynamic Decision Support System Based on Bayesian Networks, University of Sfax, National School of Engineers (ENIS), 2012*

引入“工业4.0”理念, 构建工业企业业务流程智能控制系统金字塔  
**BUILDING A PYRAMID OF INTELLIGENT CONTROL SYSTEM  
OF BUSINESS PROCESSES OF INDUSTRIAL ENTERPRISES BY  
INTRODUCING THE CONCEPT OF “INDUSTRY 4.0”**

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抽象的。通过引入“工业4.0”的概念, 提出了工业企业业务流程智能管理系统金字塔。业务流程智能管理金字塔由六个层次组成, 其第二和第三层次是“工业4.0”概念元素的应用, 第四层次是一个全新的概念——SysLM。在行业业务流程智能控制系统的金字塔中, 强调要特别关注三个方面: “商业智能”、“物理和信息安全”以及“商业知识管理”。

关键词: 业务流程管理, 控制金字塔, 系统生命周期管理, 产品生命周期管理, 商业智能, 商业知识管理。

**Abstract.** *By introducing the concept of “Industry 4.0”, the pyramid of the intelligent management system of business processes of industrial enterprises is proposed. The pyramid of intelligent management of business processes consists of six levels, its second and third levels show the application of the elements of the concept of “Industry 4.0”, and the 4th level consists of a completely new concept – SysLM. In the pyramid of the intelligent control system of business processes in industry, it is emphasized that special attention should be paid to three important aspects: “Business Intelligence”, “Physical and information security” and “Business Knowledge Management”.*

**Keywords:** *business process management, pyramid of control, systems life cycle management, product life cycle management, Business Intelligence, Business Knowledge Management.*

## **Introduction**

Today, as in all industries, the oil and gas industry is undergoing major chang-

es. Oil and gas processing technologies are being improved, it is expected to expand the nomenclature of products obtained on the basis of deep processing of hydrocarbon raw materials. In order to meet the requirements for the composition and quality of the obtained products, special importance is attached to the technological processes of separating raw materials into components in the petrochemical industry. In addition to ensuring the competitive quality of the finished product, achieving resource and energy efficiency in the organization of production is considered as a priority task. Since the products produced in the petrochemical industry are mainly gas and liquid products, the quality indicators of the products produced depend on the concentrations of the target separated components in their content. So, if we take into account that the composition of the manufactured products determines their quality indicators, then it is necessary to optimally control the technological modes of organizing the technological processes of separation of mixtures and the values of technological parameters. Today, complex technological processes of rectification of multi-component mixtures are required to be controlled with high accuracy and speed. It should be noted here that today it is possible for industrial enterprises to create more advanced automation control systems using modern advances in information technology.

With the introduction of the concept of “Industry 4.0” in the oil and gas processing industry, attention is paid to the high importance of “Systems Lifecycle Management – SysLM” systems in the intelligent business process management (iBPM) in the industry. By complementing the concept of Product Lifecycle Management (PLM) with digital modeling, the transition to SysLM is accelerating [1, 2, 3, 4]. Because digitalization is the basis of the development strategy of social life [5, 6, 7].

In the article [8], the issue of outer shell design of innovative developments is considered, in which the utility theory is described, which is considered as the main stage of systematic analysis for analytical comparison of the alternatives of the systems being created. The article [9] describes the analysis of scientific research works devoted to the automated design of technological processes and production, product life cycle management, the use of simulation modeling in design, and offers a structure and algorithm that serves to reduce the life cycle of design in the design of complex technological processes.

In the articles [10, 11], the authors made various suggestions about the management of business processes of industrial enterprises, the principles of intellectual control of business processes and their effectiveness. Also, solutions for analyzing data in the control system architecture through IoT and managing various situations in business processes are proposed.

Based on the above, in this research work, we propose a 6-level pyramid of process control and a new control system architecture for intelligent control of the

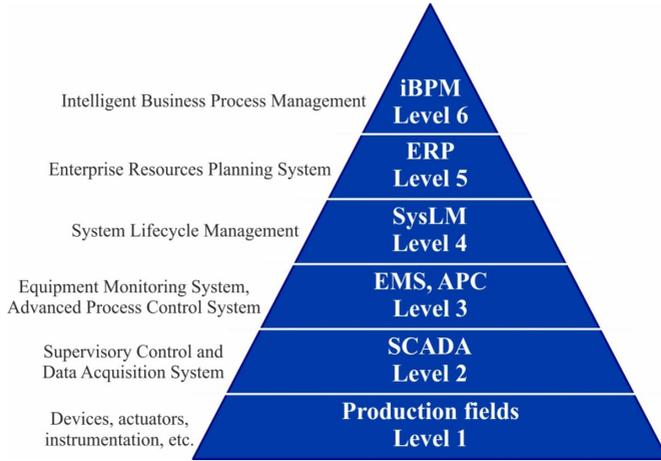
life cycle of technological complexes of rectification of multicomponent mixtures for oil and gas industry enterprises.

**Main part**

By introducing elements of the concept of “Industry 4.0” to industrial enterprises, the potential of automated control systems increases. Because the concept of “Industry 4.0” is based on the full digitization of the control of business processes of industrial enterprises and supports these processes through artificial intelligence [12]. Processing large amounts of data in industry, achieving improvement in management quality, providing control system service personnel with almost complete information about all processes in industry, making rational control decisions in order to achieve resource and energy savings in process management at all stages of the life cycle, all of this requires fast information. That’s why when talking about the concept of “Industry 4.0”, the term “informatization – datafication” rightly appeared. At the same time, due to the use of modern information technologies, direct communication between the customer and the project executors is ensured.

In the pyramid of the six-level control system proposed in this research work (Figure 1), the main task is to ensure fast and high-accuracy exchange of information at all levels. The mentioned control system is typical for oil and gas processing enterprises in the pyramid, and allows a clear visualization of information exchange in the control of the entire industrial production.

The proposed pyramid industrial enterprise intelligent business process management system (iBPM) is located at the top level 6, which in turn is closely connected vertically with all packi levels. Level 1 is called the production area, where the main technological processes are carried out in devices and hardware. At this level, the main process is the processing of raw materials to obtain a finished product, therefore, despite the fact that it is located at the bottom of the pyramid, it is the main level. All the remaining 5 levels serve to ensure the high-quality implementation of technical and technological works of the 1st level, the competitiveness of the obtained product, the achievement of energy and resource savings, and finally, economic benefits.



*Figure 1. Pyramid of the system of intelligent management of business processes in industry based on the concept of “Industry 4.0”.*

The main reason for the 2nd level SCADA system is that at this level, the real production processes of the 1st level are carried out, all the information about the technological modes and main parameters in them is collected through measurement and control tools, and the dispatching control is carried out. The 3rd level monitors the working condition of all existing devices, apparatus and equipment in production, implements improved management of technological processes. APC-systems operate at this level through special software tools. They are equipped with the necessary tools, from virtual analyzers to predictive models. The 4th level is the level based on the element of the “Industry 4.0” concept and is the system of life cycle management of systems. This level is created by integrating the product life cycle - PLM and digital twins of technological processes. This level connects level 5 and level 3, but it enables the production of products with established quantity and quality indicators based on the requirements given by the ERP system. At the same time, he controls the work of the levels below him. Digital twins in the SysLM system act as a digital model of technological processes, and with their help, real production processes are organized with optimal indicators. It is the SysLM-system that acts as the most important organizational part in the system that organizes the management of business processes in the industry, using online coordination of customer and executive requirements, cloud computing, and cyber security. Level 5 is the ERP system, which is the level responsible for enterprise resource planning. This level ensures that several departments of the enterprise, such as production, implementation of innovative developments, sales,

marketing, logistics, accounting, legal department, work together for the success of the enterprise. Also, at this level, coordination of the work of customer service and service departments, or in other words, automation tasks are assigned. The 6th level is called “Intelligent Business Process Management – iBPM”, which refers to the management of the enterprise’s business processes using “intelligent capabilities”. It usually includes at least two systems: Business Process Management System - BPMS and Business Intelligence - BI. iBPM, on the other hand, enables the execution of business processes, creates favorable conditions for the execution of the process and the creation of developments, shows the impact reaction to changes in the voluntary content of the management system, ensures the interaction of the personnel involved in the management of the process, creates integration between personnel, systems, information, tasks able to perform tasks such as actively analyzing performance, making changes, managing business processes according to rules, supporting management decisions.

Based on the concept of “Industry 4.0”, the pyramid of the intelligent management system of business processes in the industry mainly focuses on three important aspects. They include “Business Intelligence”, “Physical and information security” and “Business Knowledge Management”. In the intellectual management of business processes, by processing a very large amount of data in business processes, focusing only on the main factors that affect the efficiency of the enterprise, developing possible prospective management strategies and options, and analyzing the results of the management decisions. Ensuring security at all levels of the business process management system pyramid is important. For example, we can divide security into two types: physical and informational. Physical security means protecting the company’s physical assets from threats, while information security means protecting against cyber-attacks on networks at pyramid levels. In this regard, the cyber security element of the “Industry 4.0” concept will help. In manufacturing industries, whether chemical or oil and gas processing, knowledge of business processes and systems improves throughout the life cycle of a process organization. For example, in the management of the life cycle of technological complexes of rectification of multi-component mixtures, low-level knowledge helps to understand basic concepts such as real technological processes of rectification, execution of management decisions, impact on product quality, energy and resource consumption. And this knowledge is specific knowledge, which is managed at the lower level of the pyramid. At the same time, at the upper levels of the pyramid, there is also implicit knowledge in the form of management experience, qualifications and skills, which are acquired during work with the management system.

**Conclusion.** Based on the above, it can be said that by introducing the concept of “Industry 4.0”, the proposed control pyramid for intelligent management sys-

tems of business processes of industrial enterprises serve to improve the quality of technological process management. At the same time, it makes it possible to take into account the changes in the requirements set by the developer at all stages of the management of the life cycle of products and systems. The SysLM-system on the 4th level of the proposed pyramid of the intelligent management system is created by incorporating the product life cycle - PLM and digital twins of technological processes, and it serves to ensure the organization of production processes with optimal indicators in real time using a digital model of complex technological processes. Special attention is paid to the provision of physical and information security in the intellectual management of business processes of an industrial enterprise.

## References

1. Valentina Gecevska, Paolo Chiabert, Zoran Anisic, Franco Lombardi, Franc Cus. *Product lifecycle management through innovative and competitive business environment // Journal of Industrial Engineering and Management*, 2010. –V.3. I.2.DOI:10.3926/jiem..v3n2.p323-336.
2. Stefan Wiesner, Mike Freitag, Ingo Westphal, Klaus-Dieter Thoben. *Interactions between Service and Product Lifecycle Management // Procedia CIRP. Volume 30*, 2015. –PP.36-41. <https://doi.org/10.1016/j.procir.2015.02.018>.
3. J.Stark.*Product Lifecycle Management: 21st Century Paradigm for Product Realisation*. Springer,2011.
4. Hribernik, K., Wuest, T., & Thoben, K.D. *Towards Product Avatars Representing Middle-of-Life Information for Improving Design, Development and Manufacturing Processes*. In *Digital Product and Process Development Systems* (pp. 85-96). 2013. Springer Berlin Heidelberg.
5. V Ignat. *Digitalization and the global technology trends // ModTech International Conference - Modern Technologies in Industrial Engineering V 14–17 June 2017, Sibiu, Romania*. doi:10.1088/1757-899X/227/1/012062.
6. *Digital technologies for a new future. Digital technologies for a new future (LC/TS.2021/43)*, Santiago, 2021. 95p. [https://www.cepal.org/sites/default/files/publication/files/46817/S2000960\\_en.pdf](https://www.cepal.org/sites/default/files/publication/files/46817/S2000960_en.pdf).
7. Ike Justice Akpan. *Digitization and technological transformation of small business for sustainable development in the less developed and emerging economies: a research note and call for papers //Journal of Small Business & Entrepreneurship*, 2021. <https://doi.org/10.1080/08276331.2021.1924505>.
8. Yu.Sh.Avazov. *Control of the Facial Design Process of Innovative Developments // International scientific and technical journal “Chemical*

*Technology. Control and Management*”, 2021. -№5 (101). -PP.58-61. <https://doi.org/10.51346/tstu-02.21.5-77-0042>.

9. Yu.Sh.Avazov. *Design Lifecycle Management of Technological Processes // International scientific and technical journal “Chemical Technology. Control and Management”*, 2021. -№6 (102).-PP.5-12. <https://doi.org/10.51346/tstu-02.21.6-77-0045>.

10. Christopher Zaby, Klaus D. Wilde. *Intelligent Business Processes in CRM // Business & Information Systems Engineering*, 2018.volume60. –PP.289–304.

11. Abir Ismaili-Alaoui, Karim Baina, Khalid Benali. *IoDEP: Towards an IoT-Data Analysis and Event Processing Architecture for Business Process Incident Management // International Journal of Advanced Computer Science and Applications*, Vol. 13, No. 4, 2022. –PP.900-915. (DOI):10.14569/IJACSA.2022.01304104.

12. Kerin M, Pham D (2019) *A review of emerging industry 4.0 technologies in remanufacturing. J Clean. Prod* 237:117805. <https://doi.org/10.1016/j.jclepro.2019.117805>.

DOI 10.34660/INF.2022.98.30.134

为智能测量仪器创建软件算法的识别方法  
**IDENTIFICATION APPROACH FOR CREATING SOFTWARE  
ALGORITHMS FOR INTELLIGENT MEASURING INSTRUMENTS**

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抽象的。本文介绍了多功能测量设备并讨论了它们的应用。多功能智能仪表为开发新的测量系统、分析和优化现有方法、确定测量不确定性和纠正基于模型的系统误差提供了见解。测量算法不仅包括测量手段，还包括测量参数之间的相互作用。

关键词：智能传感器，软件分析仪，测量，数学模型，测量不确定度，多功能测量装置。

**Abstract.** *This article presents multifunctional measuring devices and discusses their application. Multifunctional smart meters provide insights for developing new measurement systems, analyzing and optimizing existing methods, and determining measurement uncertainty and correcting model-based systematic errors. The measurement algorithm includes not only the measurement means, but also the interactions between the measured parameters.*

**Keywords:** *intelligent sensors, software analyzer, measurements, mathematical models, measurement uncertainty, multifunctional measuring devices.*

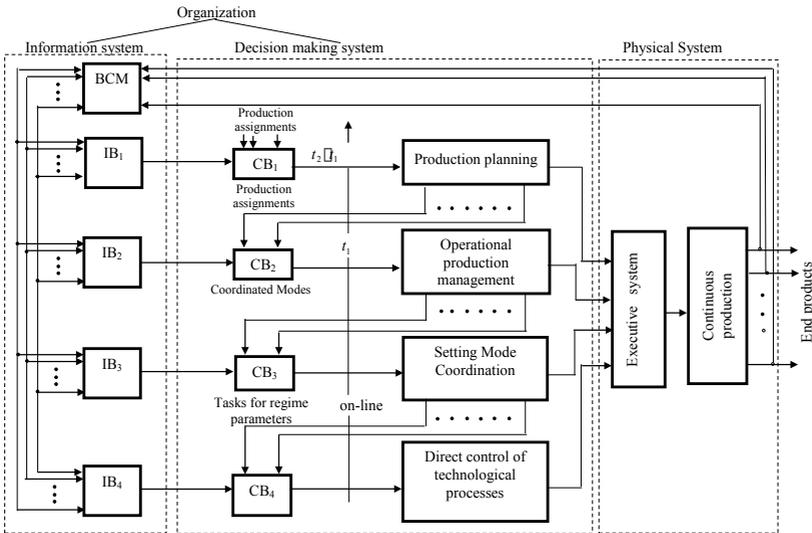
The need to develop identification analysis methods and create on their basis software algorithms for measuring instruments in the tasks of automating technological production is due to the intensification of the use of modern information technologies in industry. Achieving a competitive advantage in today's dynamic market becomes impossible for manufacturers without ensuring the highest possible information transparency and making optimal management decisions.

The intellectual content of the measuring tools of modern integrated production management systems should maximize the adoption of rational and effective management decisions. Of decisive importance in this aspect is the use of both

current and retrospective data on production processes and situations at different levels for the control system of a specific production process to the fullest extent. All these data arrays make it possible to form new knowledge in real time, which makes it possible to develop control actions in each individual section with the most efficient use of a priori information about all processes at the facility [1].

In mathematical modeling of intelligent measuring instruments based on the simplification of complex physical processes, numerical simulation of the process under study is often used, which is determined by boundary conditions and input parameters. The choice of simplifications limits the conditions of use under which the models, hence the results, are valid. [2,3]

It should be noted that intelligent measuring instruments, being a processor for processing materials and information, includes the actual physical production, a decision-making subsystem and an information subsystem. The last two together form the basis of the information management system (Fig. 1).



**Figure 1.** Scheme of representation of the organization with intellectual means of measurement. BCM - block of the current measurement; IB - integration block; CB - comparison block.

Software analyzers of the technological cycle of production are focused on solving the problems of improving the quality of the manufactured product at all stages of production, quickly determining the optimal modes of operation for

various efficiency criteria in the current situation, as well as ensuring the reliability of the operation of production equipment. They analyze the current situation and study the technological process as a control object in real time, predict the quality of the output product for the selected technological mode, and form the optimal control actions for a given quality criterion. However, in certain production conditions, not all the possibilities of the PA may be in demand. In this case, the functions of the software analyzer can be limited only to the creation of an information basis for the current control system of the MES type.

For many industries (industrial facilities, exchange processes and banking operations, etc.), one of the main requirements for management is high reliability. At the same time, the high productivity of such facilities causes large economic losses in case of failures. In some cases, the lack of completeness of information about the object leads to the need for robust control, which guarantees the functioning of the object within the framework of technological requirements and ensures the quality of the manufactured product within the allowable ranges determined by the technological regulations. Therefore, the study of the possibility of using the theory and methods of robust control in software analyzers of technological processes of production seems to be promising and economically justified.

When building models of technological processes of continuous production, it is necessary to solve the problem of identification in conditions of small samples of observations. The choice of identification algorithms should be determined in this case by the decay rate of transient processes in the identifier, and, in addition, by low sensitivity to the accuracy of the initial approximation [4].

With regard to the class of finite noise distribution densities at the output, it is possible to construct fairly simple estimation algorithms with a characteristic of the “dead zone” type, which have a high convergence rate and allow obtaining highly consistent estimates of the object’s parameters, including in cases where the input sequence is random vectors whose components are sequences of random variables correlated in time, which is relevant for a very wide class of applications.

The solution of the problem of synthesis of optimal discrete control systems involves the use of the concepts of optimality, both the structure of the control device and the optimality of adaptive identification algorithms. With the development of optimal algorithms in the case of incomplete a priori information, the introduction of the concept of optimality on a class is associated, depending on the nature of the information about the noise distribution density.

The construction of optimal algorithms is directly related to the adequate assignment of an object to a certain class [5].

As for object models, for a wide class of technological processes, a sufficient degree of adequacy is provided by object models that are linear in parameters in the presence of the stationary hypothesis. The basis for such a simplification,

despite the obvious non-linear and non-stationary nature of a wide range of processes, is provided by a relatively slow change in the parameters of the feedstock and the parameters of the object itself.

Real-time identification algorithms are recurrent procedures (stochastic gradient or pseudo-gradient) with respect to a given quality functional. In this case, the speed of the identifier is determined by information about the distribution of perturbations.

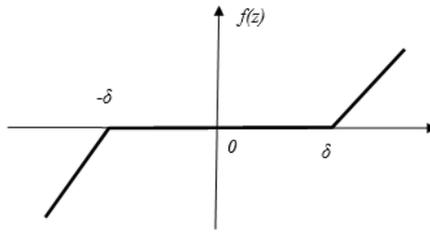
To identify linear objects, the recurrent least squares method is most often used, as well as simpler algorithms with a linear transformation of the residual without recurrent matrix inversion.

The use of such algorithms is also due to ensuring the monotonicity of the transient process in the identifier. With the obvious advantages associated with ease of implementation, it should be noted the lack of noise immunity of linear algorithms. This is due to the following factors:

- their high sensitivity to unreliable measurement results, which leads to the need for preliminary rejection;
- linear algorithms are inefficient with sufficiently good initial parameter estimates;
- in the class of algorithms with a linear characteristic, an increase in the estimation accuracy is possible only by reducing the step, which leads to a slowdown in the transient processes in the identifier and may conflict with the assumption of plant stationarity.

To achieve a compromise between the accuracy and speed of the identifier, in particular, it is possible to use non-linear residual transformations of the “dead zone” type, which do not change the steepness of the algorithm characteristics and, at the same time, provide acceptable noise immunity. The study of the assumption of limited interference is essential in the study of the convergence of the algorithm with a dead zone (Fig. 2).

When choosing the dead interval, it should be taken into account that if it overlaps the boundaries of the interference, then the adaptation stops too early, and the accuracy of the estimates obtained may be unsatisfactory. If the insensitivity interval is unjustifiably narrowed, then the algorithm approaches in its properties to the Kalmazh algorithm and coincides exactly with it when the dead zone degenerates into a point. As a consequence, a decrease in the dead interval worsens the noise immunity of the algorithm.



**Figure 2.** Static characteristic “dead zone”

Essential for the use of algorithms with a dead zone is the assumption of independence in the set of members of the sequence of inputs. Investigation of the convergence of these algorithms under conditions when the input sequence satisfies the strong mixing condition.

The study of the convergence of identification algorithms is all the more complicated in the presence of a feedback loop. The degeneration of the information matrix of the object becomes probable, and the low variability of the control and perturbing actions leads to the impossibility of unambiguous restoration of the object’s parameters. An effective identification method under conditions of correlated inputs and limited interference is the method of introducing test actions with sufficiently rich spectral properties into the control channel. However, the introduction of trial impacts is technologically possible not for all objects. Therefore, it is important to construct identification procedures of a different type, which would allow one to obtain strongly consistent estimates under conditions of dependent inputs, and, moreover, provide a gain in speed.

Further weakening of the requirement of independence of inputs emerges as an actual independent task, the solution of which significantly expands the possibilities of using the described algorithms in intelligent measuring devices of the technological process.

## References

1. U.A.Ruziev, M.K.Shodiev *Increasing the reliability of the measuring information of quality of liquid products. Chemical technology. Control and management 2015, №3-4.*
2. Yager R.R., Zadeh L.A. (Eds.), *Fuzzy sets, neural networks and Soft Computing, VAN Nostrand Reinold. - New York, 1994. – 440 p.*

3. Aliev R.A., Barak D., Chew G. at all, *Soft Computing: Fuzzy Logic, Neural Network and Distributed Artificial Intelligent*. F.Aminzadeh, Jamshidi M. (Eds.), PTR Prentice Hall Englewood Cliffs. - New Jersey, 1994. – 301 p.

4. Zurada Y.M., Marks R.J., Robinson C.Y. (Eds.). *Computational Imitating Life*, Piscataway. - NJ: IEEE Press, 1994. – 448 p.

5. Pearson D.W., Stele N.C., Albrecht R.F., (Eds.), *Artificial Neural Nets and Genetic Algorithms: Proceedings of the International. Conference In Ales.* -France, 1995. -552 p.

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高速磁悬浮运输系统中车载系统的电磁兼容性  
**THE ELECTROMAGNETIC COMPATIBILITY OF ONBOARD  
SYSTEMS IN A HIGH-SPEED MAGNETIC LEVITATED  
TRANSPORT SYSTEMS**

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抽象的。发展陆路交通的有前景的领域之一是采用直线驱动和车辆磁悬浮的高速交通。电动悬架系统能够提供高达 500-600 公里/小时或更高的速度，而悬架系统中的气隙很大（高达 100-150 毫米），这是有助于高速行驶安全的因素之一。然而，电动悬挂系统的缺点之一是由悬浮、推力和方向系统的机载超导线圈产生的强外部磁场。文章证实了确保车载设备电磁兼容性和乘客电磁安全问题与电动悬架高速车辆的相关性，并给出了外部磁场的计算结果。使用 ELCUT 软件包执行的船员舱地板水平。

关键词：电磁兼容，高速地面运输，磁悬浮，超导磁系统，外磁场

**Abstract.** *One of the promising areas for the development of land transport is high-speed transport with a linear drive and magnetic suspension of vehicles. Electrodynamic suspension systems are capable of providing speeds of up to 500-600 km/h or more with significant air gaps in the suspension system (up to 100-150 mm), which is one of the factors contributing to the safety of high-speed transportation. However, one of the disadvantages of electrodynamic suspension systems is the strong external magnetic fields created by the onboard superconducting coils of the levitation, thrust and direction systems. The article substantiates the relevance of the problem of ensuring the electromagnetic compatibility of on-board equipment and the electromagnetic safety of passengers in relation to a high-speed vehicle with an electrodynamic suspension, and also presents the results of calculating the external magnetic field at the level of the floor of the crew cabin, performed using the ELCUT software package.*

**Keywords:** *electromagnetic compatibility, high-speed ground transport, magnetic suspension, superconducting magnetic systems, external magnetic fields*

The growing need of the population for rapid movement between large cities and within urban agglomerations determines the need for the development of high-speed ground transport. At present, the development of high-speed ground passenger communications at distances up to 1000 km goes in two directions: the development of a traditional railway network, where the implementation of traction and braking forces is carried out due to the traction gearbox and the interaction of the wheel-rail pair, and the development of high-speed maglev transport, where traction and braking forces are implemented by a direct (gearless) linear drive, and the suspension of the crew is provided by magnetic levitation systems.

Currently, several transport systems with a linear drive and electromagnetic suspension are in commercial operation: Transrapid (China), Linimo (Japan), Rotem (South Korea), metro lines in the cities of Beijing and Changsha (China). The Transrapid transport system ensures the movement of passengers at speeds up to 400-450 km/h, other systems - at speeds up to 100-110 km/h. Commercial operation of transport systems with electrodynamic suspension is still limited for a number of objective reasons: only MLX-01 crews at the Yamanashi test site (Japan) are in pilot commercial operation.

In systems with electromagnetic suspension, air gaps of the order of 8–10 mm are realized, which requires high reliability, accuracy, and speed of the automated vehicle suspension control system. High-speed transport systems with electrodynamic suspension of the crew are capable of ensuring the movement of passengers at speeds up to 500-600 km/h (in the future - up to 1000 km/h) with large air gaps in the suspension system (up to 100-150 mm), while the levitation of the crews is provided by lifting forces at speeds above 80-100 km/h. Large air gaps and the natural nature of the occurrence of levitation forces in systems with an electrodynamic suspension can be considered as factors contributing to an increase in the safety of high-speed passenger transportation.

At the same time, large air gaps in electrodynamic suspension systems are provided by strong magnetic fields, which are created by onboard superconducting coils placed on the vehicle. For this reason, one of the significant problems of transport systems with electrodynamic suspension is the problem of the electromagnetic influence of the onboard superconducting coils on the onboard electrical equipment, as well as on the electromagnetic environment inside the passenger compartment.

The onboard electrical equipment of high-speed maglev vehicles can be represented by equipment for the following purposes:

1. auxiliary power electrical equipment of relatively low power, providing the crew's own needs, i.e. power supply of cryogenic systems of crew superconducting magnets, ventilation systems, air conditioning, interior lighting, etc.;

2. information and control equipment of low power (on-board wired and wireless control and communication systems, information and telecommunication equipment in passenger compartments, etc.).

The need for compact placement of sources of strong external magnetic fields (superconducting coils of traction, suspension and direction systems) and on-board auxiliary and information electrical equipment within the limited dimensions of high-speed maglev transport crews determines the inevitability of their mutual influence on each other and the urgency of the problem of ensuring their electromagnetic compatibility.

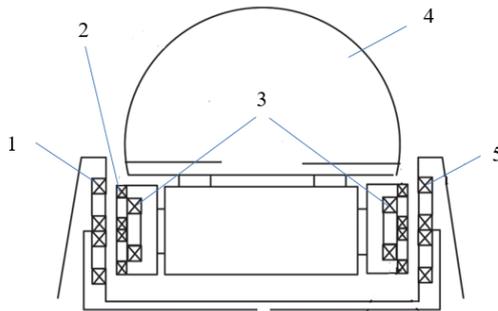
Since the onboard auxiliary and information equipment of relatively low power is a source of very weak external fields, it is advisable to take into account the one-sided influence of the crew superconducting systems of thrust, suspension and direction on the crew auxiliary and information equipment due to magnetic stray fields (external fields).

By electromagnetic compatibility, we mean the ability of onboard auxiliary and information equipment to work flawlessly (i.e., with given output power, signal parameters, and given functionality) together with sources of strong external magnetic fields [1–3].

External magnetic fields of onboard superconducting magnetic systems can have a harmful effect on the operation of onboard auxiliary and information equipment: lead to magnetic saturation of steel structural elements of onboard electrical installations and reduce their output parameters (power, voltage, current), cause distortion of information signals and failures in the order of working out given work algorithms, etc. In addition, one should also take into account the possibility of the harmful effects of external magnetic fields on passengers inside the crew cabin. For this reason, the task of ensuring electromagnetic compatibility can be reduced to two subtasks:

1. calculation of the external magnetic field of the onboard superconducting system at given points inside the crew in the absence of means of magnetic protection for passengers and equipment;
2. selection and calculation of means of protection against external magnetic fields of onboard superconducting magnetic systems (magnetic shields).

Let us evaluate the external fields of the magnetic systems of the MLX-01 crew. On fig. 1 shows a schematic section of the track and onboard magnetic systems of the MLX-01 high-speed vehicle.

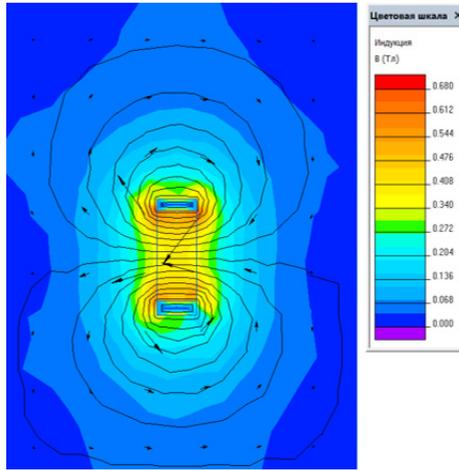


**Figure 1.** Schematic section of the MLX crew-01 [4].  
 1, 5 – travel coils; 2 – onboard coils of the linear generator;  
 3 – superconducting side coils; 4 – crew.

Figure 2 shows the picture of the external magnetic field of the superconducting coil of the MLX-01 combined propulsion, suspension and vehicle guidance system, calculated using the ELCUT software package. The parameters of the superconducting coil are presented in tab. 1. Tab. 2 presents the results of calculating the external magnetic field of the superconducting coil at the floor level of the passenger cabin of the MLX-01 crew.

**Table 1**  
 Main Features of MLX High Speed Vehicle  
 Superconducting Onboard Coils-01 [4, 5]

Parameter	Value
Pole division, m	1,35
Coil length, m	1,07
Coil height, m	0,5
Magnetizing force, kA	700
Number of coils per trolley	2*4
Distance from the center of the carriage to the axis of symmetry of the coil, m	1,49



**Figure 2.** Magnetic field pattern of the superconducting coil of the MLX-01 combined thrust, suspension and crew guidance system.

**Table 2**  
the resulting value of magnetic induction at the floor level of the passenger cabin of the MLX-01 crew.

Calculated point	X, mm	Y, mm	B, Tl
Point 1 (cabin center)	0	750	0,021
Point 2	600	750	0,083
Point 3	1200	750	0,393
Point 4 (cabin edge)	1800	750	0,344

The results of the calculation show that there are zones inside the passenger compartment of a crew with an electrodynamic suspension in which the induction of the external magnetic field of the onboard superconducting coils significantly (by 2–40 times) exceeds the safe levels normalized for a person (0.01 Tl). Obviously, external magnetic fields of this level can also have a harmful effect on the operation of onboard power and information and control equipment. This confirms the urgency of the problem of electromagnetic compatibility of magnetic systems of traction, suspension and direction, which are sources of strong external magnetic fields, with on-board electrical equipment and the need to ensure electromagnetic safety in the passenger compartment.

### References

1. Apollonsky S.M., Gorsky A.N. *Calculations of electromagnetic fields*. M.: Route, 2006. – 992 P.
2. Apollonsky S.M., Gorsky A.N., Nikitin V.V. *Problems of electromagnetic safety in modern electric power systems of railway transport // Electronics and electrical equipment of transport – 2017, № 2. – P. 43-47.*
3. *Electrical compatibility of electrical equipment of autonomous systems*. Boldyrev V.G., Bogarov V.V., Bulenkov V.P. etc. M.: Energoatomizdat, 1995.
4. Boldea I. *Linear Electric Machines, Drives and MAGLEV's Handbook*. CRC Press, 2013. – 634 P.
5. Toshiaki, M. and Shunsuke, F., *Design of coil specifications in EDS Maglev using an optimization program, Record of LDIA-1998, Tokyo, Japan, P. 343–346, 1998.*

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通过改进技术应用水力压裂  
**APPLIANCE OF HYDRAULIC FRACTURING BY ADAPTED  
TECHNOLOGIES**

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抽象的。目前，石油公司遇到开发具有油藏高含水区域的油藏的问题。以完全采油为目的，从这些地区进行流入增产是油田开发的主要任务之一。水力压裂处理 (HFT) 是通过在高压下注入气体或流体而在岩层中制造和增强裂缝的过程。已经形成的裂缝增加了储层的渗透率，从而提高了石油采收率。但在 HFT 期间使用标准方法并不总是一种有效的方法，因为正在形成的裂缝可能会进入油藏的高含水区域，这可能只会加剧石油生产过程。这项工作的目的是分析在高含水井水力压裂过程中使用合适的方法。饱和水子层和流动区域的隔离、裂缝方向管理、技术和试剂分类是 HFT 应解决的主要任务之一，以提高油田开发的盈利能力。

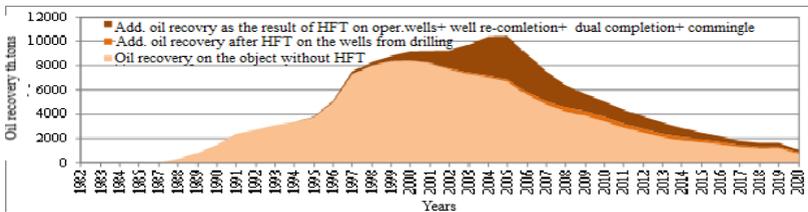
关键词：水力压裂，油井干预，流量，含水，适应技术。

**Abstract.** *Currently oil companies encounter the problem of developing oil deposits having high-water-cut regions of a reservoir. Inflow stimulation from such regions, with the purpose of complete oil extracting, is one of the main task during fields developing. Hydraulic fracturing treatment (HFT) is the process of making and enhancement fractures in a rock formation which are being made by injecting gas or fluid under high pressure. The fractures having been made increase permeability of the reservoir which allow to increase oil recovery. But using the standard methods during HFT is not always an effective method because the fractures being made may get into high-water-cut regions of a reservoir that may only aggravate oil production process. The aim of this work is the analysis of using adapted methods during hydraulic fracturing on high-water-cut wells. Isolation of water saturated sublayers and flow regions, managing fractures direction, technology and reagent assortment are one of the main tasks which should be solved during HFT for increasing profitability of a field developing.*

**Keywords:** *hydraulic fracturing, well interventions, flow rate, water cut, adapted technologies.*

Hydraulic fracturing of a reservoir is one of the most effective method of increasing oil recovery nowadays. The fractures which are made in the process of HFT stimulate flow of oil towards bottom of a well, by that increasing additional oil recovery. The fractures are made by injecting a huge volume of fluid under high pressure into needed zone of a reservoir. Usually HFT fluid consists of water, proppant and different chemical additions pumping which into a reservoir results in changing the shape of a reservoir pressure distribution curve [1].

On one of the oil fields of Western Siberia, to be exact on the object XZ, HFT were performed during bringing-in of wells and on operating well stock that resulted in achievement of additional oil recovery 4% and 19% from the total volume of cumulative production on the object correspondingly.



Picture 1. Dynamics of oil extraction change on the object XZ.

On that picture is seen that well operations significantly influence on additional oil recovery. So, more rational developing of producing well stock and more complete coverage of the horizon having been drilled happens for account of HFT during well re-completion from a developed object to a perspective. This type of work is in needed during oil production decline and as a consequence current object developing cost effectiveness decline. This is why isolation of depleted layer with the purpose of preventing from breakthroughs of fluids and other impurities through the string of piping to upper layers is performed by installing a cement plug. Then research works on various parameters are conducted by a technological project and then bottom-hole formation zone treatment (BHZ) is conducted basically by the method of multistage hydraulic fracturing (MSHF) that leads to creation of high-conductivity channels along which the filtration of extracted fluid occurs [2,3,4]

In table 1 service properties of wells after HFT having been performed with different unit weight, concentration and injection rate of proppant with indication of influence of different proppant parameters on additional oil recovery are shown.

**Efficiency of conducting HFT while increasing proppant mass being injected into BHZ**

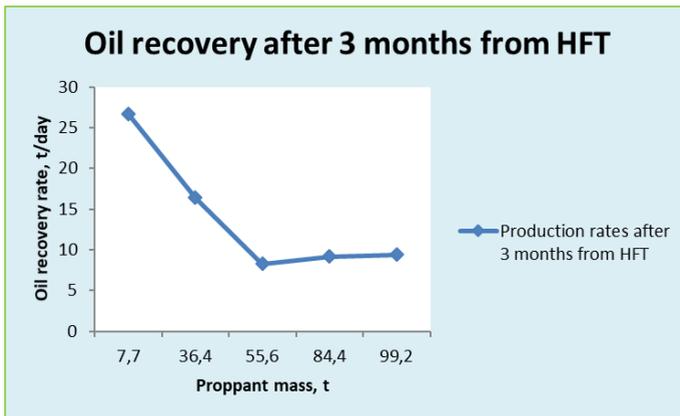
Technological parameters of the HFT process							
Proppant mass		tons	7,9	37,3	53,3	86,4	97,3
Unit weight		tons/m	0,6	4,5	4,6	8,4	8,8
Maximum concentration		kg/m <sup>3</sup>	770	954	1133	978	1000
Injection rate		m <sup>3</sup> /min	3,7	2,8	3,4	3,1	3,3
Performance index							
Accumulated parameters at the moment of HFT	as per liquid	th.tons/well	12,3	54,9	286,1	339,1	556,2
	as per oil	th.tons/well	11,6	31,8	101,9	75,7	222,0
	Water oil ratio	fr.unit	0,2	0,5	1,7	3,5	1,6
Reservoir pressure decrease at the moment of HFT		%	13	7	13	25	13
Parameters for 3 months before HFT	liquid production rate	tons per day	5,3	10,2	68,1	52,1	53,9
	oil production rate	tons per day	5,0	4,4	3,9	2,7	3,4
	water cut	%	7,6	61,3	94,4	94,5	93,5
Parameters for 3 months after HFT	liquid production rate	tons per day	34,5	57,9	122,7	112,3	162,9
	oil production rate	tons per day	27,1	18,1	7,3	8,2	8,4
	water cut	%	12,3	70,8	93,2	91,8	94,1
Initial incremental oil rate	as per liquid	tons per day	22,9	46,2	56,0	68,2	110,3
	as per oil	tons per day	22,1	11,1	4,3	6,2	6,0
Average annual increase of recovery rate	as per liquid	tons per day	23,1	43,4	56,0	69,1	92,2
	as per oil	tons per day	21,1	10,3	4,2	5,7	6,8
Additional recovery increase	as per liquid	th.tons	16201,6	32835,2	21585,3	400,8	137,8
	as per oil	th.tons	9950,1	4210,1	937,2	34,2	8,1
Average additional recovery	as per liquid	th.tons/well	142,7	80	61,5	23,7	11,2
	as per oil	th.tons/well	72,2	11,2	2,3	2,0	1,0

**Table 1.**

*Technological parameters and performance characteristics of HFT on the operating well stock of the XZ object.*

The smallest mass of proppant was used in the initial period at the same time the maximum efficiency per oil was reached. Over the years changes in technological parameters of HFT process is observed: increase in proppant mass being injected into a reservoir, variations with maximum concentration of proppant and breakdown agent injection rate, but despite that all oil production decreases. Proportional fluid production increase from increasing proppant mass being injected into a reservoir is observed. But at the same time, oil production decrease and increase of oil-water ratio in produced fluid from 12,3% to 94,1% are noticeable.

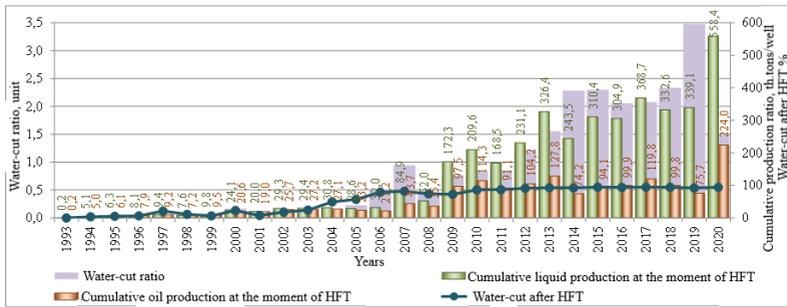
On picture 2 decrease in oil production due to increase of proppant mass being injected into the reservoir after 3 months of performed HFT is shown.



*Picture 2. Oil recovery rate after 3 months from HFT*

The data from performed researches points on water relative permeability increase as the result of making fractures in BHZ which negatively influences either on profitability of the reservoir developing and causes highly negative consequences in the reservoir itself. First of all, water relative permeability increase when water saturation exceeds 50-60% and at the same time oil relative permeability decreases [5]. As the result oil is not pumped out from pores but being carried away by water stream. Secondly, reservoir clay that is presented as pore-filling or different alternations and foliums may change their volume due to its hydration that may lead to clogging of pores with further decrease in permeability and, as a consequence result into decrease of oil production.

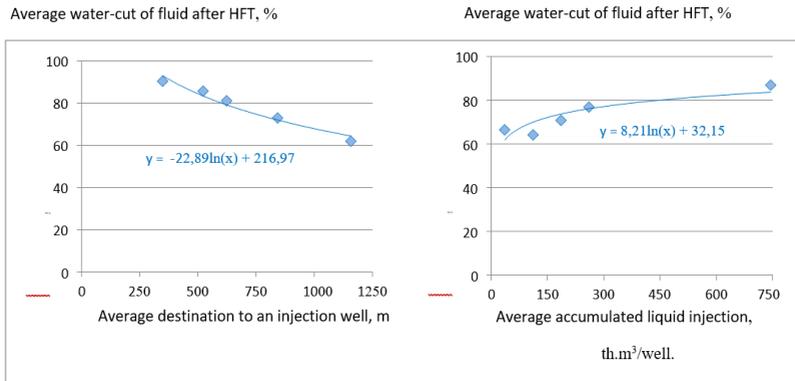
On picture 3 water-oil ratio increases at the moment of HFT is shown as the consequence of fluid leaked from aquifers and injection wells.



**Picture 3.** Dynamics of changing accumulated fluid and oil removal, water-oil ratio and water cut after HFT

During wells exploitation in the front of water-oil rate growth HFT works are conducted with the purpose of fracture height limitation (HFT with the usage of low-viscosity gel), technologies that are directed on limitation of fluid water-cut (usage of well-sealing compounds which allow to provide selectivity during HFT).

On picture 4 position of an injection well and average accumulated injection of liquid show the impact on average fluid water-cut in producing well after performed HFT.



**Picture 4.** Operating well stock water-cut dependence after HFT from the distance to the nearest injection well and cumulative production on it

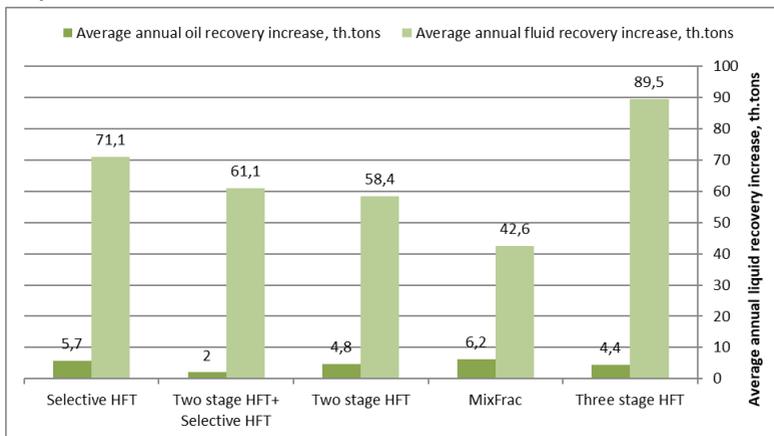
Over the years increase in water-cut of extracted product after HFT is observed, during the analysis of injection well stock impact on water-cut after HFT noticed that the less distance between producing and injection wells the more level of water-cut. It always happens due to the crack breakdown to the injection zone.

And also the higher is cumulative fluid injection on the nearest injection well, the higher is water-cut in the producing well after HFT.

Selective HFT has been used with the purpose of treatment efficiency increasing. The notion of that method is in the performing of preliminary water-shutoff treatment (well-sealing compounds injection). Each type of work may be performed as separately as in common. The technology has got wide appliance because the object XZ is characterized by wide difference in permeability rate of a geological section of formation, therefore the reservoir has got different production of reserves between top and bottom of the formation and as a consequence different water flooding rates of sublayers.

The main task of well-sealing compounds before HFT is blocking (limitation of water flow) of highly conductive flushed flumes. As the material for well-sealing compounds emulsive solution and clay mud are used. HFT is conducted in not exhausted or partially depleted formation zones with low and average reservoir permeability that results into decrease and stabilization in water-cut of produced fluids by stimulating oil flow from imperfectly drained formation zones.

On picture 5 adapted HFT, being conducted on the complicated reservoir, efficiency rates are shown.



Picture 5. Efficiency rates comparison of adapted HFT

Appliance of standard HFT in case of complicated reservoir zones with high water-cut rates is ineffective and economically impractical. Consequently appliance of adapted technologies is one the most correct solutions. This decision allows to increase reservoir's coverage zone by the created crack (two-stage HFT, three-stage HFT, «MixFrac») separately as well as simultaneously with the selective HFT [6].

The notion of two-stage HFT is in HFT being conducted in two separate stages with short period of well shut-in time between them (not more than 2 hours) that is enough for the created crack to be closed. This approach supposes short-time change in stress pattern around a well by intensive injection of breakdown fluid, formation cracking and crosslinked gel accumulation in the zone of the created crack. Formation cracking during injection at the second stage suggests displacement of a crack direction relatively to the primary [7].

This technology allows to involve oil reserves from zones of a reservoir with low permeability in the process of oil extraction as well as decreases the risks of HFT crack breakthrough in the injection zone. The technology has shown good efficiency.

Also multistage hydraulic fracturing (MSHF) by «MixFrac» technology has shown good efficiency in case of water-cut parts of the reservoir. The notion of the technology is: during the first two stages different fraction mixture is injected (30/50+20/40+16/20) into a borehole, the 3<sup>rd</sup> stage is carried out with one type of size 16/20. The first two stages are injected with appliance of low gallant mass, the time of well-shut in is 1 hour. During the first two stages low size proppant accumulates on the lowest part of a crack making barrier for breakdown fluid to flow on the next stage. That allows to involve the major part of a reservoir by HFT and to prevent the bottom of a reservoir from breakthroughs. Redistribution of water intake into the top of a reservoir occurs due to the mix-proppant appliance. Also the risk of water intrusion after HFT decreases.

Therefore the appliance of the adapted technologies during the creation of HFT cracks is one of the most rational method of oil extraction increase in water-flooded parts of a reservoir. The isolation of sublayers, cracks direction modeling, technology and reagent appliance are one of the most important tasks which needed to be solved during HFT for the developing object profitability increase. But at the same time wrong technology may lead to very negative consequences such as water breakthrough into the BHZ, clay swelling, permeability decrease and to complete oil recovery cessation.

## References

1. J. Koplos, M.T. Ellen, A.B. Rannalli. *Hydraulic fracturing overview: How, where, and its role in oil and gas.* – *Journal American Water Works Association*, 2014 – p.40.
2. N.R. Yarkeeva, A.M. Chasiev. *Appliance of HFT for additional oil recovery Oil and gas business Journal.* – 2018. – T. 16, №5. – p. 30-36.

3. I. T. Ibragimov. *Overlook of the existing methods of reservoirs commingling during drillings with horizontal ending* / I. T. Ibragimov, S. G. Vasiliev, R. C. Bakiev, A. L. Boldired. — *Young scientist Journal*. — 2021. — № 5 (347). — p. 241-244.

4. Sharma A., *Coiled-Tubing-Assisted Hydraulic Fracturing of CBM Wells India Usinf CT-Deployed Hydrajet Perforation Technology*/Ajay Sharma, Dushyant Bhalla, Sumit Bhat. — *Online Journal for E&P Geoscientists [Электронный ресурс]*/ Режим доступа: <http://www.searchanddiscovery.com/>.

5. Gimatutdinov S.C, A.I. Shirkovsky. *Physics of oil and gas reservoirs: The book for universities.-4-e publishing. Stereotyped. Reprinting from the third publishing 1982 year.* — M.: OOO TID «Alyans», 2005. — p.244-245.

6. S. Prasun., Ghalambor G. *Effect of Multi-Stage Hydraulic Fractures on Performance of Naturally Fractured Tight Oil Reservoirs with Bottom-Water.- Conference: SPE International Conference and Exhibition on Formation Damage Control, 2018-* p.6-8.

7. N.R Yarkeeva, Barhatov E.A. *The efficiency of multizone hydraulic fracturing in horizontal wel*//*Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering.* - 2017. — T. 328, № 10. — p. 50-58.

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考虑液体润滑剂可压缩性的推力轴承计算模型  
**CALCULATION MODEL OF A THRUST BEARING CONSIDERING  
THE COMPRESSIBILITY OF A LIQUID LUBRICANT**

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抽象的。 本文考虑了可压缩流体在推力轴承间隙中的准静止运动，滑块的轴承表面具有非线性轮廓。 对于解，使用了可压缩流体的运动方程、连续性方程、状态方程和描述支撑环熔融轮廓轮廓的方程。 考虑极端情况和非极端情况。

关键词：准稳态流动，极端情况，金属涂层，非标准支撑型材，水动力状态，导轨运动稳定性

**Abstract.** *The paper considers the quasi-stationary motion of a compressible fluid in the gap of a thrust bearing with a non-linear contour of the bearing surface of the slider. For the solution, the equation of motion of a compressible fluid, the equation of continuity, the equation of state and the equation describing the profile of the molten contour of the support ring were used. The case for the extreme and non-extreme cases is considered.*

**Keywords:** *quasi-stationary flow, extreme case, metal coating, non-standard support profile, hydrodynamic regime, stability of guide movement.*

### **Introduction**

Currently, as a model of hydrodynamic lubrication in plain bearings, a simultaneously compressible lubricant and liquid metal films obtained as a result of melting one of their working surfaces are accepted. An analysis of works [1-7] devoted to modeling sliding bearings with a metal coating showed that the calculations do not take into account the compressibility of the lubricant, that is, the density is constant when the pressure changes. In this article, in order to ensure the hydrodynamic regime of fluid movement, we present a calculation model of a sliding support with a non-standard support profile and a metal coating of the guide.

**Material and research methods.** The quasi-stationary flow of liquid in the gap of a sliding support with a metal coating is considered. We represent the speed

of movement of the guide as  $u^* + e'(t)$ . We assume that as a result of viscous shear, the generated heat melts the surface of the guide (fig. 1).

slider contour equation, with adapted profile:

$$y = h_0 + x \operatorname{tg} \alpha \left[ 1 - a \left( \frac{x}{L} \right)^2 \right] = h(x); \text{ molten contour guide equation}$$

$$y = H \left( 1 - \frac{x}{L} \right) = H(x); \text{ slider equation with linear contour } y = h_0 + x \operatorname{tg} \alpha.$$



Figure 1. Design scheme.

To solve the problem, the well-known dimensionless equations of motion of a compressible viscous fluid, the continuity equation, the equation of state, as well as the equation describing the molten guide contour and boundary conditions are used:

$$\frac{\partial^2 v}{\partial y^2} = \frac{1}{\Lambda} \frac{dp}{dx}; \quad \frac{\partial(\rho v)}{\partial x} + \frac{\partial(\rho u)}{\partial y} = 0; \quad p = \rho; \quad \frac{dH(x)}{dx} = -K \int_{-H(x)}^{h(x)} \left( \frac{\partial v}{\partial y} \right)^2 dy; \quad (1)$$

$$u = 0, v = 0 \text{ при } y = 1 + \eta x - \eta_1 \sin \omega x = h(x);$$

$$u = 0, v = -1 - e(t) \text{ при } y = -H(x); \quad (2)$$

$$p(0) = p(1) = p_a; \quad H(x) = \frac{h_0^*}{h_0} \text{ при } x = 0;$$

$$\text{where } K = \frac{2\mu u^* h_0}{L'}, \quad \Lambda = \frac{u^* \mu L}{p_a h_0^2}, \quad \eta = \frac{L \operatorname{tg} \alpha}{h_0}, \quad \eta_1 = \frac{a'}{h_0}.$$

Let us integrate the first equation of system (1). Taking into account the boundary conditions (2), we will have:

$$v_x = \frac{1}{2\Lambda} \frac{dp}{dx} \left( \frac{1}{h} y h + H y \right) \frac{h+H}{h+H} + \frac{1+e_1}{h+H} y \left( \frac{1+e_1}{h+H} h \right). \quad (3)$$

The solution of the problem under consideration is given at the beginning for the extreme case; for  $L \rightarrow \infty, \eta_1 \rightarrow 0$ , this corresponds to the case of a slider of infinite length.

We integrate the continuity equation from  $\frac{h_0^*}{h_0}$  to  $h$  and get:

$$p = 1 - \eta x + \eta_1 \sin x, \quad W = p^* L \left( 1 - \frac{\eta}{2} - \frac{\eta_1}{\omega} (\cos \omega - 1) \right),$$

$$L_{\text{tp}} = \frac{p^* L (1 + e_1)}{h_0 \left( 1 + \frac{h_0^*}{h_0} \right)} \left[ 1 - \frac{\eta}{2} - \frac{\eta_1}{\omega} (\cos \omega - 1) \right]. \quad (4)$$

Analyzing the results of numerical analysis of analytical dependences (4), we can say that for a given sliding bearing at  $\eta = \frac{h_0^*}{h_0} \neq 0$  the most rational mode is achieved in terms of bearing capacity and friction force (fig. 2 - 3).

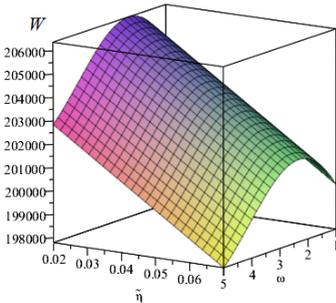


Figure 2. Dependence of the parameters:  $\tilde{\eta}$  and  $\omega$  on the load capacity.

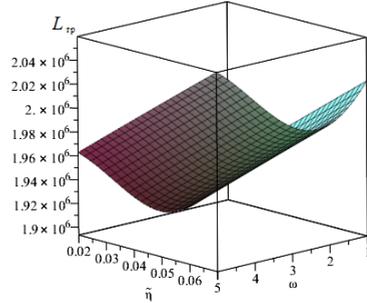


Figure 3. Dependence of the parameters:  $\tilde{\eta}$  and  $\omega$  on the friction force.

Let's move on to a more general case, first we average  $\frac{dy}{y}$  integrally in the interval  $[H, h]$ :

$$\int_{[H, h]} \frac{dy}{y} = \frac{1}{h} \int_{[H, h]} \frac{1}{1 + \dots} dy \quad (5)$$

Applying the method of successive approximations to the solution of this equation, we have

$$\int_0^1 H_1(x) dx = \frac{h_0^*}{h_0} + \frac{K}{1 + \frac{h_0^*}{h_0}} \left( \frac{1}{2} - \frac{\tilde{\eta}}{6} - \frac{\tilde{\eta}_1}{\omega} \frac{\sin \omega}{\omega} \right) = \alpha^* \quad (6)$$

Taking into account (6), we will search for the exact self-similar solution of problem (1) - (2) using the well-known method [8-10], as a result, for the velocity field and pressure we get:

$$\tilde{\psi}'(\xi) = \frac{\tilde{c}_2}{2}(\xi^2 - \xi), \quad \tilde{v}(\xi) = \frac{\tilde{c}_1 \xi^2}{2} - \left(\frac{\tilde{c}_1}{2} - 1 - e_1\right)\xi - 1 - e_1, \quad \tilde{c}_1 = -6(1 + e_1). \quad (7)$$

$$p = 1 + \Lambda \int_0^x \left( \frac{\tilde{c}_1}{(1 + \alpha^*)^2 (1 + \tilde{\eta}x - \tilde{\eta}_1 \sin \omega x)^2} + \frac{\tilde{c}_2}{p(1 + \alpha^*)^3 (1 + \tilde{\eta}x - \tilde{\eta}_1 \sin \omega x)^3} \right) dx.$$

Solving this equation by the method of successive approximations, we have

$$p_0 = 1, \quad p_1 = 1 + \Lambda \int_0^x \left( \frac{\tilde{c}_1}{(1 + \alpha^*)^2 (1 + \tilde{\eta}x - \tilde{\eta}_1 \sin \omega x)^2} + \frac{\tilde{c}_2}{(1 + \alpha^*)^3 (1 + \tilde{\eta}x - \tilde{\eta}_1 \sin \omega x)^3} \right) dx, \quad (8)$$

$$p_1 = 1 + \frac{\Lambda \tilde{c}_1}{(1 + \alpha^*)^2} \left[ \tilde{\eta} \frac{x^2}{2} - \frac{\tilde{\eta}x}{2} + \frac{\tilde{\eta}_1}{\omega} (\cos \omega x - 1) - \frac{\tilde{\eta}_1}{\omega} (\cos \omega - 1)x \right].$$

Using formulas (5) and (8) for the bearing capacity and friction force, we obtain an expression of the form

$$W = p^* L \left( 1 + \frac{\Lambda \tilde{c}_1}{(1 + \alpha^*)^2} \left[ \frac{\tilde{\eta}}{6} - \frac{\tilde{\eta}}{4} - \frac{\tilde{\eta}_1}{\omega^2} \sin \omega - \frac{\tilde{\eta}_1}{\omega} - \frac{\tilde{\eta}_1}{\omega} (\cos \omega - 1) \frac{1}{2} \right] \right), \quad (9)$$

$$L_{sp} = \frac{\mu \omega l}{h_0} \left( -6(1 + e_1) \left[ \frac{1 - \tilde{\eta} - \frac{\tilde{\eta}_1}{h_0} (\cos \omega - 1)}{2p(1 + \alpha^*)} \right] + \frac{4}{1 + \alpha^*} \left( 1 - \frac{\tilde{\eta}}{2} - \frac{\tilde{\eta}_1}{\omega} (\cos \omega - 1) \right) + \frac{e_1}{1 + \alpha^*} \left( 1 - \frac{\tilde{\eta}}{2} - \frac{\tilde{\eta}_1}{\omega} (\cos \omega - 1) \right) \right).$$

### Research results and discussion

From the results of the numerical analysis shown in fig. 2 - 3, as well as from the found analytical expressions (4) and (9) it follows that:

1. The bearing capacity of the proposed wedge-shaped support, as well as the friction force, significantly depend on the compressibility parameter  $\alpha^*$  and the parameter  $\alpha^*$ , due to the presence of the melt.

2. It has been established that at the value of  $\alpha^* = \alpha^*$  the presented wedge-shaped sliding bearing in terms of bearing capacity has the property of a double-acting sliding bearing.

### Conclusion

Theoretical significance: a set of refined calculation models of thrust bearings with a non-standard bearing surface adapted to friction conditions under conditions of hydrodynamic lubrication with lubricants and a melted metal coating has been formed, taking into account the compressibility of lubricants.

The scientific novelty of the research results lies in obtaining computational models for design and verification calculations of thrust bearings, allowing to determine the value of the bearing capacity and friction force, taking into account the compressibility of the lubricant and the support profile adapted to friction conditions.

Conventional designations.

$v_{x0}v_{y0}$  – velocity vector components;  $p$  – hydrodynamic pressure;

$\mu$  – dynamic coefficient of viscosity;  $p = \frac{\mu Lu^*}{2h_0^*}$  (Weisbach–Darcy formula);

$\rho$  – density;  $f$  – friction loss factor;  $L$  – slider length;  $L_f$  – specific heat of fusion per unit volume; the function  $H(x)$  characterizes the profile of the molten contour of the coating.

## References

1. Gao G.Y., Yin Z.W., Jiang D., Zhang X.L. Numerical analysis of plain journal bearing under hydrodynamic lubrication by water // *Tribol. Int.* 2014. V. 75. P. 31. DOI: 10.1016/j.triboint.2014.03.009
2. Mukutadze M.A. Working out of an analytical model of an axial bearing taking into account dependence of viscous characteristics of micropolar lubrication on pressure and temperature / Mukutadze M.A., Lagunova E.O., Solop K.S. // *International Journal of Applied Engineering Research.* 2017. V. 12. № 14. P. 4644-4650.
3. Khasyanova D. U., Mukutadze M. A., Mukutadze A. M., Morozova A. V. Mathematical model of a lubricant in a sliding bearing with a fusible coating, taking into account the dependence of viscosity on pressure // *Problems of mechanical engineering and automation.* – 2021. – № 2. – P. 125-132. – DOI 10.52261/02346206\_2021\_2\_125.
4. Kokhanovsky V.A., Mukutadze M.A. Matrix materials of antifriction composites // *Bulletin of the Don State Technical University.* 2001. V. 1. № 2. P. 51-56.
5. Mukutadze, M. A. Mathematical Model of a Lubricant in a Bearing with a Fusible Coating on the Pilot and Irregular Slider Profile / M. A. Mukutadze, E. O. Lagunova // *Lecture Notes in Mechanical Engineering (see in books).* 2022. – P. 834-840. – DOI 10.1007/978-3-030-85233-7\_97.
6. Akhverdiev K.S. Hydrodynamic calculation of a thrust plain bearing that operates with viscoelastic lubricant under turbulent friction conditions / Akhverdiev

*K.S., Mukutadze M.A., Semenko I.S. // Journal of Machinery Manufacture and Reliability. 2011. V. 40. № 4. P. 359-365*

7. *Mukutadze M.A. Calculation model of hydrodynamic lubrication of a non-uniform porous bearing of finite length operating in a stable non-stationary friction mode in the presence of forced lubrication / Mukutadze M.A., Flek B.M., Zadorozhnaya N.S., Polyakov E.V., Mukutadze A.M. // Engineering Bulletin of the Don. 2013. № 3 (26). P. 9.*

8. *Garmonina, A. N., Mukutadze M. A., Prikhodko V. M. Calculation model of a radial bearing with a two-layer porous coating on the surface of a shaft operating on an electrically conductive lubricant // Engineering Bulletin of the Don. – 2017. – № 3(46). – P. 49. URL: [ivdon.ru/ru/magazine/archive/N3y2017/4320](http://ivdon.ru/ru/magazine/archive/N3y2017/4320)*

9. *Akhverdiev K.S., Bolgova E.A., Mukutadze M.A., Vasilenko V.V. Mathematical model of a radial sliding bearing with a porous layer on its operating surface with a low-melting metal coating on shaft surface // In a collection: IOP Conference Series: Materials Science and Engineering. Ser. “International Conference on Mechanical Engineering, MEACS 2020” 2021. P. 012005*

10. *Bolgova E. A., Vasilenko V. V., Lagunova E. O., Mukutadze M. A. Mathematical model of a sliding bearing with a fusible metal coating of the bushing and a porous coating of the shaft // Bulletin of the Rostov State University of Communications. – 2020. – № 4(80). – P. 151-160. – DOI [10.46973/0201-727X\\_2020\\_4\\_151](https://doi.org/10.46973/0201-727X_2020_4_151).*

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无人船与远程控制中心虚拟标记传输信息交换系统架构及协议开发  
**ARCHITECTURE AND PROTOCOL DEVELOPMENT OF THE  
INFORMATION EXCHANGE SYSTEM BETWEEN AN UNMANNED  
VESSEL AND A REMOTE CONTROL CENTER FOR THE  
TRANSMISSION OF VIRTUAL MARKING**

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抽象的。本文描述了用于传输虚拟标记的信息交换系统的开发架构和协议，该系统为无人船提供有关密集导航区域安全路线的信息。

关键词。无人船导航、信息交换、虚拟标线、标线划界、确保安全机动。

**Abstract.** *This article describes the developed architecture and protocol of an information exchange system for the transmission of virtual markings, which provides an unmanned vessel with information about a safe route in areas of intensive navigation.*

**Keywords.** *Unmanned vessel navigation, information exchange, virtual marking, marking delimiting traffic, ensuring safe maneuvering.*

The successful development of unmanned vessel navigation requires a systematic approach, which includes the interaction of well-coordinated teams of highly qualified developers, the formation of a high-tech research and production and testing base, as well as the adjustment of existing legal documents.

On board a modern vessel are dozens of high-tech solutions, the task of which is to ensure safety and maximum awareness of the internal and external situation, which will lead to a reduction in the number of errors.

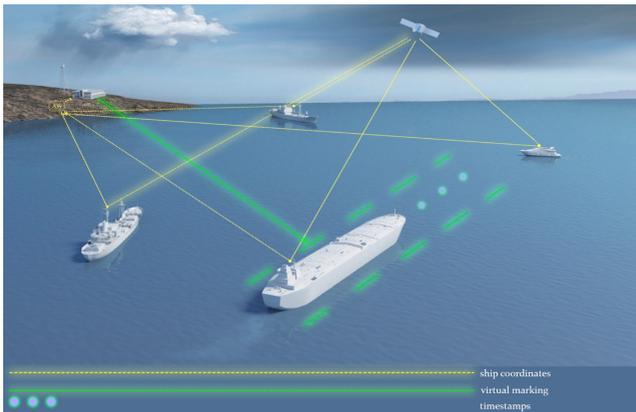
So, to ensure safe maneuvering when moving an unmanned vessel (UMV) along a given route, entering / leaving the port, mooring, a virtual marking system is proposed, the main tasks of which are to generate a route and navigate along it, taking into account hydrographic, meteorological and navigational information and risks, as well as predicting and preventing accidents based on algorithms for maneuvering and avoiding dangerous targets. [1]

The need to use a virtual marking system is to ensure safe maneuvering of UMV in a given port water area and on the way to it, providing optimal traffic routes and their dynamic adjustment, which will significantly increase the efficiency of ports in interaction with UMV and help reduce time and economic costs for operation. [1]

To consider the practical implementation of the virtual marking system, specific technologies and protocols have been developed to ensure security and transfer of information on the UMV.

The essence of the architecture is to create a platform for the exchange of information between the UMV and the remote control center (RCC) using the interaction of the client program and the server program, where the client requests and receives information.

Virtual markings are generated by a coastal RCC or a vessel traffic control system (VTCS), taking into account all the necessary navigation and meteorological data for laying a safe route for an unmanned vessel in the port water area. [1]



**Figure 1.** Physical representation of the architecture of the information exchange system for the transfer of virtual marking

With the help of a coastal radar station (CRS), data on the location of ships and UMV in the port water area are taken into account, which are transmitted to the VTCS, which receives messages from the automatic identification system (AIS), as well as meteorological data received from the weather station.

RCC generates markup and sends it to VTCS and UMV.

For crewed ships, markings are information about restrictions or time restrictions, generated in VTCS and transmitted via AIS as virtual navigation aids (VNA). Virtual AIS VNAs are used when a real VNA does not exist, but from a

given point it is necessary to transmit one or another navigation information to the ship's AIS.

VHF communication is provided for the operational management of ships. The VTCS VHF communication system is designed to provide communication between the operator of the vessel traffic control center and the vessels in the area of responsibility of the VTCS region.

The designed information system is built using the “client-server” technology, in which there are two main actors:

- client - sends a request or command to the server;
- server - receives the request and executes it.

The client program communicates with the server using a protocol that sets the rules for data exchange. In this system, the client requests data from the server.

After registering in the system and requesting a service from the UTM, when approaching the regulated area, a safe route is built upon its request.

In the architecture of the proposed system, the client program generates requests for laying or changing the route to a given area of the port water area.

Another important component of the system is a secure communication channel between the client and the server, which ensures secure data transfer.

#### Program – client

In the system being designed, the client program is installed on the UTM.

Functions of the client program:

- authentication request;
- receiving a response from the server program about the result of the authentication procedure;
- request for markup generation;
- sending a request for markup generation;
- getting markup.

#### Program – server

In the designed system, the server program is installed in the RCC. The server program waits for requests from client programs and provides them with its resource in the form of data.

Functions of the server program:

- keeping in touch with the client;
- user authentication;
- notification of the client about the result of the authentication procedure;
- receiving a request from the client to generate markup in case of successful authentication;
- formation of a response to a client's request;
- creation of a secure data transmission channel;
- transfer of markup data to the client program.

To show the work of the client algorithm on UMV, the following conditions must be met:

- registration in the system and request for marking from UMV for a given navigation area;
- generation and sending markup from RCC.

In order to be able to exchange messages within this system, the UMV must first be registered in the system. When entering the water area, the client program sends a registration request to the server - the "AUTHORIZATION" message, authorization occurs via the TLS protocol, which uses asymmetric encryption for authentication, symmetric encryption for confidentiality and message authentication codes to preserve their integrity. Using this protocol, it becomes possible for client-server applications to communicate with the impossibility of listening to packets and performing unauthorized access. [2]

Upon receiving the request, the server checks the parameters from the settings file for subsequent authentication, then waits for a response.

Upon receiving a positive response from the database, the server sends a "CONFIRMED" message to the client. After sending the message, the server becomes in the mode of waiting for a new request from the client.

After receiving the message, the client sends a "ROUTE" request to the server about the formation of a virtual marking for a given water area.

Further, the server, based on the navigation and meteorological data on the UMV movement, sends the client a JSON file with data:

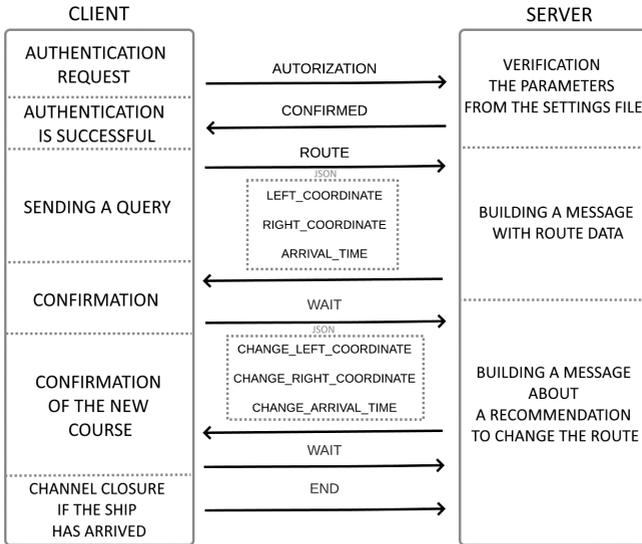
- «LEFT\_COORDINATE» (coordinates to port of ship);
- «RIGHT\_COORDINATE» (coordinates to the ship's starboard);
- «ARRIVAL\_TIME» (time of arrival at the destination).

After checking the received message from the server, the client goes into standby mode with a "WAIT" message, until a new message from the server.

The channel remains open until the ship arrives at the destination or leaves the RCC coverage area. In the event of a danger on the ship's route, the server again transmits a UMV message with recommendations for changing the route.

A repeated message is necessary if there is any danger on the way of the UMV or in case of any other problems associated with the navigation of this UMV, for example, failure to arrive at the appointed time at the appointed place.

After the ship arrives at its destination, it sends an "END" message to the server, thereby closing the channel.



**Figure 2.** Protocol for the exchange of information between UMV and RCC for the transfer of virtual marking

Thanks to the proposed solution, it is possible to create a platform for the exchange of information between UMV and RCC for the transmission of virtual markings, which will significantly improve the safety of unmanned vessel navigation.

### References

1. Using the virtual marking system on unmanned vessels. Tsybulya A.D., [Electronic resource] // Access: <https://elibrary.ru/item.asp?id=46649944>
2. TLS protocol, [Electronic resource] // Access: <https://ru.wikipedia.org/wiki/TLS>

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