



# 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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婴幼儿急性肾功能衰竭无尿期动脉脉压的昼夜节律

## CIRCADIAN RHYTHM OF PULSE ARTERIAL PRESSURE IN THE PERIOD OF ANURIA OF ACUTE RENAL FAILURE IN INFANTS

**Muhitdinova Hura Nuritdinovna**

*Doctor of Medical Sciences, Full Professor  
Center for the Development of Professional Qualifications  
of Medical Workers*

**Akalayev Rustam Nurmuhamedovich**

*Head of Department  
Center for the Development of Professional Qualifications  
of Medical Workers*

**Nazarov Bahtiyor Mahmujanovich**

*Anesthesiologist-resuscitator  
Republican Scientific Center of Emergency Medical Care*

抽象的。根据对 24 名 10 个月至 3 岁儿童 30 天的每小时脉搏动脉压 (PAP) 监测数据的研究表明,在第 1 天,第 1 组 PAP 昼夜节律的中间值 2 在生理值范围内,与正常值无差异。所有患者都接受了重复的血液透析治疗。第 3 组患者第 1 天的 PAP 水平比第 1 组低 14% ( $p < 0.05$ ),可在第 1 天指导急性心力衰竭的诊断,即从 ARF 重症监护治疗的第一天开始强心、强心代谢治疗的指征,旨在纠正早期无尿期最严重的急性肾功能衰竭 (ARF) 患者的急性心脏代偿失调,选择更多的节约方案。与其他组相比,第三组患者主要需要能量支持以确保心血管系统有更充分的代偿反应,这只有在最严重的 ARF 儿童中最明显的分解代谢过程中有针对性地提供营养才能实现。

关键词: 昼夜节律, 脉搏动脉压, 急性肾功能衰竭, 幼儿。

**Abstract.** *Based on the study of the data of hourly monitoring of pulse arterial pressure (PAP) of 24 children aged from 10 months to 3 years for 30 days, it was revealed that on day 1, the mesor of the circadian rhythm of PAP in groups 1 and 2 was within physiological values, not differing from norms. All patients underwent repeated hemodialysis sessions. The level of PAP on the 1st day of patients in the 3rd group, which turned out to be less than in the 1st group by 14% ( $p < 0.05$ ), can guide the diagnosis of acute heart failure already on the 1st day, being an indication for starting cardiotonic, cardiotropic metabolic therapy from the first day of intensive care therapy of ARF aimed at correcting acute cardiac*



*decompensation in the most severe patients with acute renal failure (ARF) in the period of anuria at an early age with the selection of more sparing regimens. Patients of the 3rd group, more than other groups, primarily needed energy support to ensure more adequate compensatory reactions of the cardiovascular system, which is possible only with targeted nutritional provision of the most pronounced catabolic processes in the most severe children with ARF.*

**Keywords:** *circadian rhythm, pulse arterial pressure, acute renal failure, young children.*

**Relevance.** Acute renal failure (ARF) is a non-specific clinical and laboratory syndrome that occurs due to the acute loss of all homeostatic functions of the kidneys. This process, with timely diagnosis and proper treatment, is reversible. On average, the incidence of acute renal failure ranges from 3 to 8 cases per 1,000,000 children (according to Russian authors), of which 1/3 occurs in infancy. ARF significantly worsens the child's condition, and mortality ranges from 3-5% in hemolytic-uremic syndrome to 30-70% in sepsis and multiple organ failure. Even with successful treatment and restoration of urinary function, long-term consequences are possible - 10-25% of children develop chronic kidney disease. ARF is dangerous by electrolyte disorders (hyperkalemia, hypocalcemia, hyperphosphatemia). An increase in blood pressure that occurs against the background of pathologies of the heart, kidneys or disorders of the endocrine system, as a result of heart damage and disorders of the nervous system, is commonly called secondary hypertension. Children often suffer from such pathologies, which is why they register both spasmodic and constant increases in pressure. However, there is not enough information in the literature on the characteristics of the reaction of pulse arterial pressure (PAP) in acute renal failure, which developed against the background of an acute bacterial pulmonary infection in children under the age of 3 years [1-4].

**Goal of the work.** To study and give a comparative assessment of the response of the circadian rhythm to pulse arterial pressure in acute renal failure in infancy, which developed against the background of an acute infection.

**Material and research methods.** The data of hourly monitoring of body temperature in 24 children with acute renal failure admitted to the ICU of RSCEM with anuria from 1 to 4 days at the age of 10 months to 3 years 4 months from the ICU of regional children's hospitals and branches of RSCEM was studied. Prior to admission to the clinic, all patients received therapy aimed at the treatment of pneumonia 22, AII-2 patient. According to indications, due to severe progressive respiratory failure, patients were provided with invasive mechanical respiratory support (MRS) on the first day according to indications. All patients underwent hemodialysis, 3 - in combination with plasmapheresis under the control of hemodynamics, acid-base balance, respiratory system, maintenance, antibacterial,

anti-inflammatory, syndromic corrective intensive therapy according to the protocols and recommendations existing in the literature. A favorable outcome with the restoration of full functional activity of the kidneys and discharge from the hospital was observed in 15 children (groups 1 and 2), an unfavorable outcome in 9 children (group 3). The first group consisted of patients who received intensive care in the ICU for up to 10 days (5 patients), the second - children with a favorable outcome after intensive care for 11-45 days (10 patients), the third - 9 patients with an unfavorable outcome.

**Results and its discussion.**

As shown in Table 1, male patients predominated in all study groups. The duration of intensive care in children of groups 2 and 3 significantly exceeded the duration of treatment in the ICU in group 1 by 18 and 23 days ( $p < 0.05$ , respectively). In group 1, mechanical ventilation was performed in 1 patient due to the severity of acute respiratory failure caused by severe acute pneumonia. In group 2, the duration of mechanical respiratory support (MRS) in all children was  $15.8 \pm 8$  days, in group 3 -  $15.1 \pm 11.1$  days.

*Table 1.  
Characteristics of patients*

Groups	Age, month.	gender, m/f	Start of ALV, days	Duration of MRS, days	In ICU, days
1	$29 \pm 2,8$	3/2.	1 patient in 1	9	$7,8 \pm 1,9$
2	$22,8 \pm 5,3$	8/2.	$3,6 \pm 1,2$	$15,8 \pm 8$	$25,1 \pm 7,9^*$
3	$25,6 \pm 5,3$	4/5.	$4 \pm 1,8$	$15,1 \pm 11,1$	$30,7 \pm 6,8^*$

No significant age differences were found. However, in group 2, there was a moderate effect of age on the duration of intensive care in the ICU (0.34), on the duration of mechanical ventilation (0.2), on the duration of spontaneous breathing before respiratory support due to the severity of ARF (0.74). In group 1, there was a slight negative effect of the age of children on the duration of intensive care in the ICU (-0.23). In group 3, the effect of age on the duration of intensive care in the ICU was 0.35, the duration of mechanical ventilation was 0.32.

The level of PAP on the 1st day of patients in the 3rd group was less than in the 1st group by 14% ( $p < 0.05$ ), characterizing the tendency to develop heart failure already on the 1st day. During the extended monitoring, a significantly significant decrease in the indicator by 14% ( $p < 0.05$ ) on the 3rd day in group 1 was found, in the following days it did not differ from the initial indicator. In the 3rd group on the 16th day there was an increase in the mesor of the circadian rhythm PAP by 18% ( $p < 0.05$ ), on the remaining days it did not differ from the indicator on day 1. Thus, the detection on the first day of a decrease in the average daily value of the

circadian rhythm of PAP by 14% can guide the diagnosis of acute heart failure already on day 1, being an indication for starting cardiotoxic, cardiotropic metabolic therapy from the first day of intensive therapy for acute renal failure, aimed at correcting acute cardiac decomensation in the most severe young patients.

**Table 2.**  
*Dynamics of the mesor of the circadian rhythm PAP*

Days	1 group	2 group	3 group
1	45,1±3,0	40,8±3,7	38,5±2,8 <sup>m</sup>
2	40,8±2,8	40,6±1,4	40,3±1,8
3	38,5±1,6*	40,5±1,8	38,6±2,0
4	41,3±3,1	41,6±1,7	40,3±2,0
5	39,7±3,3	42,6±2,3	42,2±2,0
6	41,7±3,8	41,8±1,7	41,8±2,7
7	43,2±3,2	38,9±1,7	41,2±3,3
8	43,5±2,4	40,2±2,3	42,7±2,4
9	41,9±3,4	40,1±1,5	41,4±2,4
10	49,5±5,1	37,6±2,2	40,4±2,4
11		41,3±2,3	41,2±1,8
12		42,4±2,2	40,8±1,8
13		40,7±1,7	42,2±2,3
14		38,0±1,7	40,6±2,3
15		39,3±2,6	41,5±1,8
16		40,9±1,8	45,5±2,4*
17		39,2±2,6	41,9±2,6
18		39,1±1,8	40,6±2,8
19		38,7±1,9	40,8±4,0
20		41,1±2,1	42,6±2,3
21		41,1±2,6	40,7±3,6
22		41,0±2,3	39,6±2,7
23		37,8±2,7	40,4±2,8
24		38,1±4,3	42,7±4,9
25		42,2±3,5	42,9±2,9
26		41,5±2,5	38,3±2,6
27		39,8±4,3	38,1±2,8
28		38,5±3,3	42,6±3,7
29		40,1±5,0	40,6±2,9
30		46,9±7,7	43,5±2,9

**Table 3**

*Average values of PAP in the circadian rhythm in acute renal failure up to 3 years*

Hours	1 group	2 group	3 group
8	41,9±2,7	37,4±2,9	40,0±2,3
9	41,9±3,4	38,4±2,9	40,9±3,1
10	42,0±2,8	40,0±3,1	41,5±2,8
11	43,1±3,7	40,5±3,0	41,2±3,4
12	41,3±3,7	40,3±3,1	40,7±3,2
13	41,7±4,9	40,4±2,3	40,0±2,6
14	40,4±3,1	40,7±2,2	40,5±2,8
15	41,9±5,6	41,3±2,6	40,8±3,4
16	43,8±4,1	41,1±2,9	41,7±2,9
17	42,6±4,2	40,0±2,8	40,8±3,3
18	41,6±2,6	39,7±3,4	41,1±2,8
19	41,8±2,9	40,8±2,4	41,2±3,0
20	42,6±2,5	39,9±2,1	40,9±3,0
21	42,0±3,5	40,7±3,1	40,9±2,7
22	40,9±5,5	41,1±3,3	41,2±3,2
23	40,0±4,4	41,3±2,7	40,7±3,5
24	42,1±3,5	40,3±3,2	42,3±2,3
1	42,7±3,2	40,7±2,8	41,4±3,2
2	44,2±2,8	40,2±2,7	41,7±2,5
3	45,3±3,6	41,6±3,8	42,0±2,6
4	44,2±3,0	41,4±3,0	41,3±2,4
5	43,2±4,1	40,0±3,3	42,1±3,0
6	44,5±5,0	41,1±2,8	41,3±3,0
7	43,8±5,3	40,7±3,6	41,8±2,8

\*-reliable relative to the indicator

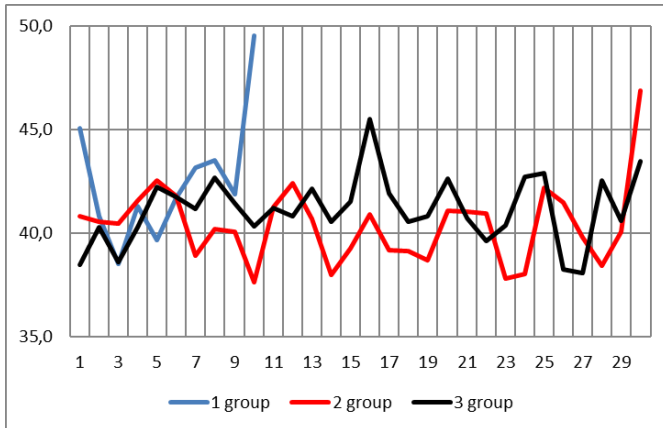
In 1 day

'''-reliable relative to the indicator

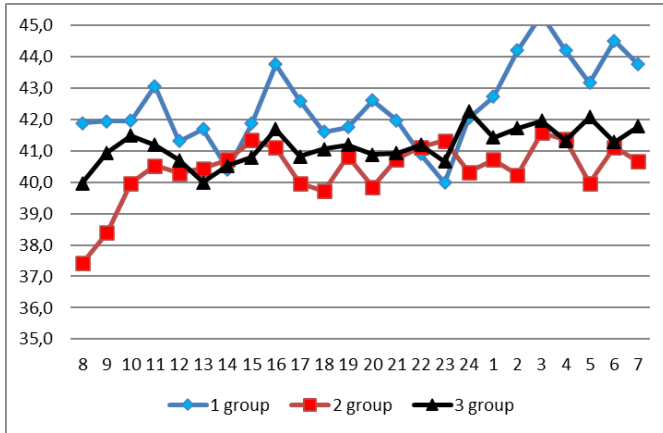
in 1 group

As shown in Fig. 1, changes in the average daily level of PAP throughout the entire observation were of an oscillatory nature, not significantly differing in groups. A trend towards an increase in the value of the PAP circadian rhythm mesor was observed on day 1 in group 1 up to 45 mm Hg, on day 10 on the day of transfer to the pediatric department in group 2 on day 30 up to 47 mm Hg, and in 3 group on the 16th day of intensive therapy up to 45.5 mmHg, which ap-

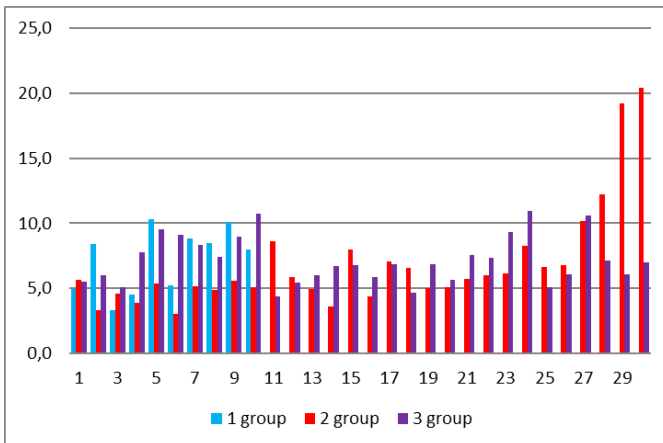
parently was due to an intermittent systemic inflammatory response in the most severe patients. Some difference in the average values in the circadian rhythm draws attention (Fig. 2). In group 1, fluctuations in PAP in the circadian rhythm had a relatively large amplitude, the average daily value was somewhat larger, amounting to  $42.5 \pm 1.1$  mm Hg, than in groups 2 and 3, where the average value of PAP was  $40.4 \pm 0.4$  mmHg and  $41.2 \pm 0.5$  mm Hg, respectively. In group 3, some monotony of hourly fluctuations in PAP was noted. Taking into account the established fact that the change in PAP in the direction of growth is an integral indicator that characterizes the compensatory mechanisms of the circulatory system under conditions of stress reactions of the body to intoxication, water, drug load, then in group 3, the revealed monotony, a decrease in the amplitude and average level of the circadian rhythm of PAP, may be related with a more significant depletion of adaptive resources, the adequacy of which depends primarily on the severity of the energy-deficient state. The results obtained indicate that patients of the 3rd group, more than other groups, primarily needed energy support to ensure more adequate compensatory reactions of the cardiovascular system, which is possible only with targeted nutritional provision of the most pronounced catabolic processes in the most severe children with acute renal failure.



*Figure 1. Dynamics of the mesor of the circadian rhythm PAP*



**Figure 2.** Average values of PAP in the circadian rhythm with acute renal failure up to 3 years



**Figure 3.** Amplitude of the circadian rhythm PAP in acute renal failure up to 3 years

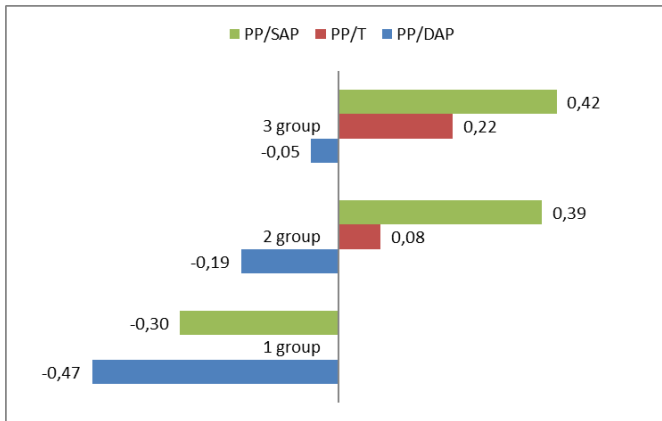
As shown in fig. 3, the average value of the amplitude of daily fluctuations in PAP during the observation period was  $7.2 \pm 2.1$  mmHg in group 1,  $6.9 \pm 2.6$  mmHg in group 2, and  $7 \pm 1.4$ . It is known that an increase in the amplitude of daily fluctuations expresses the degree of stress reaction of the studied indicator, which, despite the relatively lower average value, turned out to be more pronounced in group 2 (Fig. 3).

**Table 3**

*The duration of the shift in the acrophase of the circadian rhythm of PAP in the stage of anuria of acute renal failure is up to 3 years*

	<b>norm</b>	<b>moderate deviation</b>	<b>inversion</b>
	9-11 hours	12-21 h	22-8 hours
1 group	20% (2)	30% (3)	30% (5)
2 group	20% (6)	36% (11)	44% (13)
3 group	13% (4)	50% (15)	37% (11)

The deformation of the phase structure was also expressed in the shift of the peak of the acrophase of the circadian rhythm of PAP (inversion), which turned out to be the longest in group 2, amounting to 44% of the duration of intensive care in the ICU (13 days out of 30), in group 3 - 37% (11 days out of 30), which indicated the severity of the stress reaction in pneumonia complicated by acute renal failure at an early age.



**Figure 4.** *Correlations of PAP in the stage of anuria with acute renal failure up to 3 years*

A moderately significant direct correlation was found between changes in the mesors of circadian rhythms PAP and SAP in groups 2 and 3, amounting to 0.39 and 0.42, respectively, and an inverse correlation between PAP and DAP in group 1 (-0.47). The revealed indicators testify to the difference in compensatory reactions of hemodynamic parameters depending on the severity of the patients' condition.

**Conclusion.** On day 1, the mesor of the circadian rhythm PAP in groups 1 and 2 was within the physiological range, not differing from the norm. The level of PAP on day 1 of patients in group 3 was less than in group 1 by 14% ( $p < 0.05$ ), and can guide the diagnosis of acute heart failure already on day 1, being an indication for starting cardiostimulant, cardiostimulant metabolic therapy from the first day intensive care of acute renal failure aimed at correcting acute cardiac decompensation in the most severe patients of early age. Patients of the 3rd group, more than other groups, primarily needed energy support to ensure more adequate compensatory reactions of the cardiovascular system, which is possible only with targeted nutritional provision of the most pronounced catabolic processes in the most severe children with acute renal failure.

### References

1. <https://www.krasotaimedicina.ru/diseases/children/renal-failure>
2. [https://www.bsmu.by/downloads/kafedri/k\\_2\\_child/lohpn.pdf](https://www.bsmu.by/downloads/kafedri/k_2_child/lohpn.pdf)
3. <https://ru.wikipedia.org/wiki/%D0%9E%>
4. [https://meduniver.com/Medical/nefrologia/techenie\\_opn\\_u\\_detei.html](https://meduniver.com/Medical/nefrologia/techenie_opn_u_detei.html)



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幼儿急性肾功能衰竭无尿期平均动脉压昼夜节律的变化  
**CHANGES IN THE CIRCADIAN RHYTHM OF MEAN ARTERIAL  
PRESSURE IN THE PHASE OF ANURIA OF ACUTE RENAL  
FAILURE IN YOUNG CHILDREN**

**Muhitdinova Hura Nuritdinovna**

*Doctor of Medical Sciences, Full Professor*

*Center for the Development of Professional Qualifications of Medical  
Workers*

**Babajanovna Zumrat Omarovna**

*Candidate of Medical Sciences, Head of Pediatric Department No. 3*

*Republican Scientific Center for Emergency Medical Care*

**Mirzayeva Adiba Damirovna**

*Head of Pediatric Department No. 2*

*Republican Scientific Center for Emergency Medical Care*

抽象的。根据对 29 名 10 个月至 3 岁儿童的血流动力学参数监测结果的研究，所有受试者的 MBP 均值在急性肾功能衰竭儿童中均有所增加。在夜间（23 小时至 4 小时）MBP 指数中昼夜节律中子的整个检查期间的平均值明显下降被理解为恢复儿童 MBP 生理昼夜节律的趋势。第二组（强化治疗持续时间+血液透析 14-45 天）。在重症监护的第一个十年结束时，MBP 的平均每日水平增加超过 10 毫米汞柱是一个不利的迹象，表明对基础疾病和并发症的强化治疗效果不佳，以及伴随的加重。导致幼儿发生急性肾功能衰竭的因素。

关键词：昼夜节律，平均动脉压，无尿，急性肾功能衰竭，幼儿。

**Abstract.** *Based on the study of the results of monitoring of hemodynamic parameters in 29 children aged 10 months to 3 years, an increase in the average values of MBP in children with acute renal failure was revealed in all subjects. The noted decrease in the average for the entire period of examination of the mesor of the circadian rhythm in the MBP index at night (23 hours to 4 hours) was understood as a tendency to restore the physiological circadian rhythm of the MBP in children of the 2nd group (duration of intensive therapy + hemodialysis 14-45 days). An increase in the average daily level of MBP by the end of the first decade of intensive care by more than 10 mm Hg is an unfavorable sign, an indicator of insufficiently effective intensive therapy of both the underlying disease and complications, as well as concomitant aggravating factors that led to the development of acute renal failure in young children.*

**Keywords:** *circadian rhythm, mean arterial pressure, anuria, acute renal failure, young children.*

**Relevance.** The mechanism that triggers the formation of childhood arterial hypertension is stress tension, which causes excessive work of the sympathetic regulation system. This is accompanied by spasm of the muscle layer of small vessels. Then biological substances are included in the mechanism of formation, retaining fluid in the body and spasmodic vessels. As a rule, they are opposed by biological factors opposite in action, but when they are depleted, blood pressure begins to rise steadily. Sympathetic regulation has a direct effect on the renal vasculature. The vasospasm of the kidneys includes the renin-angiotensin-aldosterone system. This becomes the foundation for the development of a secondary increase in blood pressure (renal hypertension). At the initial stages of the development of the disease, the spasm of the muscular layer of the vessels is unstable, but over time, the muscle fibers thicken and the spasm becomes permanent. High pressure in the vessels of the brain can provoke failures in the systems of regulation of homeostasis. Before a specialist providing hemodialysis in a child, first of all, there is a problem of hemohydrobalance disturbance and its correction. A significant discrepancy between the primary volume of filling the circuit of the apparatus and the volume of the child's circulating blood, the forced need to use transfusion media, the physiological hydrophilicity of the tissues of the child's body, the imperfect function of the kidneys, the use of hemodilution, the lack of complete biocompatibility of the materials of the extracorporeal circuit and the patient's blood lead to the activation of enzymatic cascades, the development of the syndrome increased "capillary sweating" and tissue hyperhydration. The main organs that are affected in arterial hypertension are the heart, blood vessels, brain, kidneys. However, there is not enough information in the literature about the change in mean arterial pressure in the phase of anuria in acute renal failure in children [1-4]. The latter was the reason for this study.

**Goal of the work.** To study the features of the circadian rhythm of mean arterial pressure in children with acute renal failure in the period of anuria at an early age.

**Material and research methods.** The data of hourly monitoring of mean arterial pressure (MBP) were studied in 29 children with ARF admitted to the ICU of RSCEMC with anuria from 1 to 4 days at the age of 10 months to 3 years 4 months from the ICU of regional children's hospitals and branches of RSCEMC. Prior to admission to the clinic, all patients received anti-inflammatory therapy aimed at the treatment of URI-2, pneumonia 25, AII-2 patient. According to indications, due to severe progressive respiratory failure, patients received invasive mechanical respiratory support on the first day. All patients underwent hemodialysis, 4

patients underwent hemodialysis in combination with plasmapheresis under the control of hemodynamics, acid-base balance (ABB), respiratory system, maintenance, antibacterial, anti-inflammatory, syndromic corrective intensive therapy according to the recommendations in the literature. A favorable outcome with the restoration of full functional activity of the kidneys and discharge from the hospital was observed in 19 children (groups 1 and 2), an unfavorable outcome in 10 children (group 3). The first group consisted of patients who received intensive care in the ICU for up to 10 days, the second - children with a favorable outcome after intensive care for 11-45 days.

**Results and its discussion.** According to numerous studies, the average norm of blood pressure up to 3 years is 106/69, MBP= 81 mm Hg. The average values of MBP in children with ARF up to 3 years were increased in all subjects and in group 1 amounted to  $89.9 \pm 3.7$  mm Hg; in 2 -  $79.4 \pm 6.4$  mm Hg and in group 3 -  $87.5 \pm 5$  mm Hg, that is, they did not differ significantly. On the first day of observation, MBP was increased in group 1 by 8.9 mm Hg, in group 3 by 6.5 mm Hg, in group 2 - within the normative values (Table 1). Throughout the observation in groups 1 and 3, despite intensive drug vasodilating, detoxification therapy by hemodialysis almost daily and plasmapheresis in order to increase the efficiency of detoxification in the most severe children, the level of the mesor of the circadian rhythm, mean AP, remained at stably elevated levels in groups 1 and 2. In dynamics, in patients of group 2, a tendency was found to increase the studied indicator at a later date, when on the 14th and 20th days of treatment (Fig. 1) the mesor of the circadian rhythm MBP became higher than the level of the indicator on day 1 by 9 and 10 mmHg. ( $p < 0.05$ ), which indicated a negative dynamic of intrarenal mechanisms of MBP regulation, a possible increase in ischemia of the renal parenchyma, a decrease in the level of prostaglandins and bradykinins, being a factor contributing to the development of nephrogenic hypertension against the background of damage to the renal tissue, also being one of the indicators of insufficient the effectiveness of corrective measures to restore perfusion and functional activity of the kidneys. In a comparative assessment of the severity of the condition on day 2, the mesors of the circadian rhythm of MBP in children of groups 2 and 3 were significantly lower than in group 1 by 8.4 mm Hg and 8.9 mm Hg. ( $p < 0.05$ , respectively). Subsequently, for 8 days, the revealed difference persisted in both groups. On the 9th day, in patients of group 3, a repeated increase in the mesor of the circadian rhythm of MBP relative to the initial level by 11% ( $p < 0.05$ ) was found against the background of intensive therapy using methods of extracorporeal blood purification, mechanical respiratory support. On days 16.30, there was a short-term trend towards a decrease in the mesor of the circadian rhythm of MBP to the level observed on the first day, which, unfortunately, did not improve the outcome of the disease (Fig. 1). Thus, an increase in MBP by the

end of the first decade of intensive care should be considered an unfavorable sign, an indicator of insufficiently effective intensive therapy of both the underlying disease and complications, as well as concomitant aggravating factors that led to the development of acute renal failure in young children.

**Table 1.**  
*Dynamics of the mesor of the circadian rhythm in the phase of anuria of ARF in young children, in mm Hg*

Days	1 group	2 group	3 group
1	89,9±3,7	79,4±6,4	87,5±5,0
2	90,1±2,0	81,7±1,5 <sup>'''</sup>	81,2±2,6 <sup>'''</sup>
3	93,1±2,4	85,0±2,0 <sup>'''</sup>	83,6±2,0 <sup>'''</sup>
4	94,6±2,3	85,8±2,0 <sup>'''</sup>	83,6±1,7 <sup>'''</sup>
5	92,5±1,6	83,2±2,7 <sup>'''</sup>	84,0±2,9 <sup>'''</sup>
6	94,1±2,3	84,2±1,9 <sup>'''</sup>	79,7±2,8 <sup>'''</sup>
7	95,6±1,6	84,8±1,7 <sup>'''</sup>	85,6±3,0 <sup>'''</sup>
8	93,5±2,7	84,1±1,4 <sup>'''</sup>	90,4±3,6
9	92,3±3,4	85,9±2,6 <sup>'''</sup>	97,5±2,3*
10	88,2±3,3	84,1±2,2	95,7±2,8
11		84,3±2,3	94,2±3,5
12		87,3±1,8	89,4±2,9
13		82,9±2,0	91,1±5,3
14		88,2±1,9*	91,8±2,6
15		85,9±3,4	87,1±3,0
16		85,7±2,1	79,5±3,7
17		85,5±2,3	82,0±6,0
18		86,2±1,7	84,9±3,4
19		85,8±2,1	84,5±3,7
20		89,0±2,8*	82,6±3,4
21		88,9±3,9	81,2±4,2
22		88,6±2,2	80,9±2,2
23		86,5±2,5	80,4±3,3
24		80,8±3,4	84,1±3,6
25		79,8±3,9	84,1±2,7
26		84,6±3,9	84,3±3,3
27		90,0±4,8	87,8±3,6
28		85,7±4,9	85,9±4,8
29		86,4±2,5	85,1±3,0
30		86,5±4,5	79,1±4,6

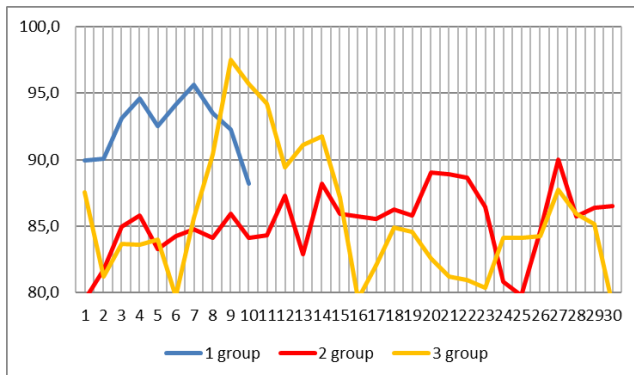
**Table 2.**  
*Mean circadian rhythm of mean AP in ARF*

Hours	1 group	2 group	3 group
8	93,6±2,2	87,5±4,2	87,7±5,7
9	93,2±1,6	86,9±3,8	86,8±5,6
10	93,6±4,0	86,0±3,3	86,4±5,3
11	91,4±2,5	85,0±3,8	85,8±4,9
12	95,0±3,3	84,9±3,1	83,2±4,9
13	93,8±2,0	84,1±3,7	86,1±4,7
14	93,1±4,2	84,7±3,5	88,2±4,9
15	92,6±3,1	84,6±3,3	87,6±6,1
16	91,0±3,1	85,0±3,6	86,6±5,4
17	93,1±3,1	85,3±4,0	86,6±4,5
18	93,6±3,5	86,8±3,5	85,4±4,5
19	93,3±3,0	86,6±3,1	86,4±4,5
20	92,9±1,9	86,3±3,2	85,2±4,5
21	91,7±3,0	85,7±3,1	85,5±4,4
22	94,0±3,1	84,7±3,1	86,2±4,4
23	92,5±2,8	84,5±3,0°	86,5±4,9
24	93,7±2,1	84,4±3,0°	84,1±4,5
1	92,3±1,7	84,3±2,6°	84,2±4,7
2	90,3±2,1	84,6±3,2°	83,3±4,8
3	91,0±1,9	83,9±2,9°	84,1±4,1
4	90,2±2,5	84,6±2,9°	85,0±5,1
5	90,5±4,1	85,2±2,9	84,0±5,2
6	90,4±4,8	85,9±2,7	85,2±4,8
7	91,8±4,7	84,5±3,1	85,0±6,9

\*-dynamics is reliable relative to the indicator in 1 day

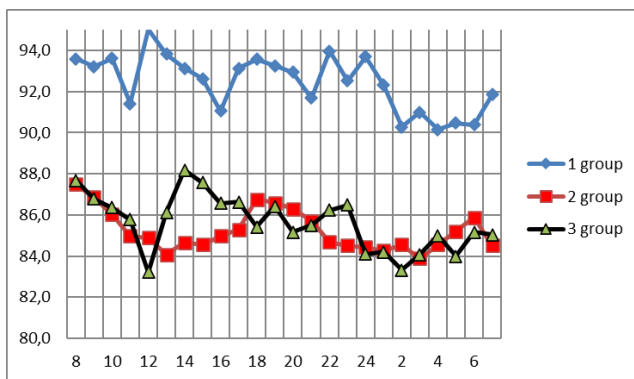
'''- difference is significant relative to the indicator in group 1

° - difference is significant relative to the indicator in 1 day



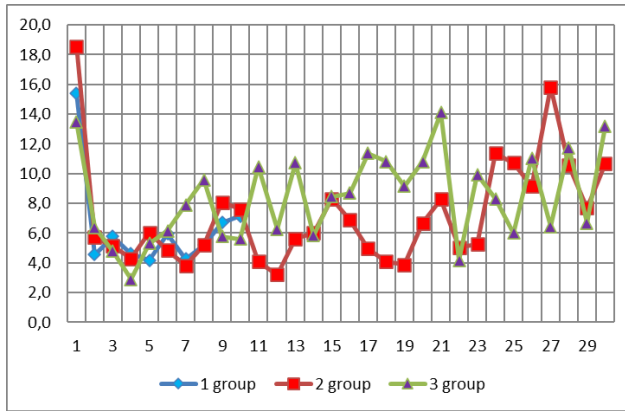
**Figure 1.** Mesor dynamics of the circadian rhythm of mean arterial pressure in the phase of anuria of ARF in infants

As shown in Table 2, the average values of the studied hemodynamic parameter in the circadian rhythm made it possible to detect relatively higher rates both in the daytime and in the dark period of the day in patients of group 1 with fluctuations of 90-95 mm Hg, while as in groups 2 and 3, daily fluctuations occurred in group 2 within 84-87 mm Hg, in group 3 - 83-88 mm Hg. During the night hours from 11 p.m. to 4 a.m., the MBP index in children of the 2nd group was significantly lower by 8-6% than in the 1st group (Fig. 2). Apparently, the identified feature of group 2 - a decrease in the MBP at night can be understood as a tendency to restore the physiological circadian rhythm of MAP. A relatively higher level of MBP (Fig. 2) in group 1 was due to a smaller amount of drug sedative, hypotensive, generally stress-limiting correction than in patients of groups 2 and 3.



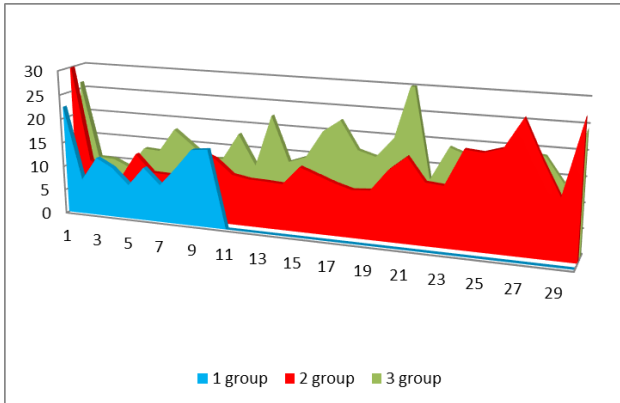
**Figure 2.** Mean circadian rhythm of mean AP in ARF in infancy, mm Hg

Based on the data obtained, it can be assumed that an increase in MBP is primarily an indicator of the degree of severity of the compensatory reaction of a hemodynamic parameter in the process of adaptation of the child's body in conditions of anuria, and only then an indicator of the severity of the state of the body at an early age due to ischemia, inflammatory changes in the renal parenchyma. In this regard, it is not hypotensive therapy that is paramount, but the correction of the mechanisms that led to the violation and restoration of the capillary function of the renal parenchyma. Most likely, these multidirectional complex corrective actions should be carried out simultaneously.



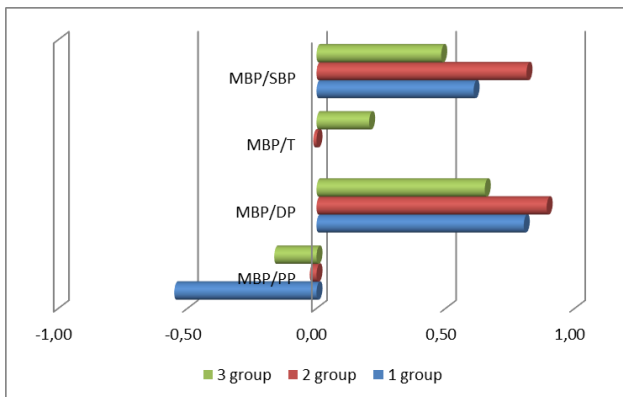
**Figure 3.** Amplitude dynamics of the circadian rhythm MBP, mmHg

The amplitude of the circadian rhythm of MBP was the largest on day 1 in all patients, characterizing the most pronounced instability of the index. Repeated progression of instability of the hemodynamic parameter during the day in group 2 was noted on day 27, in group 3 during the second or third decade of observation, hemodynamic instability was more significant than in groups 1 and 2 (Fig. 3), which corresponded to the severity of the condition of the studied patients.



**Figure 4.** The range of daily fluctuations in MBP, mm Hg

The most pronounced drops in MBP were noted in groups 1 and 2, amounting to 23 mm Hg and 30 mm Hg with a repeated increase in daily changes in group 2 on days 27 and 30 up to 25 mm Hg was due to progressive acute cardiac decompensation, failure of the functional activity of the central mechanisms of blood pressure regulation (Fig. 4).



**Figure 5.** Correlations of MBP in acute renal failure up to 3 years

Significantly significant direct correlations were found between MBP and DP (0.78) in group 1, as well as MBP and SBP (0.8), MBP and DP (0.85) in group 2, which corresponded to a relatively greater participation in the change in MBP changes in tone peripheral vessels, total vascular resistance in changes in the level of DBP (Fig. 5) in the period of anuria in children under the age of 3 years.



Conclusion. The average values of MBP in children with acute renal failure up to 3 years in the phase of anuria were increased in all subjects. The revealed decrease in the average for the entire period of examination of the mesor of the circadian rhythm in the MBP index at night (23:00 to 04:00) can be understood as a tendency to restore the physiological circadian rhythm of MBP. An increase in the average daily level of MBP by the end of the first decade of intensive care is an unfavorable sign, an indicator of insufficiently effective intensive therapy of both the underlying disease and complications, as well as concomitant aggravating factors that led to the development of acute renal failure in young children.

### References

1. <https://www.krasotaimedicina.ru/diseases/children/renal-failure>
2. [https://www.bsmu.by/downloads/kafedri/k\\_2\\_child/lohpn.pdf](https://www.bsmu.by/downloads/kafedri/k_2_child/lohpn.pdf)
3. <https://ru.wikipedia.org/wiki/%D0%9E%>
4. [https://meduniver.com/Medical/nefrologia/lechenie\\_opn\\_u\\_detei.html](https://meduniver.com/Medical/nefrologia/lechenie_opn_u_detei.html)

秋明州城市和农村居民区大学就读青少年学生的 Weissflog 指数  
**WEISSFLOG INDEX IN ADOLESCENT STUDENTS ENROLLED IN  
UNIVERSITIES FROM CITIES AND RURAL SETTLEMENTS OF  
THE TYUMEN OBLAST**

**Chiryateva Tatyana Viktorovna**

*Doctor of Medical Sciences, Full Professor  
Tyumen State Medical University*

**Prokopyev Nikolay Yakovlevich**

*Doctor of Medical Sciences, Full Professor.  
Tyumen State Medical University*

抽象的。在进入秋明国立医科大学和秋明州立大学的 42 名年龄为  $18.4 \pm 0.7$  岁、居住在城市 ( $n = 27$ ) 和农村住区 ( $n = 15$ ) 的男孩中, 长度和宽度的解剖学值 (Weissflog 指数) 脚。测量结果表明, 居住在城市和农村住区的年轻男性在研究指标上没有显著差异, 这使他们能够过上积极的生活方式并从事体育运动。

关键词: 城乡青年, Weissflog 指数。

**Abstract.** *In 42 boys aged  $18.4 \pm 0.7$  years old, living in cities ( $n = 27$ ) and rural settlements ( $n = 15$ ), who entered the Tyumen State Medical University and Tyumen State University, the anatomical values of length and width (Weissflog index) feet. The measurement results indicated that there were no significant differences in the studied indicators between young men living in cities and rural settlements, which allows them to lead an active lifestyle and engage in physical education and sports.*

**Keywords:** *young men of cities and rural settlements, Weissflog index.*

**Introduction.** For many decades, the problem of foot pathology (flat feet) has not left the pages of special literature [4, 5, 6, 7, 9, 10]. So, in particular, in children, the incidence of flat feet varies from 0.6 to 77.9%, so the problem of its morphological and functional assessment in the practice of physical culture and sports is of particular importance [1, 2, 3].

In 1896 Lovett H.W. et al. [8] were among the first to characterize the foot with a flat arch in such a way that this description has practically not changed to the present: "... the height of the medial longitudinal arch is partially or completely flat, and almost the entire plantar surface of the foot is in contact with the ground."

In the practice of sports, it is important to know the anatomical and functional capabilities of the arches of the foot for the resulting training load. To date, the question concerning the ratio of the length of the foot to its width (Weissflog index) in young men living in cities and rural settlements remains insufficiently studied.

**Purpose:** to study the ratio of the length of the foot to its width (Weissflog index) among young students who entered Tyumen universities from cities and rural settlements.

**Organization and research methods.** The study involved 47 young men aged  $18.4 \pm 0.7$  years who, before entering the university, permanently lived in cities ( $n = 31$ ) and rural settlements ( $n = 16$ ). From the anamnesis, it was established that, firstly, the parents of the young men for three generations constantly lived in the conditions of Western Siberia. Secondly, 32 (68.1%) young men systematically went in for various sports.

The length of the foot was determined (in cm) from the most prominent toe to the heel. The width of the foot (in cm) is measured at its widest part. To assess the state of the transverse arch of the foot, we used the Weissflog index ( $W$ , arb. unit), numerically equal to the ratio of the length of the foot to its width:  $W = S/P$ , where:  $S$  is the length of the foot,  $P$  is the width of the foot.

We proceeded from the fact that the decrease in the index, i.e. the approach of its value to 2 indicates transverse flat feet; the approach of the value to 3 shows the ideal transverse state of the foot and is an indicator of its good spring function.

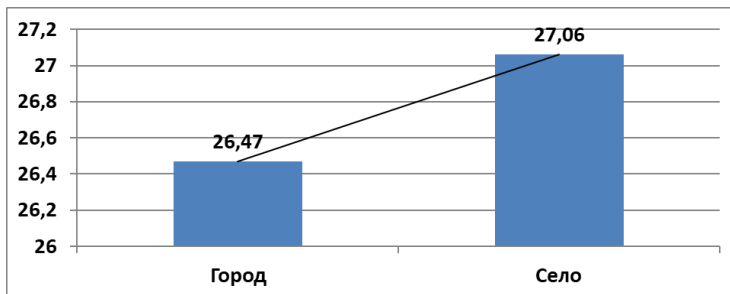
The results of the study were processed by methods of mathematical statistics using Student's t-test. The studies complied with the ethical standards of biomedical ethics committees developed in accordance with the Declaration of Helsinki adopted by the WMA, as well as the Order of the Ministry of Health of the Russian Federation No. 226 of June 19, 2003 "Rules of Clinical Practice in the Russian Federation". The principles of voluntariness, the rights and freedoms of the individual, guaranteed by Articles 21.2 and 22.1 of the Constitution of the Russian Federation, are observed. Oral permission from students to conduct the study was obtained.

**Results of the study and their discussion.** Indicators of foot length in young men who entered the university from cities and rural settlements are given in Table. 1.

**Table 1**  
*Indicators of foot length, width and Weissflog index in young men from cities and rural settlements ( $M \pm m$ )*

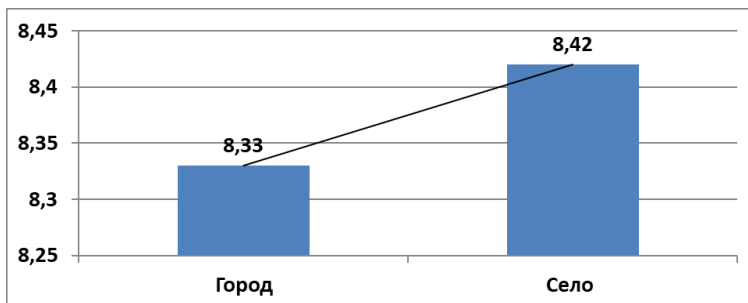
Index	Place of residence	
	City	Rural settlement
Foot length	26,47±1,09	27,06±1,17
Foot width	8,33±0,23	8,42±0,26
Weissflog index	3,177	3,213

The results of measuring the long-length dimensions of the foot in young men indicated that it was in extreme values from 23.8 cm to 27.6 cm. We did not reveal significant differences in the values of the foot length among young men depending on their place of residence ( $p > 0.05$ ), despite the fact that in absolute terms the length of the foot of young men from rural settlements was 0.59 cm longer.



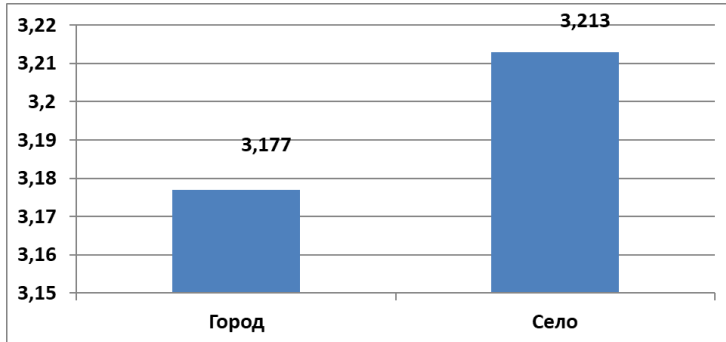
*Figure 1. The length of the foot in young men living in cities and rural settlements.*

The results of measuring the width of the foot in young men who entered the university from cities and rural settlements indicated that it has extreme dimensions ranging from 8.1 to 8.7 cm. In absolute terms, the width of the foot of young men (Fig. 2) from rural areas settlements was 0.1 cm more than among urban boys, which is not statistically significant - ( $p > 0.05$ ).



*Figure 2. The width of the foot in young men who lived in cities and rural settlements.*

Measurements of the ratio of the length of the foot to its width (Fig. 3) indicated that the Weissflog index for young men living in cities was 3.177 c.u., for those who lived in rural settlements - 3.213 c.u.



**Figure 3.** Weissflog index for young men living in cities and rural areas.

Estimating the calculated values of the Weissflog index, we can conclude that it exceeded the value of 3, which indicates, firstly, the ideal transverse state of the foot in young men, regardless of their place of residence. Secondly, it is an indicator of its good spring function, which is important when doing physical education and sports.

The use of the Weissflog index allows us to conclude that young men have an ideal transverse foot condition. However, it should be remembered that the Weissflog index can only indicate the presence of signs of transverse flatfoot, but not its degree.

## References

1. Lipayev V.F. Prevention of foot injuries in sports / V.F. Lipaev //E-Scio. 2022. – No. 3 (66). – P. 606-610.
2. Perepelkin A.I. Influence of dosed load on changes in the structure and function of the human foot: monograph. / A.I. Perepelkin, V.B. Mandrikov, A.I. Krayushkin. – Volgograd: VolgSMU Publishing House, 2012. – 182 p.
3. Prokopyev N. Ya. Medico-pedagogical approaches in the rehabilitation of victims with injuries and diseases of the ankle and foot: textbook / N. Ya. Prokopyev. – Moscow: RUSSIGNS, 2021. – 174 p.
4. Alfageme-García P., Calderón-García J.F., Martínez-Nova A., HidalgoRuiz S., Basilio-Fernández B., Rico-Martín S. Association between the Use of Backpack and Static Foot Posture in Schoolchildren with Static Pronated Foot Posture: A 36-Month Cohort Study. // Children (Basel). – 2021. – Sep. 11, 8(9):800. – 93-96.
5. Böhm H., Oestreich C., Rethwilm R., Federolf P., Döderlein L., Fujak A. Cluster analysis to identify foot motion patterns in children with flexible flatfeet

*using gait analysis – a statistical approach to detect decompensated pathology? // Gait Posture. – 2019. – 71:151-156.*

6. *Bresnahan P.J., Juanto M.A. Pediatric Flatfeet-A Disease Entity That Demands Greater Attention and Treatment. Front Pediatr. – 2020. – Feb 11, 8:19. – 94-98.*

7. *Cho Y., Park J.W., Nam K. The relationship between foot posture index and resting calcaneal stance position in elementary school students. // Gait Posture. – 2019. – 74:142-147.*

8. *Lovett H.W., Dane J. The affections of the arch of the foot commonly classified as flatfoot. // J Bone Joint Surg. – 1896. – 8: 7892.*

9. *Turner C., Gardiner M.D., Midgley A., Stefanis A. A guide to the management of paediatric pes planus. // Aust J Gen Pract. – 2020. – 49(5): 245-249.*

10. *Vijayakumar K., Senthilkumar S., Chandratre S.G., Bharambe V. An analysis of arches of the foot: Grading the severity of pesplanus and pescavus using a newly designed podoscope and parameters. // J Anat Soc India. – 2021. – 70: 85-92.*

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来自城市和农村住区的秋明国立医科大学青年男性的足部尺寸和步长  
**FOOT DIMENSIONS AND STEP LENGTH IN YOUNG MEN  
ADMITTED TO THE TYUMEN STATE MEDICAL UNIVERSITY  
FROM CITIES AND RURAL SETTLEMENTS**

**Chiryateva Tatyana Viktorovna**

*Doctor of Medical Sciences, Full Professor.  
Tyumen State Medical University*

**Prokopyev Nikolay Yakovlevich**

*Doctor of Medical Sciences, Full Professor.  
Tyumen State Medical University*

抽象的。在进入秋明国立医科大学的 42 名年龄为  $18.4 \pm 0.7$  岁、居住在城市 ( $n = 27$ ) 和农村住区 ( $n = 15$ ) 的年轻男性中,足长尺寸的解剖学值较低,在比较计划中研究了腿部和下肢及其与生长和步长的关系。测量结果表明,所研究的参数没有显著差异,这使年轻男性可以过上积极的生活方式并参加体育运动。

关键词: 城市和农村青年男子, 身高测量长度, 下肢, 脚, 步长。

**Abstract.** *In 42 young men aged  $18.4 \pm 0.7$  years, who lived in cities ( $n = 27$ ) and rural settlements ( $n = 15$ ), who entered the Tyumen State Medical University, the anatomical values of the long-length dimensions of the foot, lower leg and lower limbs and their relationship with growth and stride length were studied in a comparative plan. The measurement results indicated that there were no significant differences in the studied parameters, which allows young men to lead an active lifestyle and go in for physical education and sports.*

**Keywords:** *young men of cities and rural settlements, length measurements of height, lower limbs, feet, step length.*

**The relevance of research.** The problems of preserving, restoring the health and quality of life of the younger generation of the regions of Russia for many years occupy an important place in the scientific research of specialists in various fields [1, 8, 10].

The foot, being the most important component of the function of support and movement, has occupied a special place in scientific research for many decades, and the problem of its study has not left the pages of special literature for decades [2, 5, 6].

If we consider variations in the ratio of long-length measurements in young men from cities and rural settlements of the Tyumen region to step length from the standpoint of age morphology, then there are no such studies in the literature available to us.

**Purpose:** to consider the anatomical ratios of the long-length dimensions of the body, lower limbs, lower leg and foot to step length in first-year students of adolescence who entered the Tyumen State Medical University from cities and rural settlements.

**Material and research methods.** The study was performed at the Department of Human Anatomy of the Tyumen State Medical University. The study involved 42 young men aged  $18.4 \pm 0.7$  years who, before entering the university, permanently lived in cities ( $n = 27$ ) and rural settlements ( $n = 15$ ). From the anamnesis, it was established that, firstly, the parents of the young men for three generations constantly lived in the conditions of Western Siberia. Secondly, 28 (66.7%) young men systematically went in for sports.

The length of the foot in young men was measured using a standard device (Fig. 1), and the length of the lower limbs, lower leg and step using a rubberized tailor's tape.



**Figure 1.** Measuring the length of the foot.

The length of the body was determined with an accuracy of 0.5 cm using the stadiometer proposed by us (RF Patent for utility model No. 153076).

All young men, depending on the length of the body, we conditionally divided into two groups - from 160 to 170 cm and from 171 to 180 cm, based on which the anatomical relationships were calculated.

To measure the step length, a number of technical solutions have been proposed [4, 9, 11, 12]. When measuring the average stride length, we used the formula [3, 7]:  $LS = P/4 + 0.37$  m,

where: LS is the length of one step in meters, H is the height (length of the body) of a person in meters.

The results of the study were processed by methods of mathematical statistics using Student's t-test. The studies complied with the ethical standards of biomedical ethics committees developed in accordance with the Declaration of Helsinki adopted by the WMA, as well as the Order of the Ministry of Health of the Russian



Federation No. 226 of June 19, 2003 “Rules of Clinical Practice in the Russian Federation”. The principles of voluntariness, the rights and freedoms of the individual, guaranteed by Articles 21.2 and 22.1 of the Constitution of the Russian Federation, are observed. Oral permission from students to conduct the study was obtained.

**Results and discussion.**

The results of the examination of young men (Table 1) indicated that there were no significant differences in foot length between residents of the city and rural settlements ( $p>0.05$ ).

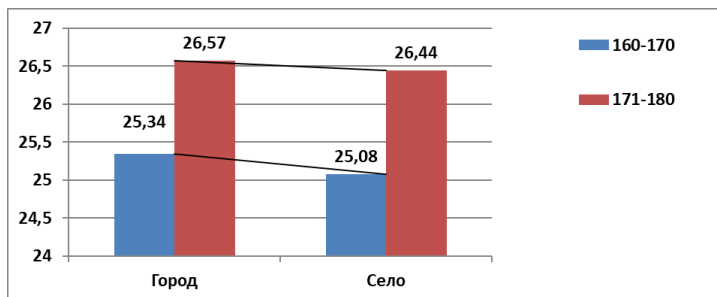
**Table 1**

*Indicators of anatomical ratios of long-length dimensions of the body, lower limbs, lower leg and foot to step length in young men of the Tyumen State Medical University, depending on the place of residence (M±m)*

Index	Location	
	City	Rural settlements
Foot length with growth: from 160 to 170 cm From 171 to 180 cm	25,34±1,09 26,57±1,14	25,08±1,07 26,44±1,12
Foot length to height ratio	2,75±0,21 2,70±0,19	2,77±0,22 2,71±0,20
Lower limb length (right)	0,158 0,155	0,156 0,154
The ratio of the length of the right lower limb to the length of the step	92,77±2,16 94,81±2,83	93,06±2,23 95,43±2,56
The ratio of step length to the length of the right lower limb	1,330 1.319	1,336 1,333
Foot length to height ratio	0,735 0,757	0,748 0,749
Growth step length: 160 to 170 cm From 171 to 180 cm	69,73±1,52 71,86±1,65	69,62±1,49 71,54±1,57
Foot width with growth: 160 to 170 cm From 171 to 180 cm	7,56±0,62 8,02±0,77	7,79±0,55 8,36±0,68
The ratio of the width of the foot to its length with growth: 160 to 170 cm From 171 to 180 cm	0,298 0,302	0,310 0,316

In young men with a body length of 171 to 180 cm, regardless of the place of residence, the length of the foot in absolute dimensions is greater (Fig. 2) than

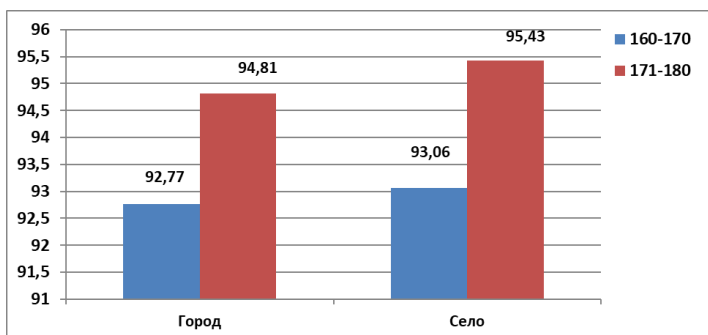
in their peers with a body length of 160 to 170 cm, although the difference is not statistically significant ( $p > 0.05$ ).



**Figure 2.** Longitudinal dimensions of the foot in adolescent students of the Tyumen State Medical University, who entered the study from cities and rural settlements.

The results of measuring the length of the lower extremities indicated that it depends on the growth of young men, although there are no statistically significant differences ( $p > 0.05$ ). So, in absolute terms, the length of the lower limbs in urban boys is 2.04 cm longer, in rural settlements by 2.37 cm, which is not statistically significant ( $p > 0.05$ ).

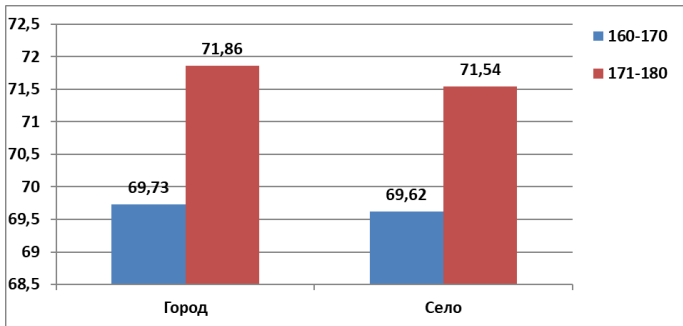
In young men, whose body length ranged from 160 to 170 cm and from 171 to 180 cm (Fig. 3), there were no significant differences in leg length between those living in cities and rural settlements ( $p > 0.05$ ). In absolute terms, the difference in the length of the lower extremities among young men from cities was 2.13 cm, and among their peers from rural settlements 1.92 cm, which is not statistically significant ( $p > 0.05$ ).



**Figure 3.** Leg length in youth students of the Tyumen State Medical University, enrolled for training from cities and rural settlements.

From a practical point of view, information about the width of the foot in young men from cities and rural settlements, depending on the length of the body, is of particular interest. By measuring the width of the foot, we indirectly judge the support function of the foot. We did not reveal significant differences in foot width between young men from cities and rural settlements ( $p>0.05$ ). In absolute terms, the difference in foot width depending on height was 0.46 cm and 0.57 cm, respectively.

The length of the step in its absolute values depends on the height of the young men. We did not reveal significant differences in step length from the place of residence of young men ( $p>0.05$ ). The difference in step length among young men living in cities, with a height of 160 to 170 cm, was 2.13 cm, in rural areas - 1.92 cm (Fig. 4).



**Figure 4.** Step length in youth students of the Tyumen State Medical University, who entered the study from cities and rural settlements.

On the basis of the study, it can be concluded that there are no significant differences in the length of the lower limbs, lower leg, foot, and stride length between the young men of the city and rural settlements. Therefore, given the normal morphological and functional parameters, there are no restrictions on the dosing of physical activity during physical education and sports, hiking, health tourism, etc. and maintaining an active healthy lifestyle.

## References

1. Alimov V.G. Influence of physical culture on the upbringing of young men as future defenders of the fatherland / V.G. Alimov, M.A. Ivanov, D.E. Sadovy // Physical culture and sport in the XXI century: current problems and solutions: collection of materials of the II International Scientific and Practical Conference.

under the general editorship. Gorbacheva V.V., Borisenko E.G., Volgograd, October 19–20, 2022. – P. 238-240.

2. Gatskan O.V. Prevention and correction of flat feet: a review of the literature / O.V. Gatskan // *International research journal*. – 2020. – No. 12-2 (102). – P. 123-128.

3. Gomon Yu. B. Calculation of the length of a step in autonomous navigation of a person / Yu.B. Gomon, V.A. Mikhailov. // *Scientific research: from theory to practice*. – 2016. – No. 2-1 (8). – P. 215-219.

4. Kozlovsky N. Method for determining the length of the step: USSR Author's certificate No. 1771691

5. Prokopyev A. N. Dependence of step length and cadence on age and height. / A.N. Prokopyev, N.Ya. Prokopyev, E.S. Gurtova. // *Morphology*. – 2019. – Volume 155. – No. 2. – P. 236.

6. Prokopyev N. Ya. Characteristics of the morphological parameters of the foot in student-athletes, diagnosed by various methods / N.Ya. Prokopyev // *Educational-patriotic and physical-sports activities in universities: innovations in solving urgent problems. Materials of the International scientific-practical conference*. – Tyumen, May 19, 2017. – P. 238-243.

7. Psarev A. A. Military topography. /A.A. Psarev. – M.: “Voenizdat” Publishing House, 1986. – 384 p.

8. Pushkareva A.M. The significance of a differentiated approach to the physical education of non-athletic students /A.M. Pushkareva A.I. Popova // *Physical education and sports training*. – 2022. – No. 1 (39). – P. 203-212.

9. Method for determining the length of the step / N.B. Sotsky, N.P. Chebotar, O.N. Kozlovsky, V.V. Klygach // Copyright certificate SU 1771691 A1, 10/30/1992. Application No. 4785533 dated January 22, 1990.

10. Tatanova DV Diagnosis of problems in terms of maintaining the health of young men of pre-conscription age. / D.V. Tatanova, M.F. Rzyankin. // *Bulletin of Public Health and Healthcare of the Far East of Russia*, 2012. – No. 3 (8). – P. 8.

11. Jimenez A. R. A Comparison of Pedestrian Dead-Reckoning Algorithms using a Low-Cost MEMS IMU, WISP 2009. – / A.R. Jimenez. // *6th IEEE International Symposium on Intelligent Signal Processing*. – 26-28 August, 2009. – Budapest, Hungary.

12. Mitja Placer. Enhancing Indoor Inertial Pedestrian Navigation Using a Shoe-Worn Marker. / Placer Mitja, Kovacic Stanislav // *Sensors* 2013. – 13. – P. 9836-9859.

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糖尿病及妊娠糖尿病孕妇视网膜血流的研究  
**STUDY OF RETINAL BLOOD FLOW IN PREGNANT WOMEN  
WITH DIABETES MELLITUS AND GESTATIONAL DIABETES  
MELLITUS**

**Kolenko Oleg Vladimirovich**

*Doctor of Medical Sciences*

*The S. Fyodorov Eye Microsurgery Federal State Institution,  
Far Eastern State Medical University, Postgraduate Institute for Public  
Health Specialists, Khabarovsk, Russian Federation*

**Pomytkina Natalia Viktorovna**

*Candidate of Medical Sciences*

*The S. Fyodorov Eye Microsurgery Federal State Institution,  
Khabarovsk, Russia;*

**Sorokin Evgeny Leonidovich**

*Doctor of Medical Sciences, Professor*

*The S. Fyodorov Eye Microsurgery Federal State Institution,  
Far Eastern State Medical University, Khabarovsk, Russia*

抽象的。

目的。使用光学相干断层扫描血管造影术 (OCTA) 研究患有糖尿病和妊娠糖尿病的孕妇的视网膜血流。

材料与amp;方法。对 203 名妊娠晚期的孕妇进行了检查: 24 名患有 1 型和 2 型糖尿病 (T1DM 和 T2DM), 143 名患有妊娠期糖尿病 (GDM), 以及 36 名明显健康的生理性妊娠妇女, 她们组成了对照组。使用 RTVue XR Avanti OCT 6 mm × 6 mm “Angio Retina” 扫描协议 (Optovue, 美国) 进行 OCTA 成像。研究了浅表毛细血管丛中的整个图像血管密度 (wiVD)、中心凹血管密度 (FVD) 和中心凹无血管区 (FAZ) 区域。

结果。患有糖尿病的孕妇的 FVD 明显低于患有 GDM 的孕妇和对照组, 在这方面, 可以假设由于此类患者碳水化合物代谢的慢性紊乱和微血管病, 视网膜微血管调节发生了变化。在没有 FVD 指标差异的情况下, 与患有糖尿病和没有 DR 的孕妇组的数据相比, 糖尿病视网膜病变 (DR) 患者的 FAZ 面积扩大和 wiVD 减少。在 2 名没有 DR 检眼镜检查征象的 T1D 患者中, OCTA 显示了眼后极的非灌注区域。

### 结论

1. 糖尿病孕妇的浅表毛细血管丛 FVD 显著降低, 而浅表毛细血管丛和 FAZ 区域的 wiVD 与 GDM 孕妇和生理妊娠的健康妇女相比没有显著差异。

2. 与没有DR的糖尿病孕妇组相比, DR患者的浅表毛细血管丛FAZ面积扩大, wiVD减少。

3. 对于没有 DR 检眼镜征象的糖尿病孕妇, OCTA 有助于识别眼后极部的视网膜非灌注区域。

关键词: 光学相干断层扫描血管造影术, 妊娠, 糖尿病视网膜病变, 妊娠糖尿病, 中央凹无血管区, 视网膜血流。

### **Abstract.**

**Purpose.** *To study retinal blood flow in pregnant women with diabetes mellitus and gestational diabetes mellitus using optical coherence tomography angiography (OCTA).*

**Material and methods.** *203 pregnant women in the third trimester were examined: 24 - with type 1 and 2 diabetes mellitus (T1DM and T2DM), 143 - with gestational diabetes mellitus (GDM), and 36 apparently healthy women with physiological pregnancy, who consisted the control group. OCTA imaging was performed using the RTVue XR Avanti OCT 6 mm × 6 mm “Angio Retina” scan protocols (Optovue, USA). The whole image vessel density (wiVD), foveal vessel density (FVD), and foveal avascular zone (FAZ) area in the superficial capillary plexus were studied.*

**Results.** *FVD in pregnant women with diabetes mellitus was significantly less than in pregnant women with GDM and in the control group, in this connection, it can be assume changes of the retinal microvascular regulation because of chronic disturbances of carbohydrate metabolism in such patients and due to microangiopathy development. FAZ area extension and wiVD diminution were revealed in patients with diabetic retinopathy (DR) compared to datas of the group of pregnant women with diabetes mellitus and absence of DR, in the absence of differences in FVD indexes. In 2 patients with T1D and the absence of ophthalmoscopic signs of DR, OCTA revealed areas of nonperfusion in the posterior pole of the eye.*

### **Conclusions**

1. *A significant FVD decrease in the superficial capillary plexus was revealed in pregnant women with diabetes mellitus, compared with pregnant women with GDM and healthy women with physiological pregnancy in the absence of significant difference in wiVD in the superficial capillary plexus and FAZ area.*

2. *Patients with DR showed an expansion of FAZ area and decrease in wiVD in the superficial capillary plexus relative to the group of pregnant women with diabetes mellitus without DR.*

3. *OCTA helps to identify areas of retinal nonperfusion in the posterior pole of the eye in pregnant women with diabetes in the absence of ophthalmoscopic signs of DR.*

**Keywords:** *optical coherence tomography angiography, pregnancy, diabetic retinopathy, gestational diabetes, foveal avascular zone, retinal blood flow.*

**Relevance.** Pregnancy occurring against the background of carbohydrate metabolism disorders is an urgent interdisciplinary problem. This is due to the fact that diabetes mellitus (DM) and pregnancy are mutually aggravating conditions. Pregnancy due to phase changes in the hormonal background makes it difficult to achieve normoglycemia, DM contributes to the development of pathology on the part of the mother and fetus [1, 2]. Gestational diabetes (GD) causes a relatively short-term violation of the glycemic status, however, affecting the state of vascular regulation, it can also lead to a number of complications [12].

The prevalence of type 1 and type 2 DM (DM1 and DM2) among women of reproductive age in the Russian Federation is 0.9–2%; in 1% of cases a pregnant woman has pregestational diabetes, and in 1–5% of cases GD occurs or true diabetes manifests (<https://rosinfostat.ru/zdravooхранenie/>). An increased risk of manifestation and progression of diabetic retinopathy (DR) during pregnancy has been established by The Diabetes Control and Complications Trial (DCCT). The appearance or progression of DR is observed in 9.7% of pregnant women with DM [6, 9]. According to N.V. Borovik, during pregnancy, microvascular complications are detected in 62.7% of women with type 1 diabetes [1].

The method of optical coherence tomography in the angiography mode (OCT-A) is widely used for early diagnosis and monitoring of DR [3, 5, 7, 8, 10, 11, 13], however, there is little information in the literature about the use of this method in the study of retinal vessels in pregnant women with diabetes or GD. At the same time, the study of the state of retinal blood flow in pregnant women with impaired carbohydrate metabolism can contribute to the early detection of DR, which is necessary for timely treatment and maintaining high visual functions.

**Purpose.** The study of retinal blood flow in pregnant women with diabetes and gestational mellitus using OCT-A.

**Material and methods.** 203 pregnant women were examined: 24 people - with DM1 and DM2; 143 people - with GD. The control group consisted of 36 practically healthy women with a physiological course of pregnancy. All patients were in the third trimester of pregnancy.

Pregnant women with disorders of carbohydrate metabolism were selected by the method of continuous sampling from among the patients referred from the Perinatal Center of the Khabarovsk Territory to the Khabarovsk branch of the S. Fyodorov Eye Microsurgery Federal State Institution in the period 2016–2018.

The control group was represented by pregnant women who were examined in the diagnostic department of the Khabarovsk branch of the S. Fyodorov Eye Microsurgery Federal State Institution. The exclusion criteria for the formation of groups were: the value of the anteroposterior axis of the eye is more than 24.5 mm, the presence of concomitant pathology of the visual analyzer that affects blood flow.

In the DM group, the average age of patients was  $29.1 \pm 4.7$  years (from 24 to 39 years). The average duration of DM was  $11.1 \pm 8.4$  years (from 1 to 32 years). The average level of glycemia was  $6.8 \pm 1.5$  mmol/l (from 4.0 to 9.0 mmol/l). 2 patients had DM2, the rest had DM1.

In 10 patients, including 2 patients with DM2, DR was not detected during pregnancy. In 14 pregnant women (58%), pre- or proliferative DR was diagnosed in the pregestational period or during pregnancy. They underwent laser coagulation of the retina before the examination.

The average age of pregnant women in the GD group was  $31.5 \pm 5$  years (from 18 to 44 years). The level of glycemia averaged  $6.0 \pm 1.5$  mmol/l (from 5.1 to 15.0 mmol/l).

Among patients with GD, three subgroups were distinguished depending on the period of development of GD during pregnancy.

The GD1 subgroup consisted of 71 patients in whom GD was detected in the first trimester. The average age of pregnant women was  $31.9 \pm 5.1$  years (from 18 to 44 years). The average value of glycemia corresponded to  $5.9 \pm 1.0$  mmol/l (from 5.1 to 9.8 mmol/l).

The GD2 subgroup was formed from 29 pregnant women who developed GD in the second trimester of pregnancy. The mean age of the patients was  $30.9 \pm 4.5$  years (25 to 38 years). The average blood glucose level corresponded to  $6.2 \pm 2.5$  mmol/l (from 5.1 to 15.00 mmol/l).

The GD3 subgroup included 43 patients who developed GD in the third trimester of pregnancy. Their mean age was  $30.9 \pm 5.2$  years (from 25 to 38 years). Mean values of glycemia corresponded to  $6.0 \pm 1.1$  mmol/l (from 5.1 to 8.2 mmol/l).

There were 25 pregnant women (17.5%) with GD on insulin therapy, 15 of them from the GD1 subgroup, 10 from the GD2 subgroup. All pregnant GD3 subgroups controlled their glycemic levels with diet.

In the control group, the average age of the patients was  $30 \pm 4.2$  years (from 23 to 37 years).

All pregnant women underwent OCT-A using the RTVue XR Avanti (Optovue, USA). The GD Angio Retina 6.0 mm scanning protocol was used. Relative vascular density (RVD), foveal vascular density (FVD) in the superficial retinal choroid plexus, and foveal avascular zone area (FAZA) were studied. One random eye of each patient was examined. All studies were performed in the third trimester of pregnancy.



Statistical data are presented as  $M \pm \sigma$ , where  $M$  is the mean value,  $\sigma$  is the standard deviation. Since not all samples followed a normal distribution, for multiple comparisons of groups, the Kruskal-Wallis test was used, followed by pairwise comparisons by the Mann-Whitney U test, taking into account the Holm-Bonferroni correction. Statistical analysis was carried out using the IBM SPSS Statistics 20 program. The critical significance level was 0.05.

**Results and discussion.** In patients with diabetes in the third trimester, the average values of RVD were  $50.47 \pm 4.45\%$  (from 39.03 to 56.98%); FVD -  $27.15 \pm 8.08\%$  (from 9.8 to 43.32%); FAZA -  $0.36 \pm 0.15 \text{ mm}^2$  (from 0.22 to 0.79  $\text{mm}^2$ ).

In the group of patients with GD in the third trimester, the average values of RVD were  $52.15 \pm 3.34\%$  (from 39.82 to 60.54%); FVD -  $34.12 \pm 5.97\%$  (from 12.54 to 47.56%); FAZA -  $0.28 \pm 0.1 \text{ mm}^2$  (from 0.09 to 0.67  $\text{mm}^2$ ).

In pregnant women of the control group in the third trimester, the average values of RVD were  $51.93 \pm 3.16\%$  (from 44.08 to 56.68%); FVD -  $34.52 \pm 6.32\%$  (from 26.57 to 49.14%); FAZA -  $0.27 \pm 0.1 \text{ mm}^2$  (from 0.02 to 0.39  $\text{mm}^2$ ).

Comparative analysis of the data obtained using the Kruskal-Wallis test did not reveal significant differences in RVD and FAZA between groups of pregnant women with DM, GD and physiological pregnancy ( $p > 0.05$ ).

According to the Mann-Whitney U test, there were no significant differences in FVD values between the GD and control groups ( $p = 0.815$ ). At the same time, there was a statistically significant difference in this indicator between the DM and GD groups ( $p < 0.001$ ), as well as between them and the control group ( $p = 0.001$ ). The FVD index in pregnant women with DM was significantly lower than in pregnant women with a physiological course of pregnancy and GD.

For a detailed analysis of the state of retinal blood flow in the GD group, the OCT-A parameters were studied depending on the timing of GD manifestation in the GD1, GD2, and GD3 subgroups.

The average values of the studied parameters in the GD1 subgroup were: RVD -  $52.00 \pm 3.48\%$  (from 39.82 to 60.54%); FVD -  $34.03 \pm 5.49\%$  (from 20.89 to 47.56%); FAZA -  $0.28 \pm 0.1 \text{ mm}^2$  (from 0.09 to 0.54  $\text{mm}^2$ ).

In the GD2 subgroup, the average values of the studied parameters were: RVD -  $51.87 \pm 3.04\%$  (from 46.02 to 56.57%); FVD -  $35.13 \pm 4.96\%$  (from 26.96 to 41.88%); FAZA -  $0.27 \pm 0.08 \text{ mm}^2$  (from 0.14 to 0.43  $\text{mm}^2$ ).

The average values of the studied parameters in the GD3 subgroup were: RVD -  $52.38 \pm 3.11\%$  (from 46.02 to 58.59%); FVD -  $34.28 \pm 6.74\%$  (from 12.54 to 43.16%); FAZA -  $0.29 \pm 0.11 \text{ mm}^2$  (from 0.14 to 0.67  $\text{mm}^2$ ).

Comparative analysis of the data obtained using the Kruskal-Wallis test did not reveal significant differences in the values of the studied parameters in the subgroups of GD1, GD2 and GD3: for RVD -  $p = 0.911$ , for FVD -  $p = 0.523$ , for FAZA -  $p = 0.977$ .

For a detailed analysis of retinal blood flow in the group of pregnant women with DM, two subgroups were identified: 14 pregnant women with DR (DR+) and 10 pregnant women without DR (DR ).

In pregnant women with DR in the third trimester, the average values of RVD corresponded to  $48.68 \pm 4.89\%$  (from 39.03 to 56.98%), FVD -  $29.93 \pm 6.93\%$  (from 18.72 to 43.32 %), FAZA -  $0.43 \pm 0.18 \text{ mm}^2$  (from 0.25 to 0.79  $\text{mm}^2$ ). In pregnant women with DM without DR in the third trimester, the average values of RVD were  $52.26 \pm 3.22\%$  (from 45.8 to 56.24%), FVD -  $24.37 \pm 8.47\%$  (from 9.8 to 34.42%), FAZA -  $0.30 \pm 0.07 \text{ mm}^2$  (from 0.22 to 0.45  $\text{mm}^2$ ).

When conducting a comparative analysis using the Mann-Whitney U test, there were no significant differences in the FVD values in the groups of pregnant women with DM with and without DR in the third trimester ( $p = 0.114$ ). However, FAZA values in patients with DR were significantly higher ( $p=0.039$ ), and RVD were significantly lower ( $p=0.035$ ) in comparison with the data obtained in the group of pregnant women with DM without DR.

In 11 pregnant women with DM and DR, OCT-A in the posterior pole of the eye visualized zones of retinal nonperfusion in the superficial vascular plexus, which in 6 patients tended to expand during pregnancy.

In 2 patients with DM1 and no ophthalmoscopic signs of DR, zones of non-perfusion were detected in the superficial choroid plexus of the posterior pole of the eye, which we regarded as subclinical signs of DR. This is consistent with literature data, in particular S.A. Agemy et al. spoke about the possibility of diagnosing subclinical DR by the appearance of areas of retinal nonperfusion, as well as identifying the progressive course of DR by reducing the density of retinal capillaries [4]. The data obtained became the basis for active dynamic monitoring of these patients.

In the conducted study, there were no significant differences in the values of RVD and FAZA in the groups of pregnant women with DM, GD and with physiological pregnancy. However, the FVD values in the superficial retinal plexus were significantly lower in pregnant women with DM compared with pregnant women with GD and the control group. This suggests that changes in microvascular regulation at the level of the retina are formed in pregnant women with DM due to chronic disorders of carbohydrate metabolism. It is also impossible to exclude the development of subclinical microangiopathy in pregnant women with diabetes without signs of DR against the background of changes in hormonal status.

Pregnant women with DR showed an increase in FAZA and a decrease in RVD in comparison with pregnant women with DM without DR, which is consistent with the literature data. Thus, a number of authors note a decrease in blood flow density in the superficial capillary network and an expansion of FAZA in patients with DR [3, 5, 8, 10, 11, 13].

A feature of GD is the transient, relatively short-term nature of glycemic status disorders, and therefore, probably, pathological microvascular reactions do not have time to form and gain a foothold. Therefore, the indicators of retinal blood flow in pregnant women with GD do not differ from healthy pregnant women with a physiological course of pregnancy; there are also no significant differences in these parameters at different dates for the onset of GD.

Thus, OCT-A, as a progressive non-invasive research method, plays an important role in detecting changes in retinal blood flow in pregnant women with carbohydrate metabolism disorders. It can contribute to early preclinical diagnosis of the manifestation and progression of DR.

### Conclusion

1. A significant decrease in FVD in the superficial retinal vascular plexus was found in pregnant women with DM compared with pregnant women with GD and healthy women with a physiological course of pregnancy in the absence of a significant difference in RVD in the superficial retinal vascular plexus and FAZA.

2. In pregnant women with different periods of development of GD, there were no significant differences in RVD, FVD in the superficial retinal plexus and FAZA.

3. Patients with DR showed an expansion of FAZA and a decrease in RVD in the superficial retinal plexus relative to the group of pregnant women with DM without DR; no differences in FVD values between groups were found.

4. OCT-A helps to identify areas of retinal nonperfusion in the posterior pole of the eye in pregnant women with DM in the absence of ophthalmoscopic signs of DR.

### Bibliography

1. Borovik N.V. *Effect of pregnancy on microvascular complications of diabetes mellitus: Abstract of the thesis. dis. ... cand. medical sciences - St. Petersburg, 2010.*

2. Kudlay I.S., Leshuta E.A. *Outcomes of pregnancies and childbirth in patients with diabetes mellitus // Vestnik MUZ GB No.2. – 2011. – No. 4. – P. 1–8.*

3. Neroev V.V., Okhotsinskaya T.D., Fadeeva V.A. *OCT angiography in diagnosing diabetic retinopathy // Point of view. East - West. – 2016. – No. 1. – P. 111–113.*

4. Agemy S.A., Scripsema N.K., Shah C.M. et al. *Retinal vascular perfusion density mapping using optical coherence tomography angiography in normals and diabetic retinopathy patients // Retina. – 2015. – Vol. 35, № 11. – P. 2353–2363.*

5. Arend O., Wolf S., Jung F. et al. *Retinal microcirculation in patients with diabetes mellitus: dynamic and morphological analysis of perifoveal capillary network // Br J Ophthalmol. – 1991. – Vol. 75, № 9. – P. 514–518.*

6. Best R.M., Chakravarthy U. *Diabetic retinopathy in pregnancy* // *Br J Ophthalmol.* – 1997. – Vol. 81, № 3. – P. 249–251.
7. Chanwimol K., Balasubramanian S., Nassisi M. et al. *Retinal vascular changes during pregnancy detected with optical coherence tomography angiography* // *Invest Ophthalmol Vis Sci.* – 2019. – Vol. 60, № 7. – P. 2726–2732.
8. de Carlo T.E., Chin A.T., Bonini Filho M.A. et al. *Detection of microvascular changes in eyes of patients with diabetes but not clinical diabetic retinopathy using optical coherence tomography angiography* // *Retina.* – 2015. – Vol. 35, № 11. – P. 2364–2370.
9. Egan A.M., McVicker L., Heerey A. et al. *Diabetic retinopathy in pregnancy: a population-based study of women with pregestational diabetes* // *J Diabetes Res.* – 2015. – № 2015. – P. 310239.
10. Goudot M.M., Sikorav A., Semoun O. et al. *Parafoveal OCT angiography features in diabetic patients without clinical diabetic retinopathy: a qualitative and quantitative analysis* // *J Ophthalmol.* – 2017. – № 2017. – P. 8676091.
11. Ishibazawa A., Nagaoka T., Takahashi A. et al. *Optical coherence tomography angiography in diabetic retinopathy: a prospective pilot study* // *Am J Ophthalmol.* – 2015. – Vol. 160, № 1. – P. 35–44.
12. Jiwani A., Marseille E., Lohse N. et al. *Gestational diabetes mellitus: results from a survey of country prevalence and practices* // *J Matern Fetal Neonatal Med.* – 2012. – Vol. 25, № 6. – P. 600–610.
13. Spaide R.F., Klancnik J.M., Cooney M.J. *Retinal vascular layers imaged by fluorescein angiography and optical coherence tomography angiography* // *JAMA Ophthalmol.* – 2015. – Vol. 133, № 1. – P. 45–50.

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精神分裂症患者血清中S100B蛋白自身抗体水平对神经受体自身抗体含量的依赖性  
**DEPENDENCE OF THE LEVEL OF AUTOANTIBODIES TO THE  
S100B PROTEIN IN THE BLOOD SERUM OF PATIENTS WITH  
SCHIZOPHRENIA ON THE CONTENT OF AUTOANTIBODIES TO  
NEURORECEPTORS**

**Baturin Vladimir Aleksandrovich**

*Doctor of Medical Sciences, Full Professor, Head of Department  
Stavropol State Medical University*

**Baturina Maria Vladimirovna**

*Candidate of Medical Sciences, Associate Professor  
Stavropol State Medical University*

**Boev Oleg Igorevich**

*Candidate of Medical Sciences, Associate Professor, Head of  
Department  
Stavropol State Medical University*

抽象的。对 119 名病程为 1 至 38 年的精神分裂症患者进行了检查。检查组中有 23 名女性和 96 名男性。在检查过程中，通过酶免疫测定法测定针对 S100B 蛋白、多巴胺、NMDA 受体（亚基 NR1 和 NR2A）、第一类和第二类多巴胺受体（DR1 和 DR2）的自身抗体（IgG）水平。结果发现，患者自身抗体水平升高，尤其是急性精神病患者和疾病发展的早期阶段（1-5 岁）。进行了多元回归分析，揭示了 S100B 蛋白自身抗体含量对 NR2A 和多巴胺自身抗体水平的统计学显著依赖性。相关性分析也证实了与这些指标的关系。

关键词：精神分裂症，自身抗体，NMDA 受体，多巴胺受体，多巴胺，S100B 蛋白。

**Abstract.** 119 patients with schizophrenia with disease duration from 1 to 38 years were examined. There were 23 women and 96 men in the examined group. During the examination, the levels of autoantibodies (IgG) to the S100B protein, dopamine, NMDA receptors (subunits NR1 and NR2A), dopamine receptors of the first and second types (DR1 and DR2) were determined by enzyme immunoassay. It was found that the levels of autoantibodies in patients were increased, especially in patients with acute psychosis and in the early periods of the development of the disease (1-5 years). A multiple regression analysis was carried out, which revealed a statistically significant dependence of the content of autoantibodies

*to the S100B protein on the levels of autoantibodies to NR2A and to dopamine. Correlation analysis also confirmed the relationship with these indicators.*

**Keywords:** *schizophrenia, autoantibodies, NMDA receptors, dopamine receptors, dopamine, S100B protein.*

In recent years, the possible involvement of autoimmune mechanisms in the development of schizophrenia has been discussed. In particular, it is suggested that autoantibodies to NMDA receptors play an important role in the development of psychopathology [1, 2]. Previously, we were able to find that the levels of autoantibodies to NMDA receptors correlate with PANSS scores in patients with schizophrenia [3]. The possible involvement of autoantibodies to dopamine type 1 and 2 receptors in the development of psychopathology is discussed [4]. At the same time, there are more and more works that discuss the regulatory role of autoantibodies [5], as well as the fact that they reflect the dysfunction of neurotransmitter systems [6]. From this standpoint, the S100B protein and autoantibodies to it are of particular importance as a marker of excitotoxicity and brain damage [7]. In this regard, it seemed interesting to determine the levels of autoantibodies to NMDA and dopamine receptors, as well as to dopamine in the blood serum and compare these indicators with the level of autoantibodies to the S100B protein in patients with schizophrenia treated in a psychiatric clinic.

**Material and methods.** 119 patients with schizophrenia (23 women and 96 men) were examined. Inclusion criteria: the presence of an exacerbation of a mental illness that led to hospitalization in a psychiatric hospital, treatment with neuroleptics, compliance with biomedical ethics when examining patients. Exclusion criteria: clinical and laboratory signs of inflammatory, infectious or autoimmune pathology detected within 2 months prior to the examination, signs of dependence on psychoactive substances in history.

Examination and treatment of patients included in the study was carried out in accordance with approved clinical guidelines with the informed consent of patients or their legal representatives. All patients received antipsychotic therapy. During the current regular examination of patients, venous blood was taken from them. Serum was isolated and the content of specific AAT – IgG to neuroreceptors and neuroproteins was determined in it.

Quantitative determination of AAT in the blood serum of patients was carried out by enzyme-linked immunosorbent assay (ELISA). The antigen of the corresponding receptor or protein was immobilized on the solid phase of polystyrene plates (Cloud-Clone Corp. - China). The study was carried out on an automatic enzyme immunoassay analyzer “Lazurit” (Dynex Technologies, USA) at a wavelength of 450 nm. The levels of AAT to the S100B protein and dopamine were determined, as well as the content of AAT to neuroreceptors: NMDA receptors

(subunits NR1 and NR2A), dopamine receptors of the first and second types (DR1 and DR2).

Statistical analysis of the obtained measurement results was carried out using STATISTICA software (StatSoft Inc., USA). Along with standard statistical methods (determination of the normality of distribution, calculation of mean values (M), standard errors of the mean and confidence intervals (CI) for the entire population of patients, correlation analysis), multiple linear regression analysis was performed to determine the dependence of the content of AAT to the S100B protein on changes in AAT levels to neuroreceptors (NR1, NR2A, DR1, DR2) and to dopamine.

### **Research results.**

During the examination, it was found that in patients with schizophrenia, an increase in the levels of autoantibodies to neuroreceptors was detected. In the vast majority of examined patients, the levels of autoantibodies were elevated (normal values up to 20 U/ml). Mean values of AAT to protein S100B – 34.5 U/ml (at 95% CI from 29.0 to 40.0 U/ml); to NR1 - 45.9 U/ml (from 39.8 to 52.0 U/ml); NR2A - 36.8 U/ml (from 31.5 to 42.1 U/ml); DR1 - 50.1 U/ml (from 42.9 to 57.3 U/ml); DR2 - 68.9 U/ml (from 59.3 to 78.5 U/ml), dopamine - 73.6 U/ml (from 62.8 to 84.4 U/ml).

It is important to note that the correlation analysis (according to Pearson) revealed a strong relationship between the content of AAT to the S100B protein and the levels of AAT to NR2A ( $r=0.95$ ;  $p<0.05$ ) and AAT to dopamine ( $r=0.92$ ;  $p<0.05$ ). In addition, a high correlation was also found with the content of AAT to NR1 ( $r=0.83$ ;  $p<0.05$ ), to DR1 ( $r=0.92$ ;  $p<0.05$ ) and to DR2 ( $r=0.84$ ;  $p<0.05$ ).

Multiple linear regression analysis confirmed the dependence of the level of AAT to the S100B protein on the concentration of AAT to NR2A and to dopamine. Multiple correlation coefficient  $R=0.961$ ; coefficient of determination  $R^2=0.924$  ( $p=0.000000$ ).

The content of AAT to NR2A is the most significant predictor: standardized regression coefficient -  $\beta=0.544$ ; standard error of the standardized coefficient = 0.095;  $p=0.000000$ . Another important predictor is AAT to dopamine:  $\beta=0.284$ ; standard error of the standardized coefficient = 0.089;  $p=0.000000$ . Other predictor variables (AAT to NR1, DR1 DR2) were less significant.

Thus, correlation and multivariate regression analyzes revealed the dependence of the content of AAT to the S100B protein in the blood of patients with schizophrenia with the levels of AAT to NMDA receptors (NR2A subunit) and to dopamine. These data are in good agreement with the autoimmune concept of the development of schizophrenia, according to which AATs to NMDA receptors cause hypofunction of the glutamate system [1, 2, 4], which in turn leads to hyperdopaminergia. At the same time, it is important to pay attention to the leading

role of AAT to the NR2A subunit. An increase in the levels of AAT to dopamine probably reflects the activation of dopaminergic mechanisms in the brain.

At the same time, numerous data have been accumulated showing that the S100B protein quite specifically characterizes brain damage of various origins [8]. A number of studies have noted an increase in serum concentrations of the S100B protein during exacerbations of schizophrenia [9]. At the same time, the expression of the S100B protein, as, indeed, of any other antigen, is accompanied by an autoimmune response with the accumulation of AAT to it. Consequently, an increase in AAT to the S100B protein reflects the fact of its increased production in the body of patients with schizophrenia.

Thus, the conducted study confirms that one of the factors determining the mechanisms of development of mental disorders in patients with schizophrenia may be autoimmune dysfunctions of the glutamatergic and dopaminergic systems. In this case, the accumulation of AAT to the NR2A subunit of NMDA receptors and an increase in the level of AAT to dopamine apparently play the leading role.

### References

1. Michael S. Zandi, Sarosh R. Irani, Bethan Lang, et al. *Disease-relevant autoantibodies in first episode schizophrenia*. *J. Neurol.* 2011; 258 (4): 686-688. DOI: 10.1007/s00415-010-5788-9.
2. Mayorova M.A., Petrova N.N., Churilov L.P. *Schizophrenia as an autoimmune disease: hypotheses and facts*. *Crimean Journal of Experimental and Clinical Medicine*. 2018. V. 8. No. 4. P. 62-80.
3. Baturin V., Baturina M., Mamtseva G.I., Boev O., Yarovitsky V., Grudina E.V. *LEVELS OF NEUROTROPIC AUTOANTIBODIES IN PATIENTS WITH SCHIZOPHRENIA*. *Medical News of North Caucasus*. 2016. T. 11. № 2. C. 176-178. DOI: 10.14300/mnnc.2016.11030
4. Pollak T.A., Beck K., Irani S.R., et al. *Autoantibodies to central nervous system neuronal surface antigens: psychiatric symptoms and psychopharmacological implication // Psychopharmacology*. 2016. Vol. 233. P. 1605-1621. DOI 10.1007/s00213-015-4156-y
5. Zaichik A. Sh., Poletaev A. B., Churilov L. P. *Natural autoantibodies: immunological theories and preventive medicine*. *Bulletin of St. Petersburg University*. 2013;11(2):3-16.
6. Tsybikov N.N., Tsybikova E.A. *Neuroimmune relationships in the pathogenesis of alcoholic delirium // Transbaikal Medical Bulletin*. 2008. No. 1. P. 19-21.
7. Baturina M.V., Beyer E.V., Zhurbin S.A., Fil A.A. *Influence of chronic administration of neuroleptics on the blood level of S100 protein and the level of*



*autoantibodies to it in rats. Medical Bulletin of the North Caucasus. 2020. V. 15. No. 4. P. 573-575. DOI: 10.14300/mnnc.2020.15136*

8. Skripchenko N.V., Shirokova A.S. *Neuron-specific enolase and S100 protein are biomarkers of brain damage. State of the art and clinical application // Neurosurgery and Neurology of childhood. 2016. No. 4. pp. 16-23.*

9. Zhukova NV, Mavrutenkov VV, Ushakova GA *Neurospecific protein S100 is a universal biochemical marker of damage. Part II. Possibilities and prospects of clinical laboratory diagnostics. Clinical infectology and parasitology. 2015;1(12):35-49.*

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根据 G.A. 的方法对受害者进行康复。 Ilizarov 腿骨闭合性骨干骨折  
**REHABILITATION OF VICTIMS ACCORDING TO THE METHOD  
OF G.A. ILIZAROV WITH CLOSED DIAPHYSEAL FRACTURES  
OF THE LEG BONES**

**Prokopyev Alexey Nikolaevich**

*Candidate of Medical Sciences*

*Tyumen Regional Clinical Hospital No. 2*

**Shchurov Ilya Vladimirovich**

*Candidate of Medical Sciences*

*Yekaterinburg Medical Clinic «Health 365»*

抽象的。62例胫骨闭合性螺旋骨干骨折，均按G.A.方法进行接骨术。 Ilizarov 的研究： 胫骨碎片的固定时间； 小腿肌肉张力； 腿部肌肉力量的时刻； 足背的氧分压； 耗氧时间； 组织血流速度； 体积血流速度； 峰值流量指数。

关键词： 小腿，骨折，功能康复。

**Abstract.** *In 62 patients with closed helical diaphyseal fractures of the shin bones, osteosynthesis was performed according to the method of G.A. Ilizarov with the study of: the timing of fixation of bone fragments of the tibia; calf muscle tone; moment of strength of the leg muscles; oxygen tension on the dorsum of the foot; oxygen depletion time; tissue blood flow velocity; volumetric blood flow velocity; peak flow index.*

**Keywords:** *lower leg, fractures, functional rehabilitation.*

**Relevance.** For many decades, the problem of choosing a method of restorative treatment of patients with closed diaphyseal fractures of the tibia has been the subject of constant discussions [2, 5, 10, 16, 17, 18, 19, 20].

Fractures of the shin bones account for 13–21% of all injuries of the skeletal system and up to 70% of lower limb fractures [21], occurring in 26–32 people per 100,000 population per year [23, 24]. From a clinical and anatomical point of view, the lower leg is considered a convenient segment for transosseous osteosynthesis [22, 25, 26].

At present, restoration of the function of the peripheral blood flow and the neuromuscular system [3], treatment for various types of fractures of the bones of the lower leg [9, 11, 14], MRI characteristics of the vessels and muscles of

the lower leg [8], the influence of the anatomical magnitude of the displacement of fragments of the tibial bones on blood circulation and the level of functional rehabilitation [11, 12]. The issues of cadence and step length in patients with the consequences of diaphyseal fractures of the leg bones are considered [13]. The possibilities of using the Ilizarov method in the treatment of patients with double diaphyseal fractures of the leg bones [4], as well as therapeutic exercises for fractures of the leg bones after osteosynthesis according to Ilizarov [6], are being studied. The issue of the influence of physical activity on the healing of fractures of the bones of the leg is subject to discussion [18, 19].

Despite such a variety of scientific studies, the issue of the possibility of combining the period of therapeutic and functional rehabilitation of victims with closed helical diaphyseal fractures of the leg bones in the treatment by the Ilizarov method has not been sufficiently elucidated.

**Purpose:** to analyze the results of therapeutic and functional rehabilitation of patients with closed helical diaphyseal fractures of the leg bones using the Ilizarov method.

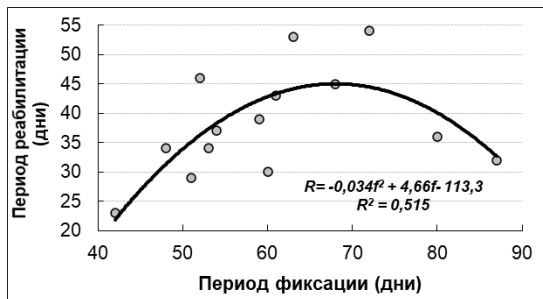
**Material and methods.** 62 patients with closed helical diaphyseal fractures of the leg bones were examined. All patients underwent osteosynthesis according to the method of G.A. Ilizarov. Studied: the timing of fixation of bone fragments of the tibia with the Ilizarov apparatus; tone of the calf muscles of the intact and injured limb; moment of strength of the muscles of the legs; oxygen tension of soft tissues on the dorsum of the foot; oxygen depletion time; tissue blood flow rate; volumetric blood flow velocity; peak flow index.

The results of the study were processed on a personal computer using modern electronic programs (STATISTIKA). The assessment of the significance of differences was carried out using Student's t-test. The study complied with the Order of the Ministry of Health of the Russian Federation No. 226 dated June 19, 2003 "On Approval of the Rules of Clinical Practice in the Russian Federation". The principles of voluntariness, the rights and freedoms of the individual, guaranteed by articles 21.2 and 22.1 of the Constitution of the Russian Federation, as well as the Order of the Ministry of Health and Social Development of Russia No. 774n dated August 31, 2010 «On the Council on Ethics» were observed. The study was conducted in compliance with the ethical standards set forth in the Declaration of Helsinki and the Directives of the European Community (8/609EC).

**Results and discussion.** Today, there is no doubt that stable fixation of bone fragments of the tibia, including screw-shaped ones, using the Ilizarov apparatus, throughout the course of rehabilitation treatment, allows the use of early axial dosed physical activity of the injured limb. In addition, it is thanks to the external fixation of a fracture of the tibia with the Ilizarov apparatus that it is possible to carry out movements in the knee and ankle joints [1, 10], which creates opportuni-

ties for maintaining not only professional activity, but also for practicing a chosen sport.

We should note that the duration of fixation of a closed helical fracture of the tibia with the Ilizarov apparatus is more than 60% of the total duration of treatment, i.e. from admission to full recovery. There is a relationship between the duration of the period of fixation of a helical fracture of the tibia with the Ilizarov apparatus and the duration of the entire treatment of the victim (Fig. 1).



**Figure 1.** Correlation between the duration of periods of fixation and functional rehabilitation in closed helical fractures of the leg bones

When using the Ilizarov method, the duration of therapeutic and functional rehabilitation of a fracture of the bones of the lower leg are combined in time. In this regard, an increase in the period of fixation with the Ilizarov apparatus for closed helical fractures of the lower leg bones for more than 70 days leads to a reduction in the duration of functional rehabilitation.

The duration of fixation with the Ilizarov apparatus of a helical fracture of the leg bones may increase in the presence of two cumulative factors. Firstly, the severity of the initial injury and, secondly, a decrease in the overall reactivity of the body. In patients with helical fractures of the tibia, with an increase in the duration of fixation to 75 days, not only the duration of the period of functional rehabilitation increases, but also the total duration of treatment.

With pronounced initial displacements of bone fragments of the tibia along the width and length of the bone and associated severe soft tissue injuries, often associated with the appearance of serous or serous-hemorrhagic blisters on the skin, the duration of functional rehabilitation and, therefore, the entire period of treatment increased.

In the long term after the end of treatment (5.3 0.8 years), a comprehensive examination of 27 patients of the period of adolescence, first and second adulthood was carried out. Transosseous osteosynthesis according to the Ilizarov method was performed on the day of admission to the clinic. The duration of fixation of bone fragments of the tibia with the Ilizarov apparatus was 78.4 10.7 days.

It is important to note that the undoubted advantage of the restorative treatment of patients with closed helical fractures of the leg bones using the Ilizarov method is that we did not reveal any limitation of movements in the joints of the injured limb. So, in particular, the amplitude of movements in the ankle joint of the intact limb was 57.6 1.20, the injured one - 53.2 5.40.

One of the most important results of rehabilitation treatment is the indicator of calf muscle tone. We found that the tone of the gastrocnemius muscle of the injured leg in a state of physiological rest was 80% of the tone level of the same muscle on the intact limb.

The state of elasticity of the skin of the posterior surface of the lower leg of the injured and intact limbs deserves attention. It was revealed that the index of elasticity of the skin of the posterior surface of the injured leg after the treatment of a fracture of the bones of the leg using the Ilizarov method was 81% of the level of elasticity of the skin of the intact limb.

The results of the studies showed that the oxygen tension in the tissues of the dorsal surface of the foot of the injured limb was in the extreme range from 54 to 68 mm Hg (61 7 mm Hg). We should note that when pure oxygen was inhaled, the oxygen tension in the tissues increased to 823 mm Hg, which is statistically significant ( $p < 0.05$ )

Also noteworthy is the fact that the duration of the oxygen supply depletion during an ischemic test with a 3-minute arterial occlusion was 420 50 s, the time of exhaustion of half the oxygen supply was 101 13 s, the recovery time was 178 24 s, which is statistically significant ( $p < 0.05$ ).

We drew attention to the fact that the rate of tissue blood flow determined by the redox method (according to the time of leaching of previously inhaled hydrogen from the tissues) did not significantly differ from the normative values (21.3 2 ml/min\*100 cm<sup>3</sup>).

We found that the volumetric blood flow velocity determined by Whitney occlusal plethysmography on the intact leg was 1.61 0.17 ml/min\*100 cm<sup>3</sup> of tissue, while on the injured leg it was 1.03 0.06 ml/min\*100 cm<sup>3</sup>, which is statistically significant ( $p < 0.05$ ).

We judged the functional reserves of the vascular bed of the limb by the index of peak blood flow (the ratio of peak blood flow to rest blood flow). The peak blood flow index on the injured leg was 9.01.3 ml/min\*100 cm<sup>3</sup>, which was 35% more than on the healthy leg

An important conclusion can be made that in the long term after injury and the associated rehabilitation treatment using the Ilizarov method, the reserve capacity of the vascular bed of the injured leg does not decrease. In addition, attention should be paid to the fact that the rate of venous outflow in the extremities was above the minimum normal level (20 ml/min\*100 cm<sup>3</sup>).

When examining the victims with the consequences of closed helical fractures of the tibia, we revealed a high level of recovery of the contractility of the leg muscles (Table 1). We used the indicator of the relative moment of force of various groups of leg muscles in order to level out differences in the body weight of the subjects.

**Table 1**  
*Relative moment of force of various muscle groups of the lower leg*

Examined limb	Relative moment of force of the leg muscles (N*m/kg)	
	Plantar flexors of the foot	Dorsal foot flexors
Intact limb	1,88 ±	0,73 ±
Injured limb	1,70 ±	0,60 ±
Ratio of indicators	91%	82%

Thus, it can be concluded that the short duration of inpatient treatment, the preservation of the function of the joints and muscles of the injured limb, the high reserve capacity of the vascular bed of the lower leg allow us to conclude that the Ilizarov method is the method of choice in the treatment of patients with helical diaphyseal fractures of the lower leg bones. With minimal traumatization of soft tissues, the method allows to activate the victims as early as possible, promotes early axial dosed physical load on the injured limb, which significantly reduces the period of temporary disability.

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

**Research transparency. The study was not sponsored.** The authors are solely responsible for providing the final version of the manuscript for publication.

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## References

1. *Beydik O.V. The method of rod transosseous osteosynthesis in the treatment of diaphyseal fractures of the leg bones /O.V. Beidik, K.K. Levchenko, Yu.V. Troshkin. //Genius of orthopedics. 2009. – No. 4. – P. 114-120.*
2. *Borzunov D.Yu. Transosseous osteosynthesis according to Ilizarov: theory and practice. Experimental and theoretical substantiation of the method of transosseous osteosynthesis /D.Yu. Borzunov //Publisher: Palmarium Academic Publishing (Saarbrücken). – Saarbrücken, 2017. – 656 p.*

3. Kandybo I.V. Restoration of the function of peripheral blood flow and the neuromuscular system in patients with diaphyseal fractures of the leg bones in the dynamics of osteogenesis /I.V. Kandybo, O.I. Shalatonina // *Bulletin of traumatology and orthopedics of the Urals*. 2012. – No. 3-4 (6). – P. 60-64.

4. Karasev A.G. Transosseous osteosynthesis according to Ilizarov in the treatment of patients with double diaphyseal fractures of the leg bones /A.G. Karasev. // *Traumatology and orthopedics of Russia*. 2005. – No. 2 (35). – P. 13-16.

5. Kuznetsova O.P. Fractures of the bones of the lower leg: structure, nature and methods of surgical treatment /O.P. Kuznetsova. // *Bulletin of the Northern State Medical University*. 2011. – No. 1 (26). – P. 19-20.

6. Kurch N.M. The method of therapeutic exercises for fractures of the leg bones after osteosynthesis according to Ilizarov /N.M. Kurch, T.A. Burambaev. // *Physical education in Siberia*. 2017. – V. 37. – No. 1. – P. 53-57.

7. Treatment of diaphyseal fractures of the leg bones. Literature review. / E.N. Toktarov, M.A. Zhanaspaev, A.S. Tlemisov, T.G. Dzhunusov, A.O. Mysaev, K.T. Kasymov. // *Science and health care*. 2018. V. 20. No. 6. P. 58-69.

8. MRI-characteristics of the vessels and muscles of the lower leg in patients after treatment by the method of transosseous osteosynthesis of closed diaphyseal fractures of the lower leg bones /G.V. Dyachkova, R.V. Stepanov, K.A. Dyachkov, M.A. Korabelnikov. // *Genius of orthopedics*. 2011. – No. 1. – P. 86-90.

9. Evaluation of the results of treatment of various types of diaphyseal fractures of the leg bones with external and intraosseous osteosynthesis /V.V. Pisarev, A.V. Aleinikov, I.V. Vasin, Yu.A. Oshurkov. // *Traumatology and orthopedics of Russia*. 2013. – No. 3 (69). – P. 29-36.

10. Pichkhadze I.M. Some new directions in the treatment of fractures of long bones and their consequences /I.M. Pichkhadze. // *Bulletin of Traumatology and Orthopedics*. N. N. Priorova. 2001. – No. 2. – P. 40-44.

11. Prokopiev A.N. Influence of the anatomical value of the displacement of tibial fragments in its diaphyseal fractures on the level of functional rehabilitation /A.N. Prokopiev, I.V. Shchurov, N.Ya. Prokopiev. // *Medical science and education of the Urals*. 2018. – V. 19. – No. 1 (93). – P. 114-118.

12. Prokopiev A.N. Influence of the anatomical value of the displacement of fragments of the tibia with its diaphyseal helical fractures on the blood circulation of the lower leg / A.N. Prokopiev, I.V. Shchurov, N.Ya. Prokopiev. // *Medical science and education of the Urals*. 2018. – V. 19. – No. 3 (95). – P. 41-45.

13. Prokopiev A.N. Cadence and stride length in young men with consequences of diaphyseal fractures of the leg bones /A.N. Prokopiev. // *Strategy for the development of mass sports work with students: Proceedings of the III International Scientific and Practical Conference*. Rep. ed. V.Ya. Subbotin, A.N. Khalin. – Tyumen, 2018. – P. 299-304.

14. Prokopiev A.N. *Mechanical and biological aspects of treatment by transosseous osteosynthesis of patients of various age periods with closed diaphyseal fractures of the leg bones* /A.N. Prokopiev, I.V. Shchurov //Monograph; Ministry of Education and Science of the Russian Federation, SEI HPE Tyumen State. Med. Academ., FSI RRC VTO named after acad. G. A. Ilizarov. – Tyumen, Publisher: «Shadrinskiy» Publishing House 2011. – 146 p.

15. Prokopiev N.Ya. *Closed fractures of the leg.* /N.Ya. Prokopiev. – Tyumen, 1991. – 184 p.

16. *Technology for the treatment of diaphyseal fractures of the leg bones, taking into account and biomechanical influence on the phases of reparative osteogenesis* /A.P. Barabash, A.G. Rusanov, Yu.A. Barabash, R.A. Alfimov. //Saratov Scientific Medical Journal. 2010. – V. 6. – No. 4. – P. 829-834.

17. *Controlled transosseous osteosynthesis of diaphyseal fractures of the leg bones* /A.P. Barabash, V.M. Ivanov, A.G. Rusanov, V.P. Morozov. // Siberian medical journal (Irkutsk). 2006. – V. 63. – No. 5. – P. 30-33.

18. Shchurov V.A. *The influence of the motor regimen of patients on the healing of fractures of the leg bones* / V.A. Shchurov, I.V. Shchurov / Scientific and sports bulletin of the Urals and Siberia. 2019. – No. 1 (21). – P. 30-36.

19. Shchurov V.A. *Treatment of fractures of the leg bones according to Ilizarov* / V.A. Shchurov, I.V. Shchurov // Lap Lambert Academic Publishing, Deutschland. Saarbrücken, 2012. – P. 167.

20. Andalib Z. *Tahririan Effectiveness of Minimally Invasive Plate Osteosynthesis (MIPO) on Comminuted Tibial or Femoral Fractures* /Z. Andalib, E. Sheikhabaei, A. Mohammad. // Arch Bone Jt Surg. 2017 Sep; 5(5): 290-295.

21. Anuar-Ramdhan I.M. *Minimally Invasive Plate Osteosynthesis with Conventional Compression Plate for Diaphyseal Tibia Fracture.* / I.M. Anuar-Ramdhan, M. Med Orth, I.M. Azahari. //Malaysian Orthopaedic Journal 2014 Vol. 8 No 3: 33-36.

22. Bhandari M. *Randomized trial of reamed and unreamed intramedullary nailing of tibial shaft fractures.* / M. Bhandari, G. Guyatt, P. Tornetta, E.H. Schemitsch, M. Swionkowski. //J Bone Joint Surg Am 2008;90: 2567-78.

23. Dior Ghafil. *Expandable intramedullary nails for fixation of tibial shaft fractures* / Ghafil Dior., Pieter Ackerman, Renaud Baillon. // Acta Orthop. Belg., 2012, 78, 779-785.

24. Fortis A.P. *Expandable nailing system for tibial shaft fractures.* /A.P. Fortis, A. Dimas, A.A. Lamprakis. //Injury. 2008; 39: 940-6.

25. Singer R.W. *Open tibial diaphyseal fractures. Results of undreamed locked intramedullary nailing* / R.W. Singer, J.F. Kellam. // Clin Orthop Relat Res. 1995;315:114-8.

26. Stürmer K.M. *Leitlinien Unfallchirurgie. Vol. 2. Volume.* 1999: Thieme Stuttgart, New York, 1999. 184-196.



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慢性泛发性牙周炎患者牙周袋内容物的微生物学评估  
**MICROBIOLOGICAL ASSESSMENT OF THE CONTENTS OF  
PERIODONTAL POCKETS IN PATIENTS WITH CHRONIC  
GENERALIZED PERIODONTITIS**

**Gimranova Irina Anatolyevna**

*Candidate of Medical Sciences, Acting Head of the Department  
Bashkir State Medical University*

**Gazizullina Gulnara Railevna**

*Head of laboratory  
Bashkir State Medical University*

**Aznagulov Alfred Aysovich**

*Chief Physician  
Dental Polyclinic No. 2*

注解。 无论冠状病毒以何种形式出现在人类身上：潜伏、轻度、中度、重度或危急，后新冠肺炎综合征都可能发生。

即使是无症状的 COVID-19 也会留下长期的不良影响。 新冠肺炎后综合征的临床表现多种多样，包括在口腔中。 牙周炎是牙科最常见的慢性炎症性疾病之一，由口腔内的微生物菌斑引发，以复杂的微生物生物膜形式形成。 牙周炎会对全身健康产生负面影响，并与风险因素相关，而这些风险因素又与 COVID-19 并发症的风险增加有关。 该研究的目的是研究后新冠时期慢性全身性牙周炎患者牙周袋内容物微生物群落的特异性和定量组成。 因此，所进行的工作的结果总体上表明，COVID 后慢性全身性牙周炎患者牙周袋内容物的微生物群落的种类和数量组成的特征是在 COVID 后没有恢复正常健康。 急性 COVID-19 感染，需要进一步研究。

关键词：微生物学评估，牙周袋，慢性全身性牙周炎。

**Annotation.** *Postcovid syndrome can occur regardless of the form in which the coronavirus occurred in humans: latent, mild, moderate, severe or critical.*

*Even asymptomatic COVID-19 can leave long-term adverse effects. The clinical picture of postcovid syndrome is quite diverse, including in the oral cavity. Periodontitis is one of the most common chronic inflammatory diseases in dentistry, initiated by microbial plaque in the oral cavity, formed in the form of a complex microbial biofilm. Periodontitis can have a negative impact on systemic health and is associated with risk factors, which, in turn, are associated*

*with an increased risk of COVID-19 complications. The aim of the study was to study the specific and quantitative composition of the microflora of the contents of periodontal pockets in patients with chronic generalized periodontitis in the postcovid period. Thus, the results of the conducted work show, in general, the state of the species and quantitative composition of the microflora of the contents of periodontal pockets in patients with chronic generalized periodontitis after COVID is characterized by the absence of a return to normal health after acute COVID-19 infection and requires further research.*

**Keywords:** *microbiological assessment, periodontal pockets, chronic generalized periodontitis.*

There is more and more data in the literature about complications after the “recovery” of COVID-19. Postcovid syndrome can occur regardless of the form in which the coronavirus occurred in a person: latent, mild, moderate, severe or critical.

Even asymptomatic COVID-19 can leave long-term adverse effects [1].

The clinical picture of postcovid syndrome is quite diverse. Signs of postcovid syndrome can be divided into several groups[2,3].

These may be disorders of general well-being, psychoemotional problems, neurological manifestations, symptoms associated with damage to the gastrointestinal tract, respiratory, cardiovascular systems, as well as pathological manifestations in the oral cavity, etc.

The mechanism of post-ovoid states has not been sufficiently studied.

The role of concomitant chronic diseases of the oral cavity in COVID-19 and in the post-ovoid period remains unclear.

The oral mucosa can play an important role in the penetration of the virus into the body, especially in patients with periodontitis. The causative agent of COVID-19, the SARS-CoV-2 virus, is introduced into human cells using a structural S-protein, attaches to cells by binding to angiotensin converting enzyme II (Apf2), which acts as a receptor for the virus.

ACE2 is expressed in many organs and tissues: on the membranes of type II pneumocytes, enterocytes of the small intestine, endothelial cells of arteries and veins, as well as smooth muscle cells in most organs, as well as in the mucous membrane of the mouth and nose. Consequently, SARS-CoV-2 can damage a wide range of organs and tissues, which leads to subsequent multiple organ failure observed in patients with COVID-19. ACE2 expression is increased in patients with certain conditions, such as old age, obesity, diabetes mellitus, and also with diseases of the kidneys, cardiovascular system, gastrointestinal tract, respiratory system, which makes them more susceptible to the virus and severe cases of COVID-19. It is noteworthy that many of these comorbidities are associated with periodontal diseases.

Periodontitis is one of the most common chronic inflammatory diseases in dentistry, initiated by microbial plaque in the oral cavity, formed in the form of a complex microbial biofilm.

Periodontitis can have a negative impact on systemic health and is associated with risk factors, which, in turn, are associated with an increased risk of COVID-19 complications. Therefore, the study of the relationship between periodontitis and COVID-19, as well as with postcovid syndrome, is of particular interest.

The aim of the study was to study the specific and quantitative composition of the microflora of the contents of periodontal pockets in patients with chronic generalized periodontitis in the postcovid period.

**Material and methods.** For the present study, 30 patients aged 28 to 65 years who had undergone COVID-19 were examined with an established diagnosis of chronic generalized periodontitis of mild and moderate severity. To carry out bacteriological seeding, the contents of the periodontal pockets of patients were also taken with sterile paper cone endodontic absorbents from META BIOMED (ISO size No. 25), injected with sterile tweezers into the deepest areas of the periodontal pockets for 15 seconds. Transportation of biological material to the bacteriological laboratory was carried out in a container with a refrigerant at +4 ° C for 2 hours immediately after the collection of clinical material.

The results of the study. Thus, from the contents of periodontal pockets in all examined patients, representatives of the normal microflora of the oral mucosa - *Candida albicans* and non-pathogenic species *N.mucosa*, *N.flava*, *N.perflava* were isolated in an amount not exceeding normal values (102-103 CFU/ml). However, it should be noted that the allocation of *Neisseria* spp. from the contents of periodontal pockets, it indicates acute serous inflammation occurring with the involvement of periodontal tissues. *Streptococcus* spp was isolated in an amount of 102-105 CFU/ml. species of *S.mitis*, *S.oralis*, *S.sanguinis* and *S.gordonii*, belonging to the “yellow” complex of periodontal microorganisms and having the least pathogenic potential. Having a high affinity for the molecules of the salivary film on the surface of the teeth, these types of microorganisms are able to quickly colonize clean tooth surfaces, acting as primary colonizers of the periodontal environment and collectively making up a high percentage (up to 70%) of the bacterial biofilm of the tooth surface (plaque). This combination of microorganisms forms an attachment substrate for later colonizers of the tooth surface and is able to modulate the pathogenicity of the main pathogens of periodontal diseases through interspecific communication mechanisms.

Among the representatives of the unstable microflora of the oral cavity, which are quite rare and not all the examined (3 patients), the types of enterobacteria *Escherichia coli* and *Serratia liquefaciens* were found in the amount of 103 CFU/ml, which should not be in the normal state of the oral microflora, which is presumably

due to a violation of the physiological state of the oral cavity, since representatives of non-permanent (transient) flora linger in it, multiplying and causing pathological processes.

From samples of biological material of three patients with periodontitis of moderate severity in the amount of 102 CFU/ml, such conditionally pathogenic microorganisms as *Staphylococcus aureus* and *Parainfluenza Hemophilus bacillus* were isolated. The ability of hemophilic bacillus to coagulate with representatives of the genus *Treponema* has been noted in literature sources, which causes indirect adhesion of these bacteria, which do not have their own attachment factors, on epithelial cells and dental surfaces and ensures colonization of the pellicle, thereby contributing to the development of dental plaque.

Thus, the results of the conducted work show, in general, the state of the species and quantitative composition of the microflora of the contents of periodontal pockets in patients with chronic generalized periodontitis after COVID is characterized by the absence of a return to normal health after acute COVID-19 infection and requires further research.

In addition, the study of this problem will ensure the development of preventive measures aimed at preventing the occurrence of destructive periodontal diseases and preventing their transition to a chronic form.

## References

1. Trypsteen W, Van Cleemput J, Snippenberg Wv, Gerlo S, Vandekerckhove L (2020) On the whereabouts of SARS-CoV-2 in the human body: A systematic review. *PLoS Pathog* 16(10): e1009037. <https://doi.org/10.1371/journal.ppat.1009037>
2. Soffritti I, D'Accolti M, Fabbri C, et al. Oral Microbiome Dysbiosis Is Associated With Symptoms Severity and Local Immune/Inflammatory Response in COVID-19 Patients: A Cross-Sectional Study. *Front Microbiol.* 2021;12:687513. Published 2021 Jun 23. doi:10.3389/fmicb.2021.687513
3. Cagna D. R., Donovan T. E., McKee J. R., Eichmiller F., Metz J. E., Albouy J. P., et al. (2019). Annual review of selected scientific literature: a report of the committee on scientific investigation of the american academy of restorative dentistry. *J. Prosthet. Dent.* 122 198–269. 10.1016/j.prosdent.2019.05.010 [PubMed] [CrossRef] [Google Scholar]

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口腔粘膜炎性和破坏性疾病中口腔微生物群的特征  
**CHARACTERISTICS OF ORAL MICROBIOTA IN  
INFLAMMATORY AND DESTRUCTIVE DISEASES  
OF THE ORAL MUCOSA**

**Akmalova Guzel Maratovna**

*Doctor of Medical Sciences, Full Professor*

*Bashkir State Medical University of the Ministry of Health of Russia*

**Hasanova Guzel Fauzovievna**

*Senior Lecturer*

*Bashkir State Medical University*

**Mannapova Guzel Rinatovna**

*children's dentist*

*LLC "Interdent"*

注解。慢性复发性口疮性口炎的发病机制中的重要作用归因于感染性过敏因素，即身体免疫系统的变化。随着口腔整体免疫力的下降，尤其是局部免疫力的下降，微生物群落的物种组成发生变化，其侵略性和抗生素耐药性增加。本研究旨在研究慢性复发性口疮性口炎患儿口腔微生物群落的定性和定量结构。30名年龄在4至15岁之间的患有慢性复发性口疮性口炎的儿童（第1组）参与了这项研究。将20名年龄从4至15岁且没有慢性复发性阿弗他性口炎和伴随的躯体病理学的几乎健康的儿童（第2组）作为对照组。作为该研究的结果，所有患有慢性复发性口疮性口炎的患者都被诊断为口腔微生物群落紊乱。

**Annotation.** *Significant role in the pathogenesis of chronic recurrent aphthous stomatitis is attributed to the infectious-allergic factor, changes in the immune system of the body. With a decrease in general and, especially, local immunity of the mouth cavity, the species composition of the microflora changes, its aggressiveness and antibiotic resistance increase. The aim of the study was to study the qualitative and quantitative structure of microbiocenosis of mouthy cavity belonged to the children with chronic recurrent aphthous stomatitis. 30 children suffering from chronic recurrent aphthous stomatitis (group 1) aged from 4 to 15 years took part in this research. 20 almost healthy children (group 2) at the age from 4 to 15 years without chronic recurrent aphthous stomatitis and concomitant somatic pathology have been formed as a control group. As a result of the study, all patients suffering from chronic recurrent aphthous stomatitis were diagnosed with microbiocenosis disorder of the mouth cavity.*

In 100% of cases, a high sensitivity to bacteriophages was revealed what makes it possible in some cases to exclude the use of antibiotics and to provide treatment with bacteriophages. Key words: recurrent aphthous stomatitis, mucous membrane of the mouth, oral microbiota.

Chronic recurrent aphthous stomatitis (HRAS) is one of the most common lesions of the oral mucosa (SOR), which affects from 20 to 60% of the population from the age of three [1]. According to the results of S. Scully, about 1% of children in developed countries suffer from HRA [2].

Despite numerous studies, the etiology and pathogenesis of the disease remain not fully understood. An infectious-allergic factor is assigned a significant role in the pathogenesis of HRAS [3,4,5,6]. Patients have sensitization of the body, which is expressed in hypersensitivity to proteus, Staphylococcus, streptococcus, E. coli.

Also, scientific works indicate the importance of changes in the immune system during the development of HRAS [7]. With a decrease in the general and, especially, local immunity of the oral cavity, there is a change in the species composition of the microflora (conditionally pathogenic microorganisms turn into a pathogenic form), an increase in its aggressiveness and antibiotic resistance. Conditionally pathogenic gram-positive and gram-negative bacteria, possessing a wide range of adaptive mechanisms, are able to produce a number of pathogenicity factors, the potential of which increases significantly with their association, which, in turn, leads to a torpid course of the disease and resistance to therapy.

The purpose of our study was to study the microbiocenosis of the oral cavity in children with HRA.

Materials and methods:

The study was conducted with the participation of 30 sick children of HRAS (group 1) aged 4 to 15 years. In group 1, 20 patients were found to have diseases of the gastrointestinal tract (gastrointestinal tract).

The control group consisted of 20 practically healthy children (group 2) without HRAS and without concomitant somatic pathology at the age of 4 to 15 years.

In addition to a comprehensive assessment of the condition of the oral cavity, including examination, determination of indices, a bacteriological study of the oral microflora from the oral mucosa was carried out to determine the quantitative composition of microorganisms, their species identification and determination of sensitivity to antibiotics. The concentration of bacteria was expressed in colony-forming units per 1 ml of oral fluid (CFU/ml).

To study the occurrence of microorganisms, the relative and absolute frequencies of the occurrence of microorganisms in groups of sick and healthy patients were calculated. The evaluation of the statistical significance of the differences in the relative frequencies of microorganisms in the two groups (sick and healthy) was carried out using the exact Fisher criterion (two-sided). The choice of this

criterion is due to the fact that it has a higher power compared to the X2 criterion when comparing small samples, just taking place in our study. The significance level adopted in the study is 0.05. Calculations were performed in the SPSSv package.20. To characterize the density of colonies, a fashion was used.

The results of the study and their discussion:

As a result of the study, an imbalance of microbial flora was revealed in all patients with HRAS.

Statistically significant differences are found in the following groups of microorganisms: *Streptococcus salivarius*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Neisseria* spp, *Candida* spp.

Disorders of microbiocenosis with a predominance of *Candida* spp. They were found in 50% of the examined patients with HRAS who have a history of gastrointestinal diseases.

Bacteriological studies have shown that in 100% of cases, the following microorganisms are isolated in the group of sick children with HRA and the control group: *Streptococcus sanguis*, *Streptococcus mitis*, *Streptococcus mutans*, *Fusobacterium nucleatum*, *Lactobacillus* spp.

However, an analysis of the colonization density of the same species in healthy patients and in patients with HRAS showed that their number varies greatly. In the identified conditionally pathogenic microorganisms, pathogenicity factors were expressed 10 times more in HRAS. In addition, a significant decrease in the number of lactobacilli was detected in group 1.

The highest sensitivity of pathogenic and conditionally pathogenic microorganisms sown with oral dysbiosis in children in most cases was detected to cephalosporin antibiotics - in 100% of cases, then to oxacillin – in 80% of cases, gentamicin – in 79%, lincomycin – in 75% of cases, tetracycline – in 74%, erythromycin – in 70% of cases.

The greatest activity to *Candida albicans* was shown by antifungal drugs of the azole series – in 98% and amphotericin – in 90% of cases.

Thus, as a result of the study in all sick children, HRAS was revealed violation of the microbiocenosis of the oral cavity.

Long-term chronic inflammatory process leads to depletion of protective mechanisms at the level of the oral mucosa, which is accompanied by a change in microbial status.

The data obtained indicate the need for timely microbiological examination of COP in children with HRA.

### References

1. Wallace A, Rogers H.J, Hughes S.C, et al. Management of recurrent aphthous stomatitis in children // *Oral Medicine*. 2015;42(6).P.564–572.
2. Scully C, Porter S. Oral mucosal disease: Recurrent aphthous stomatitis // *Br J Oral Maxillofac Surg*. 2008;46. P.198–206.
3. Akintoye SO, Greenberg MS. Recurrent aphthous stomatitis // *Dental clinics of North America*. 2014;58(2). P.281-297.
4. Belenguer-Guallar I, Jiménez-Soriano Y, Claramunt-Lozano A. Treatment of recurrent aphthous stomatitis. A literature review // *Journal of Clinical and Experimental Dentistry*. 2014;6(2).P168-174.
5. Edgar N.R, Saleh D, Miller R.A. Recurrent Aphthous Stomatitis: A Review // *Journal of Clinical and Aesthetic Dermatology*. 2017;10(3). P.26-36.
6. Gomes C.C, Gomez R.S, Zina L.G, Amaral F.R. Recurrent aphthous stomatitis and *Helicobacter pylori* // *Med Oral Patol Oral Cir Bucal*. 2016;21(2).P.187–191.
7. Preeti L, Magesh K, Rajkumar K, Karthik R. Recurrent aphthous stomatitis // *Journal of Oral and Maxillofacial Pathology*.2011;15(3). P. 252-256.



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原发性(特发性)高催乳素血症患者的人格特征  
**PERSONALITY FEATURES OF PATIENTS WITH PRIMARY  
(IDIOPATHIC) HYPERPROLACTINEMIA**

**Bulgakova Irina Viktorovna**

*Candidate of Medical Sciences, thyroid specialist  
Kursk Regional Multidisciplinary Clinical Hospital*

**Levchenko Elena Vadimovna**

*Candidate of Medical Sciences, Associate Professor  
Kursk State Medical University*

抽象的。 本文展示了通过多边人格研究 (MMPS) 的心理测量方法检查的患有特发性高泌乳素血症的女性的人格特征

关键词: 特发性催乳素血症, MMPS 心理测量法。

**Abstract.** *The article shows the personality traits of women with idiopathic hyperprolactinemia examined by the psychometric method of the multilateral personality study (MMPS)*

**Keywords:** *idiopathic prolactinemia, psychometric method of MMPS.*

### **Introduction**

In recent years, the interest of doctors of various specialties has been attracted by diseases and syndromes associated with impaired prolactin secretion (PRL). Prolactin, which changed the concept of the regulation of reproductive function, was isolated as an independent hormone from the pituitary gland in 1970. It was shown that excessive secretion of PRL, which had previously been assigned a modest role in the regulation of lactation, quite often causes menstrual and generative dysfunction. The share of hyperprolactinemia accounts for up to 25-40% of all cases of female infertility. Hyperprolactinemia also occurs in 10% of women with amenorrhea, 20% to 30% of women with galactorrhea, and 70% of women with both of these symptoms [2].

In healthy individuals, the main effect of PRL is on reproductive function, induces and maintains lactation in women after childbirth, and also participates in the formation of the fetus. Primary hyperprolactinemia (PHP) is one of the main causes of female infertility. The origin of the caused increase in the level of prolactin in the syndrome of persistent galactorrhea-amenorrhea is associated in

most cases with prolactin-producing tumors of the pituitary gland (micro- or macroadenomas), as well as with various kinds of hypothalamic disorders that cause the so-called idiopathic hyperprolactinemia.

Hyperprolactinemic states are characterized by a complex of not only physiological, but also behavioral changes, largely reflecting the functional significance of prolactin. In particular, it is known that, along with the induction of lactation and the suppression of the menstrual cycle, hyperproduction of prolactin may also be associated with a change in the behavior of women [2].

In view of the foregoing, **the purpose of this study** was to study the psychological relationships in PHP, to identify behavioral features characteristic of these patients with PHP, as well as to compare them.

### **Materials and methods**

We examined 53 women aged 18 to 64 years (average  $33.8 \pm 10.5$  years) who were observed in the Kursk Regional Clinical Multidisciplinary Hospital for idiopathic prolactinoma. ) and a standardized Russian version of the widely used MMPS psychometric test [1].

The materials were statistically processed using the Statistica for Windows software package. When comparing the obtained data, Student's t-test was used. Results with a confidence level of at least 95% ( $p < 0.05$ ) were considered significant.

### **Results and its discussion**

Reliable results on MMPS were obtained in 44 patients out of 53 examined. At the same time, 35 (66%) women had pathological deviations according to various scales of the methodology. With the greatest constancy, an excess of the normal level was noted on scale 7 (anxiety fixation and restrictive behavior) - in 39.4% of women, on scale I (anxiety somatization) - in 51.9% and on scale 8 (auguzation) - in 36.7 %. You should also pay attention to the rather high average level of the profile on scales 5 (internal determinism of behavior) and 9 (hypomanic tendencies). One-way analysis of variance indicates the presence of significant differences between groups of patients only on one scale - 0 (social inclusion) -  $p < 0.05$ .

The results of a psychodiagnostic examination of patients using the MMPS test and subsequent factor analysis of the data obtained showed that the behavior of patients with PHP is characterized by the presence of four main patterns: paranoid, somatoform, depressive, and anxious. The distribution of patients depending on the prevailing pattern of behavior was as follows. The group with a tendency to paranoid response included 4 patients, with a predominance of somatoform reactions - 18, with a depressive response style - 16, and the group with a predominance of anxiety - 15 patients. It should be emphasized that the values of the MMPS profile for each of the groups did not go beyond the limits of the norm - 70 T-points, since they characterized the average behavioral trends. However, in 33

out of 53 (62.%) patients, these values exceeded the norm. Another 11 (20.7%) patients showed pronounced tendencies to downplay the severity of psychological problems due to increased conformity. In the group of patients with a tendency to paranoid reactions, the pathological profile of MMPS was observed in 2 patients (50%), in the group with somatoform reactions - in 10 (55.5%), in the group with depressive reactions - in 6 (37.5%), and in the group with anxious response - in 5 (33.3%). At the same time, tendencies to downplay the severity of problems were most pronounced in depressive and paranoid styles of behavior. Patients with a predominance of the paranoid pattern of behavior were also characterized by a tendency to overvalued formations (especially those related to proper nutrition and maintaining health), an outwardly accusing response style, low sociability, and a tense-dysphoric mood background. Patients from the group with a predominance of the somatoform style were distinguished by a large number of complaints of somatic distress, psychovegetative disorders, demonstrativeness, as well as a tendency to conversions and mental dissociation. This also included patients with severe depersonalization, dysmorphomania, and hypervaluable hypochondria. The depressive style of behavior was determined by anergy, a general decrease in the strength of impulses, low self-esteem, relative social isolation, and pessimism.

#### **Conclusions:**

1. In patients with PHP, there is an increased frequency of mental disorders (70%), among which affective and somatoform disorders predominate.
2. Need for early diagnosis of personality traits of patients with PHP (high frequency and variety of mental pathology) for optimal complex therapy.

#### **References**

1. *Berezin F.B., Miroshnikov M.P. Russian modified version of the MMPS psychological test and its application in psychiatric practice // Problems of Psychoneurology. M., 1969. P. 337–342*
2. *SOCIAL AND CLINICAL PSYCHIATRY 2018, v. 28 No. 3 23-28 Grigoryan O.R., Larina A.A., Andreeva E.N., Melnichenko G.A. Hyperprolactinemia in the practice of a gynecologist: etiology, pathogenesis, clinic, diagnosis, treatment. Reproduction problems. 2013;(4):14 20.*

B细胞慢性淋巴细胞白血病 (CLL) 并发实体恶性肿瘤病史的适应性免疫特征  
**FEATURES OF ADAPTIVE IMMUNITY IN PATIENTS WITH  
B-CELL CHRONIC LYMPHOCYTIC LEUKEMIA (CLL)  
COMPLICATED BY THE PRESENCE OF SOLID MALIGNANT  
NEOPLASMS IN THE ANAMNESIS**

**Chuksina Yulia Yuryevna**

*Candidate of Medical Sciences, Senior Research Officer*

*M. F. Vladimirsky Moscow Regional Research Clinical Institute*

抽象的。 本文介绍了适应性细胞免疫参数的分析结果,特别是 B 细胞患者具有不同免疫表型特征 (CD4+CD25+hiCD127-) 和 (CD3+CD8+CD28-) 的 T 调节细胞 慢性淋巴细胞白血病 (CLL),与无并发症的 CLL 相比,历史上并发实体恶性肿瘤 (MN)。

发现复发性 CLL 患者中恶性肿瘤的存在显著加重了 T/NK 细胞免疫的明显紊乱,这是孤立性 CLL 患者的特征。 复发性 CLL 患者中 MN 的存在不影响具有 CD4+CD25+hiCD127- 表型的 T 调节细胞水平,但伴随着具有 CD3+CD8 表型的外周 T 调节细胞水平的显著增加 +CD28-表型。

实现 CLL 缓解伴随着具有 CD4+CD25+hiCD127- 表型的 T 调节淋巴细胞水平的正常化,而不是具有 CD3+CD8+CD28- 表型的外周 T 调节细胞水平的正常化。

关键词: 慢性淋巴细胞白血病, 恶性肿瘤, 适应性免疫, T 调节细胞, 流式细胞术。

**Abstract.** *The article presents the results of the analysis of the parameters of adaptive cellular immunity, in particular, T-regulatory cells with different immunophenotypic features (CD4+CD25+hiCD127-) and (CD3+CD8+CD28-) in patients with B-cell chronic lymphocytic leukemia (CLL), complicated by the presence of solid malignant neoplasms (MN) in history compared with uncomplicated CLL.*

*It was found that the presence of malignant neoplasms in patients with recurrent CLL significantly aggravates the pronounced disorders of T-/NK-cell immunity, which are characteristic of patients with isolated CLL. The presence of MN in patients with recurrent CLL does not affect the level of T-regulatory cells with the CD4+CD25+hiCD127- phenotype, but is accompanied by a pronounced increase in the level of peripheral T-regulatory cells with the CD3+CD8+CD28-phenotype.*

*Achieving CLL remission is accompanied by normalization of the level of T-regulatory lymphocytes with the CD4+CD25+hiCD127- phenotype, but not peripheral T-regulatory cells with the CD3+CD8+CD28- phenotype.*

**Keywords:** *Chronic lymphocytic leukemia, malignant neoplasms, adaptive immunity, T-regulatory cells, flow cytometry.*

**Introduction.** The key role in the elimination of tumor cells is played by specific (adaptive) cellular immunity, implemented by T-lymphocytes and nonspecific (innate) immunity, implemented by NK cells and macrophages, which is currently insufficiently studied during the development of various oncopathological conditions.

It has been established that certain subpopulations of regulatory CD4<sup>+</sup>-, CD8<sup>+</sup> T<sup>-</sup>-, as well as NKT cells, which use different regulatory mechanisms and function at different stages of the immune response, play a significant role in the immunopathogenesis of oncological diseases. The occurrence of multiple malignant neoplasms (MN) is a complex process in which the development of two or more neoplasias is observed simultaneously or after a certain period of time.

The frequency of such a pathology in the world, depending on the specific nosology, is set in the range from 2.4 to 17%, in the Russian Federation it ranges from 7 to 9%. [ 1] . Despite the interest in this problem, the pathogenesis of this cascade process has been little studied.

In this context, the study of the dynamic balance between immunogenic and tolerogenic mechanisms of maintaining immune homeostasis, which changes with the development of autoimmune diseases, tumor processes, and also with the induction of transplantation tolerance, is of particular relevance. These mechanisms are mediated by a special cellular subpopulation of CD4<sup>+</sup> lymphocytes, called T-regulatory cells (T-regs), which mediate the T-cell mechanism of peripheral tolerance. Functionally active T-regs are characterized by constitutive expression of the  $\alpha$ -chain of the IL-2 receptor (CD25) and low/negative expression of the  $\alpha$ -chain of the IL-7 receptor (CD127) [2]. In addition, these cells express the transcription factor FoxP3. Its suppressor effect is realized through the repression of the IL-2 gene and other genes necessary for the activation of effector cells [3]. The mechanisms of immunoregulation by T-regs can be divided into those that target effector T cells (secretion of inhibitory cytokines, disruption of metabolic processes, and induction of apoptosis) and those that target antigen-presenting cells (APCs) (decrease in co-stimulation or decrease antigen presentation) [4,5] . - references

Thus, the main T-regulatory cells are cells with the CD4<sup>+</sup>CD25<sup>+</sup>hiCD127<sup>-</sup> phenotype, but of particular interest is one of the subpopulations of peripheral regulatory T-cells that do not express the main costimulatory receptor CD28, which

is necessary for the full activation of naive T-lymphocytes - this is T -cells with suppressor activity (CD3+CD8+CD28-) [6].

**Objective:** To evaluate the clinical and prognostic value of indicators of adaptive cellular immunity in patients with CLL in the presence of solid malignant neoplasms.

**Materials and methods:** In the present study, patients were divided into 2 groups: group 1 (10 patients) (a combination of 2 or more neoplasms - solid tumors and CLL) and group 2 comparison - 12 patients with CLL without the presence of other solid neoplasms. All 22 patients had CLL recurrence. The median age of patients was 64 years. The diagnosis of CLL is confirmed by immunophenotypic examination of PC or bone marrow. Breast cancer prevailed in the structure of solid malignancies (7 patients), melanoma was diagnosed in 1 patient, kidney cancer was diagnosed in 2 patients. Subsequently, 2 groups of patients with CLL in remission of the disease were compared, depending on the presence (10 patients) / or absence of a history of malignant neoplasm (12 patients). The control group consisted of 20 practically healthy individuals matched by sex and age.

Immunophenotypic study of peripheral blood lymphocytes (PB) was carried out using 6-color flow cytometry (Becton Dickinson, USA). The number of cells expressing CD3, CD4, CD8, CD19, CD25, CD16, and CD56 antigens, the expression of activation and costimulatory CD28 molecules on T-lymphocytes was assessed within the gate of CD45+ lymphocytes, the content of T-regulatory cells (CD4+CD25+hiCD127-) and T-lymphocytes with suppressor activity (CD3+CD8+CD28-) were evaluated within the gate of CD3+ lymphocytes. As reference values were used the results of 20 practically healthy individuals, studied for similar indicators.

Results.

**Table 1.**  
*Indicators of T-/NK-cell adaptive immunity in patients with CLL recurrence depending on the presence or absence of malignant neoplasms in history, % of positive cells*

Index, %	Recurrence of CLL+ MN n = 10	Recurrence of CLLwithout MN n = 12	P	Practically healthy individuals n = 20	P
T-lf, CD3+, [within CD45+]	14,87 +- 4,27	36,4+-3,3	<0,001	74,3 +- 6,9	<0,001
T-helpers, CD3+CD4+	4,17+-1,97	17,6+-2,5	<0,001	42,8 +- 6,8	<0,001
T-cytotoxic, CD3+CD8+	7,1 +-0,21	19,5+- 2,4	<0,001	39,7 +- 7,8	<0,001
NK cells, CD3-CD16+CD56+	0,67 +- 0,23	8,7 +- 1,2	<0,001	14,2 +- 7,0	<0,001
NKT cells, CD3+CD16+CD56+	2,37 +- 1,47	3,1 +- 0,7		5,0 +-1,2	

CD4+CD25+hiCD127- [within CD3+]	12,43+-0,9	19,0 +-5,3		9,60 +- 0,8	1-3 <0,05
CD3+CD8+CD28- [within CD3+]	44,8 +- 1,42	32,7 +-4,1	<0,01	16,60+- 1,5	1-3; 2-3 <0,001

When combined in patients with recurrent CLL with the presence of malignant neoplasms, a significant ( $p<0.001$ ) decrease in the content of the population of T-lymphocytes (CD3+) was revealed due to a pronounced decrease in both helper (CD4+) ( $p<0.001$ ) and cytotoxic subpopulations (CD8+) ( $p<0.001$ ) lymphocytes, a sharp decrease in the content natural killer cells (CD3-CD16+CD56+), compared with the group of patients with CLL recurrence without cancer. These violations of the cellular immunity system in both compared groups of patients are even more pronounced than in the group of practically healthy individuals.

It was noted that the content of 2 populations of T-regulatory cells with the phenotype CD4+CD25+hiCD127- and CD3+CD8+CD28- in both groups of patients significantly ( $p<0.05$  and  $p<0.001$ , respectively) higher than in the reference group.

There were no significant differences between the compared groups of CLL patients in terms of the content of T-regulatory cells with the CD4+CD25+hiCD127- phenotype.

On the contrary, the relative content of peripheral T-regulatory cells with the CD3+CD8+CD28- phenotype was significantly ( $p<0.01$ ) higher in the comorbidity of CLL with malignant neoplasm compared to the group of patients with CLL without malignant neoplasm.

Comparative characteristics of T-/NK- cell immunity in CLL patients in remission of the disease in the context of the presence or absence of concomitant malignant neoplasms are presented in Table 2.

**Table 2.**  
*Indicators of T-/NK-cell adaptive immunity in patients with remission of CLL depending on the presence or absence of malignant neoplasms in history, % of positive cells*

Index, %	Recurrence of CLL+ MN n = 10	Recurrence of CLL without MN n = 12	P	Practically healthy individuals n = 20	P
T-I $\alpha$ , CD3+, [within CD45+]	83,95 +- 4,45	80,20 +- 1,6		74,3 +- 6,9	
T-helpers, CD3+CD4+	48,10 +- 4,4	<b>29,2 +- 1,6</b>	<0,001	42,8 +- 6,8	2-3 <0,001

T-cytotoxic, CD3+CD8+	35,95 +-0,25	47,70 +- 2,6	<0,001	39,7 +- 7,8	
NK cells, CD3-CD16+CD56+	14,65 +- 4,6	14,97 +- 1,5		14,2 +- 7,0	
NKT cells, CD3+CD16+CD56+	7,85 +- 6,05	5,50 +- 0,7		5,0 +-1,2	
CD4+CD25+hiCD127- [within CD3+]	10,90 +- 0,5	8,90 +- 1,3		9,60 +- 0,8	
CD3+CD8+CD28- [within CD3+]	25,10 +- 3,2	32,5 +- 4,7		16,60+- 1,5	1-3 <0,05 2-3 <0,005

When the disease remission was achieved in both groups of patients with CLL, regardless of the presence or absence of malignant neoplasm, normalization of the relative number of T-lymphocytes, T-cytotoxic and NKT lymphocyte subpopulations, as well as the level of natural killer (NK) cells in peripheral blood was revealed.

However, there was a pronounced ( $p < 0.001$ ) decrease in the relative number of T-helper lymphocytes (CD3+CD4+) and an increase in the content of T-cytotoxic subpopulation of lymphocytes (CD3+CD8+) in patients with CLL without the presence of malignant neoplasm, even compared with the group of patients with concomitant pathology.

When CLL remission was achieved, the level of T-regulatory cells with the **CD4+CD25+hiCD127-** phenotype in both groups of patients did not differ significantly from those of practically healthy individuals, however, the level of peripheral T-regulatory cells with the CD3+CD8+CD28- phenotype remained significantly ( $p < 0.05$ ;  $p < 0.005$ , respectively) is higher than normal in both groups of patients, although no statistically significant differences were found between them.

**Conclusion.**

1. The presence of MN in patients with recurrent CLL significantly exacerbates severe disorders of T-/NK-cell immunity, which are characteristic of patients with isolated CLL.

2. The presence of MN in patients with recurrent CLL does not affect the level of T-regulatory cells with the CD4+CD25+hiCD127- phenotype, although there is a significant increase compared to the reference values in both groups.

3. The presence of MN in patients with recurrent CLL is accompanied by a pronounced increase in the level of peripheral T-regulatory cells with the CD3+CD8+CD28- phenotype, both in comparison with the reference values and in comparison with CLL patients without MN.

4. Achieving CLL remission is accompanied by a pronounced decrease in the relative number of T-helper lymphocytes (CD3+CD4+) and an increase in the content of T-cytotoxic subpopulation of lymphocytes (CD3+CD8+) in CLL patients without malignant neoplasm.



5. Achieving CLL remission is accompanied by normalization of the level of T-regulatory lymphocytes with the CD4+CD25+hiCD127- phenotype, but there is no normalization of the level of peripheral T-regulatory cells with the CD3+CD8+CD28- phenotype, which remains significantly increased in both study groups of patients.

Thus, in the structure of CD3+CD8+ SC lymphocytes in patients with CLL, a subpopulation of T-lymphocytes with suppressive activity (CD8+CD28-) predominates, containing the so-called “VETO” cells with the CD8+CD28-FOXP3+ phenotype. These cells are induced T-regulatory cells that do not show effector cytotoxic activity and inhibit the expression of co-stimulatory molecules CD80, CD86 on antigen-presenting cells. Perhaps, it is this population that plays the most important role in the development of tolerogenic immune mechanisms, contributing to the blocking of the antitumor immune response.

## References

1. Vogt A, Schmid S, Heinemann K, et al. Multiple primary tumours: challenges and approaches, a review. *ESMO Open*. 2017;2(2):e000172. doi: 10.1136/esmoopen-2017-000172.
2. Liu W, Putnam AL, Xu-Yu Z, Szot GL, Lee MR, Zhu S, Gottlieb PA, Kapranov P, Gingeras TR, de St F, Groth B et al (2006) CD127 expression inversely correlates with FoxP3 and suppressive function of human CD4+ T reg cells. *J Exp Med* 203(7):1701–1711
3. Ohkura N, Hamaguchi M, Morikawa H, Sugimura K, Tanaka A, Ito Y, Osaki M, Tanaka Y, Yamashita R, Nakano N, et al. 2012. T cell receptor stimulation-induced epigenetic changes and Foxp3 expression are independent and complementary events required for Treg cell development. *Immunity* 37: 785–799
4. Shevach EM (2009) Mechanisms of foxp3+ T regulatory cell-mediated suppression. *Immunity* 30(5):636–645
5. Li X, Xu H, Huang J, Luo D, Lv S, Lu X and Xiao C (2021) Dysfunctions, Molecular Mechanisms, and Therapeutic Strategies of Regulatory T Cells in Rheumatoid Arthritis. *Front. Pharmacol.* 12:716081. doi: 10.3389/fphar.2021.716081
6. Chen C., Chen D., Zhang Y. et al. CD4+CD25+FOXP3+ and CD8+CD28-regulatory T cells in non-small cell lung cancer patients undergoing surgery // *Int. Immunopharmacol.* – 2014. – Vol. 18, No. 2. – P. 255–261.

来自自体间充质干细胞的组织技术和脊柱损伤中椎体塑料中多孔钛纳米颗粒的成骨拟像

**TISSUE TECHNOLOGIES FROM AUTOLOGOUS MESENCHYMAL STEM CELLS AND SIMULACRA OF OSTEOGENESIS WITH GRANULES OF POROUS TITANIUM NICEDITE IN THE PLASTIC OF THE VERTEBRAL BODY IN SPINAL INJURIES**

**Mukhametzhano Khanat**

*National Scientific Center of Traumatology and orthopedics named after Academician N.D. Batpenov, RK, Astana*

**Mukhametzhano Dulat Zhakachuch**

*National Medical Research Center of Neurosurgery named after Academician N.N. Burdenko, Russian Federation, Moscow*

**Karibayev Burutai Medchebaevich**

*National Scientific Center of Traumatology and orthopedics named after Academician N.D. Batpenov, RK, Astana*

抽象的。作者基于在 35 例脊柱损伤患者的椎体塑料中使用自体间充质干细胞和多孔钛镍钛合金颗粒成骨拟像,总结了其在骨组织塑料中的有效性。第一组由 13 名患者组成,他们使用基于镍化钛颗粒和间充质干细胞 (MSC) 的生物复合植入物接受了椎体经椎弓根整形手术。第二组由 22 名接受椎体经椎弓根整形手术的患者组成,使用多孔镍化钛颗粒,富含术前从患者血液中提取的自体纤维蛋白团。多孔镍化钛颗粒与 MSC 和多孔镍化钛颗粒与自体血浆在脊柱损伤植骨中的应用前景广阔。获得的多孔镍化钛研究表明,在植入骨组织期间有足够的密度,这首先是保留其成骨性、骨诱导性的骨碎片所必需的,而间充质干细胞的许可和自体纤维蛋白质量有助于其骨传导性。钛nicedite植入物与生物组织的饱和和加速成骨在组织工程中具有广阔的应用前景。

关键词: 经椎弓根固定, 镍化钛颗粒, 间充质干细胞, 来自自体纤维蛋白块的骨诱导因子。

**Abstract.** *The authors, based on the use of autologous mesenchymal stem cells and simulacra of osteogenesis with granules of porous titanium nicedite in the plastic of the vertebral body in spinal injuries in 35 patients, conclude about its effectiveness in bone tissue plastic. The first group consisted of 13 patients who underwent transpedicular plastic surgery of the vertebral body using a biocomposite implant based on titanium nickelide granules and mesenchymal stem cells (MSCs).*

*The second group consisted of 22 patients who underwent transpedicular plastic surgery of the vertebral body using granules of porous titanium nickelide enriched with autologous fibrin mass taken from the patient's blood before surgery. The use of granules of porous titanium nickelide with MSC and granules of porous titanium nickelide with autologous plasma is promising when used in bone grafting in spinal injuries. The obtained studies of porous titanium nickelide showed sufficient density during implantation into bone tissue, which is necessary at first to retain bone fragments of its osteogenicity, osteoinductivity and the permission of MSCs and autologous fibrin mass contributes to its osteoconductivity. Saturation of titanium nicedite implants with biological tissues that accelerate osteogenesis has great prospects for its use in tissue engineering.*

**Keywords:** *transpedicular fixation, titanium nickelide granules, mesenchymal stem cells, osteoinductive factors from autologous fibrin mass.*

Porous titanium nickelide (NiTi) has been used for more than 50 years for fractures of the spine and long tubular bones in orthopedics and traumatology, neurosurgery, dentistry, etc. Porous NiTi is used in St. Petersburg, Moscow, Asian Russia, Ukraine, Belarus, Kazakhstan, Turkmenistan, China, South Korea, Japan, etc.

The shape memory effect (SME) based on (NiTi) is a group of metallic materials capable of restoring a previously set length or shape when exposed to an appropriate thermomechanical load, has high biochemical and biomechanical compatibility, high porosity of NiTi implants (80-90%) promotes good ingrowth of hard and soft tissues of the body [1]. Introduction to the NiTi composite allows us to obtain a class of materials with high mechanical characteristics, among which high physical and mechanical strength, plasticity, wear and cycle resistance, significant resistance to “fatigue” mechanisms, weldability, heat resistance, corrosion resistance. In the normal functioning of implants, the characteristics of wettability, permeability and porosity of the material, as well as the hysteresis properties of tissues in the implantation area, play an important role [1,3].

Carcinogenic studies of the alloy based on NiTi (TN – 10 alloy) were carried out in accordance with the methodological developments of the Ministry of Health of the USSR and with its direct participation [1]. It was found that NiTi-based alloys (in particular, TN - 10) manufactured at the Research Institute of Medical Materials and Implants with shape Memory did not exhibit carcinogenic effects. The Ministry of Health of the USSR by Order No. 1027 of 05.08.1986 authorized the use of titanium nickelide structures in clinical practice [3,5].

The permeable porosity of NiTi implants makes it possible to regulate the processes of osseointegration after implantation of porous permeable structures into the bone bed and the use of technologies for saturation of implants with biological tissues that accelerate osteogenesis [1.4].

The ability of the material is to incubate cell cultures and create conditions for their growth in the permeable structure of the implant, and after implantation to maintain the function of the organ [7]

**The aim** of this report was tissue technology from autologous mesenchymal stem cells and simulacra of osteogenesis with granules of porous titanium nicedite in the plastic of the vertebral body in spinal injuries.

**Materials and methods.** The study material was 35 patients aged 18 to 62 years, the average age was  $40.3 \pm 12.9$  years, there were 22 men, 13 women. Patients were admitted in the acute period of 20, in the early period - 3 and in the intermediate period of trauma – 12. The injury was received in a traffic accident (road accident) - 5 patients, in everyday life - 27, sports injuries – 3. In an accident: a pedestrian, 2 drivers, 2 passengers; Injuries from falling from a great height – 17, the result of a falling from their own height - 12, sports injury in 1 patient. The number of damaged vertebrae in most patients was one vertebra – in 22, 2 vertebrae – in 10 and three vertebrae in 3 victims. Damage to the thoracic spine was observed in 19 patients, lumbar spine in 16, two spine sections in 6 and two-level fractures in 3 patients. All patients had unstable, uncomplicated fractures. The injuries were isolated in 31 patients and combined in 4 patients.

### **Methods**

Granules of porous titanium nickelide were manufactured at the Research Institute of Medical Materials and Implants with Shape Memory (Tomsk), there is a certificate of conformity. The permission of the ethics commission is also available [1].

The preparation of a biocomposite implant and fibrin hydrogel was carried out at the Biotechnology Center. Preparation of subcutaneous fat from the anterior abdominal wall the day before surgery under local anesthesia with specially prepared needles, or during open surgery from the adjacent subcutaneous fat layer. Then the collected fat layer of subcutaneous fat was recovered at the Biotechnology Center, where osteocytes and neurocytes are selected from the biopsy material. After processing, the material is delivered to the operating room.

Autologous platelet mass was collected from blood taken from the patient before surgery with the addition of sodium heparin gel and centrifugation.

After a clinical and neurological examination, all patients underwent radiography of the spine in two projections, computed tomography, according to indications - X-ray densitometry. Patients with combined injuries received X-rays of the areas concerned, according to indications - ultrasound of the abdominal cavity, pelvic organs, computed tomography. Operations were performed using O-arm from the StealthStation navigation station (Medtronic).

The results of treatment were evaluated according to the F Denis scales [8].

## Results and discussion

The patients were divided into two groups: the first group consisted of 13 patients who underwent transpedicular plastic surgery of the vertebral body using a biocomposite implant based on titanium nickelide granules, fibrin hydrogel. The second group consisted of 22 patients who underwent transpedicular plastic surgery of the vertebral body using granules of porous titanium nickelide enriched with autologous fibrin mass taken from the patient's blood before surgery. All patients were operated by the method of transpedicular fixation (TPF), transpedicular reconstruction of the vertebral body, which was carried out by the method developed earlier by us.

According to X-ray densitometry, bone mineral density (BMD) was normal in 10 patients, reduced to the level of osteopenia in 8 and to the level of osteoporosis in 9.

Our previous studies (more than 400 operations) using porous NiTi alloys obtained by self-propagating high-temperature synthesis showed that no toxic reactions and carcinogenic effects were observed in any ballroom.

The proximate results of treatment in all patients were good in 12 patients, and after 12 months in 23 other patients, the results were also good. There were no complications after the operation.

The compressibility of TiNi and the porous structure promote the growth and mineralization of bone and prevent the formation of a fibrous capsule, which makes the fixation of the implant more natural and safe, according to the type of primary corn. Implantation of porous permeable structures into the bone bed and the use of technologies for saturation of implants with biological tissues that accelerate osteogenesis (autologous fibrin mass) [4] is perceptible in tissue engineering.

TiNi alloys have unique characteristics: superelasticity and shape memory effect, which ensure the versatility of the implant (high recovery, high strength and relatively low Young's modulus) [9,10,11].

Taking into account the fact that mesenchymal stem cells (MSCs) are multipotent cells, permeable porous TiNi materials will be biocompatible with other cell lines originating from MSCs, including adipogenic, neurogenic and myogenic cells. Porous permeable materials based on TiNi can be used to create artificial tissue engineering structures to obtain the desired amounts of chondro- and osteogenic tissues of various maturity. Specific properties and high biocompatibility are good prerequisites for the use of TiNi scaffolds in cellular technologies. Using MSCs, it was shown that porous permeable TiNi scaffolds are unique incubators for cell cultures suitable for tissue engineering [4,7].

Thus, the obtained studies of porous titanium nicedite showed sufficient density during implantation into bone tissue, which is necessary at first to retain bone fragments, its osteogenicity, osteoinductivity, and the addition of osteoinductive

factors and mesenchymal stem cells to porous NiTi ensures its osteoconductivity. Saturation of titanium nickelide implants with biological tissues that accelerate osteogenesis has great prospects for its use in tissue engineering.

### Literature

1. Gunter V.E. *Alloys and constructions with shape memory in medicine: // Diss. – Dr. tech. Sciences, Tomsk, 1989. 356c.*
2. Ryhänen J, Kallioinen M, Tuukkanen J, Lehenkari P, Junila J, Niemelä E, Sandvik P, Serlo W *Modeling of bone and reactions at the interface of cells and materials induced by a nickel-titanium shape memory alloy after periosteal implantation // Biomaterials 1999 July;20(14):1309-17 PMID: 10403049 DOI: 10.1016/s0142-9612(99)00032-0*
3. Gunter V.E. *Biocompatible materials with shape memory and new technologies in medicine // Tomsk: NTL 2004; 440s.*
4. Kokorev O. V. *Assessment of the cell population during cultivation with 2-D and 3-D structures made of porous-permeable materials based on titanium nickelide [Text] / O.V. Kokorev, G.Ts Dambaev, V.E. Gunter // Materials with shape memory and new technologies in medicine / ed. Gunther. - Tomsk: “NPP”MIZ” 2006,. - pp. 13-16*
5. *By the Ministry of Health of the USSR by Order No. 1027 of 05.08.1986*
6. Slizovsky G.V., Sitko L.A., Kuzhelivsky I.I., Fedorov M.A., Kozyrev A.A., Stepanov M.Yu. *Surgical treatment of degenerative-dystrophic diseases of the musculoskeletal system in children using titanium nickelide implants // Siberian Medical Journal (Irkutsk). 2016. - No. 2. - pp. 76-79*
7. V. Khodorenko, N. N. *Physico-chemical properties of porous materials based on titanium nickelide obtained by SHS and sintering methods / V.N. Khodorenko, S.G. Anikeev, O.V. Kokarev [et al.] // Materials and implants with shape memory in medicine / edited by V.E. Gunter. - Tomsk: “NPP”MIZ”, 2014. - p. 17*
8. Denis F. *The tricolon spine and its significance in the classification of acute injuries of the thoracolumbar spine. Spine. - 8(8). - 1983. – P. 817-831*
9. Gunter V. E., Khodorenko V. N., Monogenov A. N., Yasenchuk Yu. F. *The effect of deformation on the permeability of porous titanium-nickel alloys is published // 2000. - Physics Technical letters on physics DOI:10.1134/1.1262830*
10. Gunter V.E., Khodorenko V.N., Yasenchuk Yu.F. et al. *Titanium nickelide // Tomsk: Publishing House of MIT, 2006. – 296c/*
11. Henkel J., Woodruff M. A., Epari D. R. et al. *Bone regeneration based on tissue engineering concepts is a 21st century perspective. Doctor of Medical Sciences, Professor of Dentistry in Western China. - 2013. - Volume 1. - No.3. - pp. 216-248. DOI: 10.4248/BR201303002*

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配方成分对面食氨基酸组成的影响

**THE INFLUENCE OF THE COMPONENTS OF THE RECIPE  
ON THE AMINO ACID COMPOSITION OF FLOUR CULINARY  
PRODUCTS**

**Vasyukova Anna Timofeevna**

*Doctor of Technical Sciences, Professor  
Russian Biotechnological University, (ROSBIOTECH)*

**Kusova Irina Uruzmagovna**

*Candidate of Technical Sciences, Associate Professor  
Russian Biotechnological University, (ROSBIOTECH)*

**Moshkin Aleksandr Vladimirovich**

*graduate student  
Moscow State University of Technology and  
management named after K.G. Razumovsky (PKU)*

**Dyshekova Milana Mukhamedovna**

*graduate student  
Russian Biotechnological University, (ROSBIOTECH)*

**Vadovskiy Ilya Konstantinovich**

*graduate student  
Russian Biotechnological University, (ROSBIOTECH)*

**Moiseeva Anastasia**

*master  
Russian Biotechnological University, (ROSBIOTECH)*

注解。在现代条件下扩大新的优势产品范围是一项重要的国民经济任务。通过使用推荐用于餐饮或食品行业的现代技术可以最有效地解决这个问题，这使得以低生产成本获得高分类质量的产品成为可能。对于面粉产品的生产，这意味着使用集约化技术来增加产品的体积、扩大产品范围、提高质量，并通过减少冗长的面团准备阶段来降低产品成本。该文章包含有关面粉烹饪产品新技术的信息，该产品使用非传统类型的食品添加剂：干辛辣芳香和浆果提取物（芝麻、苋菜、莖菜、牛至、龙蒿、姜黄、多香果、大麻和葡萄种子）。对新处方成分的组成进行了详细的研究和分析，揭示了其对提高开发产品氨基酸组成价值贡献的积极影响。

关键词：干燥的辛辣芳香和浆果提取物，面粉烹饪产品，干混料。

**Annotation.** *Expanding the range of new competitive products in modern conditions is an important national economic task. It can be most effectively solved through the use of modern technologies recommended for use in catering or the food industry, which make it possible to obtain a product of high assortment quality at low production costs. With regard to the production of flour products, this means the use of intensive technologies that allow increasing the volume of products, expanding the range, improving quality, reducing the cost of products by reducing the lengthy stages of dough preparation. The article contains information about new technologies for flour culinary products using non-traditional types of food additives for this product: dry spicy-aromatic and berry extracts (sesame, amaranth, coryder-andre, oregano, tarragon, turmeric, allspice, hemp and grape seed). The composition of new prescription ingredients has been studied and analyzed in detail, and the positive impact of their contribution to improving the value of the amino acid composition of the developed products has been revealed.*

**Key words:** *dry spicy-aromatic and berry extracts, flour culinary products, dry mixes.*

## **Introduction**

Flour culinary products are part of the nutrition of the Russian population, they include the daily selection of the diet of most consumers, being one of the main sources of energy and food poisoning [1].

The development of technologies for flour culinary products containing a significant amount of easily digestible, essential amino acids, essential fatty acids, fibrous acids, vitamins, macro- and microelements is possible due to a violation of the nutritional structure of the country's population. Potential sources of these sources can be legumes and oilseeds: soybeans, chickpeas, lupins, sesame and flax [2].

A line of products balanced in terms of biological value, vitamin, mineral composition,  $\omega$ -6/ $\omega$ -3 fatty acids has been developed. A technology is proposed for the use of chickpeas in the production of bread, the digestibility of which is 8.5% higher than that of the control sample. In the method of making cookies from oatmeal, alkalinity is reduced by 1.4 degrees, sugar is replaced by fructose and its content is 3 times less. The biological value of the finished product is 68%. The introduction of peach puree rich in biotin, riboflavin,  $\beta$ -carotene, ascorbic acid and minerals into the bread recipe approaches the Ca:Mg:P ratio, which plays an important role in enriching flour culinary products (1:0, 6: 1.3) to recommended (1:0.5:1.5). balance the ratio of  $\omega$ -6 /  $\omega$ -3 fatty acids (4:1), which corresponds to the one recommended by the Institute of Nutrition of the Russian Academy of Medical Sciences for preventive nutrition; increase the mass fraction of vitamins and minerals and expand the range of rich bakery products for functional and preventive purposes [2].



A technology for obtaining chickpea hydrolyzate has been developed, which has found application in the production of Polevoi bread. In products containing chickpea hydrolyzate, there is an improvement in organoleptic and physico-chemical indicators of bread quality, as well as a significant ratio of composition and composition in bread - 1:4 (10.6:42.6). The biological value of Polevoi bread increased by 76%, that is, it increased by 22%; score for lysine - from 65.6% to 95.6%, for threonine - from 76.7% to 134.3%; the Ca:P:Mg ratio increases to the recommended value (1:0.5:1.5). Protein digestibility in the tuygo system in the test sample is 8.5% higher than in the control [3].

Proposed Pashchenko L.P., Ostroborodova S.N. and Pashchenko V.L. the method of preparing bread "Vostorg" by adding honey and peach puree to the recipe, allows you to increase the nutritional and biological value of bread; increase its quality indicators: specific volume by 7%, porosity by 10.0%, aroma by 47%; bring the mineral composition (Ca:Mg:P=1:0.6:1.3 ratio) closer to that recommended by the Institute of Nutrition of the Russian Academy of Medical Sciences [4].

In the bread "Legend" there is a high concentration of magnesium, phosphorus, while it contains a proportional ratio of magnesium and phosphorus, equal to 1: 1.5. This is due to the introduction of sugar sorghum as a multicomponent sugar-containing raw material into the recipe [5].

The expansion of the range and quality of products depends on the use of non-traditional vegetable raw materials in the production and the use of manual work in the creation of branded flour culinary products. The quality standards of the new product cover such indicators as: increased content of carbohydrates, more concentrated protein composition, a product from several types of cereals. In addition, such a product is better absorbed and can be recommended for the prevention of diseases of the gastrointestinal tract. According to the specialists of the Dellos holding, consumers have only two requirements for products - taste and freshness, which ultimately come down to one thing - the quality of buns, cheesecakes, pies [6].

Kolomnikova Ya. P. and Pitaikina E. A. suggested ways to improve the recipes of a semi-finished biscuit product by introducing several types of cereals [6].

Melnik E.V. developed the technology of painful prophylactic products using delayed egg products, which made it possible not only to increase the biological value of products by introducing complete proteins with an optimal complex of essential amino acids, but also to reduce the cost of finished products by reducing the cost of egg products with critical shelf life [ 7].

Kholodova E.N. [8] developed the technology and researched the consumer properties of a semi-finished biscuit product using triticale and millet flour. This made it possible to adjust the nutritional value of the finished product and stabilize the rheological characteristics.

Ausheva T.A. [9] revealed the dependence of the nutritional value of bakery products on the composition of biologically active substances of plant and animal origin in the technologies of bread and flour confectionery. The introduction of rowan powder into the egg-sugar mixture before whipping makes it possible to obtain a high pH value, at which the foaming properties of egg white are most pronounced, and the baked acquisition acquires a chocolate-colored crumb and a smooth surface [9].

The purpose of the research is to identify the dependence of the influence of the constituent components of the recipe on the amino acid composition of flour culinary products.

### **Materials and methods**

When performing the work, generally accepted, standard and original research methods were used. The studies were carried out in triplicate. Statistical processing of the obtained data was carried out using the following programs: SPSS, Microsoft Excel, and MathcadPrime 1.0.

The bulk of the research was carried out at the ROSBIOTEKH Central Analytical Laboratory and the Innovation Laboratory of the Department of Food Industry, Hotel Business and Service.

### **The object of the study**

The objects of research at various stages of work were: grain of the main cereal crops - wheat, barley, rye, grown in the Moscow region; wheat flour (GOST R 52189-2003); grain extrudates; semi-finished products and ready-made flour culinary products made using textured cereal products and dry aromatic and berry extracts (sesame, amaranth, coriander, oregano, estragon, turmeric, allspice, hemp and grape seed).

### **Results and discussion**

A methodology for a comprehensive assessment of the quantitative and qualitative indicators of grain raw materials for the production of textured products is proposed. Based on the generated database of quantitative and qualitative indicators of wheat, barley, oats, lentils and millet grown in various zonal conditions of the Moscow region in the period from 2021 to 2022, a statistical analysis of the qualitative characteristics of grain raw materials was carried out, an assessment the grain market, taking into account its use in the flour-grinding, cereal and baking industries and analysis of the technical equipment of grain processing enterprises. To obtain raw materials with an optimal amino acid composition for the manufacture of flour culinary products, the following were introduced into the flour mixture: buckwheat, oats, lentils, sunflower seeds, millet, grape seed, amaranth, hemp, coriander, turmeric, oregano and allspice. Grinding of grain, spices has been completed and grinding batches have been determined, a technological scheme for grinding a multicomponent grain mixture has been developed.

The calculations of the multidimensional statistical model are based on the use of the method of paired comparisons and ranking the degree of correspondence between the quantity and quality of grain produced in various zones of the Moscow Region and other regions of Russia, and the characteristics of grain processing enterprises in these zones.

The use of innovative efficient extrusion technologies and methods of ultrasonic cavitation processing of grain makes it possible to obtain grain texturates with a high content of useful substances, which make it possible to increase the nutritional value, digestibility of finished products and obtain new food products with increased nutritional value.

Recipes for enriched grain texturates are given in table. 1.

**Table 1**  
*Formulations of textured grain functional mixtures*

<b>Composition of the components of the formulation</b>	<b>Grape seed cake blend and amaranth, %</b>	<b>Grape Seed Cake Blend &amp; Sesame, %</b>	<b>Grape Seed &amp; Quinoa Meal Blend, %</b>
buckwheat	36	30	-
oats	22	-	-
lentils	14	-	-
sunflower	10	1	6
millet	7	22	18
rye	-	17	35
pearl barley	-	16	15
quinoa	-	-	15
grape seeds	5	5	4
amaranth	2,5	4	1,5
sesame	-	3	1,5
hemp	1,1	-	2,0
coriander	0,3	-	-
turmeric	0,3	0,2	-
tarragon	-	0,2	0,2
oregano	0,2	-	-
allspice	0,2	0,2	0,2
oregano			0,2

Recently, a large number of so-called combined, multi-component, composite mixtures have appeared on sale, which can be considered as a kind of mono-product, consisting of a number of ingredients that mutually complement the desired mixture.

To carry out the calculations, a program was developed in Microsoft Excel, which, when entering the initial data on the content of fat, fiber, glycemic index and cost for the components, made it possible to control these indicators and the energy of the mixture. Table 2 shows the results of calculations of three-component mixtures of cereals and legumes with the proportion of legumes corresponding to the minimum NAC score of the mixture equal to one ( $C = 1$ ).

An analysis of the NAC scores of cereals and legumes showed that cereals are limited in lysine and have a low minimum score, but are rich in “methionine + cystine”. Legumes have a minimum score for “methionine + cystine”, but some of them have a complete protein, and some have a defective one. When mixed with leguminous cereals, lysine will increase in the mixture and “methionine + cystine” will decrease. The minimum speed of the mixture is determined by lysine and, with an increase in the concentration of legumes, it reaches the value of unity earlier than methionine and cystine fall below unity. Therefore, in the simplest case, NAC can be balanced by lysine.

Based on the considered combinations of nutrients, barley groats can be recognized as acceptable according to the main criteria (minimum NAC score and carbohydrate/protein ratio). For all legumes, with a minimum score of NAC (lysine) equal to one, the mixture has a complete protein of more than 12% and the carbohydrate / protein ratio is slightly less than the recommended 5.1. For corn and rice cereals with a complete protein, there is a deviation of carbohydrates / protein from the recommendation upwards. Millet and spelled groats have a significant downward deviation.

Obviously, a high protein component with a “good” protein and low carbohydrate content (low carbohydrate/protein ratio) must be added to the mixture of rice and corn grits with legumes. In millet and spelled cereals - on the contrary, a high-carbohydrate product with a very low protein (with a high ratio of carbohydrates / protein). However, in the latter case, the high level of addition of legumes (more than 30%) raises doubts about the taste qualities of such a mixture. In addition, there are problems with the third high-carbohydrate supplement. Cereals such as starch sago, such as tapioca sago, would be suitable for this purpose.

As a low-carbohydrate component with a relatively “good” protein, sesame seeds and the kernel of industrial hemp were considered, the characteristics of which are available in the tables of the chemical composition of food products [10]. The results of calculations for corn and rice groats with a minimum rather (rather  $\sim 1$ ) NAC of the mixture equal to one are presented in Table 2.

**Table 2**  
*Rational formulations of three-component mixtures*

Legumes	Part, %	Type of dietary supplement	Part, %	Total protein, %	Fast (~1)	% of the daily rate	Carbohydrates, %	Carbohydrates/ Protein (4,7-5,2)	% of the daily rate	Fats, %	Fats/ Protein (~1,2)	% of the daily rate
Mixture 1 - Corn												
Chickpeas	28	Hemp	5	12,5	1	13,9	63,0	5,0	14,2	5,1	0,41	4,5
Lentils	26	Hemp	6	13,1	1	14,5	66,3	5,1	14,9	4,1	0,32	3,6
Beans	30	Hemp	3	13,0	1	14,5	60,7	5,1	15,9	2,8	0,22	2,5
Peas	20	Hemp	8	12,8	1	14,0	65,7	5,1	14,8	5,1	0,40	4,5
Mixture 2 - rice												
Chickpeas	25	Sesame	10	12,1	1	13,5	61,0	5,0	13,7	7,5	0,62	6,6
Lentils	20	Sesame	12	12,6	1	14,0	63,3	5,0	14,2	7,3	0,52	6,5
Beans	26	Sesame	9	12,8	1	14,2	63,9	5,0	14,4	5,8	0,45	5,1
Peas	18	Sesame	14	12,3	1	13,7	62,6	5,1	14,1	8,5	0,69	7,5
Mixture 3 - rice												
Chickpeas	25	Sesame	10	10	12,7	1	14,1	63,0	5,0	14,2	4,0	0,31
Lentils	20	Sesame	12	11	13,2	1	14,7	67,7	5,1	15,2	2,4	0,18
Beans	26	Sesame	9	11	13,2	1	14,7	67,1	5,1	15,1	2,2	0,17
Peas	18	Sesame	14	11	13,5	1	15,0	66,9	5,0	15,0	2,7	0,20

As can be seen from Table 2, the addition of sesame or hemp seeds makes it possible to balance mixtures based on corn and rice cereals according to two criteria, however, the total amount of additives increases, which may affect the taste. It should be borne in mind that with the addition of oilseeds, the content of fat in the mixture increases in some cases up to 7%, which may affect the shelf life of the product.

The requirements of formal criteria for assessing quality (fast and carbohydrates / protein) are met by two-component barley groats and all variants of three-component mixtures. For the selection of promising multicomponent mixtures, other indicators of their consumer properties are needed. Therefore, the final selection of promising compositions should be determined by tasting. Previously, mixtures of barley, rice, and tritipotassium groats with additions of up to 10–35% chickpeas and lentils were tested, which showed manufacturability in preparation and good taste [11, 12].

Using the resulting mixtures to improve the nutritional value of flour culinary products, corn No. 1 or rice No. 2 and No. 3 mixtures were introduced into the developed recipe for buns in the amount of 15, 20 and 25%. As a result of the organoleptic evaluation, it was found that samples with an additive concentration of 20% received the maximum number of points [13-20].

We should not forget about the economic side of the issue. The prices for the components differ significantly, which also affects the cost of their mixtures.

Thus, a promising direction is the development of composite mixtures based on extrudants and micronized grain products, which can be used as dietary supplements to increase the nutritional value of flour culinary products.

### **Conclusion**

On the basis of the conducted studies, it can be noted that the introduction of dry functional mixtures based on leguminous raw materials with the addition of spicy-aromatic components, we get a product balanced in terms of the protein-carbohydrate complex with a complete protein. The optimal addition of corn No. 1 or rice No. 2 and No. 3 mixtures at a concentration of 20% allows you to get a high-protein flour culinary product with optimal organoleptic quality indicators.

The design of such products, especially with the expansion of quality indicators in terms of fats and a mineral-vitamin complex, requires great imagination and experience, including in the field of cooking. It seems promising to develop knowledge bases or neural networks to simplify this work.

## References

1. Vasyukova, A.T. Influence of the constituent components of the recipe on the quality of yeast dough / A.T. Vasyukova, T.S. Zhilina, O.A. Khlebnikova, A.I. Belenkov, V.F. Puchkova // *Proceedings of the Timiryazev Agricultural Academy*, 2013. - Issue. 5. - S. 101-108.
2. Kolomnikova, Ya.P. New technologies of flour culinary products with improved nutritional value for public catering enterprises / Kolomnikova Ya.P., Tefikova S.N., Pashchenko V.L. // *Bulletin of VGUIT*, 2014. - P. 112-120.
3. Pashchenko L.P., Fedorov S.Yu., Pashchenko V.L. Development of bread technologies with biologically activated chickpea seeds // *Proceedings of the VI International Scientific and Practical Conference "Jerusalem artichoke and other inulin-containing plants - problems of cultivation and use"*, Tver, September 12 - 14, 2006: TGSMA Publishing House, 2006. C 166.
4. Pashchenko L.P., Ostroborodova S.N., Pashchenko V.L. Development of bread technology Delight functional purpose. Bread products. [Bakeries], 2007, No. 1. 12, pp. 36-37.
5. Pashchenko L.P., Kolomnikova Ya.P., Pashchenko V.L., Nikitin I.A. Development of functional rye-wheat bread technologies for public catering enterprises. 2012. No. 12. S. 59-61.
6. Kolomnikova Ya. P., Pitaikina E. A. Ways to improve the formulation of semi-finished biscuit // *Actual biotechnology*. 2013. No. 1. S. 27-32.
7. Melnik E.V., Development of technologies for painful prophylactic products using delayed egg products: author. dis. ... cand. tech. Sciences: 18.05.01. M., 2009. 27 p.
8. Kholodova E.N. Development of technologies and assessment of consumer properties of a biscuit semi-finished product using triticale and millet flour: Ph.D. dis. ... cand. tech. Sciences: 18.05.01. Eagle, 2010. 18 p.
9. Ausheva T.A. The composition of biologically active substances of plant and animal origin in the technology of bread and flour confectionery: author. dis. ... cand. tech. Sciences: 18.05.07. Voronezh, 2012. 16 p.
10. Chemical composition of Russian food products. Handbook / Ed. corresponding member MAI, prof. I. M. Skurikhin and Academician of the Russian Academy of Medical Sciences, prof. V. A. Tutelyan. – M.: DeLi print, 2002.
11. Zverev, S., Sesikashvili, O., Pruidze, E. (2020). Enrichment of protein barley and triticale groats by adding chickpea. *Journal of Food and Nutrition Research*, 59(3), 202–206.
12. Зверев С.В., Политуха О.В. Сбалансированный состав многокомпонентных круп в условиях концепции адекватного питания/ С.В.Зверев, О.В.Политуха// *Пищевые системы*. – 2022. – т. 5(3). – С.185-194.

13. Vasyukova A.T. *Special requirements for water used in baking* / Vasyukova A.T., Talbi M. / In the collection: *Topical issues of quality and safety of food raw materials, culinary products, bakery and confectionery industries. Collection of scientific papers of the All-Russian Forum and competition of scientific works.* Managing editor: I.U. Kusova. Moscow, 2023. P. 30-38.

14. Vasyukova, A.T. *Development of food products enriched with a complex of dietary supplements for children* / Vasyukova A.T., Krivoschonok K.V., Akchurina A.I., Bogonosova I.A., Bondarenko Yu.V., Alekseeva A.A. / В сборнике: *Process Management and Scientific Developments. Proceedings of the International Conference.* Birmingham, 2022. С. 192-199.

15. Vasyukova, A.T. *Determination of extractive characteristics of products from fish raw materials by NMR studies* / Vasyukova A.T., Krivoschonok K.V., Moshkin A.V., Kobzh Z.N., Vedenyapina M.D., Kuznetsov V.V. / In the book: *Innovations in life sciences. Collection of materials of the IV International Symposium.* Rep. editor A.A. Prison. Belgorod, 2022, pp. 334-335.

16. Vasyukova, A.T. *The influence of dietary supplements on the consumer properties of functional minced meat* / Vasyukova A.T., Kusova I.U., Krivoschonok K.V., Edwards R.A., Talby M. // *Commodity manager of food products.* 2022. № 3. P. 174-179.

17. Filimonau V. *Food waste in foodservice provided in educational settings: an exploratory study of institutions of early childhood education* / Filimonau V., Ermolaev V.A., Vasyukova A. // *International Journal of Gastronomy and Food Science.* 2022. T. 28. C. 100531.

18. *Rational nutrition of organized teams* / Vasyukova A.T., Bogonosova I.A., Bazhenov N.S. // In the collection: *Applied research and technology ART2019. Proceedings of the regional conference.* 2019. S. 28-31.

19. Vasyukova, A.T. *Products with herbal supplements for a healthy diet* / Vasyukova A.T., Slavyansky A.A., Khairullin M.F., Alekseev A.E., Moshkin A.V., Makhmadaliev E.Sh. // *Food industry.* 2019. No. 12. S. 72-75.

20. Vasyukova. A.T. *Technology of public catering products* / Vasyukova A.T., Slavyansky A.A., Kulikov D.A. - *Textbook for bachelors* / Moscow, 2018. - 426 p.



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苋菜饼鱼组合制品工艺  
**TECHNOLOGIES OF FISH COMBINED PRODUCTS WITH  
AMARANTH CAKE**

**Vasyukova Anna Timofeevna**

*Doctor of Technical Sciences, Professor*

*Russian Biotechnological University, (ROSBIOTECH)*

**Moskalenko Alexandra Sergeevna**

*graduate student*

*Russian Biotechnological University, (ROSBIOTECH)*

**Edvars Anatoliy Rostislavovich**

*master*

*Russian Biotechnological University, (ROSBIOTECH)*

**Tokareva Tatyana Your'evna**

*assistant professor*

*Russian Biotechnological University, (ROSBIOTECH)*

**Vadovskiy Ilya Konstantinovich**

*graduate student*

*Russian Biotechnological University, (ROSBIOTECH)*

**Sharova Tamara Nikolaevna**

*professor*

*Moscow State University of Technology and  
management named after K.G. Razumovsky (PKU)*

注解。 本文介绍了行业提供的食品市场分析结果，以及配方组成成分的研究，这使得获得具有特定营养和生物学特性的功能性产品成为可能。 鱼是生产功能性食品的理想原料，因为它含有人体必需的氨基酸，包括赖氨酸和亮氨酸、必需脂肪酸、脂溶性维生素、微量元素和大量元素，比例适宜。 该研究的目的是开发具有草本生物活性添加剂的鱼类功能性产品——苋菜饼。 获得了鱼半成品和鱼烹饪产品的食谱：“商人”果冻鱼、“Stanichnye”炸肉排（带有苋菜种子的蛋糕）和“农民”炸肉排（带有苋菜种子的面粉）。 鱼产品含有额外的功能成分，例如具有广泛的已证明生物矫正特性的生物活性添加剂，使用香料。 确定了半成品鱼产品的生产技术制度及其对人类日常消费的好处。

关键词：鱼原料，糕点，苋菜，功能性营养，食谱。

**Annotation.** *The article presents the results of the analysis of the market of food products offered by the industry, the study of the constituent components of the recipe, which make it possible to obtain a functional product with specified nutritional and biological properties. Fish is an ideal raw material for the production of functional food products, as it contains essential amino acids, including lysine and leucine, essential fatty acids, fat-soluble vitamins, micro and macro elements in favorable proportions for the body. The purpose of the research is the development of fish functional products with herbal biologically active additives - amaranth cake. Recipes for fish semi-finished products, as well as fish culinary products were obtained: “Jellied fish “Merchant”, cutlets “Stanichnye” (with cake from amaranth seeds) and cutlets “Peasant” (with flour from amaranth seeds). Fish products contain additional functional components, such as biologically active additives with a wide range of proven biocorrective properties, spices are used. The technological regimes for the production of semi-finished fish products, as well as its benefits in daily human consumption, are determined.*

**Key words:** *fish raw materials, cake, amaranth, functional nutrition, recipes.*

## **Introduction**

One of the main directions of the state policy in the field of healthy nutrition is the creation of combined products by including additives in their formulations that are sources of proteins, fats, carbohydrates, dietary fiber, vitamins, essential amino acids, mineral, coloring and other substances.

Insufficient content of micronutrients in food is a constantly acting unfavorable factor, is all-weather in nature, is detected in almost all population groups in various regions of the Russian Federation, which has an extremely negative effect on the health of the nation: life expectancy is reduced, the productivity of the working population and resistance to diseases are reduced. Even optimally balanced food is not a guarantee against a deficiency of vitamins necessary for the human body, some polyunsaturated fatty acids, individual amino acids, dietary fiber, micro and macro elements.

Therefore, the purpose of our research is to develop scientifically based recipes and technologies for combined protein culinary products based on amaranth processing products.

Among the possible measures to prevent diseases, it should be noted the use of amaranth seed processing products in the production of catering products.

Due to its unique composition, amaranth seed can be considered a nutraceutical, that is, a product that heals the human body. This conclusion was reached by Russian scientists, who summarized the results of a study of flaxseed in laboratories around the world.

The Russian market currently offers the following food products based on amaranth seeds - amaranth oil, flour, amaranth seed cake, cereal mixtures with amaranth seed, mayonnaises and salad dressings based on amaranth oil.

Amaranth cake has a high energy value: 1 kg of cake contains 1.27 k.u., 13.73 MJ (as in 1.3 - 1.4 kg of oats) and 287 g of digestible protein, as well as a rich composition of trace elements and vitamins [1 -4].

It is believed that regular consumption of amaranth helps restore vitality and rejuvenates the body, protects a person from diseases, helps fight tumors, treats impotence, etc.

The stems, leaves and flowers of amaranth are used in folk medicine as a strong hemostatic agent for internal bleeding, water infusions are taken for stomach pains and headaches.

Amaranth is widely used as a food product. It is fried, boiled, dried, baked, added to soups. The stem and young leaves, plucked before flowering, are used like spinach or raw lettuce to make high-protein salads. To make the leaves tender, you can pre-soak them for 2-3 minutes in boiling water, and then cook soup on this water.

Fresh amaranth leaf salad includes green onions, parsley, vegetable oil and salt. Young amaranth leaves are cut into strips, put in a salad bowl, finely chopped green onions and parsley are added, seasoned with vegetable oil.

To prepare cutlets from amaranth leaves, eggs, chopped onions, grated cheese, chopped bread, wheat flour, black pepper, vegetable oil and salt are added to boiled finely crushed amaranth. Everything is thoroughly mixed. If the resulting mass is very thick, then add a little milk. Cutlets are formed, breaded in breadcrumbs and fried. Served with lemon juice.

Meatballs from amaranth seeds are prepared with the addition of flour, minced fish, eggs and salt. Mix all the constituent components until a homogeneous mass is obtained. Form meatballs with a diameter of about 4 cm. Served with mild tomato sauce.

Amaranth leaf soup dressing is made from young leaves that are dried and ground. Used for seasoning soups [19].

Since amaranth leaves do not have a special taste, it is advisable to use them together with other vegetables. You can also prepare for the winter by freezing, drying and canning.

If, when preserving cucumbers for 3 liters, add one leaf of amaranth, then the cucumbers will be fresh and elastic until spring. Amaranth seed flour can be mixed with wheat flour in a ratio of 1:2 and used for baking.

From fresh and dried amaranth leaves, a fragrant drink is obtained. If you add lemon balm and oregano to it, then the tea will not yield to the best Indian varieties in aroma. Toasted amaranth seeds taste like nuts and are especially good in

baked goods. By the way, many food products with amaranth additives have been produced in the USA for a long time. [4-8].

For livestock, amaranth is a wonderful feed, besides, it gives 2-3 cuttings of greenery over the summer. Being a very tall plant, it is excellent for flower arrangement in the form of groups and single plants in the background of the lawn. It is suitable for cutting, which is best used in independent bouquets without adding other flowers.

By the way, amaranth inflorescences have the property not to change their shape or color when dried. In this form, they can be used to arrange dry bouquets.

Along with the adverse impact of technogenic and anthropogenic factors, insufficient human consumption of natural food components comes to the fore, which leads to metabolic disorders and numerous diseases [1]. With such a quality of nutrition, the population of developed countries, including Russia, begins to degrade both in terms of natural population reduction and deterioration of the gene pool [2, 3].

The purpose of the research is the development of fish functional products with herbal biologically active additives, amaranth cake.

#### **Materials and methods**

Amaranth cake is a crushed product of vegetable raw materials, light chocolate color, with a pleasant nutty flavor, from which 8-14% fatty, essential oils are extracted, which provides sorption properties for products made from it. Cake from flax seeds contains a large amount of mucus, which protects the stomach and intestines from mechanical, thermal and chemical irritants. Amaranth oil and amaranth seed meal are the main sources of PUFAs, especially  $\omega$ -3 and  $\omega$ -9, and the most important micro and macro elements.

In the process of research in the formulations of fish semi-finished products, cake of their amaranth seeds was used [13, 15, 18].

Sampling for physical and chemical studies was carried out in accordance with GOST 4288-76, GOST 26313, GOST 27853, GOST 7269-72.

To determine the yield of finished products, a weight method was used using electronic scales MK-3.2-A20 with a resolution of up to 5.0 kg and a measurement error of 0.01. The samples were studied by organoleptic and physicochemical methods. The quality of additives was determined according to GOST 26574-2017. The nutritional value of the samples was determined by the calculation method. Evaluation of "Stanichny" and "Peasant" cutlets, "Merchant" fish - by the method of sensory analysis on a 5-point scale for each indicator (Rodina, Vuks, 1994), the establishment of profiles with descriptors characteristic of this group of products (ISO11053: 1994. ISO 6658:1985).

#### **The object of the study**

The objects of research are fish semi-finished products and culinary products: "Merchant's jellied fish", "Stanichnye" cutlets (with cake from amaranth seeds) and "Peasant" cutlets (with flour from amaranth seeds).

## Results and discussion

To achieve the goal, the following tasks are outlined: to investigate the chemical composition and properties of pollock, to establish the influence of technological factors on the quality indicators of structure-forming raw materials and rheological characteristics during gelation of jelly fillings; consider the influence of the mass fraction of gelling agents in the system; to develop the technology of jelly fillings with milk protein, to investigate the composition and properties; to develop recipes for “Jellied fish “Merchant”, cutlets “Stanichnye” (with cake from amaranth seeds) and cutlets “Peasant” (with flour from amaranth seeds); justify the choice of components of jellied fish. Determine the optimal mass fraction of the structurant in the gelling filling, investigate the physical and chemical properties of fish raw materials, investigate the quality indicators of the finished product during storage; calculate the cost of producing the developed products; develop technical documentation for the production of jellied fish “Merchant”, cutlets “Stanichny” and “Peasant”.

Then, studies of the physico-chemical parameters of chopped fish products were carried out: jellied fish “Merchant”, cutlets “Stanichny” and “Peasant”. Experimental data on the general chemical composition of chopped semi-finished products subjected to heat treatment are presented in tables 1 and 2.

**Table 1**  
*General chemical composition of chopped fish products  
with cake from amaranth seeds*

Indicators	Fish Replacement Level, %					
	Control	3,0	5,0	7,5	10,0	12,5
Влага	66,2±1,11	61.60±1,13	63,58±1,23	66,17±1,35	66,82±1,23	64,34±1,34
Белок	13,4±0,31	20,11 ±0,29	19,81±0,30	19,70±0,32	19,51±0.30	15,91±0,39
Жир	2,68±0,12	3,38±0,11	3,39±0,11	3,31±0,17	3,28±0,17	3,17±0,13
Зола	1,49±0,13	1,45±0,15	1,54±0,11	1,62±0,16	1.64±0,03	1,69±0,05

**Table 2**  
*General chemical composition of fish minced products  
with flour from amaranth seeds*

Indicators	Fish Replacement Level, %					
	Control	3,0	5,0	7,5	10,0	12,5
Влага	66.2	56,20±11,33	56,61±11.24	53,20±11.46	67.20± 11,51	61.12±11.30
Белок	17.4	18.40±0.27	18,38±0.28	18,10±0,26	17.38±0.27	17.21±0.24
Жир	2.3	5.69±0.18	4,71±0.11	4.19±0.22	3.40±0,11	3.41±0.15
Зола	1.2	1.65±0.07	1.97±0.07	2.42±0.08	2.51±0,11	2,65±0.14

The data obtained indicate that as the addition of cake or flour from amaranth seeds in minced fish products tends to some increase in the mass fractions of fat and ash, and in samples with a content of 12.5% of the latter, there is a decrease in the amount of moisture, which correlates with indicators water-holding capacity [9-12].

During heat treatment, all samples containing cake retain more moisture than flour, so less moisture loss is ensured during frying products. With an increase in the amount of food additives, a decrease in the fat content occurs (Table 2), at the same time, the degree of fat oxidation during heat treatment changes slightly, as evidenced by the small values of peroxide and acid numbers of fat. In addition, their values are less than in the control, which is associated with a large amount of fat in the control semi-finished product.

As a result of the research carried out within the framework of the project, with an increase in the addition of cake or flour from amaranth seeds, the content of protein substances increased in products with the replacement of 3% of fish by 9.3%; with a 5% replacement for 7.8%, with a 7.5% replacement for 7% compared to the control product. In the product with the replacement of fish with 12.5% additives, the indicators differ slightly from the control sample. An increase in the amount of fat suggests that the supplement has more fat than skinny pollock.

The protein content in fish and vegetable products with cake differs little from the control sample, only in products with 10% and 12.50% content of both cake and amaranth seed meal, there is a decrease in the mass fraction of protein compared to the control by 5.1% and 6.5%, respectively.

During heat treatment, changes in the protein content in products occur in comparison with semi-finished products. The mass fraction of protein substances increases. This increase can probably be explained by the partial breakdown of protein-polysaccharide complexes formed in mince products as a result of the addition of ground amaranth flour and cake to the samples. The protein part of the additives included in the recipes of minced fish is quite large, therefore it affects both the recipe of the semi-finished product and the physicochemical process that occurs during frying. This assumption is explained by the fact that the nitrogen content in the composition of denatured proteins after heating increases in all products. Along with this, it is possible that the combination of proteins of animal and vegetable origin contributes to the weakening of the protein structure, which led to its more complete hydrolysis [12-18].

One of the most important stages of the work is the study of the functional and technological properties of chopped fish products. The most important characteristic of the technological properties of fish systems is the water-retaining and fat-retaining capacity (Tables 3 and 4).

Table 3  
Water and fat-holding capacity of products with amaranth cake

Object investigations	Fish Replacement Level, %	VUS, %	ZHUS, %	Losses during heat treatment, %
Semi-finished products with cake from amaranth seeds	Control	70,10	65,71	18,80±0,12
	3,0	71,15	72,15	17,92±1,44
	5,0	71,72	77,81	16,19±1,52
	7,5	75,23	80,32	15,51±1,32
	10,0	74,75	84,57	15,07±1,39
	12,5	76,46	87,42	15,04±1,04

Table 4  
Water and fat retaining capacity of products with amaranth flour

Object investigations	Fish Replacement Level, %	VUS, %	ZHUS, %	Losses during heat treatment, %
Semi-finished products with flour from amaranth seeds	Control	68,88	65,77	18,81±1,02
	3,0	69,95	72,19	17,92±1,44
	5,0	72,72	77,91	17,35±1,52
	7,5	75,88	78,21	15,41±1,32
	10,0	75,77	85,57	15,27±1,39
	12,5	78,48	87,72	14,78±1,04

It was experimentally revealed that an increase in the mass fraction of vegetable fillers in model samples of chopped products of the ability of model minced meat

The generally accepted physical and chemical methods of analysis make it possible to determine and control the qualitative and quantitative composition of the product. However, they do not reflect the shelf characteristics of food products. Therefore, the primary task was the organoleptic assessment of the compatibility of the fish mass and the plant component.

### Conclusion

An analysis of the results of the organoleptic evaluation made it possible to establish that the introduction of cake and flour from amaranth seeds into model minced meats has a positive effect on the appearance and consistency. Samples with 3% flour content and 5% oilcake from amaranth seeds have the best quality. Products with a cake content of 12.5% have cracks on the surface; with a cake content of 7.5%, mass delamination occurs on the cut, which is obviously associated with the high humidity of the products. The halls and the taste of amaranth appear. In samples with flour from amaranth seeds, as the level of fish replacement increases over 10%, such organoleptic indicators as taste and smell deteriorate, the consistency is slightly smeared, mucous, the flour contains a certain amount of mucus.

## References

1. Roslyakov Yu.F. Prospects for the use of amaranth in the food industry / Roslyakov Yu.F., Shmalko N.A., Bochkova L.K. // *News of higher educational institutions. North Caucasian region. Technical sciences*, 2004. - S. 92-96.
2. Gapparov M.M., Panchenko S.N., Ugreninov V.G. *Natural products - food of the XXI century* // *Food industry*. 1999. No. 9. S. 58.
3. Paredes-Lopez O. *Amaranth: biology, chemistry, and technology*. Mexico, 1994.
4. Bresler G., Brizzio S.B., Vaamonde G. *Mycotoxin-producing potential of fungi isolated from amaranth seeds in Argentina* // *Int. J. food microbial*. 1995. Vol. 25. № 1. P. 101-108.
5. Bresler G., Vaamonde G., Brizzio S. *Natural occurrence of zearalenone and toxicogenic fungi in amaranth grain* // *Int. J. food microbial*. 1991. Vol. 13. № 1. P. 75-80.
6. Calderon de la Barca A.M., Ochoa J.L., Valencia M.E. *Effect of the extraction of a hemagglutinin on the nutritive value of Amaranthus leucocarpus seeds* // *J. of food sci*. 1985. Vol. 50. № 6. P. 1700-1702.
7. Oleszek W., Junkuszew M., Stochmal A. *Determination and toxicity of saponins from Amaranthus cruentus seeds* // *J. agric. food chem*. 1999. Vol. 47. № 9. P. 3685-3687.
8. Whistler Roy L., Bemiller Tames N. *Carbohydrate chemistry for scientists. - USA: Eagan press*, 1997.
9. Vasyukova A.T. *Special requirements for water used in baking* / Vasyukova A.T., Talbi M. / *In the collection: Topical issues of quality and safety of food raw materials, culinary products, bakery and confectionery industries. Collection of scientific papers of the All-Russian Forum and competition of scientific works. Managing editor: I.U. Kusova. Moscow, 2023. P. 30-38.*
10. Vasyukova, A.T. *Development of food products enriched with a complex of dietary supplements for children* / Vasyukova A.T., Krivosonok K.V., Akchurina A.I., Bogonosova I.A., Bondarenko Yu.V., Alekseeva A.A. / *В сборнике: Process Management and Scientific Developments. Proceedings of the International Conference. Birmingham, 2022. C. 192-199.*
11. Vasyukova, A.T. *The influence of heat treatment of meat products in a combi oven on their quality* / Vasyukova A.T., Edvars R.A., Vasyukov M.V., Lyubimova K.V., Shagarov S.N. / *В сборнике: Process Management and Scientific Developments. Proceedings of the International Conference. Birmingham, 2022. C. 200-206.*
12. Vasyukova, A.T. *Determination of extractive characteristics of products from fish raw materials by NMR studies* / Vasyukova A.T., Krivosonok K.V., Moshkin



A.V., Kobzh Z.N., Vedenyapina M.D., Kuznetsov V.V. / *In the book: Innovations in life sciences. Collection of materials of the IV International Symposium. Rep. editor A.A. Prison. Belgorod, 2022, pp. 334-335.*

13. Vasyukova, A.T. *The influence of dietary supplements on the consumer properties of functional minced meat / Vasyukova A.T., Kusova I.U., Krivoshonok K.V., Edwards R.A., Talby M. // Commodity manager of food products. 2022. № 3. P. 174-179.*

14. Filimonau V. *Food waste in foodservice provided in educational settings: an exploratory study of institutions of early childhood education / Filimonau V., Ermolaev V.A., Vasyukova A. // International Journal of Gastronomy and Food Science. 2022. T. 28. C. 100531.*

15. Vasyukova, A.T. *Regulation of organoleptic indicators and nutritional value of minced systems from lean oceanic fish using functional dietary supplements / Vasyukova A.T., Tikhonov D.A., Tonapetyan T.A. // Food industry. 2020. No. 6. P. 47-51.*

16. Belenkov A. *Impact of various cultivation technologies on productivity of potato (solanum tuberosum) in central non-cenozoic zone of Russia / Belenkov A., Peliy A., Diop A., Vasyukova A., Moskin A., Burlutskiy V., Borodina E. // Research on Crops. 2020. T. 21. № 3. C. 512-519.*

17. *Rational nutrition of organized teams / Vasyukova A.T., Bogonosova I.A., Bazhenov N.S. // In the collection: Applied research and technology ART2019. Proceedings of the regional conference. 2019. S. 28-31.*

18. Vasyukova, A.T. *Products with herbal supplements for a healthy diet / Vasyukova A.T., Slavyansky A.A., Khairullin M.F., Alekseev A.E., Moshkin A.V., Makhmadaliev E.Sh. // Food industry. 2019. No. 12. S. 72-75.*

19. Vasyukova, A.T. *Technology of public catering products / Vasyukova A.T., Slavyansky A.A., Kulikov D.A. - Textbook for bachelors / Moscow, 2018. - 426 p.*

生态监测水体生物膜指示方法  
**METHODS FOR INDICATION OF BIOFILMS IN ECOLOGICAL  
MONITORING WATER BODIES**

**Lenchenko Ekaterina Mikhailovna**

*Doctor of Veterinary Sciences, Full Professor  
Russian Biotechnological University (BIOTECH University),  
Moscow, Russia  
<https://orcid.org/0000-0003-2576-2020>*

**Subbotina Yulia Mikhailovna**

*Candidate of Agricultural Sciences, Associate Professor  
Russian Biotechnological University (BIOTECH University),  
Moscow, Russia*

**Bublik Svetlana Andreevna**

*Student  
Moscow State Academy of Veterinary Medicine and Biotechnology -  
MVA named after K.I. Scriabin, Moscow, Russia  
<https://orcid.org/0000-0002-9058-6927>*

抽象的。 本文总结了水体卫生微生物监测中微生物生物膜指示方法的资料。研究了从鱼类水库水样中分离的参考菌株和分离株的单种和多种生物膜发展动力学的一般规律。 细菌和酵母样真菌生物膜的发展阶段的特点是细胞生物量和细胞外基质的逐渐积累, 以及由细菌、酵母和胶束形式的异质结构共同聚集形成的簇。

关键词: 生物膜、微生物、细菌、酵母样真菌、簇、基质。

**Abstract.** *The article summarizes data on the methods of indication of biofilms of microorganisms during sanitary and microbiological monitoring of water bodies. The general regularities of the development dynamics of monospecies and polyspecies biofilms of reference strains and isolates isolated from water samples of fish reservoirs were studied. The stages of development of biofilms of bacteria and yeast-like fungi were characterized by a gradual accumulation of cell biomass and extracellular matrix, and the formation of clusters from coaggregation of heterogeneous structures of bacterial, yeast, and micillary forms.*

**Keywords:** *biofilms, microorganisms, bacteria, yeast-like fungi, clusters, matrix.*

## Introduction

Biofilms are the predominant, possibly exclusive, form of development of microorganisms in natural ecotopes, including water bodies [1]. With a global change in natural and climatic conditions, an increase in anthropogenic load, the risks of the occurrence and development of diseases of aquatic organisms increase [2, 3]. The rapid growth of anthropogenic loads and pollution of water bodies contribute to a decrease in the natural resistance of the organism of aquatic organisms [4, 5, 6, 7]. The development and outcome of the infectious process are mediated by both the resistance of susceptible animal species and the adaptive potential of heterogeneous biofilms [8]. The ability to regulate the expression of the gene expression of microorganisms, “Quorum sensing”, yeast-like fungi at the earliest stage of hyphae development is inhibited by polyhydric alcohols, in particular, farnesol [9]. When developing effective measures to combat infectious pathology, preventive measures are the analysis of statistical reporting data on the etiological structure of infectious pathology to replenish the epizootic data bank by region [3]. Comparative evaluation and development of effective methods for studying biofilms will improve the methods and methods for assessing biological safety and manage the risks of contamination of raw materials of animal and vegetable origin when organizing control of critical points of agricultural technologies. In addition to applied aspects, the empirical substantiation of the methodology for studying the etiological structure of infectious pathology expands the boundaries of knowledge of evolutionary microbiology.

**The purpose of the research:** to test and select effective methods for indicating biofilms of microorganisms during sanitary and microbiological monitoring of water bodies

## Research methods

Reference strains of bacteria *Aeromonas hydrophila* ATCC 22492, *Candida albicans* ATCC 10231, as well as isolates isolated from fish pond water samples were used in the experiments. Microorganisms were cultivated at  $22\pm 1^\circ\text{C}$  for 6-72 h on *Difco bacto agar* media (*Difco*, USA); “*Nutrient Both*” (“*Hi Media*”, India); “*Blood Agar Base*” (“*Biomerieux*”, France). Bacteriological and mycological studies were carried out by conventional methods [8, 9, 10]. The preparations were fixed with a mixture of alcohol and ether (1:1), for 10 minutes, and stained with aniline dyes. The assessment of the presence of biofilms of microorganisms was carried out with a representative sample of a reliable frequency of occurrence  $\geq 90.0\%$  of the field of view of the optical microscope “BIOMED MS1 Stereo” (Russia).

## Research results and discussion

Comparative evaluation of preparation staining methods showed that 0.1% solution of gentian violet allows to detect blue cells and pale red extracellular

matrix. Staining with 0.5% methylene blue solution is effective for differentiating the degree of formation of yeast-like fungi. Gram staining makes it possible to differentiate Gram-negative and Gram-positive bacteria in polyspecies biofilms. The stages of development of biofilms of both bacteria and yeast-like fungi were characterized by the formation of clusters from coaggregation of heterogeneous structures of bacterial, yeast, and micillary forms united by exocellular structures. During the formation of biofilms, the implementation of the processes of intercellular communication was accompanied by adsorption, i.e., settling and the so-called reversible adhesion by the attachment of planktonic bacterial cells and yeast forms to the surface of the substrate. Attachment of cells to the surface of the substrate occurred due to the release of ecocellular polymers that provide coaggregation and strong fixation. Tightly packed, surface-attached microorganisms, retained by the extracellular matrix, facilitated the attachment of subsequent cells. Gradually, closed structures of various sizes of microcolonies were formed - a diffuse layer of bacterial cells and yeast forms, united by an exocellular matrix. Due to the process of coaggregation of the formation of intercellular bonds, densely packed cell structures of various sizes were revealed, united by an intercellular matrix - these are microcolonies. The formation of biofilm architectonics during the development of the population was ensured by the synthesis of an ecocellular matrix consisting of complex mobile gel structures. The presence of microorganisms attached to the substrate promotes the attachment of subsequent cells. The formation of secondary microcolonies was observed, part of the cells of the secondary microcolony was associated with primary microcolonies. As a rule, detached planktonic forms were detected on the periphery, and areas of biofilms separated by matrix voids were detected. The presence of cell strands united by a common matrix, intercellular connections determined the population immobilization of bacteria. On the surface of biofilms, exocellular substances were detected in the form of polymeric networks, which determine the mechanical stability of the population. In some areas, destructive processes of the intercellular matrix were revealed, as well as the dispersion of microorganisms that retained the ability to adhere and form new microcolonies. Cell dispersion in biofilm clusters occurs passively as a result of shear stress, and not as a result of scattering caused by a signal from a transcription regulator that controls the degree of migration of heteromorphic structures.

Promising for reducing the formation of biofilms by microorganisms should be recognized as preparations containing substances that regulate the processes of hyphae formation and initiate protein synthesis. For bioremediation, the use of biofilms is preferable, due to the fact that this type of microorganism community is more resistant to changing environmental conditions compared to planktonic forms of microorganisms.

Methodological approaches to diagnostic research and the development of anti-epizootic measures for fish aeromonosis and candidiasis, as well as for other in-

fectious pathologies, are based on the use of multi-level diagnostic algorithms, in accordance with the use of a complex of epizootological, clinical-morphological, mycological, and statistical research methods.

### Conclusion

1. Stages of development of monospecies and polyspecies biofilms were characterized by the formation of clusters from coaggregation of heterogeneous structures of bacterial, yeast, and micellar forms, united by exocellular structures.

2. Preparations containing substances that regulate the processes of hyphae formation and initiate protein synthesis are promising for reducing the formation of biofilms by microorganisms.

### References

1. Nozhevnikova A. N. Bochkova E.A., Plakunov V.K. *Multivodic biofilms in ecology, medicine and biotechnology \ Microbiology*, 2015, Volume 84, No. 6, p. 623–644.

2. Vasiliev A.G. *Evolution of the immune system and regulatory effects of antibodies / A.G. Vasiliev, L.P. Churilov, A.P. Trashkov [et al.] // Tsitol. - 2018. - V. 60, no. 2. - S. 71-80.*

3. Rudakova S. L. *Ensuring the ichthyopathological well-being of objects and farms of aquaculture in Russia / Proceedings of VNIRO. - 2016. - T. 162 - S. 104-115.*

4. Pronina G.I. *Immunity of poikilothermic hydrobionts. / G. I. Pronina, A. A. Ivanov, A. G. Mannapov [and others] // Proceedings of the Timiryazev Agricultural Academy. - 2021. - 2. - S. 71-91. - DOI: 10.26897/0021-342X-2021-2-71-91.*

5. Kodama H. *Granulocyte responses to experimental injection of live and formalin-killed bacteria in carp (Cyprinus carpio) / Hitoshi K., Kiyohiko T., Tadaaki M. et al // Veterinary Immunology and Immunopathology. - 2020. - Vol. 90, Issues 1-2. - P. 101-105. - DOI: [https://doi.org/10.1016/S0165-2427\(02\)00230-1](https://doi.org/10.1016/S0165-2427(02)00230-1).*

6. Meng, X., Wu, S., Hu, W., Zhu, Z., Yang, G., Zhang, Y., Qin, C., Yang, L. and Nie, G. *Clostridium butyricum improves immune responses and remodels the intestinal microbiota of common carp (Cyprinus carpio L). Aquaculture. - 2021. - 530(4): 735-753.*

7. Overland H.S. *Phagocytosis by B-cells and neutrophils in Atlantic salmon (Salmo salar L.) and Atlantic cod (Gadus morhua L.) / H.S. Overland, E.F. Pettersen, A. Ronneseth et al // Fish Shellfish Immunology. - 2020. - Vol. 28 - P. 193-204. - DOI: <https://doi.org/10.1016/j.fsi.2009.10.021>*

8. Lenchenko E. Interaction of *Cyprinus carpio* Linnaeus with the biofilm-forming *Aeromonas hydrophila* / E. Lenchenko, S. Lenchenko, N. Sachivkina et al // *Veterinary World*. - 2022. - 15 (10). - R. 2458-2465. - DOI: [www.doi.org/10.14202/vetworld.2022.2458-2465](http://www.doi.org/10.14202/vetworld.2022.2458-2465).

9. Sachivkina N. Reduction in Pathogenicity in Yeast-like Fungi by Farnesol in Quail Model // N. Sachivkina, E. Vasilieva, E. Lenchenko et al // *Animals*. - 2022. - Vol. 12 (489). - DOI: <https://doi.org/10.3390/ani12040489>.

10. E. Zahran, R. Engy, F. AbdelHamid et al // *Fish & Shellfish Immunology*. - 2014. - Vol. 38, Issue 1. - P. 149-157. - DOI: <https://doi.org/10.1016/j.fsi.2014.03.002>.

狭义相对论：孪生悖论

## SPECIAL THEORY OF RELATIVITY: THE TWINS PARADOX

Vinogradov Evgeniy Leonidovich

Doctor of Technical Sciences, Full Professor

St. Petersburg Polytechnic University of Peter the Great

注解。在相对论运动学或 A. Einstein - STR 的狭义相对论中，空间坐标和时间的变换  $\{x, y, z, t\} \rightarrow \{\xi, \eta, \zeta, \tau\}$  被认为是在从一个惯性转换过程中参考系统 (IRS) 到另一个也是惯性的，它沿着直线轨迹以非常大的恒定速度  $v_0 \leq c$  ( $c$  是不可逾越的光障，即光在真空中的传播速度) 远离静止系统  $c \cong 3 \cdot 10^8$  米/秒)。严格证明，移动的 IRS 2 中的时间流变慢， $\Delta t > \Delta \tau$ 。这种效应通常被称为双胞胎悖论——两个处于不同参照系的观察者使用相同的时间间隔测量仪器。在经典 STR 中，时间变换在系统 2 加速移动且非惯性的情况下未被研究。本文致力于研究双胞胎在这种更复杂情况下的讨论效果。

关键词：相对论，参照系加速，孪生效应。

**Annotation.** In relativistic kinematics or in the special theory of relativity of A. Einstein - STR, the transformation of spatial coordinates and time  $\{x, y, z, t\} \rightarrow \{\xi, \eta, \zeta, \tau\}$  is considered during the transition from one inertial reference system (IRS) to another, also inertial, which moves away from the motionless system 1 along a rectilinear trajectory with a very big constant speed  $v_0 \leq c$  ( $c$  is an insurmountable light barrier, that is, the speed of light propagation in vacuum  $c \cong 3 \cdot 10^8$  m/s). It is strictly proved that the flow of time in a moving IRS 2 slows down,  $\Delta t > \Delta \tau$ . This effect is commonly called the paradox of twins - two observers who are in different reference frames and have the same instruments for measuring of time intervals. In classical STR, time transformation is not investigated in circumstances when system 2, move with acceleration and is not inertial. This article is devoted to the study of discussed effect of twins in such more complex situation.

**Keywords:** relativity theory, acceleration of reference frames, twins effect.

### Introduction

STR is based on two postulates. The first of them - the principle of relativity - is intuitively recognized as unquestionable. It states that all physical laws are invariant with respect to the transition from one inertial frame of reference to another. According to the second postulate, the speed of propagation of electromagnetic

waves, including light waves, does not depend on the direction of movement of their sources and receivers. Such a statement, of course, cannot but cause doubts, since it clearly contradicts the “everyday” experience, that is, the results of visual observation of the movement of massive “slow” substance objects. However, as accurate instrument experiments show, both STR postulates are correct.

The paradoxical “crazy” idea of A. Einstein about the absence of the influence of the motion parameters of sources and receivers of electromagnetic radiation on the speed of its propagation, in contrast to the “trivial” principle of relativity, is far beyond both the “everyday” experience and classical physics of the XIX century. The perception of this idea first led to the creation of relativistic kinematics, also paradoxical in general, and then to the formation of modern natural science [1].

Let’s present examples of the paradoxicity of STR. Impeccable mathematical logic, based on the postulates quoted above, leads to the following conclusions:

- there is a light barrier  $c$ ;
- space and time are inextricably linked;
- the mass of a physical object increases with increasing speed of its movement;

- finally, in accordance with the twins paradox, the time intervals  $\Delta t$  and  $\Delta \tau$  measured in the motionless and moving inertial reference systems do not coincide,

$$\Delta t > \Delta \tau, \Delta t = \Delta \tau / \sqrt{1 - v_0^2 : c^2} \quad (1)$$

( $v_0 < c$  is the velocity module of the moving IRS).

What does the relation between values  $\Delta t$  and  $\Delta \tau$  look like in the case when the moving system of reference is not inertial? This article proves that the answer to this question is not difficult to obtain if we use the additions to the special theory of relativity described in [2].

### The results achieved and their discussion

Suppose, at the initial moment of time, there is a material object in the center of the reference frame 1 and the dimensions of this object are insignificant (it is the material point – MP). The center of system 2, which coincides with the center of the first system, is rigidly connected with MP. At this moment, the MP begins to move along the  $x$ -axis with acceleration  $\vec{a}$ ; along with it, the second system moves accelerated, without rotating. The MP in system 2 remains motionless during the entire observation time, so that  $\xi = \eta = \zeta = 0, \frac{d\xi}{dt} = 0$ . If the reference frames were

moving apart at a constant speed  $\vec{v}_0$  not exceeding  $\vec{c}$ , then, as follows from laws of classical SRT, an observer located in the center of a motionless system would have recorded the coincidence of the velocities of MP and system 2,  $\frac{dx}{dt} = v_0$ . It is



natural to assume that in a more difficult situation  $\frac{dx}{dt} = v = v(t)$ . At the same time,

however, one should not forget about the existence of an insurmountable light barrier, so that the rate of increase in the speed of MT and system 2 over time cannot but decrease to zero. By the way, it should be noted that for the interpretation of this phenomenon it is not necessary to invent some retarding forces – it is explained within the framework of relativistic kinematics by the fundamental properties of space-time.

This article does not define the exact type of dependence  $v(t)$ ; it is proposed to approximate it with a function, which at  $t \rightarrow 0$  tends to  $at$ , and whose slope to the abscissa axis with an unlimited increase in the argument (at  $t \rightarrow 0 \infty$ ) monotonically decreases to zero:

$$v(t) = \frac{dx}{dt} = c \left[ 1 - \exp\left(-\frac{at}{c}\right) \right]. \quad (2)$$

If the object with which the non-inertial frame of reference is connected first moved away from the stationary observer at a speed  $\bar{v}_0$ , and then at the moment  $t = 0$  began to slow down with acceleration ( $-\bar{a} = const$ ), then up to a stop at  $t = v_0/a$

$$v(t) = \frac{dx}{dt} = v_0 - at. \quad (3)$$

Taking into account the assumptions made, we will now establish the relations between the time intervals  $\Delta t$  and  $\Delta \tau$ . To do this, it is not enough in formula (1) to replace the constant velocity  $v_0$  with a function (2) or (3) – you also need to keep in mind the unidirectionality of time. It turns out, with accelerated movement along the  $x$ -axis in any direction MP and the associated system 2

$$\Delta \tau = \int_0^{\Delta t} \left[ 1 - \left( 1 - e^{-at/c} \right)^2 \right]^{1/2} dt < \Delta t; \quad (4)$$

in cases of delayed removal to a stop of the non-inertial system 2 from the motionless system 1 and delayed convergence of the two systems

$$\Delta \tau = \int_0^{\Delta t} \left[ 1 - \left( \frac{v_0 - at}{c} \right)^2 \right]^{1/2} dt < \Delta t. \quad (5)$$

## Conclusion

In the classical special theory of relativity, it is proved that a certain event occurring in two inertial reference frames, one of which is motionless and the other is moving at a high constant speed, are characterized by mismatched time intervals.

This effect, called the twins paradox, is a consequence of the continuity of space and time, it not evidence of a change in the time characteristics of the observed event when the place of its observation changes.

Indeed, the twins (experimenters who are in different IRS) are identical from all points of view: they study the same event, use the same measuring instruments, each of them moves away from a colleague at the same speed, each can claim a slowdown in the passage of time in a different frame of reference – and at the same time both of them they will make a mistake. The fact is that it is impossible to study events occurring in other reference frames with the instruments at hand.

The situation changes fundamentally if one of the reference systems is non-inertial. It follows from equations (4) and (5) that time flows more slowly in such a system. This means that an astronaut who went on an interstellar journey and returned to Earth had been in non-IRS at least four times. He turned out to be younger than the homebody – his twin brother. Is it fantastic?

### References

1. Fok V. A. *Theory of space, time and gravity*. Moscow: State Publishing House of Technical and Theoretical Literature. 1955, 504 p. (rus)
2. Vinogradov E. L. *Relativistic kinematics: Transformation of spatial coordinates and time during the transition from an inertial frame of reference to a non-inertial one*. Collection of scientific articles on the results of the International Scientific Forum «Science and Innovation –Modern Concepts». Moscow: Infiniti. 2022, pp. 68-76. (rus)

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别拉肖夫六轴飞行器  
**BELASHOV HEXACOPTER**

**Belashov Alexey Nikolaevich**

*Theoretical Physicist*

*ORCID 0000-0002-4821-8004*

抽象的。 这篇文章致力于一种无人驾驶飞行器，它能够在没有操作员的帮助下根据给定的程序以任何速度在水平或垂直方向上移动，具有快速爬升、在水平方向上发展高速和绕过的能力 沿途的任何障碍物或悬停在距物体给定距离的物体上。 无人驾驶飞行器旨在保护边界，对必要的物体进行空中测量或在没有操作员参与的情况下将必要的货物运送到指定地点。 用于军事用途时，无人机可以配备智能识别系统，在出现危险时迅速改变运动轨迹，远离武器，无需操作员参与。

关键词：无人驾驶飞行器，军事发展，六轴飞行器，无人机，无人驾驶飞机，直升机，未来自动化。

**Abstract.** *The article is devoted to an unmanned aerial vehicle that is capable of moving in a horizontal or vertical direction at any speed without the help of an operator according to a given program with the ability to quickly climb, develop high speed in the horizontal direction and bypass any obstacles along the way or hover over an object on given distance from it. An unmanned aerial vehicle is designed to protect borders, conduct aerial surveys of the necessary objects or deliver the necessary cargo to a given point without the participation of an operator. When used for military purposes, an unmanned aerial vehicle can be equipped with an intelligent recognition system and quickly change the trajectory of movement and move away from weapons when any dangers appear to it without the participation of the operator.*

**Keywords:** *unmanned aerial vehicle, military developments, hexacopter, UAV, drones, copters, automation of the future.*

Since ancient times, mankind has sought to the sky to fly like birds or move something through the air. An analogue of the oldest aircraft in the world is a bamboo helicopter, invented in China around 400 BC in the form of a toy, which flew up if its main rod was quickly spun. With the progress of mankind, people began to use other types of aircraft in the form of flying lanterns or balloons. The first manned balloon flight, which was invented by the Montgolfier brothers, was

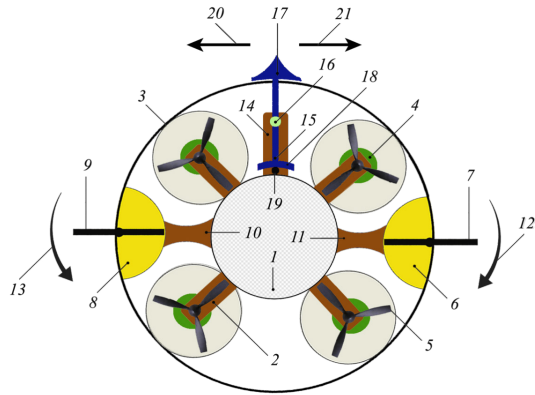
carried out by aviation pioneers Pilâtre de Rozier and the Marquis d'Arlande in 1783 in Paris. Later, the ornithopter was invented, which was inspired by the flight of birds and is an airplane that flies by flapping its wings. One of the earliest concepts for such an aircraft was developed by Leonardo da Vinci in the 15th century.

A helicopter is a rotary-wing aircraft that can take off and land vertically, hover and fly in any direction. Over the past centuries, there have been many concepts similar to modern helicopters that are analogues of unmanned aerial vehicles, but it was not until 1936 that the first working Focke-Wulf Fw 61 helicopter was built.

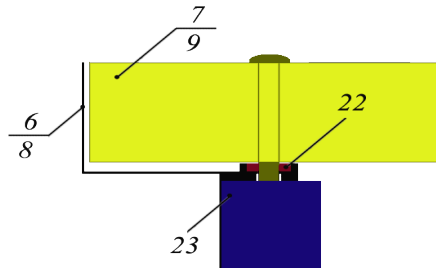
Currently, a new progressive direction in science and technology is unmanned aerial vehicles controlled by radio signal. The pioneer of robotics and the founder of radio-controlled moving machines, engineer and inventor Nikola Tesla, who demonstrated a miniature radio-controlled ship in 1899 at an exhibition in Madison Square Garden, can be considered to control aircraft.

At present, unmanned aerial vehicles related to the field of aviation technology have many modifications and all of them are almost similar in their design data and differ little from each other, but have a complex control system that only qualified specialists can handle. In the current models of unmanned aerial vehicles, it is very difficult to lay down an intelligent system to protect it from unforeseen situations that the operator who launches the unmanned aerial vehicle may not know about.

Unmanned aerial vehicle Belashov figure 1 contains a container 1. Around the container 1 is fixed an even or odd number of rigidity 2 associated with the fairing fairing 3. On the basis of the rigidity 2 fixed engines 4, which by means of rolling or sliding elements are connected with propellers 5 used for vertical moving the unmanned aerial vehicle up or down. The rim fairing 3 contains a recess 6 with a turbine 7 and a recess 8 with a turbine 9, which are connected with the container 1 by means of stiffness 10 and stiffness 11. The air turbine 7 is designed to rotate clockwise 12, and the air turbine 8 is designed to rotate counterclockwise 13. The air turbine 7 and the air turbine 8 serve to horizontally move the unmanned aerial vehicle forward or backward. On the basis of the container 1 fixed rigidity 14 with a rotary control mechanism 15 mounted on the hinge 16. The rotary mechanism 15 is made in the form of a divider of air flows 17 and the control system 18 interacting with the reversible motor 19, which serves to turn the unmanned aerial vehicle in motion in the direction 20 and direction 21.



**Figure 1.** The air turbine 7 and the air turbine 9 through the rolling or sliding elements 22 interact with the reversible engine 23, which is rigidly connected to the rim fairing 3 and the container 1.



**Figure 2.**

The purpose of this invention is to simplify the control methods of unmanned aerial vehicles, which will have better performance and have only signals up or down, left or right, forward or backward as control. Moreover, all controls are speed-related, which facilitates their maintenance, programming and management without involving additionally qualified specialists.

In conclusion, we can say that unmanned aerial vehicles that are made in this design will be in demand in our national economy for the delivery of goods or the inspection of especially dangerous objects. For military purposes, this type of unmanned vehicle will be in demand for reliable border protection, which can, along a previously set trajectory, examine any hard-to-reach sections of the border in one direction and, after refueling at certain points, autonomously return to the starting point. For military purposes, this unmanned aerial vehicle can be equipped with

an intelligent protection system that is capable of timely diverting the unmanned aerial vehicle from all dangers to a safe distance at high speed using sensors to detect any threat to its security.

### References

1. O.Yu. Agapov, S.V. Bedenko "Unmanned aerial vehicle" application for invention No. 2017127075 dated 07.27. 2017.
2. S. P. Stroukhov "Aerodynamics of propellers and ring propellers", Moscow, ed. «Fizmatlit», 2014, pp.23-25.
3. A.N. Belashov, patent of the Russian Federation "Belashov's universal electric machine", 2118036 KL H 02 K 23/54, 27/24, 27/00 for 1998.
4. A.N. Belashov, patent of the Russian Federation "Belashov screw", No. 2046996 KL. F 03 D 7/00 for 1995.
5. A.N. Belashov, patent of the Russian Federation "Belashov generator", No. 20258847 KL. F 03 D 7/00 for 1994.
6. S.V. Bedenko, S.V. Butsev, A.V. Zanozin, A.N. Rudenok, I.A. Rudenok "Complex for the formation of a signal-interference environment". Application for invention No. 2016127154 dated May 7, 2016.
7. A.N. Beloglazov and A.P. Ponamarev, patent for UM 88372 "Astroflex composite reinforcement" KL E 04C 5/07 for 2009.
8. A.N. Belashov, "Discoveries, inventions, new technical developments."  
URL: <http://www.belashov.info/index.html>
9. L.A. Sena, book "Units of physical quantities and their dimension", publishing house "Nauka" Main editorial office of physical and mathematical literature, Moscow, 1988.
10. V.I. Grigoriev, G.Ya. Myakishev, "Forces in Nature", Moscow "Nauka", 1988.
11. O.F. Kabardin, book "Physics, reference materials", publishing house "Prosveshchenie", Moscow, 1988.
12. V.E. Kitaev and L.S. Shlyapintokh, the book "Electrical Engineering with the Basics of Industrial Electronics", "Higher School", publishing house Moscow, 1973.

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磁性材料的无核原子形成磁铁的证据

## EVIDENCE OF THE FORMATION OF A MAGNET FROM NUCLEAR-FREE ATOMS OF A MAGNETIC MATERIAL

**Belashov Alexey Nikolaevich**

*Theoretical Physicist*

*ORCID 0000-0002-4821-8004*

抽象的。这篇文章致力于证明磁性材料的无核原子形成磁体的证据，该证据由理论物理学家 A.N. 于 2016 年发现并发表在科学期刊上。Belashov, 它基于德国实验物理学家 Philipp Eduard Anton von Lenard 于 1903 年开发的无核原子动力学模型的发现。这种无核原子模型部分类似于太阳系结构的行星模型，其中将太阳系行星保持在其轨道上的主要功能是由外层空间物质或旧名称执行的“宇宙以太”和我们恒星周围的小自由落体加速度。在无核原子中，该功能由所研究物质体的物质执行，该物质体具有自己的密度和不同数量的电子偶极子，这已被太阳系行星形成的新定律所证实。

关键词：磁性原子结构，原子无核结构，反驳原子核模型，原子电子偶极子。

**Abstract.** *The article is devoted to the evidence of the formation of a magnet from nuclear-free atoms of a magnetic material, discovered and presented in a scientific journal in 2016 by the theoretical physicist A.N. Belashov, which was based on the discovery of a dynamic model of a nuclear-free atom developed in 1903 by the German experimental physicist Philipp Eduard Anton von Lenard. This model of a nuclear-free atom partially resembles a planetary model of the structure of the solar system, where the main function of keeping the planets of the solar system in their orbits is performed by the substance of outer space, or by the old name “cosmic ether” and a small free fall acceleration around our star. In a nuclear-free atom, this function is performed by the substance of the studied material body, which has its own density and a different number of electron dipoles, which were confirmed by the new laws of the formation of planets in the solar system.*

**Keywords:** *structure of a magnetic atom, nuclear-free structure of an atom, refutation of the nuclear model of an atom, electron dipoles of an atom.*

Since ancient times, magnets have been considered a very mysterious thing. The Greeks also called magnetic iron ore - the stone of Hercules. And even now,

many are excited by the idea of creating some kind of magnetic device that, without outside interference, will perform constant work or constant movement, like magnetic dipoles in a magnetic system. However, in the atoms of magnetic materials, magnetic dipoles are inactive and begin to move or do work if they are subjected to any external or internal action.

At the end of the 19th and the beginning of the 20th centuries, many new scientific discoveries occurred, which forced to reconsider a number of basic provisions of Newton's classical physics, who was far ahead of several generations of his followers in his scientific insights, and established a new view of this world. An opponent of the theory of relativity and changes in the direction in the study of physics was the winner of the Nobel Prize in Physics in 1905, for research work on cathode rays, Philipp Eduard Anton von Lenard, a German experimental physicist, author of many works in the field of solid state physics and atomic physics. In 1936, Lenard's textbook German Physics in Four Volumes was published. He described only areas of classical physics and did not deal with either quantum mechanics or the theory of relativity. The discoveries of modern physics were explained using the theory of the ether and the atomic model of Johannes Stark.

The first models of the structure of the atom appear at the very beginning of the 20th century. The French physicist Jean Baptiste Perrin in 1901 proposed a nuclear-planetary structure of the atom. The model of the structure of the atom was widely used in 1902 by the cake model of the atom by the British physicist, mechanic and engineer William Thomson, who suggested that the atom is a bunch of positively charged matter, inside which electrons are evenly distributed. A similar model was proposed in 1904 by the Japanese physicist Hantaro Nagaoka. A detailed model of the structure of the atom was developed by the English physicist Joseph John Thomson, who believed that the electrons inside a positively charged ball are located in the same plane and form concentric rings and proposed a method for determining the number of electrons in an atom, based on the scattering of X-rays, based on the assumption that electrons should be scattering centers. Experiments have shown that the number of electrons in the atoms of elements is approximately half the size of the atomic mass. Joseph John Thomson suggested that the number of electrons in an atom increases continuously from element to element and for the first time tried to connect the structure of atoms with the periodicity of the properties of elements.

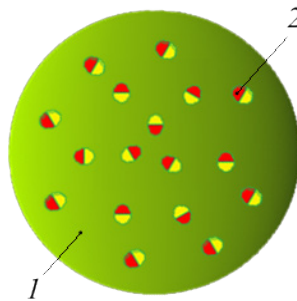
The basis of the modern theory of the structure of the atom is the planetary model, supplemented and improved. According to this theory, the nucleus of an atom consists of protons (positively charged particles) and neutrons (uncharged particles). And around the nucleus, electrons (negatively charged particles) move along indefinite trajectories.

Scientists who adhere to these views on the given structure of the atom need to answer one elementary question who inside each atomic nucleus determines the



chemical composition and properties of the material under study, the number of rotating electrons and distributes them over different levels, for example, during the melting of copper and zinc in various proportions. Indeed, the model of the atom in some way corresponds to the planetary structure of the planets of the solar system. The planets of the solar system are kept in their orbits with the help of the substance of outer space «cosmic ether» emanating from the surface of the Sun. The matter of the substance of outer space emanating from our star has its own composition, mass, density and energy, which is distributed throughout the solar system, holding and connecting all cosmic bodies in their orbits. Inside the atom of the material under study, which has its own individual density, electron dipoles interact with each other using the forces of gravitational attraction, counteraction forces and interaction forces that can be determined according to the new laws of physics discovered by A.N. Belashov.

However, the atom has a great difference from the planetary system, since the atom does not have a nucleus. The main function of keeping the planets of the solar system in their orbits is the substance of outer space or, according to the old name, «cosmic ether» emanating from our star. In the nuclear-free atom of figure 1, this function is performed by the substance of the investigated material body 1 given by the chemical and physical properties of the studied material, which has its own density and a different number of neutral particles 2 «dynamide».



*Figure 1.*

As mentioned earlier in the modern interpretation, this expression can be defined as «electronic dipoles», as pointed out by the German experimental physicist Philipp Eduard Anton von Lenard.

It should be emphasized that after a detailed study of new discoveries explaining the mechanism of formation of the Sun's magnetic field, the mechanism of formation of the substance of outer space, the mechanism of movement of the planets of the Solar System around the Sun and the law of determining the distance

from the surface of the Sun to any planet of the Solar System, it becomes clear that the previously approved model of the structure atom is not consistent. In fact, the model of the atom, which was proposed by the German experimental physicist Philipp Eduard Anton von Lenard, is the most relevant. An atom, according to the Lenard model, consists of neutral particles «dynamide» in the translation into modern language «electronic dipoles» located in the substance of various materials having different physical and chemical properties, having different properties and different density of the substance of the material under study. According to this model of the structure of the atom, it is easy to explain the electrical, electromagnetic and dielectric properties of any material. According to the new laws of forces of gravitational attraction, forces of reaction and interaction, it is possible to determine the different forces that arise between electronic dipoles, and also to understand the mechanism of movement of electric charges through a conductor or semiconductor, it is easy to explain the mechanism of diffusion between different metals during their long contact, and so on. .

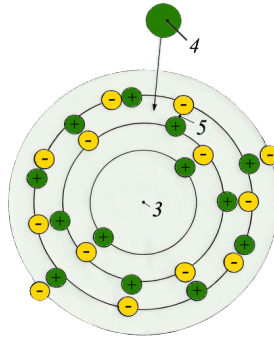
The most important thing in the structure of such an atom is that the studied materials, different in physical properties, having different densities, when they are fused, a new material is formed with different physical and chemical properties of the material. It must be remembered that in any atom there is no nucleus, which, as it were, should be responsible for the chemical and physical properties of this material, and even in their percentage and a different number of electron dipoles, which are distributed over different levels.

In my opinion, the atomic model proposed by the German experimental physicist Philipp Eduard Anton von Lenard is closer to reality. The atom, according to Lenard's model, consists of neutral particles «dynamide», each of which is an electric doublet. The calculations performed by Lenard showed that these particles must have extremely small dimensions, and, consequently, most of the volume of the atom is a void. The concentration of the mass of an atom in a small part of its volume was partly confirmed by the experiments carried out by Leonard in 1903, in which a beam of fast electrons easily passed through a thin metal foil.

The mechanism of formation of a magnet from non-nuclear atoms of a magnetic material was discovered and popularly described in the scientific and practical journal «Journal of Scientific and Applied Research» No. 09 for 2016, page 48. «Infiniti» Publishing House, Ufa. From the previously published materials, which were based on the laws and mechanisms of the formation of the planets of the solar system, it was clear that the atom does not have a nucleus, and its electrons form dipoles with the help of gravity, which is confirmed by the excerpts from this article.

Figure 2 shows a nuclear-free atom of a magnetic material that does not have a nucleus 3. After an increase in energy from an external source of electric charge

4, active and passive electrons of the magnetic material inside the atom form dipoles 5, which have magnetic properties. According to the planetary model of the structure of the atom, it was mathematically proved that two electrons of the first row form gravitational forces between electrons several tens of thousands of times greater than the gravitational force of each electron of the first row «to the nucleus» of the atom.



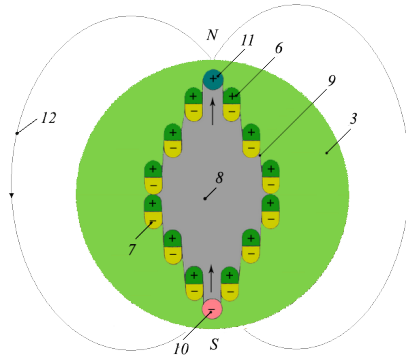
*Figure 2.*

In a previous article, “The Mechanism of the Formation of a Magnet from Atoms of a Magnetic Material”, it was concluded that if an atom of a magnetic material is divided into dipoles, then two electrons of each dipole will have magnetic properties. A dipole is a system of two oppositely equal charges (electric or magnetic) located in close proximity to each other. The electrons of the dipole of an atom are characterized by their moment, which is a vector that is directed from a negative charge to a positive charge.

The evidence of the internal structure of a nuclear-free atom was confirmed and popularly presented at the international scientific conference «Scientific research of the SCO countries: synergy and integration», which took place on February 10, 2023 in Beijing, China.

As a result of a detailed analysis of new scientific discoveries, it is necessary to clarify that the space of atom 3 has peculiar properties and an individual density of the studied magnetic material, which does not have a barrier gap.

After connecting the atom of figure 3 of the magnetic material to an external source of electric charge 4, the energy inside it begins to increase. With an increase in energy inside the atom of the magnetic material, the gravitational forces begin to decrease, and the atom 3 accumulates and fills with additional electron dipoles 5 having positive poles 6 and negative poles 7, which makes the atom of the magnetic material enriched.



**Figure 3.**

With an increase in energy inside the atom of the magnetic material, the atom of the magnetic material is saturated and the density increases inside the formed chamber 8 of the closed space 9. When the depleted electron dipoles enter through the passage 10 in the closed space 9 of the chamber 8, the depleted electron dipoles are converted into magnetic dipoles emerging through the passage 11.

It must be emphasized that magnetic dipoles are very different from electronic dipoles, since electronic dipoles cannot freely penetrate dielectric materials, and magnetic dipoles freely pass through any medium, depending on the power of the magnetic source, and do not release any radiant energy.

After the atom of the magnetic material 3 is completely saturated with positive electrons 4 in the space of the atom between the electronic dipoles 5, magnetic field lines 12 start to act, emanating from the north pole to the south pole. In this case, it is necessary to pay special attention to the fact that magnetic field lines consist of magnetic dipoles, which are interconnected by the forces of gravity and the energy of the dipole itself. No work is done inside and outside the magnetic system, since there is no external or internal influence on the magnetic dipoles and magnetic lines of force 12. At this stage, the process of creating an atom of magnetic material is completed.

In order to calculate the interaction forces between electronic or magnetic dipoles inside atoms, it is necessary to use the new Belashov laws based on the inverse speed constant of light. First of all, it is necessary to proceed from the fact that electrically charged particles from the power of an energy source come from the diffusion of an electric charge.

The power of the radiation source can be calculated according to the following law.

$$P = \frac{F_i}{B_1} = \frac{\kappa_2 \cdot M}{c^2} \cdot \frac{M}{c} = \frac{\kappa_2 \cdot M^2}{c^3} = Bm$$

where:

P - power of electric source, W

F<sub>i</sub> - the strength of the source of electric charge passing through the conductor, N

B<sub>1</sub> - constant of the reverse speed of light of the measured material body, s/m.

The strength of the source of electric charge can be calculated according to the following law.

$$F_i = \frac{U \cdot I}{g \cdot t} = \frac{P}{g \cdot t} = \frac{\kappa_2 \cdot M^2}{c^3} = \frac{c^2}{M} \cdot \frac{M}{c} = \frac{\kappa_2 \cdot M}{c^2} = H$$

where:

F<sub>i</sub> - electric charge source strength, N

B<sub>1</sub> - constant of the reverse speed of light of the measured material body, s/m

U - voltage of the electric charge source, V

P is the power of the electric charge source, W

I - current strength of the source of electric charge, A.

The diffusion coefficient of the electric charge emanating from the energy source can be calculated according to the following law.

$$D = \frac{F_i \cdot I \cdot R}{g \cdot t} = \frac{\kappa_2 \cdot M}{c^2} \cdot \frac{A \cdot c^3}{\kappa_2 \cdot M^3} \cdot \frac{\kappa_2 \cdot M^2}{A^2 \cdot c^3} \cdot \frac{A \cdot c^3}{\kappa_2 \cdot M^2} = \frac{c}{M^2}$$

where:

D - electric charge diffusion coefficient, s/m<sup>2</sup>

U - voltage of the electric charge source, V

F<sub>i</sub> - electric charge source strength, N

I - current source of electric charge, A

R - load resistance, Ohm.

The new law of energy of material bodies located in the space of our Universe is formulated as follows:

The energy of material bodies inside outer space is equal to the product of the volume of all material bodies located inside outer space by the constant of the substance of outer space (density of outer space medium) by the acceleration of free fall inside outer space and the rate of expansion or contraction inside outer space.

$$E = V \cdot p \cdot g \cdot v = \frac{M^3 \cdot \kappa_2 \cdot M \cdot M}{M^3 \cdot c^2 \cdot c} = \frac{\kappa_2 \cdot M^2}{c^3}$$

Where:

E - energy of material bodies located inside outer space, W

V - the total volume of all material bodies in outer space, m<sup>3</sup>

$p$  is the constant of the substance of outer space or the density of the medium of outer space,  $\text{kg/m}^3$

$g$  - free fall acceleration inside outer space,  $\text{m/s}^2$

$v$  - speed of expansion or contraction inside outer space,  $\text{m/s}$ .

The new law of the stored energy of any measured material body is formulated as follows:

The stored energy inside any measured material body is equal to the product of the volume of the measured material body and the density of the medium of the measured material body, the free fall acceleration inside the measured material body and the rate of expansion or contraction inside the measured material body.

$$E = V \cdot p \cdot g \cdot v = \frac{M^3 \cdot K2 \cdot M \cdot M}{M^3 \cdot c^2 \cdot c} = \frac{K2 \cdot M^2}{c^3}$$

Where:

$E$  - stored energy inside any measured material body,  $\text{W}$

$V$  - total volume inside any measured material body,  $\text{m}^3$

$p$  - is the density of the medium inside any measured material body,  $\text{kg/m}^3$

$g$  - free fall acceleration inside any measured material body,  $\text{m/s}^2$

$v$  - speed of expansion or contraction inside any measured material body,  $\text{m/s}$ .

At the same time, it is necessary to emphasize that the total consumed or expended energy of the measured material body, when its physical or chemical properties change, must include the volume and density of the medium that contributes to its change. For example, during the combustion of wood, this material body uses oxygen when its physical or chemical properties change. The volume and density of oxygen must be summed up and included in the energy of the measured material body. In addition, during the combustion of wood, any number of various auxiliary and accompanying combustible materials can be added to it, for example, kerosene, where the volume and density of auxiliary and accompanying combustible materials must also be included in the total volume and total density of wood.

The new law of consumed or expended energy of any measured material body is formulated as follows:

The consumed or expended energy of any measured material body is equal to the product of the total volume of the  $N$ -number of volumes of the measured material body and auxiliary substances, the total density of the medium of the measured material body and the  $N$ -number of auxiliary substances, the acceleration of free fall inside the measured material body and the rate of expansion or contraction of the measured material body.

$$E = (V + V_n) \cdot (p + p_n) \cdot g \cdot v = \frac{M^3 \cdot KZ \cdot M \cdot M}{M^3 \cdot c^2 \cdot c} = \frac{KZ \cdot M^2}{c^3}$$

Where:

E - total consumed or expended energy of the material body and N-amount of auxiliary substances, W

V - volume of measured material body, m<sup>3</sup>

V<sub>n</sub> - volume N-amount of auxiliary and related substances, m<sup>3</sup>

p - the density of the medium of the measured material body, kg/m<sup>3</sup>

p<sub>n</sub> - density of the medium N-amount of auxiliary and related substances, kg / m<sup>3</sup>

g - free fall acceleration inside any measured material body, m/s<sup>2</sup>

v - speed of expansion or contraction inside any measured material body, m/s.

In addition to this proof, a new law was discovered that makes it possible to determine the interaction between the electron dipoles of an atom and between the rows of any material in the medium of interatomic space, which can be formulated as follows:

The force of interaction between the electron dipoles of an atom of the material under study is equal to the product of the density of the medium of the interatomic space and the thermal diffusivity of the electron dipoles of the inner and outer row containing a certain number of electron dipoles having a different diameter, different density, which are located at different levels in the medium of the interatomic space.

$$F = P \cdot (\lambda \cdot n_b) \cdot (\lambda \cdot n_n) = \frac{KZ}{M^3} \cdot \left( \frac{M^2}{c} \cdot \text{шт} \right) \cdot \left( \frac{M^2}{c} \cdot \text{шт} \right) = H$$

Where:

F - the force of interaction between the electronic dipoles of the atom, N

p - the density of the medium of the interatomic space of the material, kg/m<sup>3</sup>

λ - thermal diffusivity of the electronic dipoles of the material at 25 °C, m<sup>2</sup>/s

n<sub>b</sub> - the number of electronic dipoles of the internal series under study, pcs.

n<sub>n</sub> - the number of electronic dipoles of the outer investigated row, pcs.

An atom of a magnetic material works as follows:

An atom of magnetic material is interconnected by a plurality of magnetic dipoles by means of gravity, energy and magnetic field lines 12, which keep the atom of magnetic material in a balanced state. After stabilization of the magnetic field lines 12 of the magnetic system consisting of a magnetic material having a north pole and a south pole, the magnetic dipoles of the atom are in stable equilibrium and do not produce any work.

In conclusion, we can say that our material world is very diverse and all the processes performed in it from random circumstances that occur in time affect one

another to a different extent, therefore a new theory of multifaceted dependence is put forward. In this world, everything is intertwined, and one natural phenomenon is dependent on another to a different extent. More active material bodies dominate less active material bodies, therefore there cannot be constant constants, laws or physical quantities. For example, the new law of gravitation between two material bodies located in the space of the Solar System or another system is closely connected with the new law of gravitation of one material body located in the space of the Solar System to the central star of the Sun. At the same time, the laws of gravitation are in constant dependence on the new law of activity of a material body located in space and the new law of acceleration of the free fall of bodies in space. And the listed laws are closely connected with the new law of energy between two material bodies that are in the space of the solar system and the new law of energy of one material body located in the space of the solar system, to the central star the Sun and many others...

### References

1. Belashov A.N. «New views on the model of the internal structure and structure of the atom». *Information and analytical journal «Actual problems of modern science»*, No. 1 for 2023, page 7. Publishing house «Sputnik +», Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.
2. Belashov A.N. «Evidence of the internal structure of a nuclear-free atom». *International Scientific Conference «Scientific research of the SCO countries: synergy and integration»*, City of Beijing, China 10 February 2023, page 144.
3. Belashov A.N. «The law of determination of energy within various spaces and additions refuting the law of conservation of energy have been discovered.» *Information and analytical journal «Actual problems of modern science»*, No. 4 for 2022, page 30. Publishing house «Sputnik +», Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.
4. Belashov A.N. «Discovery of the mechanism of rotation of the planets of the solar system around the sun». *Journal of relevant scientific information «Postgraduate student and competitor»*, No. 6 for 2022. Publishing house «Sputnik +», Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.
5. Belashov A.N. «Reverse speed constant of light». *Scientific and analytical journal «Scientific Observer»*, No. 1-25 for 2013, page 64. Infiniti Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2220-329X.
6. Belashov A.N. «Mechanism of formation of gravitational forces and a new law of acceleration of free fall of bodies in space». *International Research Journal*, No. 2-9 for 2013, page 7. Impex Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.



7. Belashov A.N. «New energy laws of material bodies located in the space of the solar (or other) system». *International Research Journal*, No. 3-10 for 2013, part 1 page 12. «Impex» Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.

8. Belashov A.N. «A new law of gravitation between two material bodies located in the space of the solar system». *International Research Journal*, No. 4-11 for 2013, part 1 page 9. «Impex» Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.

9. Belashov A.N. «A new law of gravitation of one material body located in the space of the solar system to the central star». *International Research Journal*, No. 4-11 for 2013, part 1 page 12. Impex Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.

10. Belashov A.N. «The evolutionary development of the planets of the solar system». *International Scientific Research Journal*, No. 7-14 for 2013, part 1 page 14. Impex Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.

11. Belashov A.N. «New Views on the Law of Conservation of Energy». *Scientific and analytical journal «Scientific Perspective»*, No. 11-45 for 2013, page 94. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-38591 ISSN 2077-3153.

12. Belashov A.N. «Mechanisms for the formation of planets in the solar system». *Scientific and analytical journal «Scientific Perspective»*, No. 9-43 for 2013, page 45. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-38591 ISSN 2077-3153.

13. Belashov A.N. «Refutation of the fundamental law of conservation of energy in mechanics and hydrodynamics». *International Research Journal*, No. 9-16 for 2013, part 1 page 7. «Impex» Printing House, Yekaterinburg. Certificate of state registration PI No. FS 77 - 51217 ISSN 2303-9868.

14. Belashov A.N. «An explanation of the laws of motion and mutual dependence of the planets of the solar system». *Scientific and practical journal «Journal of Scientific and Applied Research»*, No. 11 for 2015, page 139. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-38591 ISSN 2306-9147.

15. Belashov A.N. «The law of gravitational attraction between two material bodies». *Scientific and practical journal «Journal of Scientific and Applied Research»*, No. 05 for 2016, page 145. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-38591 ISSN 2306-9147.

16. Belashov A.N. «Refutation of the Law of Conservation of Energy and the Gravitational Constant». *Scientific and practical journal «Journal of Scientific and Applied Research»*, No. 08 for 2016, page 72. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-38591 ISSN 2306-9147.

17. Belashov A.N. «Constant of the substance of outer space». *Scientific and practical journal «Higher School»*, No. 17 for 2017, page 39. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

18. Belashov A.N. «A new value that determines the substance of outer space». *Scientific and practical journal «Higher School»*, No. 18 for 2017, page 27. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

19. Belashov A.N. «A new physical quantity that determines the acceleration of free fall of bodies in the space of the solar system.» *Scientific and practical journal «Higher School»*, No. 19 for 2017, page 33. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

20. Belashov A.N. «Mechanism of gravitational attraction of the planets of the solar system». *Scientific and practical journal «Higher School»*, No. 12 for 2018, page 5. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

21. Belashov A.N. «Laws of the energy of the planets of the solar system». *Scientific and practical journal «Higher School»*, No. 14 for 2018, page 88. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

22. Belashov A.N. «A new law for determining the distance from the surface of the Sun to the surface of the planets of the solar system». *Scientific and practical journal «Higher School»*, No. 17 for 2018, page 49. «Infiniti» Publishing House, Ufa. Certificate of state registration PI No. FS 77-42040 ISSN 2409-1677.

23. Belashov A.N. «New Laws of the Forces of Gravitational Gravitation». *Journal of relevant scientific information «Postgraduate student and competitor»*, No. 4 for 2018, page 48. «Sputnik +», Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.

24. Belashov A.N. «A new law for determining the acceleration of free fall of bodies in space on the planets of the solar system». *Journal of relevant scientific information «Postgraduate student and competitor»*, No. 5 for 2018, page 48. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.

25. Belashov A.N. «Discovery of new parameters of planet Earth». *Journal of relevant scientific information «Postgraduate student and competitor»*, No. 6 for 2018, page 48. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.

26. Belashov A.N. «Discovery of the mechanism of the forces of gravitational attraction, the forces of cosmic counteraction and the forces of cosmic interaction». *Journal of up-to-date scientific information «Postgraduate student and competitor»*, No. 1 for 2019, page 65. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.

27. Belashov A.N. «Additions to the refutation of Newton's law of universal gravitation». *Information and analytical journal «Actual problems of modern science»*, No. 2 for 2019, page 106. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.

28. Belashov A.N. «A Complement to the Discovery of the Inverse Speed Constant of Light and the Refutation of Einstein's Postulates». *Journal of up-to-date scientific information «Postgraduate student and competitor»*, No. 1 for 2019, page 38. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1608-9014.

29. Belashov A.N. «Mathematical evidence for the existence of the cosmic ether or substance of outer space». *Information and analytical journal «Actual problems of modern science»*, No. 1 for 2021, page 33. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.

30. Belashov A.N. «The law of determination of energy within diverse spaces and additions refuting the law of conservation of energy» have been discovered. *Information and analytical journal «Actual problems of modern science»*, No. 4 for 2022, page 92. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.

31. Belashov A.N. «The magnetic field of the Sun, its rotation and the formation around it of the acceleration of the free fall of bodies in space.» *Information and analytical journal «Actual problems of modern science»*, No. 6 for 2022. «Sputnik +» Publishing house, Moscow. Registration certificate PI No. FS 77-39976 ISSN 1680-2721.

32. A.N. Belashov «Device of rotation of magnetic systems». Description of the application for the invention No. 2005129781 dated September 28, 2005.

33. A.N. Belashov «A new theory of multifaceted dependence», which was formulated as a result of a comprehensive scientific and analytical method of studying the description of the application for invention No. 2005129781 dated September 28, 2005 and the description of the application for invention No. 2012142735 dated October 09, 2012 URL: <http://www.belashov.info/LAWS/theory.htm>

34. A.N. Belashov «Discoveries, inventions, new technical developments». URL: <http://www.belashov.info>

35. L.A. Seine. «Units of physical quantities and their dimensions», Ch. ed. *Phys.-Math. lit.*, for 1988.

36. Yu.A. Khramov «Physicists» biographical guide, Kyiv «Naukova Dumka» 1977.

以资源和能源节约为理念的供暖系统创新  
**INNOVATIONS OF HEATING SYSTEMS IN THE CONCEPT OF  
RESOURCE AND ENERGY SAVING**

**Sevryugina Nadezhda Savelyevna**

*Doctor of Technical Sciences, Leading research worker  
Moscow Polytechnic University, Russia, Moscow c.*

**Zakharova Kseniya Romanovna**

*Student, Laboratory Assistant  
Moscow Polytechnic University, Russia, Moscow c.*

**Mukhamadeeva Yasmin Ruslanovna**

*Student, Laboratory Assistant  
Moscow Polytechnic University, Russia, Moscow c.*

抽象的。考虑了经典和最常见的加热系统方案；给出了它们的分类，揭示了优点和缺点。已经确定了有前途的解决方案，这些解决方案的实施有助于节省建筑物和构筑物供热的能源和资源。提供了传统能源和创新能源的选择，例如热电机、浸入式冷却方法等。此外，还关注加热系统的高效运行，无论其方案或接收的能量如何。建议通过对供热系统进行广泛的改造，广泛采用创新的供热方式，以增加资源和能源的节约。

关键词：资源、供热系统、分类、方案、评估、创新、节能、发展。

**Abstract.** *The classical and most common schemes of heating systems are considered; their classification is given, advantages and disadvantages are revealed. Promising solutions have been identified, the implementation of which contributes to saving energy and resources for the heat supply of buildings and structures. Options are presented for both traditional sources of energy generation and innovative ones, such as a thermoelectric generator, an immersion cooling method, etc. Also, attention is paid to the efficient operation of the heating system, regardless of its scheme or the energy received for it. It is proposed to increase resource and energy saving by the widespread introduction of innovative methods of heat supply by carrying out a widespread reconstruction of heating systems.*

**Keywords:** *resources, heating systems, classification, schemes, evaluation, innovations, energy saving, development.*

**Formulation of the problem.** Every year the population, and especially the population of multi-million-strong cities, is growing. For example, in Russia, the

number of residents of such cities as Moscow, where by 2022 the population exceeded 12 million people, St. Petersburg - 5.3 million people, Novosibirsk - 1.6 million people, Yekaterinburg - 1.3 million people, people are increasingly striving to move to megacities for the sake of new opportunities. The larger the population, the more funds are needed to provide it, scientists are trying to come up with new ways to effectively distribute and use resources.

**The purpose of the study:** to justify the feasibility of switching from standard heating schemes to alternative ones that take into account the existing disadvantages and retain the existing advantages.

**Materials and research methods.** Each country is trying to find a more profitable way for its conditions and opportunities to obtain the necessary resources. The intelligent and efficient operation of a large-scale urban district heating system (UDHS) is a hot topic in the field of urban energy systems.

Depending on climatic conditions and indicators of thermal insulation of buildings, scientists are trying to find a more profitable way to generate energy for the UDS. The connection between thermal energy, demand and the consequences of the application of systems depending on the characteristics of the building is also specified.

A fairly large number of studies are being carried out in the world aimed specifically at obtaining energy, not only from standard sources (gas, coal, electricity). And also, development and experimental research are being carried out, which allow inventing and testing new types of heating systems [1].

For example, in the book “Monitoring Solar Heating Systems” [2], the results of a study on monitoring solar heating systems are presented, the data obtained made it possible to highlight the benefits of installing solar heating systems in various parts of the European Economic Community. The book notes that a small number of residential solar heating systems have been built and installed in Europe, both in private homes and, more commonly, in homes built through national research and development programs. To demonstrate the value of solar energy and monitor the behavior and performance of solar heating systems, performance monitoring systems have been installed to collect relevant performance data [2-3].

Also, it should be noted, research in the field of wind generation, development of ways to transfer energy to heating systems. For all its efficiency, wind generation stands out as yet unsolvable problem of unpredictability and variability of the wind. For example, work [4] explores the potential of coordinated operation of an integrated power supply and district heating system to mitigate the effects of wind energy uncertainty using a controlled reliable interval approach [4-5].

In the world of science, a huge part of the articles aims to analyze, identify advantages and disadvantages, and find the best option for the efficient use of energy resources. Based on research experience and experimental data, this paper analyzes the classical schemes of heating systems and identifies the most promising directions for their development.

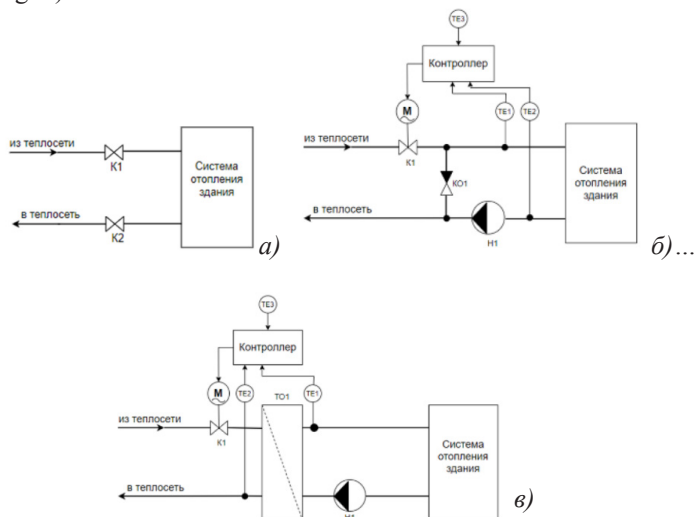
### Results and discussions

On the territory of the Russian Federation, the main part is occupied by regions with a harsh, cold climate, requiring special attention in providing heat supply for buildings and structures. In the direction of the country's economic policy, it can be revealed that energy conservation and energy efficiency have a priority role in its development. These tasks contain the concept of rational use of the resources available to the country and the growth of domestic markets.

To provide the necessary amount of heat to the premises in any of the periods of the heating season, when choosing heating system schemes, one should pay attention to many additional characteristics.

According to SP 347.1325800.2017 "Internal heating systems, hot and cold water supply. Operating Rules" in accordance with paragraph 5 "Classification of internal heating systems, hot and cold water supply" internal heating systems include: an input node, a distributing pipeline network, risers, connections to heating devices and process equipment, shut-off and control valves, heat exchange equipment, pumps, expansion tanks and instrumentation according to SP 60.13330, SP 124.13330 [6].

There are three types of schemes for connecting heating systems, these include schemes dependent without mixing water, dependent with mixing water and independent (Fig. 1).



**Figure 1.** Scheme of dependent connection without mixing water: a) dependent connection without mixing water; б) dependent connection with mixing of the coolant; в) independent scheme for connecting the heating system

In a heating system with dependent connection without mixing water (Fig. 1, a), the consumer is supplied with coolant from the heating system without temperature drop, control valves (K1; K2) are included in the circuit. In a mixed heating system, the following are additionally switched on: a heating medium temperature sensor installed in the supply pipeline (TE1); coolant temperature sensor installed in the return pipe (TE2); outdoor temperature sensor (TE3); pump (H1, which circulates the coolant in the internal circuit; check valve (KO1). A heat exchanger (TO1) is included in an independent connection scheme for the heating system.

The main disadvantage of a heating system with dependent connection without mixing water is that it has a dependence of the thermal regime of the building on the “impersonal” temperature of the water of an external source in the heat pipe, which may require a local water supply system, and it is not possible to regulate the temperature of the coolant.

In most cases, buildings and structures have a heating system with a dependent circuit with a mixture of coolant, which provides for the presence of in-house heat points. The difference between the schemes with a hydraulic elevator and a thermostat is how the hydraulic mode is created, and if in the first case it is constant, then in the second it has a variable effect, therefore, automatic regulation of systems connected to the heating network through a mixing pump should be used.

The use of automatic pump control, regardless of whether it is a single-pipe or two-pipe system, reduces the cost of thermal energy due to the fact that when heat control approaches the consumer, certain factors are calculated to help determine the exact need of buildings for space heating. Automatic control based on sensors for reading the temperature of the outdoor and indoor air helps to change the temperature of the coolant in the internal circuit of the heating system.

A dependent connection system provides a hydraulic connection between the heating network and the heating system of a building or structure, the equipment for this system is inexpensive, and the input is quite simple to implement. However, along with the advantages, there are also disadvantages. Among them, a significant consumption of energy resources, high complexity of operation and low efficiency, and when the temperature is transferred, although endurance is present, it is difficult to adjust the temperature regime.

Connecting an independent scheme for connecting the heating system, which occurs with the help of an addition in the form of a heat exchanger, helps save the resources used by 10-40%. In this case, heating is carried out on the basis of two hydraulically isolated circuits, where the external heating circuit heats the water of a closed internal heating main. Thanks to the circulation pumps, the coolant moves in the heating mechanism through a regular supply of water to the heating devices.

Often, such an independent connection is used for multi-storey buildings, since a high level of reliability of the heating mechanism and a flexible ability to adjust

the temperature are required there. The advantages include the ability to use various coolants and the presence of a significant energy-saving effect. Among the disadvantages are: labor-intensive maintenance and repair of such a system, as well as high costs.

Considering the development of heating systems, it is necessary to highlight the promising areas of innovative heating systems [7-9].

Studies show that the design of heating circuits is based on the exchange of heat in the air flow of a closed room. Additionally, it should be noted that energy efficiency is evaluated by the calorific value of the heat source. Based on what should be singled out as the most promising and less costly - a solar heat source, our task is only how to accumulate this heat, at present, this solution is solar panels of various modifications. The disadvantage of this type of energy storage is the instability of its receipt in places with a limited number of sunny days and cloudless weather conditions, and there are a significant number of such in Russia.

Promising today is a heat transfer method based on the effect of sunlight, but created artificially: panel-radiant heating systems.

Studies show that the radiant heat flux provides a more uniform heating of the room and eliminates the decrease in the level of oxygen in the air, moreover, it has been established that heat consumption for heating purposes is reduced by 25-30% [10].

Additionally, it is necessary to single out a resource-saving method that works on the principles of a "closed cycle", i.e. collection and reuse of thermal energy from various sources that ensure the comfort of the room, in particular, heat from a working refrigerator, computer, stove and other household appliances, which are not only consumers of electricity and are a source of heat release, but also the energy potential of a person whose heat also stands out and at a certain concentration of people can create a certain thermal background in the room.

In this case, the immersion cooling method is used, which allows the secondary thermal energy to be removed from electrical equipment using a dielectric inert liquid, which is fed into the heat exchange device and can serve as a source of thermal energy for the heating system [11-12].

Work is also underway to combine the operation of cooling systems for electronic devices with the operation of supply and exhaust ventilation. At the same time, one of the promising scientific directions is the use of thermoelectric generators, which makes it possible to partially convert secondary heat releases into electrical energy [13]. The use of the method of secondary thermal energy allows the most practical use of energy and resources. The introduction of new innovative technologies makes it possible to increase the productivity of equipment and obtain an additional source of electrical energy of at least 10% of the installed capacity [14].



Do not forget that one of the energy-saving areas for saving energy resources is to increase the efficiency of the heating system. Therefore, no matter what method of obtaining energy for heating is chosen, classical or innovative, how the received energy will be used, among other things, will affect energy saving [14-15].

All of the above innovations are already applicable at the present time, so it will be possible to gradually implement promising ideas for improving heating systems in already built structures, when renovating buildings and structures, and for new buildings and structures, it is proposed to introduce innovative schemes of heating systems into the project, as well as use an apartment heating system for efficient operation and saving resources.

### **Conclusions:**

The main types of schemes of typical heating systems and their classification are considered. A critical assessment of the advantages and disadvantages of the proposed schemes is given, taking into account the provision of efficiency and performance. Innovative developments in heat transfer technologies are highlighted, which increase the efficiency of the equipment used and guarantee energy savings during operation. It has been established that the reconstruction of the heating system is required everywhere, with a possible change in the placement of heating devices in the room by introducing promising heating solutions.

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### **References**

1. Lushin, K. I. *Analysis of trends in the change in the efficiency of using heat sources for heat supply of housing and communal services in the regions of the central federal district of the Russian Federation* / K. I. Lushin // *Natural and technical sciences*. – 2014. – No. 9-10(77). – P. 394-396.
2. Ferraro R., Godoy R. (1984). *Monitoring the performance of solar heating systems*. In: Den Ouden, C. (eds.) *First conference of E.C. for solar heating*. Springer, Dordrecht. [https://doi.org/10.1007/978-94-009-6508-9\\_12](https://doi.org/10.1007/978-94-009-6508-9_12)
3. Sheranov, N. M. *Improvement and optimization of building heating systems using solar and geothermal energy* / N. M. Sheranov // *Proceedings of the Osh Technological University*. – 2018. – No. 2. – P. 64-67.
4. Eremkin, AI *Rationale for the use of wind energy for heating systems of buildings in Russia and abroad* / AI Eremkin, DS Maksimova // *Problems of scientific thought*. – 2019. – V. 4. – No. 4. – P. 26-30.

5. Dorzhiev S. S., Bazarova E. G., Pilipkov V. V., Rozenblyum M. I. *Multi-unit wind power plant for areas with low wind potential // Agrotechnics and energy supply*. – 2021. – No. 2 (31). – P. 45-52.

6. SP 347.1325800.2017 “Internal heating systems, hot and cold water supply. Operating Rules”. *Electronic resource: Website of the Ministry of Construction of Russia [Electronic resource]: <https://minstroyrf.gov.ru/docs/16891/> - Access mode: open (date of access: 01/27/2023)*

7. Samarin, O. D., Lushin K. I., Kirushok D. A. *Energy-saving air treatment scheme with indirect evaporative cooling in plate heat exchangers // Zhilishchnoe stroitel'stvo*. – 2018. – No. 1-2. – P. 43-45.

8. Zubarev, K. P. *Ways of heating buildings and structures. Literature review / K. P. Zubarev, A. A. Nikishova // BST: Bulletin of construction equipment*. – 2021. – No. 6 (1042). – P. 46-47.

9. *The numerical and analytical methods of calculations of two-dimensional temperature fields in dangerous members of building enclosures / N. Parfentjeva, O. Samarin, K. Lushin, S. Paulauskaite // 7th International Conference on Environmental Engineering, ICEE 2008 - Conference Proceedings: 7, Vilnius, May 22–23, 2008. - Vilnius, 2008. - P. 854-858.*

10. Volgin, A. E. *Design features of radiant heating systems / A. E. Volgin // Modern scientific research and innovation*. – 2020. – No. 12(116). – P. 3.

11. Pekhurov, N. V. *Comparison of traditional cooling methods with the immersion method of cooling systems / N. V. Pekhurov, P. A. Natsarenus // Bulletin of the Magistracy*. – 2019. – No. 6-2 (93). – P. 62-63.

12. Osinin, I. P. *Technical aspects and economic effect of using an immersion cooling system / I. P. Osinin, A. V. Shatokhin // Supercomputer days in Russia: Proceedings of the international conference, Moscow, September 26–27, 2016. – Moscow: Moscow State University. M.V. Lomonosov (Publishing House (Typography), 2016. – P. 1008-1019.*

13. Shelekhov, I. Yu., Zalutskiy, A. A., and Kovalenko, A. E. *Analysis of the possible use of thermoelectric generators in mobile buildings, Trends in the development of science and education*. – 2022. - No. 82-2. – P. 101-104. – DOI 10.18411/trnio-02-2022-64.

14. Lushin, K. I. *Analysis of trends in the change in the efficiency of using heat sources for heat supply of housing and communal services in the regions of the central federal district of the Russian Federation / K. I. Lushin // Natural and technical sciences*. – 2014. – No. 9-10(77). – P. 394-396.

15. *Influence of the outside climate parameters on the selection of the optimum combination of the energy saving measures / O. Samarin, K. Lushin, S. Paulauskaite, K. Valančius // Technological and Economic Development of Economy*. – 2009. – Vol. 15. – No 3. – P. 480-489. – DOI 10.3846/1392-8619.2009.15.480-489.

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大麻中过氧乙酸微晶纤维素的性质  
**PROPERTIES OF PERACETIC MICROCRYSTALLINE  
CELLULOSE FROM HEMPEN HEMP**

**Pen Robert Zusievich**

*Doctor of Technical Sciences, leading research worker  
Reshetnev Siberian State University of Science and Technology*

**Shapiro Ida Lvovna**

*Candidate of Technical Sciences, Senior Research Officer  
Reshetnev Siberian State University of Science and Technology*

**Karetnikova Natalya Viktorovna**

*Candidate of Chemical Sciences, Associate Professor  
Reshetnev Siberian State University of Science and Technology*

注解。工业大麻 (*Cannabis sativa*) “Surskaya” 牌大麻 (组分质量分数: 纤维素71.2%、木质素5.35%、提取物9.32%、灰分1.75%) 用乙酸、过氧化氢和催化剂-硫酸的水溶液脱木素 酸在85°C的温度。研究了硫酸浓度 (0.5...1.5%) 和工艺持续时间 (1.5...3.5 小时) 对工业纤维素产量和性能的影响。在 44...50% 的产率下, 纤维素的聚合度接近 100...120 的极限值。根据该指标和碘值 (大于10mg/g), 该产品符合微晶纤维素的规格。

关键词: 纤维素, 微晶纤维素, 大麻, 脱木素, 过氧化氢, 过氧乙酸。

**Annotation.** *Hemp of industrial hemp (Cannabis sativa) “Surskaya” brand (mass fraction of components: cellulose 71.2%, lignin 5.35%, extractives 9.32%, ash 1.75%) was delignified with an aqueous solution of acetic acid, hydrogen peroxide and catalyst - sulfuric acid at a temperature of 85 °C. The influence of the concentration of sulfuric acid (0.5...1.5%) and the duration of the process (1.5...3.5 hours) on the yield and properties of technical cellulose has been studied. At yields of 44...50%, the degree of polymerization of cellulose approaches the limit value of 100...120. According to this indicator and iodine number (more than 10 mg/g), the product meets the specifications for microcrystalline cellulose.*

**Keywords:** *cellulose, microcrystalline cellulose, hemp, delignification, hydrogen peroxide, peracetic acid.*

When decorticating the stems of technical hemp, a trust is obtained, which is mechanically divided into hemp and bonfire. The share of hemp in the bast layer

of the hemp stem is on average 20...25%, reaching in some varieties. 40%. The chemical composition of hemp (table 1) has a number of features. Unlike wheat straw and hemp fire, hemp contains significantly more cellulose and less lignin. Earlier it was reported [1] about the possibility of obtaining microcrystalline cellulose (MCC) by delignification of hemp in the medium “acetic acid - hydrogen peroxide - water - sulfuric acid (catalyst)” at a sulfuric acid concentration of 3...5% and a temperature of 85°C for 4. ...5 o'clock. An analysis of the results suggested the possibility of obtaining MCC with the same properties with a decrease in the concentration of the catalyst and a reduction in the duration of the process by slightly increasing the temperature. Below are the results of an experimental verification of this assumption.

The raw material for the study was hemp from technical hemp (*Cannabis sativa*) of the “Surskaya” brand of industrial production, its chemical composition is shown in Table 1.

The hemp fibers were ground in a dry disk mill. For experiments, we used the fraction that passed through a sieve with a hole diameter of 8 mm.

**Table 1.**  
*Chemical composition of plant materials [2]*

Vegetable raw materials	Mass fractions of components in raw materials, %			
	cellulose	lignin	extractives	ash
Wheat straw	46,6	22,0	1,22	5,37
Hemp fire	41,2	23,4	4,64	1,10
Hempen hemp	71,2	5,35	0,32	1,75

The prepared hemp was delignified with the reaction mixture “acetic acid - hydrogen peroxide - sulfuric acid catalyst - water”. During cooking, acetic acid is oxidized to peracetic acid, which in turn oxidizes lignin. Constant delignification conditions: the initial concentration of hydrogen peroxide in the cooking solution is 6 g-mol/dm<sup>3</sup>, acetic acid - also 6 g-mol/dm<sup>3</sup>; liquid module 4.5; temperature of isothermal cooking 92...93°C.

Variable cooking factors (in parentheses - the intervals of their variation):

$X_1$  – concentration of sulfuric acid in the cooking solution, % (0.5...1.5);

$X_2$  - cooking time, hour. (1.5...3.5).

The values of these factors varied according to a three-level second-order experiment plan on cube elements [3] (Table 2).

The results of the experiments were characterized by the following output parameters:

$Y_1$  – cellulose yield, %;

$Y_2$  is the degree of cellulose polymerization;

$Y_3$  is the proportion of the remaining hydrogen peroxide in the liquor from the initial amount, %;

$Y_4$  – residual concentration of peracetic acid in liquor, %;

$Y_5$  is the iodine number of cellulose, mg J/g.

The results of the experiments are shown in Table 2, their statistical characteristics - in Table 3. Mathematical processing of the results was performed using the Statgraphics Centurion XVI software package [3].

**Table 2.**  
*Conditions and results of the experiment*

Mode number	Variable factors		Output parameters				
	$X_1$ , %	$X_2$ , час.	$Y_1$ , %	$Y_2$	$Y_3$ %	$Y_4$ %	$Y_5$ , мг/г
1	0,5	1,5	70,3	311	64,8	1,14	5,3
2	1,0	1,5	69,7	173	41,9	1,52	8,7
3	1,5	1,5	68,3	220	35,2	2,09	11,2
4	0,5	2,5	66,0	151	29,4	1,14	15,8
5	1,0	2,5	62,3	101	13,3	0,57	14,7
6	1,0	2,5	61,7	113	13,8	0,57	13,9
7	1,5	2,5	55,0	151	7,6	0,76	13,1
8	0,5	3,5	55,0	97	10,4	0,19	19,3
9	1,0	3,5	44,7	82	2,1	0,23	17,4
10	0,5	3,5	46,3	123	1,1	0,15	13,1

**Table 3.**  
*Statistical characteristics of the experimental results*

Characteristics	Output parameters				
	$Y_1$	$Y_2$	$Y_3$	$Y_4$	$Y_5$
	characteristic values				
Average	59,9	152,2	21,9	0,84	13,2
Variance	87,2	4484	419,4	0,40	16,8
Standard deviation	9,34	69,3	20,5	0,63	4,09
Minimum	44,7	82,8	1,1	0,15	5,30
Maximum	70,3	311,8	64,8	2,09	19,3

The dependence of each of the output parameters on the variable factors was approximated by polynomial second-order regression equations of the general form

$$\hat{Y} = b_0 + b_1X_1 + b_2X_2 + b_{12}X_1X_2 + b_{11}X_1^2 + b_{22}X_2^2.$$

The regression coefficients are shown in Table 4.

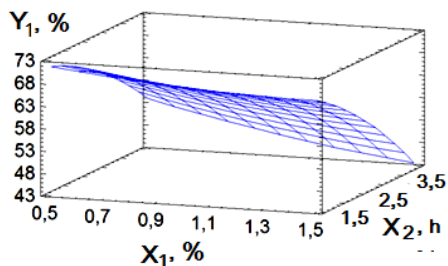
**Table 4.**
*Coefficients and statistical characteristics of regression equations*

<b><math>B_{ij}</math> coefficients and statistical characteristics</b>	<b>Output parameters</b>				
	<b><math>Y_1</math></b>	<b><math>Y_2</math></b>	<b><math>Y_3</math></b>	<b><math>Y_4</math></b>	<b><math>Y_5</math></b>
	<b>Values of coefficients and characteristics</b>				
$b_0$	74,63	837,1	190,4	2,304	-22,72
$b_1$	-6,40	-598,2	-89,4	0,031	17,38
$b_2$	4,75	-274,4	-76,4	-0,691	19,18
$b_{12}$	-3,35	58,5	10,1	-0,495	-0,05
$b_{11}$	3,77	213,1	21,9	0,691	-1,63
$b_{22}$	-2,36	29,8	8,9	0,098	-1,81
R-squared, %	95,5	95,4	99,7	91,3	81,6
Standard Error of Est.	2,94	22,1	1,50	0,281	0,31
Durbin-Watson statistic	2,57	2,78	2,71	1,62	1,33

After eliminating statistically insignificant terms (at a significance level of 0.05) and recalculating the regression coefficients, the equations were used to plot the results as 3D response surfaces.

The yield of technical pulp decreases with an increase in both technological factors  $X_1$  and  $X_2$  (Fig. 1), which is consistent with a priori information about delignification processes.

There are correlations between all output parameters (Table 5). The degree of polymerization of cellulose and the proportion of residual hydrogen peroxide change symbatically with the yield (Fig. 3, 4), antisymbatically - the sorption capacity of cellulose (Fig. 5), which also does not contradict existing ideas.


**Figure 1.** *Dependence of pulp yield on cooking factors*

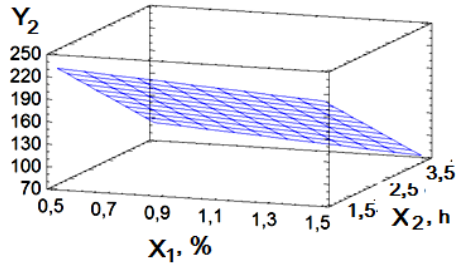


Figure 2. Dependence of the degree of cellulose polymerization on variable factors

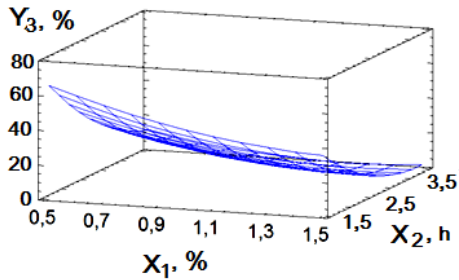


Figure 3. Dependence of the share of unspent hydrogen peroxide on variable factors

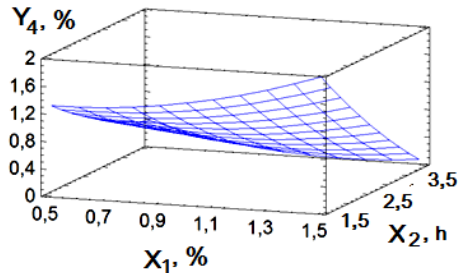
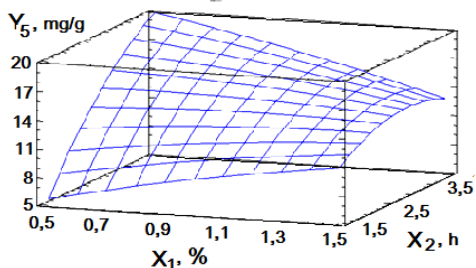


Figure 4. Dependence of the residual concentration of peracetic acid on variable factors



**Figure 5.** Dependence of the sorption capacity (iodine number) of cellulose on variable factors

**Table 5.**  
Linear correlation coefficients between output parameters

	$Y_1$	$Y_2$	$Y_3$	$Y_4$	$Y_5$
$Y_1$	–	0,681	0,857	0,810	-0,622
$Y_2$	0,681	–	0,902	0,681	-0,869
$Y_3$	0,857	0,902	–	0,726	-0,801
$Y_4$	0,810	0,681	0,726	–	-0,696
$Y_5$	-0,622	-0,869	-0,801	-0,696	–

The nature of the change in the concentration of peracetic acid is more complex (Fig. 4), since this reagent during cooking is involved in two successive processes: it is generated during the interaction of hydrogen peroxide with acetic acid and is consumed in the oxidation reactions of the components of plant materials.

According to the norms of the technical specifications in force in the Russian Federation, microcrystalline powder cellulose for the food and pharmaceutical industries must have a polymerization degree of no more than 300 and an iodine sorption capacity of at least 10 mg/g. These requirements are met by most of the manufactured samples of cellulose. Obviously, as the optimal cooking mode at this stage of the study, we can take the conditions of experiment No. 3 (Table 2), in which the product with the highest yield was obtained.

Studies were carried out in the laboratory “Deep processing of plant raw materials” of Reshetnev Siberian State University of science and technology. This work was supported by the Ministry of Science and Higher Education of the Russian Federation within the framework of State Assignment of the “Technology and equipment for the chemical processing of biomass of plant raw materials” project (FEFE-2020-0016).



## References

1. Pen R.Z., Shapiro I.L. *Microcrystalline peracetic Cellulose from Hemp // Proceeding of the International University Scientific Forum “Practice Oriented Science: UAE – Russia – India”, UAE, February 24, 2023, pp. 61-66. DOI: 10.34660/INF.2023.30.45.144*
2. Pen R.Z., Shapiro I.L., Karetnikova N.V., Marchenko R.A. *Peroxide cellulose from annual plants. Krasnoyarsk, Siberian State University, 2022. 144 p.*
3. Pen R.Z., Pen V.R. *Statistical methods of mathematical modeling, analysis and optimization of technological processes St. Petersburg, Lan, 2020. 308 p.*

用于寻找费米悖论解决方案的时空银河系网格  
**SPATIO-TEMPORAL MILKY WAY GRID FOR FINDING FERMI  
PARADOX SOLUTION**

**Vasilev Pavel Vladimirovich**

*Candidate of Technical Sciences, Associate Professor  
Belgorod State University of Russia*

抽象的。 本文考虑了银河系的时空建模问题以及解决费米悖论的计算方法。 已经开发出用于创建银河系网格模型 MWG 的一系列操作。 它包括星形站点、四面体网格和带有插值块的体积网格。 距离太阳最近的星系块大小为  $10^3$  光年, 是根据盖亚卫星望远镜目录中的天文数据构建的。 同时, 对同一区域使用随机蒙特卡罗模型, 调整其恒星组成和分布密度以适应天文数据。 考虑到星系宜居带 GHZ 的螺旋结构和体积不均匀性的特殊性, 对具有  $10^6$  个块的 MWG 模型的其余部分进行外推。

提出了生死函数的卷积方程, 其中包含根据恒星光谱组成计算的演化滤波器。 建议在四面体网格和均匀块模型上计算远程行星系统之间的最短路径和最佳通信。 结果旨在评估 SETI 计划的生物圈和技术圈的存在, 这些计划应针对银河盘内潜在的宜居环位点。

关键词: 网格建模、网格、星系演化、恒星卷积、光谱类型、四面体化、生物特征、技术圈、通信、寻找路径。

**Abstract.** *The paper considers the problem of spatio-temporal modeling of the Galaxy and the computational approach for a solution to the Fermi paradox. A sequence of operations for creating the Milky Way grid model MWG has been developed. It includes star sites, tetrahedral meshes and a volume grid with interpolation blocks. The nearest galactic block of the solar neighborhood by size of  $10^3$  ly is constructed based on the astronomical data from the Gaia satellite telescope catalog. In parallel a stochastic Monte Carlo model is used for the same region, and its stellar composition and distribution density is adjusted to fit astronomical data. Extrapolation to the rest of the MWG model with  $10^6$  blocks is performed taking into account the peculiarities of its spiral structure and volume inhomogeneities for the galaxy habitable zone GHZ.*

*An equation for the convolution of birth and death functions is proposed with the inclusion of an evolution filter calculated in accordance with the spectral composition of stars. Finding the shortest paths and optimal communications*

*between remote planetary systems is proposed to be computed both on a tetrahedral grid and on a uniform block model. The results are aimed at evaluating the existense of biospheres and technospheres for the SETI programs which should be targeted to the potential habitable ring loci inside the Galaxy disc.*

**Keywords:** *grid modeling, meshes, galaxy evolution, convolution of stars, spectral types, tetrahedralization, biosignatures, technospheres, communications, finding paths.*

## **Introduction**

Since the physicist Enrico Fermi asked the question “Where are they all?” and did not find an answer the large number of papers are presented on the paradox. It should be noted that the article by Freitas R. [1] and others provides a justification for the fact that the paradox itself does not exist as such, since we simply do not yet have sufficiently reliable data for such a bold statement about the absence of aliens or evidence of their visits to Earth, but the very problem of modeling evolution and estimating the prevalence of intelligent beings in the Galaxy nevertheless, it is quite possible to consider within the framework of this paradigm. The size of the PHZ habitable zone in a star cluster correlates with the probability of the appearance of extraterrestrial civilizations in it, their number and expansion of areas of influence. The model assumes the existence of not planetary, but stellar extraterrestrial civilizations of type II according to Kardashev [2], and not assumes the possibility of estimating the probability of the appearance of a type III civilization. Here we will distinguish simply between the biosphere and the technosphere, as a high-tech civilization.

The accumulated volumes of astrophysical data and the ever-increasing arrays of telescopic observations, both terrestrial and satellite, create the need to build discrete models on the basis of which statistical estimates of the main characteristics of stellar systems can be obtained and visualization of which makes it possible to get a picture of their evolution in space and time. Purpose of the study therefore is to build a discrete model for assessing the distribution of bio-technospheres in the galactic ring of habitability and finding the shortest paths and communications between them, taking into account the different limitations.

## **Description of methods**

In this approach, a regular grid model of the Galaxy is built - Milky Way Grid (MWG), consisting of 100x100x100 galablocks. Each galablock is a cubic box with the size of 1000 light years. The catSGB halablock with the Sol in his center is the basic one, which has the most reliably determined measurements presented in astronomical catalogs, in particular those as in Gaia Data Release 3 [4].

When constructing the basic galablock catSGB for the vicinity of the Sun, a tetrahedral Delaunay network with stars at the vertices of the tetrahedra and

its dual graph of Voronoi polyhedra are created [12]. The latter is necessary for constructing a spatial-temporal volumetric mosaic with the ability to quickly determine the nearest neighbors of stars, combine cells into clusters with habitable zones, and distribute areas with catastrophic cosmic phenomena and processes in the galablock. The precalculation stores the indexes of neighboring tetrahedra or cells, which makes it possible to implement fast algorithms for finding the shortest paths using Dijkstra or Floyd-Warshall shortest path network algorithms graphs [10], the A\* algorithm, the Lee wave method or using directional vector with bypass adjacent tetrahedra TvPath. The averaged star data for Harvard spectral types using Gaia Dr 3 stars catalog required for stochastic modeling are summarized in Table

**Table 1.**  
*Accepted average characteristics of the spectral types of stars*

Spectral star class	Star formation rate $n_s / 0.1 \text{ Gyr}$	Fraction, units	Expected Lifetime, Gyr
O	$10^3$	0.00001	0.01
B	$2 \cdot 10^3$	0.00109	0.10
A	$5 \cdot 10^3$	0.0519	1.00
F	$10^4$	0.037	3.50
G	$2 \cdot 10^4$	0.06	10.0
K	$4 \cdot 10^4$	0.12	50.0
M	$6 \cdot 10^4$	0.73	200.0

The model takes into account the intensity of star formation during the evolution of the Galaxy and the lifetimes of the main spectral classes of OBAFGK-M+SH stars, including brown dwarfs + SH (supernovae and dangerous regions with new stars, pulsars, magnetars, and black holes). Currently available satellite data on exoplanets are used to probabilistically estimate the number of planets with lithospheres, putative biospheres, and technospheres.

In parallel a galablock is procedurally generated for the vicinity of the Sun using the Monte Carlo method - ranSGB, by generating a random arrangement of stars with the same stellar composition as catSGB. Its average characteristics, attributes, including the probabilities of finding exoplanets in the habitable zones of stars, are approximated to match the actual catSGB values.

The model uses convolution of the birth and death of various spectral types of stars depending on the duration of their existence [9], recalculating the Voronoi tiling and excluding SH and voids by distance from the interpolation node, to obtain a dynamic model on the time scale of galactic life. The principle of stereology of integral geometry on the reliability of statistical estimates for representative

volumes of a set of scattered stars is taken into reconstruction. Next, the probabilities for ranSGB are extended to the rest of the halablocs based on similarity and corrected for astronomical observational data from ground-based and satellite telescopes with images of the galactic disk, nucleus, spiral arms, and halo. On the actual catMWG and random ranMWG models, one can consider problems of optimizing transport routes or communications, bending around and bypassing restrictions and obstacles on 3D graphs. Programmatically, a subgrid of type GLxyzGrid TGLxyzGrid with XSamplingScale.Step = 10 light years and with the same step along the Y, Z axes is created programmatically inside the boundaries of catSGB. We interpolate the point attributes of the array of stars into the central nodes of the lattice in order to obtain isosurfaces in the volume of the halablock and isolines in projections on its sections and on the face of the cube for the parameters of interest. Below is a block diagram of model building operations

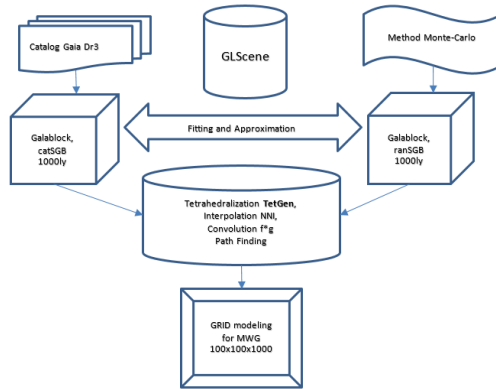


Figure 1. Block diagram for building a grid model MWG

Additional details of the simulation algorithm include the following steps:

Step 1. Selection from the catalog of stars for a galacub with a size of  $10^3$  ly. Distances can also be represented in parsecs. SQL in Gaia.sqlite database - *SELECT StarID, (Distance\*3.262) AS Light\_Years, Id, Spectrum, X, Y, Z FROM GaiaDr3 WHERE (Distance\*3.262) <= 866;*

Step 2. For a random haloblock in the process of evolution, the lifetimes of stars are recalculated in relative units in proportion to the average age of each spectral class of stars. The initial age of the Galaxy is assumed to be  $10^{10}$  years or 10 Gyr., since, according to a number of publications, the spiral structure was not formed in an earlier period and the composition differed significantly.

Step 3. After the death or fading of any star in class O, B, A, F, G, a new star of one of the spectral classes is generated in a random position at a distance of one

light year from the previous position to maintain a constant population of stars. The processes of star formation from gas-dust clouds and stellar dynamics are not simulated in the model. The lifetime of class K and M for many stars will significantly exceeds the age of the galaxy.

Step 4. Stars of all classes, except O, upon reaching the age  $T_s \geq 0.1 \text{ Gyr}$  form planetospheres with probability  $P_{ps}=1.$  , stars of all classes, except O and B, when exceeding the age  $T_s \geq 1 \text{ Gyr}$  may have planets with lithospheres (with an Earth-like index  $PHI \geq 0.7$ ) with a probability  $P_{ls} = 0.4$ .

Step 5. Stars of classes F, G, K, M with age  $T_s \geq 3 \text{ Gyr}$  can form Earth-like planets with biospheres with probability  $P_{bs} = 0.3$ . The choice is made by a random number generator.

Step 6. Stars of classes G, K, M when the age is exceeded  $T_s \geq 4 \text{ Gyr}$  may have Earth-like planets with noospheres with probability  $P_{ns} = 0.2.$  , and stars of classes G, K, M when exceeding the age  $T_s \geq 4.5 \text{ Gyr}$  with probability  $P_{ns} = 0.1$  can acquire Earth-like exoplanets with technospheres.

Step 7. Marking stars with lithospheres, biospheres, noospheres and technospheres using a random number generator in accordance with the established probabilities.

Step 8. Construction of Delaunay and Voronoi grid diagrams to compare options for a) isotropic transmission of communication signals and b) transmission of SETI messages with signal amplifiers and repeaters located at the nodes of a tetrahedral network.

Step 9. Calculation of integral values according to the discrete equation of convolution of functions of the birth and death of the population of stars and statistical indicators of the extension of the search to the peripheral regions of the cluster.

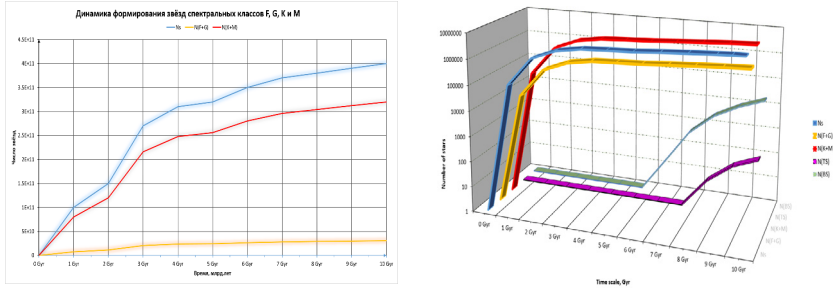
When constructing grid models of DT/VD star arrays, Delaunay tetrahedralization and Voronoi diagrams, the TetGen grid generator was used. In the calculation of the local cosmic evolution filter  $\varphi(s, t)$  data on the nearest neighbors of each star, their spectral types, are determined by the Delaunay tetrahedral grid. After comparing the model with the actual data on spectral types, the Markov chain of transition probabilities is also changed and the star formation rate is rebuilt over discrete time periods. For the discrete case, the convolution of functions  $\eta(s, t)$  the birth and death of stars in space and time is written as

$$\eta(s, t) = f \otimes g = \sum_{\lambda=\lambda_n}^S \sum_{\tau=\tau_n}^T f(\lambda, \tau) \cdot \psi(\lambda, \tau) \cdot \varphi(s - \lambda, t - \tau) ,$$

where the summation is performed over spectral classes S with a characteristic radiation wavelength  $\lambda$  and over time intervals  $\tau$  within each time T interval.

### Results and discussion

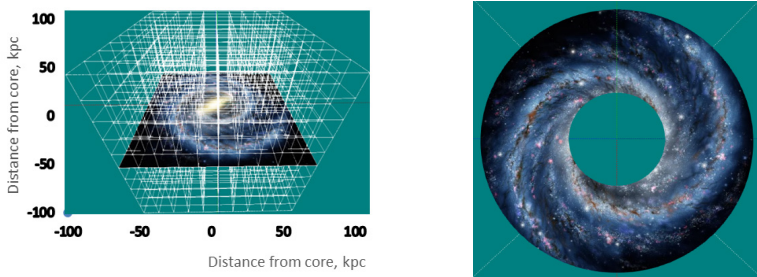
The resulting probabilities estimate star’s population densities that are illustrated in the following figure.



**Figure 2.** Curves for probabilities of a) FGKM class stars and b) Earth-like planets and super-Earths with bio- technospheres in the habitable zones of stars.

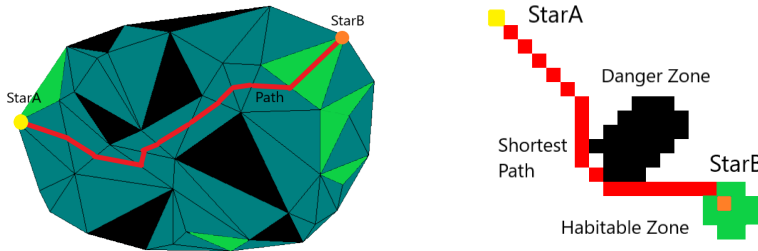
As can be seen from the graph, the probability of the formation of biospheres reaches significant values only after 6 billion years from the beginning of the evolution of the habitable zone of the Galaxy. To animate the curves over time periods from 0 to 10 Gyr, the discrete time intervals of the timer were chosen accordingly in the range from millisecond to hour.

Visualization and volumetric rendering of the entire MWG grid model were performed using the GLScene graphic platform [4], where a separate timer for counting discrete age intervals was used for each spectral class of stars. The color palette of the visualization of spectral types matched the apparent color on the Harvard Hertzsprung-Russell main sequence stars to allow comparison of the resulting images of the model and astronomical images obtained using satellite telescopes.



**Figure 3.** Grid with Galaxy disc and habitable ring without its core and periphery

The results of the MWG construction, in particular, with the probabilities of detecting biospheres and technospheres, can be obtained in a summary form. They can also be presented for substitution in the F. Drake formula [3]. However, in contrast to the integral approach applied in 1960 by F. Drake, in the general case, a differential approach is currently used in modeling and estimation. These dynamical structures of MWG can be used, in particular, get closer to computational solution of the Fermi paradox finding paths between nearest technospheres as shown below.



**Figure 4.** The shortest paths between stars in habitable zone on tetrahedral mesh and grid

In the case of the expansion of a communicating civilization into other star systems, up to the colonization of a large region of the Milky Way behind an impenetrable core, Drake’s integral approach does not imply the possibility of estimating the number of individual stars with exoplanets that have bio-technospheres or transmit signals that can be detected in SETI/METI programs.

### Conclusion

As a result of volumetric rendering of the MWG grid model, using the simulated spatio-temporal dynamic structure, which reflects the evolution of the system as a whole, it is possible to determine which regions of the stars exist inside habitable ring of the MilkyWay. Finding shortest paths between pairs of stars inside the habitable ring show the difficulties of overcoming interstellar distances, taking into account obstacles and danger zones, even at near-light speeds. Detailing the model makes it possible to delineate the areas of potential habitability of the zones of the Galaxy, where the existence of Earth-like exoplanets is most likely and to purposefully receive / transmit radio signals using the SETI program to search for a solution to the Fermi paradox, including by identifying these zones by methods of spatio-temporal modeling . A project of the Fermi paradox simulator has been developed at <https://github.com/geoblock/fermipx>, which is supposed to be supplemented with new data during further surveys Gaia dr4 (2025) and Gaia dr5 (2030), including new data on exoplanets inside habitable zones of stars.



## References

1. Freitas, R. A. (1985). *There is no Fermi Paradox*. *Icarus*, 62(3), 518–520.
2. Kardashev, N.S. (1964) *Transmission of Information by Extraterrestrial Civilizations*. *Soviet Astronomy*, 8, 217–221.
3. Circovic M.M. (2018) *The Great Silence*. Oxford, 395p. ISBN 978–0–19–964630–2.
4. Smart R.L. et al. (2021) *Gaia Early Data Release 3*. *A&A* 649, A6
5. Cartin D. (2014). *Quantifying the Fermi Paradox in the local Solar neighborhood*. *JBIS* 67, pp. 119-126.
6. Spada, G., & Melini, D. (2020). *Evolution of the number of communicative civilizations in the Galaxy: implications on Fermi paradox*. *International Journal of Astrobiology*, 1–6.
7. Lee, C.Y. (1961) *An Algorithm for Path Connections and Its Applications*, *IRE Transactions on Electronic Computers*, vol. EC-10, number 2, pp. 364–365
8. Prantzos N.(2020). *A probabilistic analysis of the Fermi paradox in terms of the Drake formula: the role of the L factor*, arXiv:2003.04802 [physics.pop-ph]
9. Agoston, Max K (2004). *Computer Graphics abd Geometric Modeling: Implementation and Algorithms*. 786p.
10. Aho A.V., Hopcroft J.E., Ullman J.D. (2000) *Data structures and Algorithms*. Addison-Wesley Publishing Company. 382p..
11. Xiang Cai 1 , Jonathan H. Jiang 2 , Kristen A. Fahy 2 , Yuk L. Yung. *A Statistical Estimation of the Occurrence of Extraterrestrial Intelligence in the Milky Way Galaxy*.
12. Si Hang. *Adaptive tetrahedral mesh generation by constrained delaunay refinement*. *International Journal for Numerical Methods in Engineering*, 75(7):856–880, 2008.

注水井作业过程中各种因素对岩石渗透率下降的影响

**THE INFLUENCE OF VARIOUS FACTORS ON THE DECREASE  
IN ROCK PERMEABILITY DURING THE OPERATION OF  
INJECTION WELLS**

**Dmitrieva Alina Yurievna**

*Candidate of Technical Sciences, Senior Research Officer  
Tatar Oil Research and Design Institute*

**Baturin Nikita Igorevich**

*Engineer  
Tatar Oil Research and Design Institute*

**Prostikova Natalya Fedorovna**

*Engineer  
Tatar Oil Research and Design Institute*

抽象的。该分析工作基于分析各种因素对注入井作业期间岩石渗透率下降的影响，并确定其在井底井区处理技术中的有效性。

关键词：渗透率，注入井，堵塞，剩余油饱和度，井底形成区。

**Abstract.** *This analytical work is based on the analysis of the influence of various factors on the decrease in the permeability of rocks during the operation of injection wells and the determination of their effectiveness in technologies for treating the bottomhole zone of wells.*

**Keywords:** *permeability, injection well, clogging, residual oil saturation, bottomhole formation zone.*

**Introduction**

The main requirement for the operation of injection wells is to maintain the required injectivity throughout the entire period of reservoir development.

The stability of the injectivity of injection wells depends on many factors: on the reservoir parameters, on the operation of adjacent production wells, on the method of well development and injection pressure, on the quality of the injected water, etc. One of the main reasons for the decrease in injectivity is the gradual or volley clogging of the filtering surface of the formation with mechanical impurities, salts and dispersed particles brought by water, as well as corrosion products that are torn off by the water flow when it moves through conduits and tubing, and

decomposition products the layer itself. During long-term operation of a well, a large amount of suspended particles accumulate in the bottomhole formation zone (BFZ), which clog the formation pores and significantly reduce its permeability [1].

A review of the work in the field of combating organic deposits, both in the conditions of the bottomhole zone of wells and in downhole equipment, shows that when planning and implementing technologies for combating complications, it is necessary to introduce a systematic approach that involves the analysis and evaluation of technologies from the point of view of negative impact on the functioning of the oil production system as a whole. It is necessary to assess the possible consequences of the use of enhanced oil recovery technologies, production stimulation, and well operation technologies on the emergence of complications in the technological processes of well operation.

The deterioration of the filtration characteristics of the bottomhole formation zone of injection wells, as a rule, is associated by researchers with the injection of a working agent [2]. In particular, it was noted that the most dangerous option is the formation pores clogging with particles commensurate with the pore sizes that can enter them and block the channels completely. This should also include options for the formation of dense impermeable membranes by particles, for example, particles of clay or any other particles wetted with oil.

The pore space of the bottomhole zones of injection wells has some residual oil saturation [3]. This is confirmed by the problems that arise when transferring high-water production wells to injection. According to the nature of the change in phase permeabilities, at high values of water saturation, oil becomes practically immobile. Obviously, the decrease in the permeability of the bottomhole zone of injection wells and the adjacent washed zone of the productive horizon is influenced by the nature of the interaction in the system rock - residual oil - injected fluids. Depending on the features of the geological and thermodynamic characteristics of the bottomhole zone of an injection well, a change in the permeability of the bottomhole zone is possible due to the direct appearance and growth of particles in the pore space with residual oil saturation, clogging effects and subsequent filling of the pore volume with particles during filtration of water with residual oil saturation. , adhesion of particles to rock grains. One of the most important reasons that also determine the possibility of clogging the pore space of the bottomhole zone of injection wells with organic substances is the presence of emulsified oil in the injected water. An increase in the oil saturation of a porous medium correspondingly reduces its permeability to water.

The change in free surface energy or Gibbs thermodynamic potential  $\Sigma P$  in the elementary act of sticking (or detachment) of an oil drop to a solid surface in an aqueous medium will be determined by the sum of changes in free surface ener-

gies at all interfaces: solid surface - water  $S_s$ , solid surface - oil  $S_o$ , water-oil  $S_{wo}$  in the initial and final states of this process. Following [4], under isobaric-isothermal conditions in the absence of phase transitions, the equation for estimating the change in the free surface energy of the system  $\Sigma G$  in the process of selective wetting and sticking of an oil drop to a washed solid surface in a washing solution has the form:

$$\Sigma G = -\sigma_{12}(1 - \cos\theta)S_2 + \sigma_{12}(S_2 + S_1 - S^k) = -G_a + G_o - G_{cm}, \quad (1)$$

where:  $\sigma_{12}$  – coefficient of interfacial tension at the water-oil interface;

$\theta$  – contact angle measured in the aqueous phase;

$S_1$  – area of the outer surface of the droplet segment located on a solid substrate;

$S_2$  – area of contact of an oil drop with a solid surface;

$S^k$  – surface area of the oil drop in solution.

In equation (1), the first term characterizes the work of adhesion or sticking of an oil drop  $G_a$ , and the second term characterizes the work of changing (deforming) the surface area of the drop  $G_o$  during spreading over the substrate during sticking. The work of formation of the three-phase wetting perimeter  $G_{cm}$  is the resultant of these two processes. The minus sign indicates that wetting occurs spontaneously with a decrease in surface energy.

On the basis of expression (1), final equations for the work of adhesion, change (deformation) of the drop during adhesion to the substrate and wetting are obtained in a form convenient for calculations: [5]

Work of adhesion

$$A_a = -\frac{G_a}{S^k} = 0,25\sigma_{12}(1 - \cos\theta)(1 - \cos^2\theta)[4/(2 + 3\cos\theta - \cos^3\theta)]^{\frac{2}{3}}, \quad (2)$$

Work of change (deformation) of a drop during adhesion to a substrate

$$A_d = -\frac{G_o}{S^k} = \sigma_{12} \left\{ 1 - (1 + \cos^2\frac{\theta}{2}) + (1 + \cos^2\frac{\theta}{4})4/(2 + 3\cos\theta - \cos^3\theta) \right\}^{\frac{2}{3}}, \quad (3)$$

Work of wetting

$$A_{CM} = \frac{G_{CM}}{S^k} = \sigma_{12}[1 - (2 + 3\cos\theta - \cos^3\theta)/4]^{\frac{1}{3}}, \quad (4)$$

The values of the specific work of wetting calculated by the equations are presented in Table 1.

**Table 1**

Calculated values of specific work (in mJ/m<sup>2</sup>) depending on  $\theta(\Phi)A_{CM} = G_{\text{отрп}}/(4\pi r_k^2 \sigma_{12})(1 - ((2 + 3\cos\theta - \cos^3 \frac{\theta}{4})^{1/3}) = A_a + A_d$

F, degree	$\theta$ , degree	Sticking work $\Delta A_{CM}/(4\pi r_k^2 \sigma_{12})$	Work of adhesion $A_a/(4\pi r_k^2 \sigma_{12})$	Oil Dispersion Work $\Delta A_d/(4\pi r_k^2 \sigma_{12})$	The work of separating a drop of oil from a solid surface $-A_{\text{отрп}} = A_a - A_d$
0	180	1,00			
1	179	0,99	32,3	-31,31	63,61
3	177	0,99	12,0	-11,01	23,01
5	175	0,98	10,0	-9,02	19,02
10	170	0,94	5,3	-4,36	9,66
20	160	0,87	3,37	-2,50	5,87
30	150	0,765	2,16	-1,395	3,555
40	140	0,633	1,62	-0,957	2,577
50	130	0,563	1,251	-0,688	1,939
60	120	0,454	0,970	-0,516	1,486
70	110	0,375	0,734	-0,359	1,093
80	100	0,289	0,550	-0,261	0,811
90	90	0,200	0,400	-0,200	0,600
100	80	0,144	0,300	-0,186	0,486
110	70	0,093	0,179	-0,086	0,265
120	60	0,055	0,106	-0,051	0,156
130	50	0,02	0,056	-0,036	0,092
140	40	0,01	0,0248	-0,0148	0,0396
150	30	0,0044	0,0085	-0,0041	0,0126
160	20	$1,46 \times 10^{-1}$	$1,75 \times 10^{-4}$	$-2,9 \times 10^{-5}$	$2,04 \times 10^{-4}$
170	10	$5,7 \times 10^{-5}$	$7,4 \times 10^{-5}$	$-1,7 \times 10^{-5}$	$9,1 \times 10^{-5}$
175	5	$3,6 \times 10^{-6}$	$4,0 \times 10^{-6}$	$-8,036 \times 10^{-6}$	$4,3 \times 10^{-6}$
178	2	$8,0 \times 10^{-8}$	$8,0 \times 10^{-8}$	0	$8,0 \times 10^{-8}$
179	1	$6,0 \times 10^{-9}$	$6,0 \times 10^{-9}$	0	$6,0 \times 10^{-9}$
180	0	0	0	0	0

It can be seen from the table that for almost all contact angles, regardless of the properties of the porous medium, the work of tearing off a drop from a solid surface exceeds the work of sticking. This means that the work of oil sticking to a solid surface is energetically favorable, and additional work must be expended to wash film oil. Based on the foregoing, it was concluded that in the bottom-hole zone of injection wells there are favorable conditions for the existence of

non-recoverable film oil, which, when cold water is injected and the temperature decreases accordingly, is one of the reasons for the decrease in the porosity and porosity characteristics of the bottomhole formation zone of injection wells. In addition, a change and a significant difference in the size of the capillary channels lead to a decrease in the permeability of the bottomhole zone due to the penetration of high-viscosity residual drop oil into larger channels, which, gradually accumulating in the bottomhole zone, can reduce the injectivity of the well, in some cases until the injection is completely stopped. As it moves through the water conduit system, oil coalesces and can accumulate in the wellbore and bottomhole zone in significant volumes, which is confirmed in field practice.

As a result of the study of the state of residual oil in wastewater, it was found that oil resembles evenly scattered elastic balls with a diameter of 0.1...10  $\mu\text{m}$  [2]. Dispersion analysis of emulsified oil performed by the authors [6] showed that the main volume of particles (80%) has a size of less than 10  $\mu\text{m}$ . At the same time, there are particles with a size of 100  $\mu\text{m}$  or more. The content of fractions with solid particles smaller than 100  $\mu\text{m}$  was 75.1%, with sizes from 100 to 300  $\mu\text{m}$  - 15%.

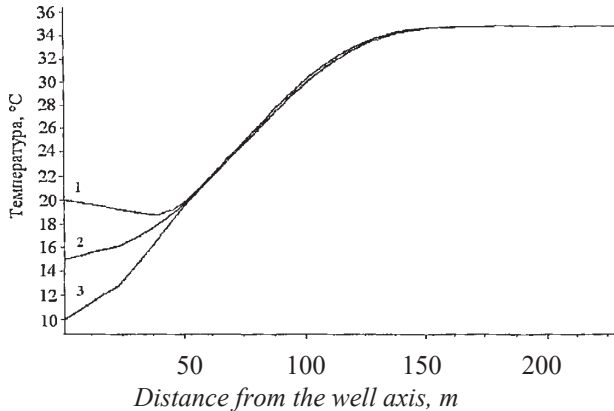
As a result of analyzes of the component composition of samples of oil filtered from water, an increased content of high-molecular hydrocarbon compounds, such as resins, asphaltenes, naphthenic and fatty acids, was found in them; the most active part of the oil, whose role in the formation of boundary layers is known from a number of works [7].

Thus, as a result of the analysis of the change in the free surface energy of the system in the process of selective wetting, it has been shown that there is a ratio of the forces of adhesion of oil or oil to rock grains and the force of tearing off under the influence of the velocity pressure of the flow, which is favorable for the existence of film oil, since the work of detaching a drop from a solid surface exceeds the adhesion work. Unrecoverable film oil, into which the emulsified oil contained in the injected water passes, with a corresponding decrease in temperature, is one of the reasons for the decrease in the porosity and porosity characteristics of the bottomhole formation zone of injection wells.

The temperature of the water injected into the reservoir at any time of the year is below the reservoir temperature. And during the entire period of operation of the injection well, the rocks of the bottomhole zone and the productive formation are cooled. At the same time, due to the presence of film oil and precipitation of organic substances in the cooled areas, the linear dimensions of porous blocks and interpore channels decrease. Studies [8] found that even with a slight decrease in reservoir temperature ( $T_{\text{низ}} = 59\text{--}65\text{ }^{\circ}\text{C}$ ) single clogging paraffin crystals appear in a porous medium, and at  $45^{\circ}\text{C}$  its mass crystallization takes place.

As a result of calculations using mathematical modeling, temperature profiles in the reservoir were built (Fig. 1), corresponding to periodic injection with the

calculated temperature value at the end of summer and time = 114 months. (curve 1) and with the calculated value of temperature at the end of winter and time = 120 months. (curve 3) and non-periodic injection with an average temperature  $T = 15$  °C and time = 120 months. (curve 2) [9].



**Figure 1.** Horizontal formation temperature profiles

The curves are plotted for the following conditions: 1 – intermittent injection, water temperature 20 °C, injection duration 114 months; 2 - non-periodic injection, water temperature 15 °C, injection duration 120 months; 3 – intermittent injection, water temperature 10 °C, injection duration 120 months.

It can be seen from the results of mathematical modeling that seasonal temperature fluctuations have a significant impact on the temperature distribution only in the immediate vicinity of the well. At a distance of 50 m and further, the influence of seasonal fluctuations on the formation of the temperature field of an oil-bearing formation is negligible.

## References

1. Fadeyev, V.G. *The technology of cleaning the bottomhole formation zone of injection wells using spout methods [text]* / V.G. Fadeev, R.B. Fattakhov, A.A. Arsentiev, M.A. Abramov // – M.: JSC «VNIOENG», 2009. – 108 p.;
2. Khisamutdinov, N.I. *Experience in restoring and regulating the productivity of producing and injection wells [text]* / N.I. Khisamutdinov, G.Z. Ibragimov, N.I. Kobayakov, R.Kh. Muslimov, A.G. Temin // *Review. inform. Ser. Technique and technology of oil production, and development of oil fields.* – M.: «VNIOENG», 1990. – P. 1-51 .;

3. Surguchev, M.JI. *Physical and chemical microprocesses in oil and gas reservoirs [text]* / M.L. Surguchev, Yu.V. Zheltov, E.M. Simkin // – M.: «Nedra», 1984. – 215p.;

4. Koretsky, A.F. *Mechanical work of cleaning and washing action of surfactant solutions [text]* / A.F. Koretsky, V.A. Kolosanova, T.A. Kretskaya // *Colloid journal.* – 1983. – No. 1. – P.74-80.;

5. Ibatullin, P.P. *Increased oil recovery at a late stage of field development [text]* / P.P. Ibatullin, N.G. Ibragimov, Sh.F. Takhautdinov, R.C. Khisamov // *Theory. Methods. Practice.* – M.: OOO «Nedra-Business Center», 2004. – 292 p.;

6. Suchkov, B.M. *Oil production from carbonate reservoirs [text]* / B.M. Suchkov // *Moscow-Izhevsk: Research Center «Regular and Chaotic Dynamics», 2005.* – 688p.;

7. Kudinov, V.I. *Intensification of viscous oil production from carbonate reservoirs [text]* / V.I. Kudinov, B.M. Suchkov // *Samara: Book publishing house,* – 1996. – 440 p.;

8. Tarko, Ya.B. *Evaluation of the influence of cooling of the bottomhole formation zone on their injectivity [text]* / Ya.B. Tarko // *E.I. No. 4 Oilfield business series.* – M.: «VNIIOENG», 1987. – 59p.;

9. Avramenko, A.N. *Calculation of the effect of reservoir cooling taking into account seasonal fluctuations in the temperature of injected water [text]* / A.N. Avramenko // *Publishing house «Oilfield business».* – 2001. – No. 2. – P.19-20.



自主移动机器人的多传感器融合研究  
**MULTISENSOR FUSION STUDY FOR AUTONOMOUS  
MOBILE ROBOTS**

**Cao Wenye**

*Master, student*

*Bauman Moscow State Technical University*

**摘要。** 文章介绍了自主移动机器人的研究和应用, 以及使用多模态传感器的方法; 介绍了多传感器融合的定义和方法; 创建了多模式自主移动机器人模型。

**关键词:** 移动机器人, 多模式传感器, 信息融合。

**Abstract.** *The article presents the research and application of autonomous mobile robots, with the method of using multimodal sensors; presents the definition and method of multisensor fusion; created a model of multimodal autonomous mobile robots.*

**Keywords:** *mobile robotics, multimodal sensors, information fusion.*

### **Introduction**

Nowadays, the robot industry is developing rapidly, and human-computer interaction technology is becoming more and more mature. Various shopping malls have begun to use robotic guides to provide services to customers. Service autonomous mobile robots must recognize human intentions, facilitate human actions and ensure human safety. We need vision, distance, force, and other sensors to perform the task of pointing and capturing objects by the robot. This is why there is a need for research to evaluate multimodal sensor information perception.

Indeed, recent technological developments in bionic sensors have made these sensors cheap and lightweight. As a result, their use in robotics, especially in anthropomorphic robots such as humanoid robots, is simplified. These sensors include RGB-D cameras, haptic skin sensors, force/torque sensors, and capacitive proximity sensors. Traditionally, data from heterogeneous sensors are fed into aggregation algorithms [1] (e.g., Kalman- or Bayesian-based algorithms) to produce state estimates for environmental simulations. However, since these sensors typically measure different physical phenomena, they are best used directly in low-level servo controllers rather than for aggregating multiple sensors or de-

veloping complex finite state machines. This idea was originally proposed in the context of a hybrid paradigm for position and force control [2], and when it is extended to multiple sensors, new problems such as control design arise.

Service robots for supermarkets have powerful intelligent technology. Thanks to three-dimensional visual perception, they can automatically perceive the environment. For example, when we go to the mall, it is not difficult to find a service robot. At various key positions in the mall, it provides services for tourists in malls and supermarkets.

### **Fusion of multisensory information**

Combining information from multiple sensors is a popular study in large industries today. Robots today are equipped with sensors such as radar, vision sensors, millimeter-wave radar, and force sensors. The advantages of radar are its small size and weight, high resolution, and ability to protect against interference, but it is susceptible to environmental influences and too expensive. Millimeter wave radar is unaffected by weather, suitable for long- and medium-range detection, has strong anti-jamming capabilities, but lacks the ability to identify lane information, and has serious interference. Vision sensors are widely used and inexpensive, but are affected by environmental factors, have limited range of vision, and are computationally expensive. Force sensors measure force moments and convert them to digital signals with accuracy and stability, but detection and feedback are separate, and immediate force detection is achieved at the terminal, but the actual implementation element is far from the terminal. Because of the lack of sensing efficiency of a single sensor and the limitations of each sensor, information fusion is often performed using two or more sensors.

Information fusion technology, also known as data fusion, is the process of correlating and synthesizing data from multiple sources of information to obtain more accurate information, and includes immediate state and threat assessment and continuous correction to obtain more accurate information. In information fusion, each sensor is the hardware device needed to fuse the information, the information from the sensor is the object of the information fusion, and the complex information processing is the core of the information fusion.

Information fusion technology uses multiple modern disciplines to intersect and synthesize research directions [3], using computer technology to collect and transmit sensor information, detection and analysis, filtering and synthesis, correlation and evaluation, and synthetic processing as the basis for accurate state information and timely situation assessment.

Wald offers one definition of synthesis [4], which is the use of mathematics and various tools to process multiple sources of information and ultimately produce different types of persuasive information for our various needs through different structural frameworks. Therefore, we need to perform various forms of

fusion, such as data fusion, feature fusion, decision fusion, as well as image fusion, sensor fusion, etc.

Information fusion technology brings together a number of modern disciplines and is closely related to computer and communication technology. Due to the leapfrog development of computer technology, communication technology and networking technology in our time, information fusion technology is also developing rapidly. Information fusion technology is used in various disciplines and fields, beginning with the military and gradually flowing into the civilian sector, such as intelligence, medicine, agriculture and industry. Information fusion techniques can be used for target detection [5-7], such as tracking and situation assessment [8-9].

Information fusion algorithms underlie information fusion technology and are usually divided into two main categories: classical methods and modern methods. Classical methods are a class of fusion algorithms based on mathematical methods. They include weighted mean method, maximum likelihood method [10], least squares, Kalman filter [11], Bayesian inference [12], classical inference and proof theory D-S. method, proof theory D-S (Dempster- Shafer Inference) [13], qualitative factorization method, etc. Modern synthesis algorithms are a class of synthesis algorithms developed in accordance with the development of artificial intelligence theory, modern information theory, and so on. The main algorithms used in this category are: cluster analysis, fuzzy logic, neural networks, wavelet theory, rough set theory [14], support vector machines [15]. Vector machines [16] and other methods.

Commonly used data fusion methods include neural networks, machine learning, pattern recognition, fuzzy theory, genetic algorithms, etc. Two or more methods are often used for data fusion. For example, the combination of genetic algorithm and fuzzy theory uses certain genetic operators to better simulate fuzzy relations to obtain higher accuracy; fuzzy theory and neural networks form fuzzy neural networks are widely used in pattern recognition and data fusion; and the combination of genetic algorithm and neural network, genetic algorithm and fuzzy neural network [17] has a data processing [18] and control training [19] with significant advantages.

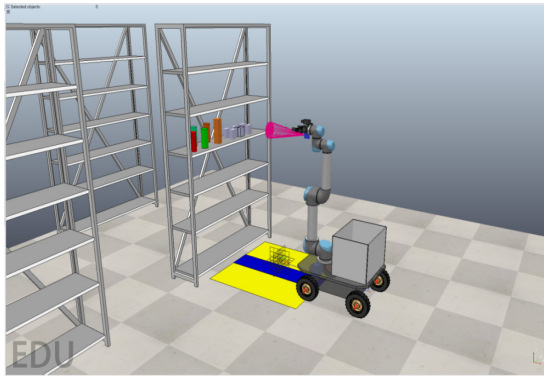
### **Algorithm and development of simulation model of manipulator operation**

The use of sensors provides autonomous gripping by the manipulator. Vision-assisted grasping technology is now widely used in practice [20]. Autonomous grasping means that the robot arm control system obtains the position of the target object using sensors, such as cameras, and controls the robot arm to perform the grasping task without human intervention.

The entire capture process is conventionally divided into the following stages: (1) reading information from the camera → (2) identifying the target object

and determining its position → (3) converting the two-dimensional coordinates of the object in the camera into three-dimensional coordinates relative to the optical center of the camera, and then into world coordinates relative to the base of the manipulator → (4) calculating the position of the end effector when the object is grasped at the time of the grasp of the object → (5) then we need to calculate the angle by which each manipulator motor should turn based on the known target position and information about the end effector position

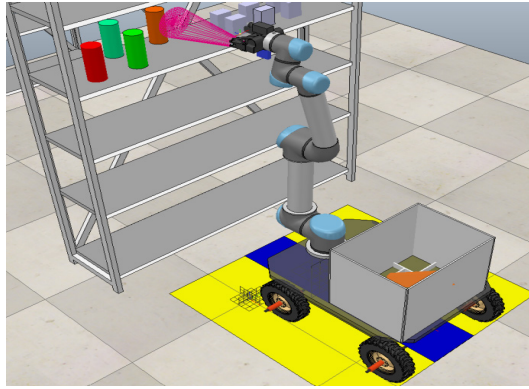
It is simulated in V-REP and its environment is constructed (in Fig. 1.).



**Figure 1.** General structure of the model in the V-REP environment

The robot itself consists of two parts - the mobile cart module and the robot arm grip module. The mobile cart module consists of a body, four wheels. Once the target object is identified, the cart moves to the target point and waits for the gripper to occur.

The manipulator gripper module consists of the UR-5 manipulator, the RO-BOTIQ-85 two-finger gripper and the sensor module. The sensor module consists of a vision sensor, a distance sensor, a force sensor and two tactile sensors. In the simulation, the camera detects the target and the distance sensor determines its position, after which the gripper arm moves to the destination point and grabs the target. The end of the robotic arm and the object are then moved together into the box on the cart, the gripper is released, and the manipulator returns to its original position (in Fig. 2).



**Figure 2.** Simulation of the manipulator gripper module

### Conclusion

This paper presents the research and application of multi-sensor fusion for autonomous mobile robots. The finite nature of single sensors is analyzed, the definition of multi-sensor fusion and the approach of information fusion algorithm is given, the data fusion method is described. The design of the multimodal sensor system model in V-REP is completed. A manipulator capture module is constructed, and the solution to the inverse kinematic problem of the manipulator in V-REP.

### References

1. Xu Fang. State and development of industrial robot industry [J]. *Robotics and Applications*. 2007.30(05):2-4.
2. Wang Tianran, Development of Robotics [J], *Robot*, 2017, 39(04): 385-386.
3. WaldL.AnEuropeanproposalforterms ofreference in data fusion. *International Archives of Photo gramme try and Remote Sensing*, 1998,XXXII(7):651~ 654.
4. Bastiere A. Methods for multisensor classification of airborne targets integrating evidence theory. *Aerospace Science and Technology*, 1998,2(G): 401~ 411.
5. Kam M. RorresC,Chang W,Zhu X. Performance and geometric interpretation for decision fusion with memory. *IEEE Transactions on Ssystems, Man, and Cybernetic- Part A: Systems and Humans*, 1999, 29(1): 52~ 62.
6. Lampropoulos G A,Anastassopoulos V, Boulter J F.Constant false alarm rate detection of point targets using distributed sensors. *Optical Engineering*, 1998,37(2): 401~ 416.

7. Buede D M, Girardi P. A target identification comparison of Bayesian and Dempster-Shafer multisensor fusion. *IEEE Transactions on Systems, Man, and Cybernetic- Part A: Ssystems and Humans*, 1997, 27(5): 569~ 577.

8. Aziz A M, Tummala M, Cristi R. Fuzzy logic data correlation approach in multisensor-multitarget tracking systems. *Signal Processing*, 1999, 76(2): 195~ 209.

9. GAO Liping, HUANG Haining, XU Demin. On data fusion using maximum likelihood method and its application to underwater robot[J]. *Journal of Northwester Polytechnical University*, 1999, 17(2): 306- 310.

10. GAO Qing. Algorithms research on multi-sensor data fusion[D]. Xi'an: Xidian University, 2008.

11. SOMMER K D, KUEHN O, LEON F P, et al. A bayesian approach to information fusion for evaluating the measurement uncertainty[J]. *Robotics and Autonomous Systems*, 2009, 57: 339- 344.

12. WANG Xin. The research on multi-sensor data fusion[D]. Changchun: Jilin University, 2006.

13. BASIR O, YUAN Xiaohong. Engine fault diagnosis based on multi-sensor information fusion using dempster-shafer evidence theory[J]. *Information Fusion*, 2007(8): 379- 386.

14. LIU Zhiping, SHAN Gang, WANG Fengqun, et al. Information fusion algorithm of traffic based on support vector machine[J]. *China High Technology Enterprises*, 2007(10): 99- 100.

15. Sun Youfa, Chen Shiquan, Wu Jinpei, et al. A fuzzy genetic neural network-based information fusion technique and its application[J]. *Control and Decision Making*, 2001(16): 717- 720.

16. Abdel-Aty-Zohdy H. S., Ewing R. L. Intelligent information processing using neural networks and genetic algorithms // *Proceedings of the 43rd IEEE Midwest Symposium on Circuits and Systems (Cat. No. CH37144)*. – IEEE, 2000. – T. 2. – C. 840-845.

17. Chou C. J., Yu F. J., Su C. T. Combining neural networks and genetic algorithms for optimizing the parameter design of inter-metal dielectric layer // *2008 4th International Conference on Wireless Communications, Networking and Mobile Computing*. – IEEE, 2008. – C. 1-4.

18. KerhT, ChanY L, Gunaratnam D. Treatment and assessment of nonlinear seismic data by agenetical gorithm based neural network model[J]. *International Journal of Nonlinear Sciences and Numerical Simulation*, 2009, 10(1): 45- 56.

19. Kun Zhao, Mirko Meuter, Christian Nunn, Dennis Muller, Stefan Muller-Schneiders and Josef Pauli. A Novel Multi-lane Detection and Tracking System[J]. *2012 Intelligent Vehicles Symposium, Alcalade Henares, Spain, June 3-7, 2012*.

20. Hu Peicheng, Li Ning, Zhou Jianjiang Improved self-calibration method of ring dot camera[J] *Optoelectronic Engineering*, 2007, 34(12): 54

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沼泽环境污染物扩散及其自净能力研究(以鄂毕沼泽为例)

**STUDY ON THE DIFFUSION OF POLLUTANTS AND THEIR SELF-PURIFICATION ABILITY IN SWAMP ENVIRONMENT (TAKING OB SWAMP AS AN EXAMPLE)**

**Zhou Dan**

*PhD student*

*National Research Tomsk Polytechnic University*

**Savichev O. G.**

*Dr. Sc., professor*

*National Research Tomsk Polytechnic University*

**摘要** 本文以西西伯利亚托木斯克地区的鄂毕沼泽为研究对象,对沼泽生态系统污染物的扩散和自净能力进行了研究。研究结果表明:(1)鄂毕沼泽生态系统的自净能力很强;(2)在泥炭沉积物的下部,研究区已经形成了局部水屏障,阻止了泥炭沉积物中物质的扩散;3)指示剂(Cl<sup>-</sup>) 在泥炭沉积物上的分布在很大程度上不仅取决于 NaCl 的初始体积和浓度以及防水层的存在,还取决于沼泽湿度的性质。

**关键词:** 鄂毕沼泽, 污染物扩散, 自净能力。

**Abstract** *In this paper, taking the Ob swamp in the Tomsk area of West Siberia as the research object, the diffusion of pollutants and the self-purification ability of the swamp ecosystem are studied. The research results show that: (1) The self-purification ability of the Ob swamp ecosystem is very strong; (2) in the lower part of the peat deposit, a local water barrier has formed in the study area, preventing the spread of substances in a peat deposit; 3) the distribution of the indicator (Cl<sup>-</sup>) over the peat deposit largely depends not only on the initial volume and concentration of NaCl and the presence of a water barrier, but also on the nature of the wetness of the swamp.*

**Key words:** *Ob Swamp, Diffusion of Pollutants, Self-purification Ability.*

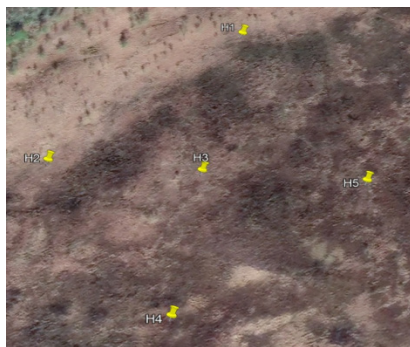
**Introduction**

Environmental pollution is one of the key problems of our time. It is very acute in the West Siberian region - one of the most important oil and gas producing regions in the world, a feature of which is a very high swampiness of watershed areas[1-3]. The Ob swamp is one of the largest floodplain swamp systems in Western

Siberia, located at the foot of high terraces, occupying the ancient old rivers of the left-bank segments of the Ob floodplain in the south of the forest zone. Ob swamp in the form of a strip about 104 km long and 1.5–7.0 km wide [4]. This swamp is characterized by an average depth of the peat deposit of about 3.2 m, a maximum depth of 6 m, and the occurrence of lowland peat with a degree of decomposition of 34% and an ash content of 28–29%. Economic activities are closely related to the swamp ecosystem, such as the discharge of waste water by residents, and the swamp has a certain self-purification ability. After the sewage is discharged into the swamp, its state may change. With this in mind, the authors performed a simulation of the diffusion of pollutants using NaCl as an indicator and studied its self-purification ability.

### **Object and methodology of research**

The research object is the Ob eutrophic swamp in West Siberia, located on the left bank of the Ob River. On March 18, 2021, five wells were drilled in the area of the Ob swamp near the village of Nashchekovo (Fig. 1), in which samples of swamp waters were taken from the active horizon of the peat deposit, and then samples of peat and mineral deposits were taken at intervals (through 0.25 m) along the entire depth of the peat deposit up to and including the mineral soil. After sampling the bog water and peat, pour 50 L of NaCl solution (20 g/dm<sup>3</sup>) on the bog surface 0.5 m from the H3 well. On October 16, 2021, swamp water and peat samples were collected again at the same location.



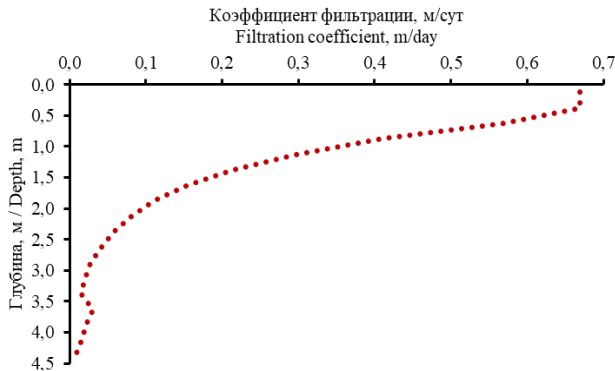
*Figure 1. The layout of wells in the Ob swamp near the Nashchekovo village in the left-bank part of the Ob river valley during the experiment*

The main approach to explaining the nature of changes in Cl<sup>-</sup> concentrations in water extracts from peat before and after the release of NaCl solution is to select a mathematical model of Cl<sup>-</sup> distribution, taking into account the regime of groundwater and marsh waters.



### Research results and discussion

As a result: 1) the accumulation of chlorides on March 18, 2021 is confined to the interval of 3.50–4.25 m, composed of lowland woody waterlogged peat; 2) the actual calculation of the distribution of indicator substances in a peat deposit can be limited to a section of a peat deposit from its surface to a depth of 3 m, formed mainly by low-lying sedge-hypnum peat; 3) within this area, the advective transport is significant (taking into account the levels of bog waters near the middle surface of the bog) mainly in the tow layer, and the main mechanism for the transport of pollutants along the peat deposit is diffusion, taking into account the processes of sorption and dissolution - sedimentation [5]; 4) a section of a peat deposit from 3.0 to 3.5 m, composed of lowland sedge peat, can be considered as a local aquiclude (note - only in the calculated profile of the Ob swamp, which does not exclude more significant filtration properties of sedge peat and the absence of the specified aquiclude on other areas of the Ob swamp), within which the interaction “water - organic matter - gas - mineral inclusions” prevails with almost no advective transfer and minimal diffusive transfer.

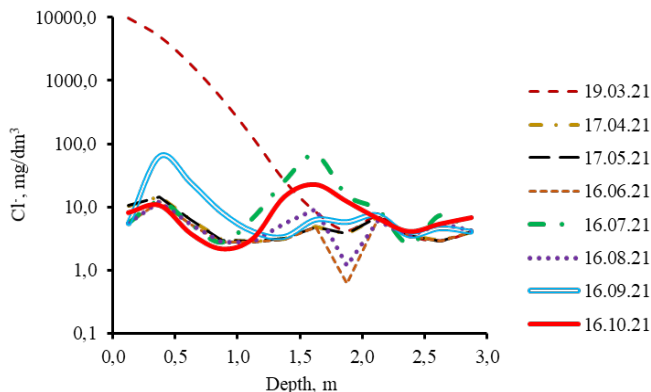


**Figure 2.** Estimated change in the filtration coefficient of peat by the depth of the peat deposit of the Ob swamp

To study the distribution of the indicator substance  $\text{Cl}^-$  in the peat water extract in the study area, a one-dimensional steady-state model was established, and more detailed information on the model structure and parameters are given in [6].

The calculated and measured  $\text{Cl}^-$  content in the peat water extracts indicated a satisfactory description of the final state of the peat deposits, and obtained a rather unexpected picture of the monthly distribution of  $\text{Cl}^-$  concentrations over the depth of peat deposits. Thus, a sharp decrease in the content is observed already in April. However, in the following months, in the absence of an additional supply of

solution, noticeable fluctuations are observed associated with the “pulling up” of the water mass with an increase in rainfall and “lowering” down with the predominance of evaporation (Fig. 3).



**Figure 3.** Calculated changes in the concentration of  $Cl^-$  in water extracts from peat at the depth of the peat deposit from 03/18/2021 to 10/16/2021 [Savichev, Yang Heng, Zhou Dan, 2022]

### Conclusion

The experimental research shows that (1) In March 2021, 50L of NaCl solution with a concentration of  $20\text{g/dm}^3$  was poured into well H3, and as of October 2021, the relative depth range of  $Cl^-$  in the active layer increased to 1.50 - 1.75 m, and there is no significant change at points H1, H2, H4, and H5, indicating that the swamp system has a strong self-purification ability. (2) Before the release of the indicator NaCl solution,  $Cl^-$  accumulation was found in the depth range of 3.5-4.5 m, indicating the existence of an aquifer there, which prevented the diffusion of substances, and also prevented the formation of swamp water and groundwater. exchange. (3) The distribution of the indicator ( $Cl^-$ ) on peat deposits depends largely not only on the initial volume and concentration of NaCl and the presence or absence of an aquitard, but also on the nature of the wetting of the bog.

### References

1. Liss O.L., Abramova L.I., Avetov N.A. Bolotnye sistemy Zapadnoy Sibiri i ikh prirodookhrannoe znachenie [Bog of Western Siberia and their conservation value]. Tula, Grif i K<sup>o</sup>Minayeva T., Bleuten W., Sirin A., Lapshina E.D. Eurasian mires of the Southern Taiga Belt: modern features and response to Holocene

*palaeoclimate. Wetlands and Natural Resource Management. Ecological Studies. Vol. 190. Eds. J.T.A. Verhoeven, B. Beltman, R. Bobbink, D.F. Whigham. Berlin Heidelberg, Springer-Verlag, 2006. pp. 315–341.*

2. Hu S., Niu Zh., Chen Y., Li L., Zhang H. *Global wetlands: Potential distribution, wetland loss, and status. Science of the Total Environment, 2017, vol. 586, pp. 319–327. DOI: 10.1016/j.scitotenv.2017.02.001.*

3. Schipper A.M., Zeefat R., Tanneberger F., Van Zuidam J.P., Hahne W., Schep S.A., Loos S., Bleuten W., Joosten H., Lapshina E.D., Wassen M.J. *Vegetation characteristics and eco-hydrological processes in a pristine mire in the Ob River valley (Western Siberia). Plant Ecology, 2007, vol. 193, pp. 131–145. DOI: 10.1007/s11258-006-9253-x.*

4. Lishtvan I.I., Bazin E.T., Kosov V.I. *Physical processes in peat deposits [Fizicheskiye protsessy v torfyanykh zalezakh]. Minsk, Science and technology Publ., 1989. 287 p.*

5. Oleg G. Savichev, Yang Heng, Zhou Dan. *Hydrogeodynamic and hydrogeochemical conditions of self-clearance of the water of the obskoye fen(western siberia). Bulletin of the Tomsk Polytechnic University. 2022, vol.333 (4) pp. 115-125.*

中华人民共和国和俄罗斯联邦湿地与地下水关系问题研究  
**THE STUDY OF THE PROBLEM OF THE RELATIONSHIP  
BETWEEN WETLANDS AND GROUNDWATER IN THE PEOPLE'S  
REPUBLIC OF CHINA AND THE RUSSIAN FEDERATION**

**Yang Heng**

*Ph.D. Student*

*National Research Tomsk Polytechnic University*

**Savichev O.G.**

*Professor*

*National Research Tomsk Polytechnic University*

抽象的。湿地在世界范围内广泛存在。在湿地地区，湿地水与地下水的关系一直是世界各国研究者关注的热点。同时，湿地也是地下水与湿地水交换最频繁的场所以之一，交换过程复杂多变。本文以俄罗斯联邦鄂毕湿地和中华人民共和国鄱阳湖湿地为例，全面阐述湿地水与地下水关系研究过程中存在的一些问题。

关键词：湿地水，地下水，鄱阳湖，鄂毕沼泽。

**Abstract.** *Wetlands exist widely in the world. In wetland areas, the relationship between wetland water and groundwater has always been a hot spot for researchers from all over the world. At the same time, wetland is also one of the places where groundwater and wetland water exchange most frequently, and the exchange process is complex and changeable. This article takes the Ob wetland in the Russian Federation and the Poyang Lake wetland in the People's Republic of China as examples, and comprehensively expounds some problems existing in the process of studying the relationship between wetland water and groundwater.*

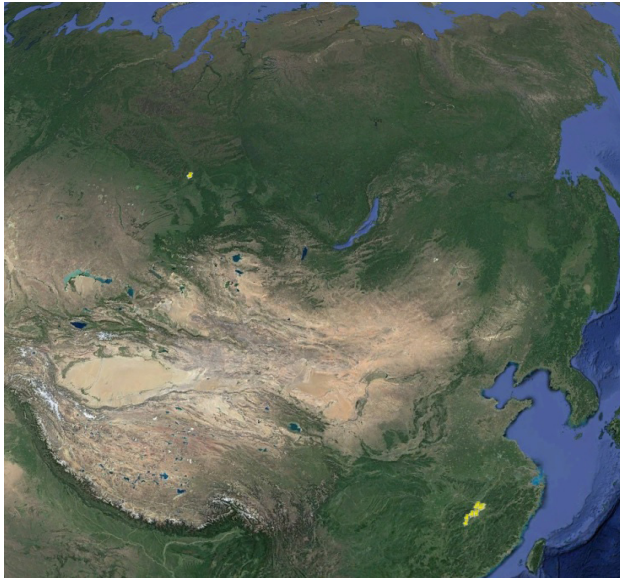
**Keywords:** *wetland water, groundwater, Poyang lake, Ob swamp.*

### **1. General statement of the research on the composition of wetland ecological water body and geochemical conditions**

The objects of study are groundwater of the hypergenesis zone and water of wetlands. According to [1], a water body is understood as a concentration of natural waters on the land surface or in rocks, which has characteristic forms of distribution and regime features - a set of regularly repeating changes in the state inherent in this water body, and hypergenesis, in accordance with [2], - a set of processes of physical and chemical transformation of matter in the upper parts of

the earth's crust and on its surface during the interaction of the bio-, atmospheric, hydro- and lithosphere.

According to the [2], water bodies are divided into underground and surface ones; The first includes groundwater basins and aquifers, and the second - seas or their separate parts, watercourses (canals and rivers), water bodies (lakes, reservoirs, flooded quarries), swamps, natural outlets of groundwater (springs, geysers), glaciers, snowfields, and surface water bodies consist of surface water and covered by them of land within the coastline, determined by the average long-term water level during the period when there is no ice(Fig. 1).



**Figure 1.** Scheme of placement of research objects in the area of the Ob swamp (I) and in the watershed of Lake Poyan (II)

As stated in the introduction, a swamp is “a natural formation that occupies a part of the earth's surface and is a peat deposit saturated with water and covered with specific vegetation” [3], which, depending on the thickness of peat deposits, distinguish between wetlands (“a swamp with mineral soils or peat deposits of not more than 0.3 m in a non-drained state”) and peat bogs(respectively, with deposits of peat from 0.3 m in the non-drained state) [2]. Bogs, wetlands and a number of objects subject to permanent or periodic flooding (lagoons, floodplains and overgrown lakes) are in some cases considered wetlands.

## **2. The study of wetlands and groundwater in the basin of Poyang Lake**

The watershed of Poyang Lake, one of the largest freshwater lakes in the world in general, and East Asia in particular, is located on the border of sections of the middle and lower reaches of the Yangtze River (in the southern part of this territory), and in administrative terms-in the south-east of the People's Republic of China, within the Jiangxi provinces. The hydrographic network is represented by the Poyang Lake itself, connected to the River Yangtze channel, tributaries of Lake Poyang, the main ones are the Ganjiang, Fuhe, Xinjiang, Raohe and Xiushui rivers. A significant part of the lakeside territories is occupied by wetlands, some of which are not used.

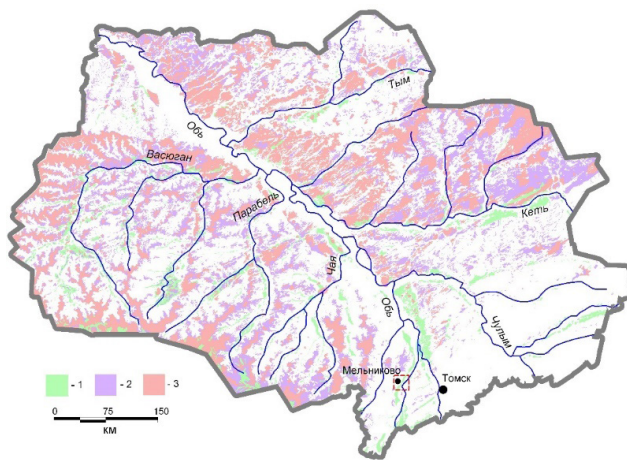
All of these water bodies are fed by rain and underground, which, among other things, additionally determines the relevance of water and environmental research, since (1) the regulation of the flow of the River Yangtze and climatic changes affect the level regime of Lake Poyang, which, in turn, (2) leads to significant changes in the groundwater regime and the state of wetlands. The changes mentioned above complicate the problems of water use due to the scarcity of water resources of the required quality (3). At the same time, the problem of water quality (4) is further exacerbated due to the relationship between underground and river waters, and wetland waters. In general, the general problem of the formation and functioning of the aquatic ecosystem of Poyang Lake is obvious, which includes aspects of the study of the lake itself, the conditions of its interaction with the River Yangtze, groundwater, wetland waters, etc.

However, the issues regarding the mutual influence of wetlands in the watershed of Lake Poyang and groundwater in terms of the formation of the chemical composition and quality of the latter (groundwater) remain insufficiently developed, especially in terms of quantitative assessments of the regularities of spatio-temporal changes and explanations of the mechanisms of such mutual influence. This determined the relevance, purpose and objectives of the work under consideration, which is a further development of Russian-Chinese hydrogeochemical studies in the watershed of Poyang Lake, carried out over the past 10 years. [4].

Since the objectivity of the expected results in accordance with the tasks in the general case increases when considering various conditions, the study under consideration included not only the study of wetlands and groundwater in the Poyang catchment (PRC), but also the Ob swamp in Western Siberia (RF). This is a low-lying swamp, located in the valley of another largest Asian river, the Ob, on the border of the forest-steppe and forest natural zones and closest in terms of water and geochemical regimes to the wetlands in the Poyang Lake catchment (as far as possible).

### 3. Study of the Ob swamp and groundwater of adjacent territories

Western Siberia is characterized by very high swampiness, exceeding 50% of the territory for the watersheds of a number of medium-sized rivers [5]. Accordingly, high swampiness has a significant impact on almost all aspects of the functioning of the geosystems of this region, including groundwater. Since marsh waters contain a large amount of organic and a number of other substances, their entry into underground aquifers can adversely affect the quality of groundwater—the main source of water supply in the plains of Western Siberia[6]. All this determines the permanent relevance of research on both groundwater and swamp waters, especially against the background of observed climate changes and economic activity[3], including in the Tomsk region, the swampiness of which exceeds 25%(Fig. 2).



**Figure 2.** Scheme of types of bogs in the territory of the Tomsk region (1 - lowland; 2 - transitional; 3 - raised) and the location of the studied area of the Ob swamp [Savichev, 2010]

Among the swamps of the Tomsk region, large swamp complexes stand out, for example, the giant Vasyugan swamp [7], consisting of smaller swamps and different types (upland, transitional, and lowland). There are also very large lowland swamps located in river valleys. One of these swamps is the Ob. It is included in the Cadastre of peat bogs of the Russian Federation (formerly the USSR) (Map of peat deposits..., 2000). His study until the 2000s. in most cases, they were engaged in solving geobotanical and ecological problems, or problems of substantiating the use of peat [8]. In 2007, the paper [9] was published, which comprehensively

considered the formation of the ecological state of the Ob swamp and the hydrogeological conditions of its functioning. Then a series of works was published on the study of the chemical composition of the waters and peat of this swamp in its natural and disturbed states [10], which are continued by the present study.

The area of the Ob swamp is located in the southeastern part of the West Siberian artesian basin (WSAB) on the border with the Sayan-Altai hydrogeological folded region (SAGS). The results of the study of groundwater in this and adjacent territories are presented in a large number of publications, among which it is necessary to note large generalizations.[9]. Annual information on the state and use of groundwater in the region is given in the publications of the Siberian Regional Center (SRC) of the FGBU “Gidrospegeologia” [8]. We also note that various aspects of the formation of resources and the chemical composition of groundwater in the study area have been considered in recent years in[10].

The issues of interaction between underground and marsh to varying degrees were discussed earlier in the works, but either on the example of specific swamps, or by comparing individual geochemical indicators of waters, but in any case, usually without taking into account the water regime and the specifics of swamps of different types.

#### 4. Discuss

“The relationship between wetland water and groundwater” has always been a hot topic of research by scholars around the world, but there is a lack of systematic theoretical demonstration and experimental simulation of the whole process of wetland water and groundwater exchange in the research process; especially for the interaction between wetland water and groundwater There is considerable controversy over the issue of the boundary determination.

#### References

1. Alekin O.A. *Fundamentals of hydrochemistry*. – Leningrad: Gidrometeoizdat, 1970. – 444 p.
2. *Album of aerial photographs of the vegetation cover of peat deposits in the central part of Western Siberia*. – M.: Geoltorfrazvedka, 1973. – 83 p.
3. Afanas'eva T.V., Vasilenko V.I., Terzhina T.V., Sheremet B.V. *Soils of the USSR*. – Moscow: Thought, 1979. – 380 p.
4. Belousova A.P., Gavich I.K., Lisenkov A.B., Popov E.V. *Ecological hydrogeology*. – M.: Akademkniga, 2006. – 397 p.
5. Venitsianov E.V. *Physical and chemical processes in surface waters // Water problems at the turn of the century*. – M.: Nauka, 1999. – S. 241–255 p.



6. *Hydrometeorological regime and water balance of raised bogs in the North-West of Russia (on the example of the Lammin-Suo bog) / ed. CM. Novikova, V.I. Batuev. - St. Petersburg: Own publishing house, 2019. - 448 p.*

7. *Shang Lijun, Liao Huamei, Tu Zhe, Zhong Keyuan, Meng Lihong, Du Chao. Extreme temperature changes in the Poyang Lake Basin from 1960 to 2018 and their relationship with atmospheric circulation [J]. Resources and Environment of the Yangtze River Basin, 2021, 30(01):160-171.*

8. *Soldatova E., Gromyak I., Dogadkin D., Dong Y., Li J., Sun Z., Ivanova I., Toropov A. Geochemical conditions of natural wetland and paddy fields in the Poyang lake area, China // SN Applied Sciences. 2021. T. 3. № 1. DOI: 10.1007/s42452-020-04060-8.*

9. *Zemtsov V.A., D.A. Vershinin, V.V. Khromykh, O.V. Khromykh Long-term dynamics of maximum flood water levels in the middle course of the Ob River // IOP Conference Series: Earth and Environmental Science. Bio-Clim-Land. – 2019. – V. 400. – 012004. DOI:10.1088/1755-1315/400/1/012004.*

10. *Weight W.D. Hydrogeology Field Manual. 2-nd edition, 2008. USA: The McGraw-Hill Companies, Inc., 2008. – 751 p.*

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